Fickian to Single-File Diffusion Transition in nano-colloids

by

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Abstract

Nano-colloids are present or arise in diverse processes, from the manufacturing of solar panels and pharmaceutics, treatment of mine tailings, and a lead example to the production of unconventional hydrocarbon resources and molecular fluids are frequently added to the colloids during processing. A detailed understanding of the relative importance of impacts of Fickian diffusion, Single-File diffusion, and sorption of penetrants on colloid surfaces provides insights on the time scales and outcomes that govern process designs for specific cases. Therefore, first potential roles played by Fickian diffusion, Single-File diffusion arising from constrictions among heavy oils nano-dispersed phase domains, and sorption of penetrants by these dispersed phase domains were explored. Detailed models including diffusion and sorption were prepared and applied to previously published composition profile data for light hydrocarbons diffusing into heavy oils and heavy oil fractions. These data sets showed deviation from Fickian diffusion at high heavy oil mass fractions. These deviations were attributed to a shift in the dominant mechanism from Fickian to Single-File diffusion. The impact of sorption on composition profiles could be ignored even when high sorption rates and equilibrium extents of sorption were assumed.

Furthermore, sorption of toluene on carbon nanotubes, nano-diamonds, and nano-silica particles was investigated using a TAM III solution calorimetry module. Toluene was then added to colloidal suspensions comprising polybutene + carbon nanotubes, nano-

diamonds and silica nanoparticles. Baseline cases including only Fickian diffusion, as well as Fickian diffusion + Single-File diffusion, and Fickian diffusion + Single-File diffusion + sorption were examined. Diffusion measurements with nanoparticles having different sizes, shapes and surface properties showed that when the average nearest neighbor distance among nanoparticles was ~120 nm or larger Fickian behavior was observed (n_w = 0.5). At shorter nearest neighbor distances the diffusion mechanism transitions to Single-File diffusion. When the average nearest neighbor distance among nanoparticles became less than ~20 nm, the transition to Single-File diffusion (n_w = 0.25) was complete. Although sorption on colloid surfaces impedes diffusion of solvent into nanocolloids, it did not appear to interfere with the values of n_w and active diffusion mechanism identification for the cases studied in this work. The impacts of nanoparticle shape and surface properties on the transition from Fickian diffusion to Single-File diffusion were not resolved in the measurements, suggesting that nearest neighbor distance is the primary parameter impacting the diffusion mechanism. Particle shape and surface properties appear to be secondary variables.

Preface
(Mandatory due to collaborative work)

Chapter 3 was done in collaboration with Dr. Petr Nikrityuk, a professor in Department of Chemical and Material Engineering at University of Alberta. Dr. Nikrityuk was responsible for numerical solutions of equations used in the chapter and provided support and advice during the work. I was responsible for solving part of the partial differential equations and applying all of the simulation data to previous literature data as well as writing the manuscript.

Chapter 4 was done in collaboration with Dr. Amin Pourmohammadbagher, a postdoctoral fellow in Department of Chemical and Material Engineering at University of Alberta. Dr. Pourmohammadbagher was in charge of calorimetric measurements and editing manuscript. I did experimental measurements and put together the manuscript.

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Chapter 1. Introduction

Colloids comprise a particulate/discrete liquid phase dispersed in a continuous fluid phase. Examples include aerosols, milk, and emulsions[1,2]. Nanocolloids arise in diverse processes, from the manufacturing of solar panels, pharmaceutics and biochemical products, to the production of unconventional hydrocarbon resources, and the treatment of mine tailings[1,3–5]. A detailed understanding of the relative importance of impacts of Fickian diffusion[6–8], Single-File diffusion, and sorption[9] of penetrants on colloid surfaces provides insights regarding the time scales and outcomes that govern process designs for specific cases. A lead example in this area is production from unconventional resources. It is predicted that global energy consumption will increase by almost 50% over the next 20 years[10]. Most of this increase will come from oil and gas, particularly as coal consumption, currently a major energy source, has been mandated to decrease or to be phased out over this interval. These are the only sources available in sufficient quantity to replace coal and provide a significant fraction of the increasing demand[11,12].

Optimized extraction from unconventional oil resources will continue to contribute to energy supply moving forward because the greenhouse gas (GHG) emissions/GWatt of useful energy produced are less than 2/3 of those arising from coal.

Considerable research especially related to nanotechnology and microfluidics has been done recently to improve and enhance the rate of recovery from both conventional and especially unconventional reservoirs[4,13–15]. For example, fluid flow control is one of the

most important factors in hydrocarbon fluid extraction processes. Injectant fronts should move uniformly thus, they could penetrate formations without leaving large zones containing hydrocarbon resources. Nanoparticles can improve fluid flow in extraction processes by impacting reservoir rock wettability or the surface tension between hydrocarbon and water or between either fluid and the reservoir rock[13,16].

Detailed understanding of interactions between injectant and hydrocarbon resource interactions at interfaces within reservoirs is critical from the perspective of optimizing production processes. In addition to displacing hydrocarbon resources, injectants are intended to reduce their viscosity. This is done thermally with steam injection and with diluents such as CO_2 and light hydrocarbons that dissolve into reservoir fluids leading to orders of magnitude reductions in viscosity. Steam assisted gravity drainage (SAGD) and vapor extraction (VAPEX)[17–19] processes reflect these two extremes. Other processes such as expanding solvent steam assisted gravity drainage (ES-SAGD)[20] combine both effects. The SAGD process has gradually being supplanted with ES-SAGD because it generates lower GHG emissions, and reduces water consumption relative to SAGD. These environmental impact markers as well as economic factors are driving this transition.

Diffusion of organic injectants into the hydrocarbon resource, determines the time frame and extent of viscosity reduction while the effectiveness of the related processes is controlled by molecular diffusivity and other effects arising at the injectant/hydrocarbon

resource interfaces. Interactions at these interfaces are poorly understood and are debated in the literature[21].

This thesis focuses on the diffusion mechanism identification in nano-colloids and also the impact of the phase behavior of heavy oils on the identification of the dominant or active diffusion mechanisms in hydrocarbon resources and on the ongoing development and refinement of processes for their production, transport and processing.

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Chapter 2. Literature Review

Mass transfer and diffusion rates for a large number of binary mixtures including polymers, heavy oils, light hydrocarbons and aromatics are available in the literature[1–5]. In most of the studies, Fickian diffusion is assumed and mutual diffusion coefficients are determined by solving Fick's second law. In Fickian diffusion, molecules bypass each other freely, which is the case for simple binary mixtures (Figure 2.1a). However, when nanoparticles are added, a network of nano-channels is formed, and the active diffusion mechanism shifts from Fickian to Single-File diffusion. In addition, sorption of penetrants on surface of particles can impede diffusion and the dominant diffusion mechanism may also change (Figure 2.1b) at lower nano-particle volume fractions than might otherwise occur. Case studies in which the active diffusion mechanism is Single-File diffusion or include both Fickian and Single-File diffusion effects, or for which sorption of penetrants occurs are important to investigate as they establish criteria for process specification and process design optimization.

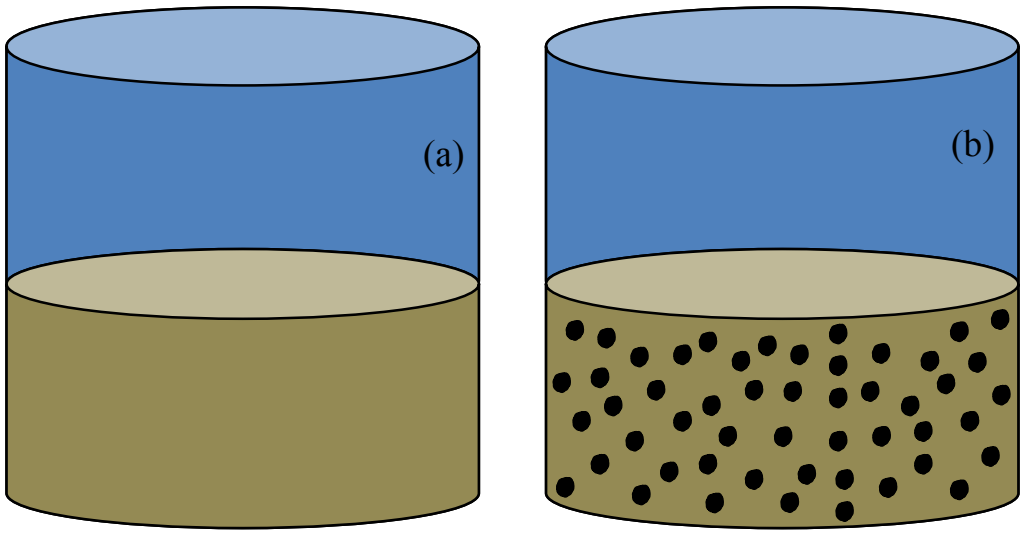

Figure 2.1 Schematic of an idealized interface at time = 0 for diffusion in a binary molecular mixture (a) and in a binary molecular mixture + nanoparticles (b).

2.1. Fickian diffusion

Fick's second law or Fickian diffusion equation describes the movement of molecules through molecular diffusion over time and can be derived based on a control volume moving in one dimension[6].

$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial x}\left(D\frac{\partial c}{\partial x}\right) \tag{2.1}$$

where c is concentration (kg/m^3), x is distance (m) and D is mutual diffusion coefficient (m^2/s).

Two practical cases of equation 2.1 are diffusion with a static interface at the beginning (Figure 2.2a) and instant diffusion of a source (Figure 2.2b). Both cases possess clear analytical solutions. For example, equation 2.2 shows the concentration as a function of time and distance for diffusion front movement.

$$c(x,t) = (1 - \frac{c}{2}) \times erf(\frac{x}{2\sqrt{Dt}}) \quad (2.2)$$

where *erf* is the error function defined in equation (2.3).

$$erf(x) = \frac{1}{\sqrt{\Pi}} \int_{-x}^{x} e^{-t^2}\ dt \quad (2.3)$$

Numerical solution of equation 2.1 demands one initial condition, due to the time derivative term ($\frac{\partial c}{\partial t}$), and two boundary conditions because of the second order ($\frac{\partial^2 c}{\partial x^2}$) spatial derivative.[7]

Constant concentration and flux boundary conditions or a combination of both are typical boundary conditions used for mass transfer problems[6,8].

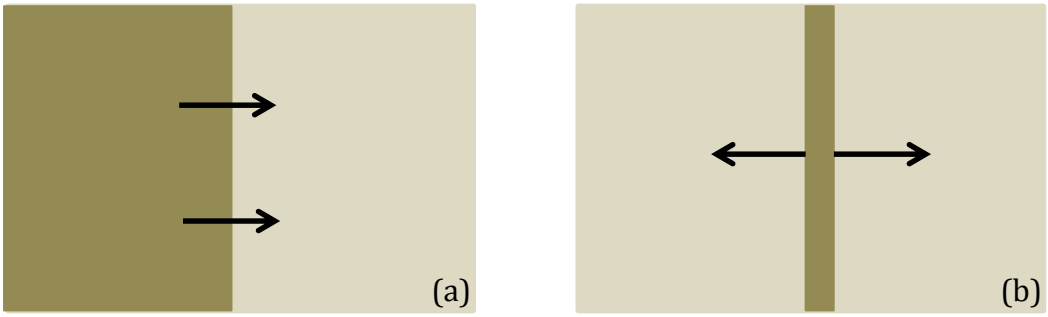

Figure 2.2 Schematic of diffusion at time zero for static interface diffusion (a) and instant release diffusion (b)

Direct measurement of composition profiles with time in liquid phases is the most certain approach for determining mutual diffusion coefficients and their dependence on composition, if convection is not present or is minimized. Different techniques such as a spinning disk[9], chromatography[10], Taylor dispersion[11], laser transmission imaging[12], x-ray transmission imaging[4,5,13,14], and visible light transmission imaging[2] have been used

for this purpose. Indirect approaches such as measuring the pressure drop of a species in a gas phase in contact with a liquid have been discredited for this application, because required assumptions regarding interface behavior can lead to one thousand fold differences in the values of liquid phase diffusion coefficients identified[15].

2.2. Single-File diffusion

Single-File diffusion arises when molecules must move one by one because of physical constraints[16–20] that prevent molecules from moving freely past one another. The concept of Single-File diffusion was first proposed by Hodgkin and Keyness[21] to describe movement of water and ions through channels with molecular scale dimensions, and then experimentally observed for: xenon adsorbed in zeolites[22,23]; water transport through interior channels within carbon nanotubes[24–26]; and ion transport within biological membranes[27–29]. These studies led to additional applications for Single-File diffusion such as heterogeneous catalysis and mass separation, water desalination and gas adsorption[30].

Richards[31] and Fedders[32], who studied ions conduction through biological membranes, developed a relationship describing mean square displacement of molecules in infinite Single-File channels:

$$< \Delta x^2 > = 2F\sqrt{t} \qquad (2.4)$$

where x is displacement (m), F is the Single-File mobility coefficient ($m^2/s^{1/2}$) and t is time (s).

Single-File diffusion has been explored experimentally in diverse nano channels, as illustrated in Table 2.1. In each case cited, the Single-File diffusion mechanism was identified by tracking mean squared displacement of molecules over time and showing that the values were proportional to the square root of time. Single-File mobility coefficients were identified using equation 2.4.

Table 2.1. Studies done on Single-File diffusion

System	Penetrant size	Channel size
Paramagnetic colloidal spheres in circular trenches[33]	3.6 μm	7 μm
Colloidal particles confined to one dimensional channels[17]	2.9 μm	< 5.8 μm
CF_4 gas molecules in AlPO4-5[34]	4.7 Å	7.3 Å
Methane in ZSM-48[18]	3.8 Å	5.3 Å

2.3. Fickian to Single-File transition

Quite a few studies have investigated the concept of bimodal diffusion and transition from Fickian to Single-File diffusion[26,35,36]. For example, Sane et al.,[36] simulated movement of colloidal particles in one-dimensional channels. They started from pure Signle-File channel and kept increasing the channel size and observed and measured the time it takes for molecules to bypass each other to identify the transition from Single-File to Fickian diffusion. Chen et al.,[26] studied diffusion of binary mixtures of Lennard-Jones fluids (Ar/Ne, Ar/Kr, Ar/Xe) in Single-Walled carbon nanotubes. They observed that the primary factor in transition from Fickian to Single-File diffusion is the size of particles

and that diffusion mechanism does not depend on the mixture concentration. Although Chen et al.,[26] studied the effect of concentration, most of the literature relates the transition from Single-File to Fickian diffusion to size of channels and penetrant molecule diameter and possible effects of shape, concentration and surface properties of particles are often missing.

2.4. Adsorption

Adsorption of species on a surface is categorized as physiosorption or chemisorption. In physiosorption, the sublimation energy is around 20-40 kJ/mol and the adsorbate is free to rotate. For chemisorption, the sublimation energy is 100-400 kJ/mol and the adsorbate is relatively motionless[37,38]. The material on which molecules sorb is called the adsorbent. Molecules before and after sorption are called adsorpt or adsorptive and adsorbate respectively.

The surface concentration of adsorbates is described by adsorption isotherms showing the amount adsorbed/per unit area vs. the concentration or pressure of particles[39] in the fluid. Henry adsorption isotherm is the simplest case. Surface concentration increases linearly with adsorpt concentration. Friendlich isotherm is a common adsorption type. It indicates high sorption extents at low adsorpt concentrations for surface sites with higher affinity. Langmuir adsorption isotherm, shows saturation above a certain concentration where all the sites have been occupied. Langmuir and Friendlich isotherms were introduced about seventy years ago and remain the most common used for their simplicity and ability to fit a wide range of data.[39] Sigmoidal isotherm is used only for flat and homogeneous

adsorbents and step isotherm is often observed with porous materials. A detailed description of other isotherms is provided elsewhere.[37,38]

2.5. Heavy oils/Bitumen Production

Heavy oils/Bitumens are immobile and shear rate dependent viscosities that can surpass $10^3 Pa.s$ arise at reservoir conditions[40]. Significant flow rates only arise at orders of magnitude lower viscosities. Current and proposed in situ production methods target viscosity reduction. Steam assisted gravity drainage (SAGD) is the most commonly used method for recovery enhancement processes. SAGD exploits the high rate of thermal diffusion in reservoirs. Steam, produced on the surface, is injected into and heats the reservoir to over 200 ℃. The heated bitumen has a lower viscosity of ~0.01 Pa.s[41–43] at 200 ℃. Hydrocarbons and liquid water are produced and pumped up to the ground for further treatment[44,45]. This method consumes large amounts of water and energy[46,47] per barrel of hydrocarbon produced and alternatives that reduce water and energy consumption are being pursued actively. For example, in the Vapor extraction (VAPEX) process**,** low molar species (propane and butane with CO_2[48–50]) are injected into reservoirs and diffuse into the bitumen at near ambient temperature. Mixtures of bitumen + low molar mass species have low viscosities compared to bitumen. For example the viscosity of bitumen + 0.261 propane mass fraction at 290 K[48] is equivalent to the viscosity of bitumen at 420 K[42,43]. Mass diffusion is slow relative to thermal diffusion. The Expanding solvent steam assisted gravity drainage process combines both mass and heat transfer as a mixture of high-temperature steam and low molar mass species which are injected into the reservoirs. The steam heats the reservoir and the low molar mass

species diffuses into the heavy oil/bitumen. Mass diffusion rates increase with increasing temperature and targeted viscosities are achieved at lower temperatures than with steam alone, and at lower diluent concentrations than in the VAPEX process. For example, Gates and Chakrabarty[43] have shown that after five years of operation an optimized ES-SAGD process uses 15% less steam than an optimized SAGD processes and produces 1.3 times more bitumen. This approach requires detailed process and materials knowledge to optimize water consumption, energy consumption and diluent use. High recovery rates are needed for this process to be economically feasible[43], and diluent losses due to sorption on clay and other surfaces in reservoirs must be mitigated[51].

For the technical, environmental impact, and economic optimization of ES-SAGD and VAPEX and related production processes, the rate of penetration of low molar mass species into hydrocarbon resources, the time scale determining step for viscosity reduction and hence production rate, must be understood. Molecular diffusion and other interactions arising at penetrant/resource interfaces are poorly understood and are debated in the literature[52,53]. In most reservoir models, diffusion coefficients are fitted to production data to match production rates[1,2,4,5,54]. Little concern is paid to whether the values fall within the range for liquids[4] and little attention is paid to whether self, mutual, or tracer Fickian diffusion coefficients are relevant or whether another diffusion mechanism, such as the Single-File diffusion or sorption, are relevant[3,55,56]. For example, Wen and Kantzas[4] reported values as high as $5x10^{-10}$ m^2/s for diffusion of heptane in Cold Lake bitumen at room temperature or Guerrero-Aconcha et al.,[14] have reported up to $85x10^{-11}$ m^2/s for diffusion of n-octane into heavy oil at room temperature. Tang[57]

reported values as low as $0.068x10^{-10}$ m^2/s for diffusion of toluene in bitumen. This lack of understanding regarding the controlling mechanisms and diffusion rates related to solvent penetration at hydrocarbon resource/penetrant interfaces in reservoirs represents perhaps the most important area of uncertainty for the development of solvent based or solvent assisted production processes with economic and environmental benefits.

2.6. Nano colloids

Colloids arise in natural environments and in the manufacturing of products. Colloids are sometimes confused with terms such as solution or suspension. A solution is made up of a solute in the form of ions, atoms or molecules and a solvent, which is usually a liquid. Suspensions comprise a solvent and large particles, which settle in the absence of external forces. The difference between a colloid and a solution can be identified by using the Tyndall effect. Light does not scatter passing through a solution while does in a colloid. Figure 2.5 shows examples of a colloid, a solution and a suspension. Particles (with a range of 1-1000 nm) in a colloid cannot be seen with the naked eye, and do not settle over time or take a long time to settle if they aggregate[58,59]. Colloids are divided into seven common categories depending on the nature of the dispersed phase and dispersion medium[58]. A summary is presented in Table 2.2.

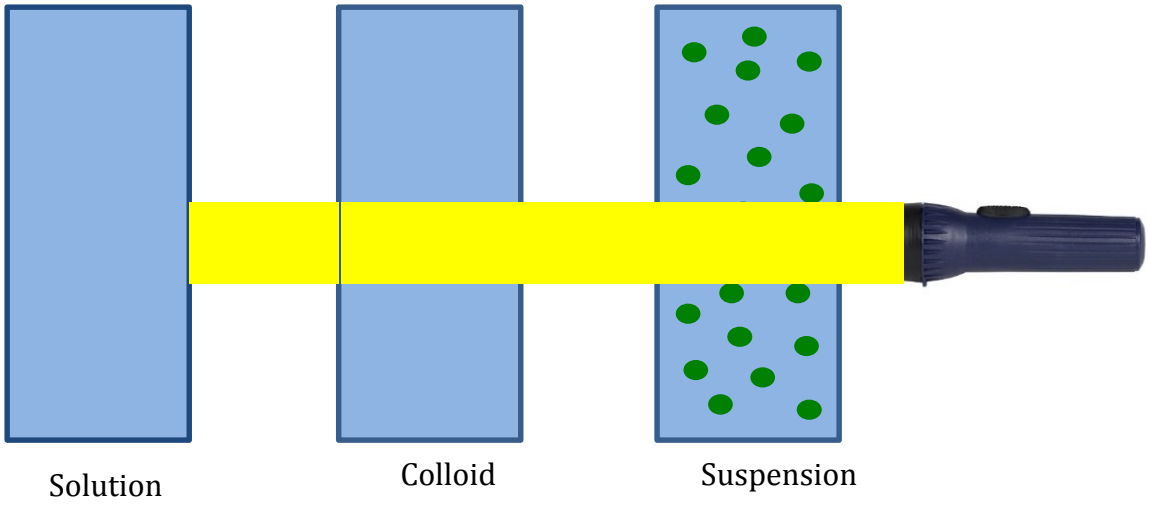

Figure 2.3 Comparison of a solution, a colloid and a suspension in the presence of light

Table 2.2 Types of colloids

Dispersion medium	Dispersed phase	Name	Example
Gas	Solid	Aerosol	Industrial smoke
Gas	Liquid	Aerosol	Fog
Liquid	Liquid	Emulsion	Milk
Liquid	Solid	Solid	Paint
Liquid	Gas	Foam	Froth
Solid	Solid	Suspension	Glass
Solid	Gas	Solid foam	Zeolites

2.7. Nanoparticles relevant to this work

Adding nanoparticles such as nanodiamonds, nanosilica or carbon nanotubes to a liquid phase can form colloids. Carbon nanotubes are either Multi-Walled or Single-Walled. They possess hydrophobic surfaces and therefore strong interactions between them and

organic chemicals is presumed[60,61]. Such particles are layered in structure. Each carbon atom is attached to three other carbon atoms and the pattern extends in two dimensions to form a hexagonal array, and there is weak van der Waals force holding carbon sheets together[61]. Although lighting a match produces carbon nanotubes, the purity is so low that it is not a useful method to produce carbon nanotubes. Arc discharge, laser ablation and chemical vapor deposition techniques are preferred [62–65].

Diamond and graphite are allotropes of carbon. They have different properties due to their unique structure. Diamond has a tetrahedral structure. Carbon atoms are attached to four neighbors, which results in an infinite network of atoms. This structure results in extreme hardness, strength and resistance to compression. It has five times the thermal conductivity of copper although it is an insulator in terms of electricity[67].

For many applications nanoparticles should be small and uniform.[69] However, nanoparticles in the form of dry powders tend to agglomerate. Techniques such as sonication, centrifugation, milling are used to break agglomerates in general and for detonation nanodiamond in particular[70–72].

Fumed silica (pyrogenic silica) is produced from pyrolysis of a homogeneous mixture of silicon tetrachloride or quartz sand, steam hydrogen and dry air in a oxyhydrogen flame in a 3000 ℃ electric arc furnace[73]. Fumed silica is used commercially to increase the viscosity of fluids and in biochemistry to adsorb lipids from sera[74].

2.8 Summary

Diffusion of organic injectants into the hydrocarbon resource, determines the time frame and extent of viscosity reduction, and the effectiveness of the related processes is controlled by molecular diffusivity and other effects arising at the injectant/hydrocarbon resource interfaces. Interactions at these interfaces are poorly understood and are debated in the literature[52]. This thesis focuses on the identification of active diffusion mechanism in nanocolloids and the impact of the phase behavior of heavy oil on the identification of the dominant or active diffusion mechanisms in hydrocarbon resources and on the ongoing development and refinement of processes for their production, transport and processing.

Chapter 3 builds on prior work[3], where the limits of Fickian and Single-File diffusion were identified in heavy oil + diluent mixtures. In Chapter 3 potential roles played by Fickian diffusion and sorption of penetrants by dispersed phase domains are explored numerically. Detailed models including these behaviors were prepared and applied to previously published composition profile data for light hydrocarbons diffusing into heavy oils and heavy oil fractions. The dominant diffusion mechanism is shown to shift from Fickian diffusion to some combination of Single-File diffusion + sorption as the mass fraction of the light hydrocarbon penetrant decreases. Impacts of sorption and Single-File diffusion cannot be discriminated based on mathematical analysis alone.

In chapter 4, a detailed understanding of the relative importance of impacts of Fickian diffusion, Single-File diffusion, and sorption of penetrants on colloid surfaces is developed. Fickian diffusion, Single-File diffusion – in nano-scale constrictions among

particles, and penetrant sorption on colloidal particles impact transport of penetrants in colloidal suspensions. Their relative importance is dictated by the size, size distribution, shape, volume fraction and surface properties of particles. Without foreknowledge of active transport mechanisms it is difficult to interpret experimental outcomes and to optimize specific process designs/process concepts. Baseline cases including only Fickian diffusion, as well as Fickian diffusion + Single-File diffusion, and Fickian diffusion + Single-File diffusion + sorption are examined.

Numerical solutions to all equations used in chapter 3 are explained and coded in Appendix A.

Conclusions are provided in chapter 5, and all the literature data and their model fits as well as experimental data are reported in tables as Appendix B.

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Chapter 3. On Diffusion Mechanism Discrimination In Heavy oil + Light Hydrocarbon Pseudo Binary Mixtures

3.1 Introduction

Heavy oils are nanostructured fluids comprising a continuous fluid phase + a nanodispersed asphaltene rich phase.[1,2] The nanodispersed phase can be filtered from the parent hydrocarbon resource samples without addition of solvents and may be considered to be pentane asphaltenes – to a first approximation[2–5]. These domains possess a bimodal size distribution with one peak comprising ~ 50 wt.% of the domains at ~ 10 nm or less and a more distributed second peak at a larger and variable length scale. None of the domains appear to be larger than ~ 200 nm. At ~ 300 K and below, the continuous liquid phase begins to solidify[6–9]. This phase behavior is shown schematically in Figure 3.1. Diffusion processes arising in heavy oils + light hydrocarbon pseudo binary mixtures, shown schematically in Figure 3.2, may therefore include classical Fickian diffusion[10,11], equation 3.1, as well as Single-File diffusion[12, 13–16] of species among the nano-dispersed asphaltene-rich domains, if they are close enough together to impede molecular movement[17,18]. Sorption, equation 3.2, of the low molar mass hydrocarbon, e.g., toluene or pentane by nano-dispersed asphaltene-rich domains presents a confounding variable, impacting the interpretation of the evolution of experimental composition profiles with time. For example, n-alkanes are sorbed by asphaltenes[19].

$$\frac{\partial}{\partial t}(\rho c) = \frac{\partial}{\partial x}\left[\rho D \frac{\partial c}{\partial x}\right] \tag{3.1}$$

$$\frac{\partial}{\partial t}(c) = \frac{\epsilon - 1}{\epsilon} \times \frac{\partial c_p}{\partial t} \tag{3.2}$$

In equations 3.1-2, c is the light hydrocarbon mass fraction, ρ is mixture density, D is the Fickian mutual diffusion coefficient, $\in$ is void fraction (fluid phase volume fraction), c_p is the mass fraction of solvent adsorbed on dispersed phase surfaces, x is distance and t is time.

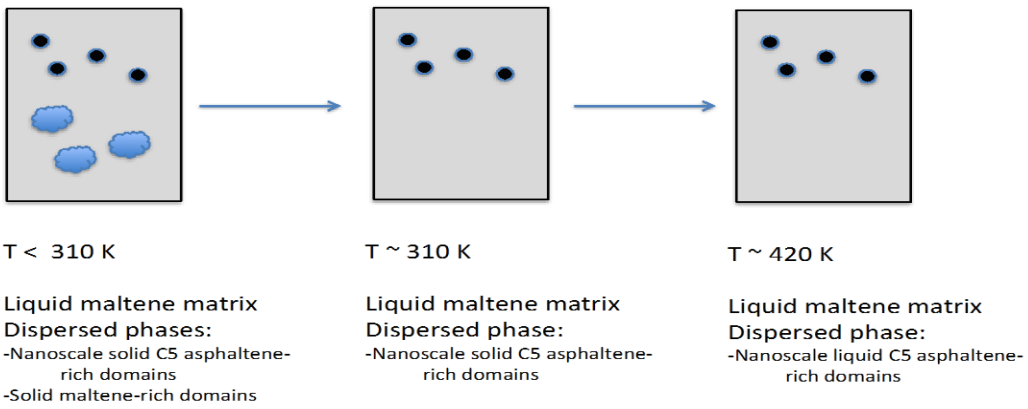

Figure 3.1 Phase behavior schematic of heavy oils

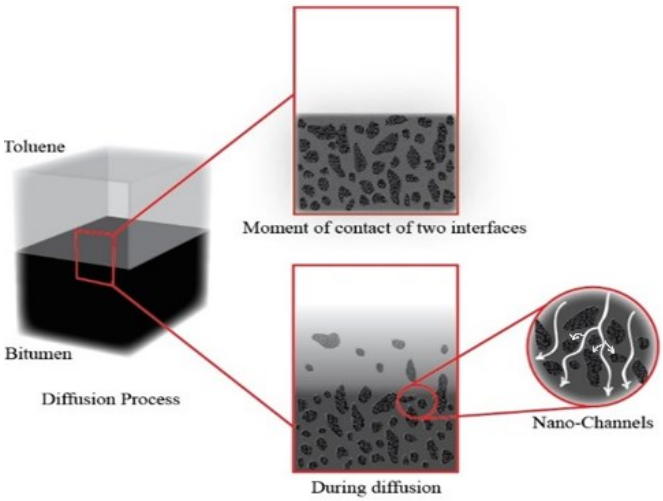

Figure 3.2 Schematic showing mutual diffusion of toluene and bitumen (taken from Alizadehgiashi et al.[20])

Direct measurement of composition profiles with time in liquid phases is the most certain approach for determining mutual diffusion coefficients and their dependence on composition, if convection is not present or is minimized. Indirect approaches such as measuring the pressure drop of a species in a gas phase in contact with a liquid have been discredited for this application, because required assumptions regarding interface behavior lead to one thousand fold differences in the values of liquid phase diffusion coefficients identified [21]. Acoustic, x-ray and visible light telemetry have been adapted to investigate diffusion processes in low molar mass hydrocarbon + heavy oil pseudo binary mixtures. Zhang et al.,[22,23] and Sadighian et al.,[24] used x-ray transmission tomography to measure local composition profiles and to obtain mutual diffusion coefficient of Athabasca bitumen (18.6 wt. % pentane asphaltenes), and atmospheric residue + pentane mixtures. Wen et al.,[25] studied heptane diffusion into Cold Lake bitumen with a CAT scanner. Their composition profile data were re-analyzed by Zhang and Shaw[22]. Fadaie et

al.,[26] used a microfluidics approach and visible light transmission to obtain mutual diffusion coefficients of Athabasca bitumen + toluene mixtures. For these latter measurements, the time frame of composition profile measurements is in the order of seconds, which minimizes possible impacts of convection. These works are summarized in Table 3.1. The Fickian mutual diffusion coefficient values are constant, within measurement uncertainty, over broad ranges of composition – from 0.10 to 0.90 heavy oil mass fraction in most cases – and fall within a narrow range at room temperature. Impacts of Single-File diffusion and sorption are thus expected only at high heavy oil mass fraction.

Table 3.1 Fickian diffusion coefficient evaluation based on liquid phase composition profile measurements in heavy oil and heavy oil fractions + low molar mass hydrocarbon mixtures at room temperature.

Solvent + solute	Methodology	Number of compositions	Composition resolution (mass fraction)	Composition range of validity of D	Mutual diffusion coefficient (m^2/s)
Toluene + Athabasca bitumen[26]	Microfluidics	5	0.0015	0.2 - 0.8	$(1.1 \pm 0.9)x10^{-10}$
Toluene + Athabasca bitumen[20]	Acoustic transmission	7	0.01	–	–
Pentane + Athabasca bitumen[22,23]	X-ray tomography	9	0.003	0.1 - 0.9	$(1.8 \pm 0.4)x10^{-10}$
Pentane + Athabasca bitumen[24]	X-ray tomography	7	0.003	0.1 - 0.9	$(1.6 \pm 0.3)x10^{-10}$
Pentane + Athabasca atmospheric residue[24]	X-ray tomography	5	0.003	0.66 - 0.77	$(0.57 \pm 0.07)x10^{-10}$
Heptane + Cold Lake bitumen[22,25]	X-ray tomography	5	0.01	0.1 - 0.6	$(1.5 \pm 0.7)x10^{-10}$

Where Fickian diffusion dominates, composition vs. elevation (x) profiles obtained at different times (t) superimpose if compositions are plotted against the joint variable $<x>/t^{0.5}$. Where Single-File diffusion dominates, composition profiles superimpose when plotted against $<x>/t^{0.25}$. The corresponding mutual diffusion and mobility coefficients are the constants associated with the proportionalities:

$$< x >^2 = 2Dt \quad (3.3)$$

$$< x >^2 = 2Ft^{0.5} \quad (3.4)$$

that appear as joint distance-time variables in the corresponding diffusion equations. Alizadehgiashi and Shaw[20] reviewed the composition profile data in Table 3.1 from the perspective of identifying governing diffusion mechanisms and showed that at high heavy oil mass fractions, the dominant diffusion mechanism shifted away from Fickian diffusion by tracking the value of the exponent with composition that led to superposition of the composition profiles. They also performed control experiments with polybutene + toluene with and without carbon nanotubes and attributed the diffusion mechanism shift for both sets of data as a shift from Fickian diffusion at high solvent mass fraction to dual-mode[17] and then to Single-File diffusion as the dispersed phase mass fraction increases, and the corresponding average distances among adjacent nano-dispersed domains becomes smaller. This analysis did not include the possible impact of sorption of toluene, pentane, or heptane on or by the nano-dispersed phase domains.

In the present work, the mixtures listed in Table 3.1 are reanalyzed from the perspectives of Fickian diffusion, Fickian Diffusion + sorption and a control experiment where all three mechanisms are known to occur is evaluated. For each case, the number of fitted coefficients is minimized and the range of coefficient values is constrained by known

physics and chemistry for analogous systems. For example, liquid phase mutual diffusion coefficients fall within narrow ranges and are treated as constants. Sorption coefficients are similarly constrained. Thus composition and governing diffusion mechanism are not independent. The goals of this work are therefore to determine the level of ambiguity among model fits to composition profile data and to identify methodologies and protocols for resolving ambiguities among diffusion/sorption mechanisms thus, the physics of diffusion in heavy oil + low molar mass compounds can be better understood.

3.2 Methodology

3.2.1 Fickian diffusion model

Equation 3.1 makes use of density and composition variables. ρ is the mixture mass density and it is well approximated assuming ideal mixing[22,26]:

$$\rho = \frac{1}{\frac{c}{\rho_1} + \frac{1-c}{\rho_2}} \tag{3.5}$$

where subscript 1 refers to the density of the low molar mass compound and subscript 2 refers to the heavy oil, and c is the mass fraction of the low molar mass compound.

Bulk density and mutual diffusion coefficient values are insensitive to composition and their variation relative to the variation in composition is ignored. For example, mixture densities of toluene + Athabasca bitumen vary by less than 10% from their mean value at 300 K. This assumption is also tested and validated in the present work. Mutual diffusion coefficient values, *D*, vary within experimental uncertainty over broad ranges of composition as validated in our prior work[22–24]. With these assumptions, equation 3.1 reduces to:

$$\frac{\partial}{\partial t}(c) = D\frac{\partial^2 c}{\partial x^2} \tag{3.6}$$

Equation 3.6 can be solved both analytically and numerically. Here, we took a numerical approach to solve the diffusion equation using one initial condition and two boundary conditions (see Appendix A for details). The composition profile at time zero is the initial condition, if provided, otherwise a step change in the composition at the cross over point (interface elevation between solvent and solute at time zero) is assumed. The boundary conditions are based on either constant mass fraction (Dirichlet) or constant flux (Neumann) according to the experimental data provided[10]. The numerical methods and modeling for this solution are well-established and well-understood, and are presented elsewhere in detail[27].

3.2.2 Fickian diffusion + sorption model

This model accounts for Fickian diffusion and for changes in composition in the continuous liquid arising from sorption on the dispersed phase surface. The differential equation for this model[28] is:

$$\frac{\partial}{\partial t}(c) = D\frac{\partial^2 c}{\partial x^2} + \frac{\epsilon - 1}{\epsilon} \times \frac{\partial c_p}{\partial t} \tag{3.7}$$

ϵ is the continuous fluid volume fraction. 1- ϵ is the volume fraction (equated to the mass fraction of asphaltenes) of the dispersed asphaltene-rich phase. Density differences among constituents and phases are ignored. c_p is the mass fraction of the low molar mass compound on the surface of the dispersed phase identified using the well-established Langmuir adsorption isotherm[29]:

$$c_p = \frac{K_l q \times c}{1 + K_l \times c} \quad (3.8)$$

K_l and q are sorption parameters. In the absence of light hydrocarbon + asphaltene-rich domain sorption isotherms, the sorption parameters for toluene dissolved in water onto carbon black and activated carbon[30–32], shown in Table 3.2, provide benchmarks for low to high rates and extents of adsorption. Sorption by activated carbon F300 is greater than sorption by activated carbon F400, which is much greater than sorption by carbon black. Equations 3.7 and 3.8 may be solved using explicit or implicit numerical methods (see Appendix A for details).

Table 3.2 Langmuir parameters for toluene sorption from water onto carbon black and activated carbon

Toluene Langmuir Parameters	Carbon black[32]	Activated carbon (F300)[30]	Activated carbon (F400)[31]
q (g/g)	2.8×10^{-3}	0.25	0.18
K_1 (l/mg)	6×10^{-4}	0.50	0.07

3.3 Experimental Section

HPLC grade toluene (with a molar mass of 92.14 g/mol, viscosity of 0.56 mpa.s and density of 865 kg/m^3 at room temperature) and polybutene (with a mean molar mass of 900 g/mol, viscosity of 58 pa.s and density of 892 kg/m^3 at room temperature) were

obtained from Sigma Aldrich and Cannon Instrument respectively. Multiwall carbon nanotubes (length 5 μm, median diameter 6.6 nm) were purchased from Sigma Aldrich. Composition profiles were measured using calibrated speed of sound values (see Appendix C for details). Detailed explanations of the apparatus, procedures and work flow are provided in a recent publication[20]. Two experiments were performed at 298 K. In the first experiment, polybutene was heated to 60 ℃ in this way it could be poured into a 4 cm long polybenzimidazole acoustic cell where it was degassed overnight. Toluene was injected slowly on top of the polybutene using a syringe. An initial speed of sound profile was obtained and four additional profiles were obtained at 3 hr intervals. In the second experiment, a mixture of polybutene + 0.05 carbon nanotubes mass fraction was prepared in the acoustic cell at 80 ℃. The carbon nanotubes were added to the cell and mixed slowly (to minimize the introduction of air bubbles) with preheated polybutene for 15 min. The cell was then sonicated for 1 hr at 60 ℃ to eliminate air bubbles. Acoustic measurements were then performed in the same way as in the first experiment. Illustrative speed of sound profiles are shown in Figure 3.3. The homogeneity of the profiles above and below the interface supports the quality of mixing and the absence of air bubbles in the mixtures.

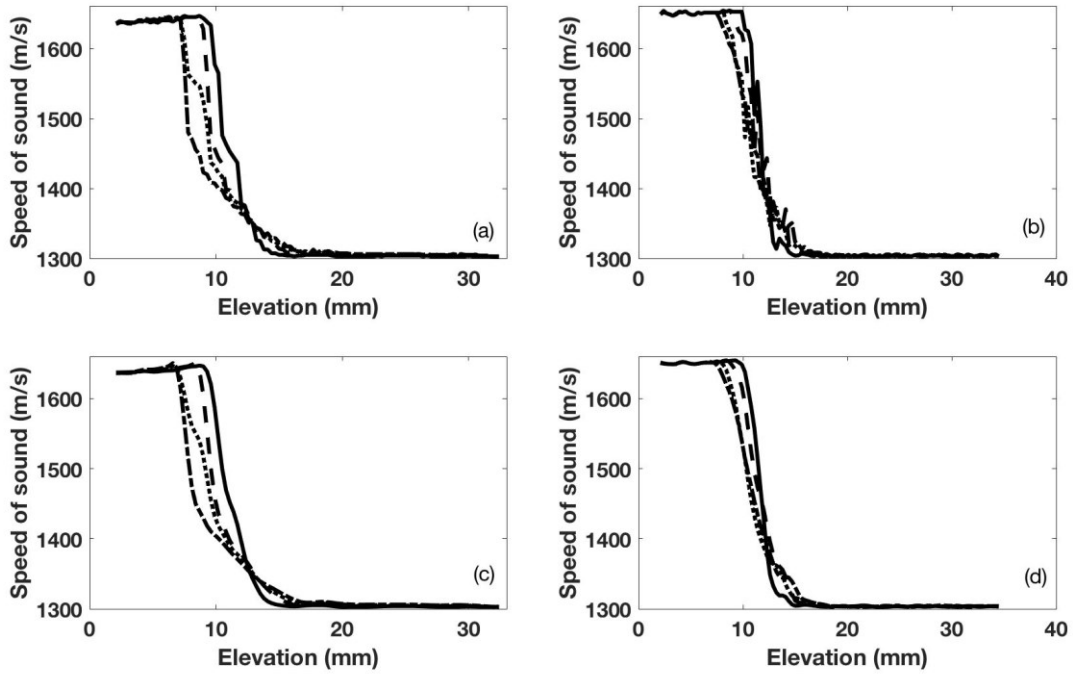

Figure 3.3 Speed of sound profiles for (a) toluene + polybutene (raw data) (b) toluene + (0.05 mass fraction carbon nanotubes + polybutene) (raw data) (c) toluene + polybutene (smoothed data) and (d) toluene + (0.05 mass fraction carbon nanotubes + polybutene) (smoothed data) after 3hr (−), 6hr (----), 9hr (….) and 12hr (-.-.-).

3.4 Results and Discussion

3.4.1. Fickian diffusion model

3.4.1.1.Validation of constant density assumption

Figure 3.4 provides a comparison between computed and measured composition profiles based on the Fickian diffusion model for all sets of composition-elevation profile data. The diffusion model, equation 3.1, is solved assuming constant density and ideal mixing, using data in Table 3.3 and equation 3.5. The impact of density variation is subtle and

does not impact outcomes significantly at short times or at the longest time in each data set.

3.4.1.2 Deviation from literature data at high heavy oil mass fraction

A subset of composition-elevation profiles for data sets shown in Table 3.1 are compared to Fickian diffusion model outcomes in Figure 3.5. Composition profile data and model fits for all cases are provided in Appendix B. As expected, the Fickian model deviates from the composition profile data from Fadaie et al.[26], Figure 3.5a, at low toluene mass fraction. Deviations from the data of Zhang et al.[22,23], Figure 3.5b, at low pentane mass fraction are not evident. At high pentane mass fraction deviations are more evident but these cannot be attributed to a shift in the diffusion mechanism. Other attributions such as convection are tenable. The Fickian diffusion model deviates from the composition profiles for Athabasca bitumen and Athabasca vacuum residue + pentane mixtures[24], Figure 3.5c and Figure 3.5d, at low pentane mass fraction. The outcomes from this analysis, while expected[20], provide a baseline for more detailed analysis.

Table 3.3 Densities of materials used for simulation

Material	Density (kg/m^3)
Toluene	865[33]
Pentane	626[33]
Heptane	684[33]
Athabasca bitumen	1026[26]
Athabasca atmospheric residue	1028[24]
Cold Lake bitumen	927[34]

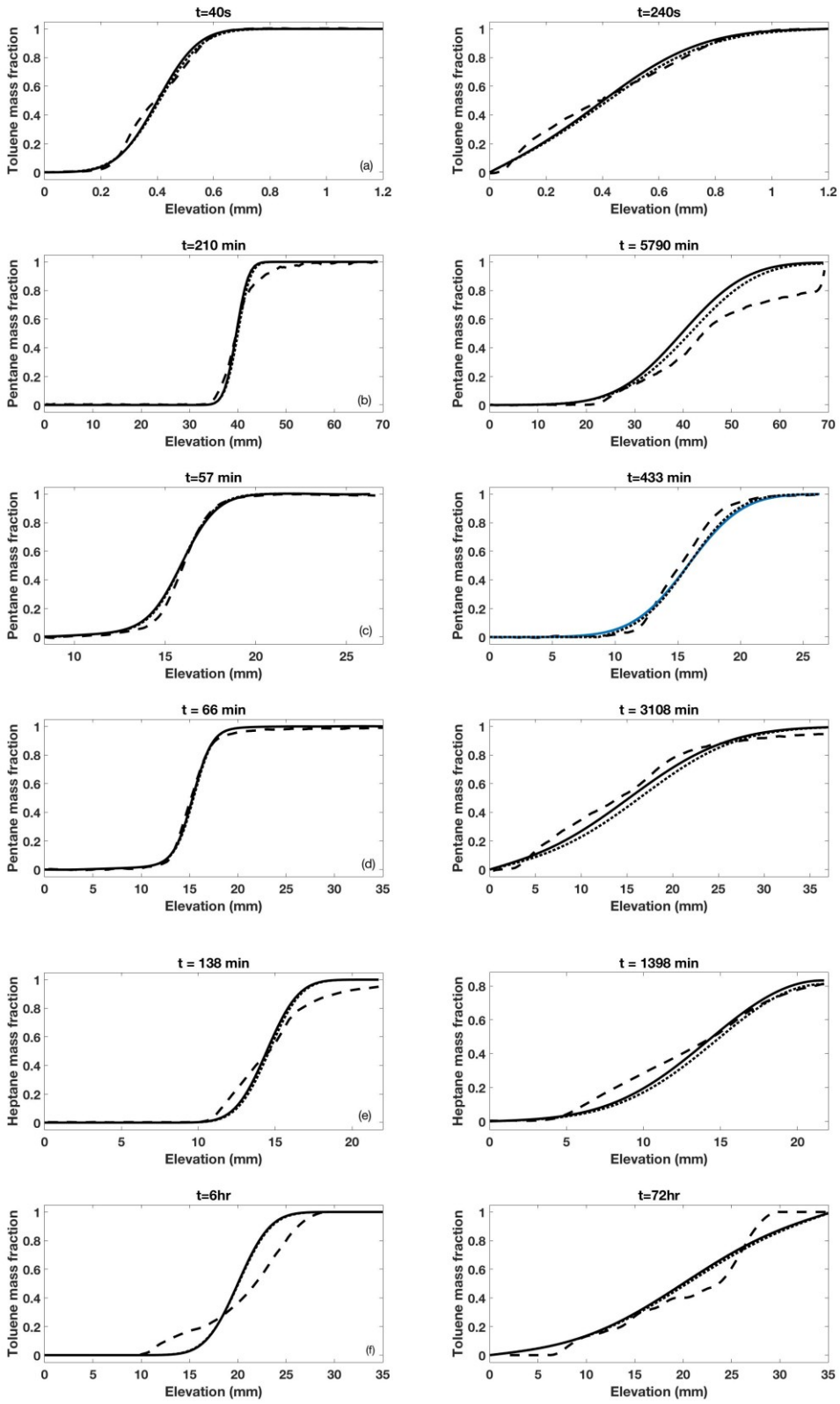
t=40s
Toluene mass fraction
Elevation (mm)
(a)
t=240s
Toluene mass fraction
Elevation (mm)
t=210 min
Pentane mass fraction
Elevation (mm)
(b)
t = 5790 min
Pentane mass fraction
Elevation (mm)
t=57 min
Pentane mass fraction
Elevation (mm)
(c)
t=433 min
Pentane mass fraction
Elevation (mm)
t = 66 min
Pentane mass fraction
Elevation (mm)
(d)
t = 3108 min
Pentane mass fraction
Elevation (mm)
t = 138 min
Heptane mass fraction
Elevation (mm)
(e)
t = 1398 min
Heptane mass fraction
Elevation (mm)
t=6hr
Toluene mass fraction
Elevation (mm)
(f)
t=72hr
Toluene mass fraction
Elevation (mm)

Figure 3.4 Effect of density variation on Fickian diffusion model for (a) Athabasca bitumen + toluene[26] (b) Athabasca bitumen + pentane[23] (c) Athabasca atmospheric residue + pentane[24] (d) Athabasca bitumen + pentane[24] (e) Cold Lake bitumen + heptane[25] (f) Athabasca bitumen + toluene[20]. Time is a parameter for each set of composition profiles. Solid line is Fickian model with constant density, dotted is with density variations consideration and dashed lines are experimental data D = 1.6×10^{-10} m^2/s

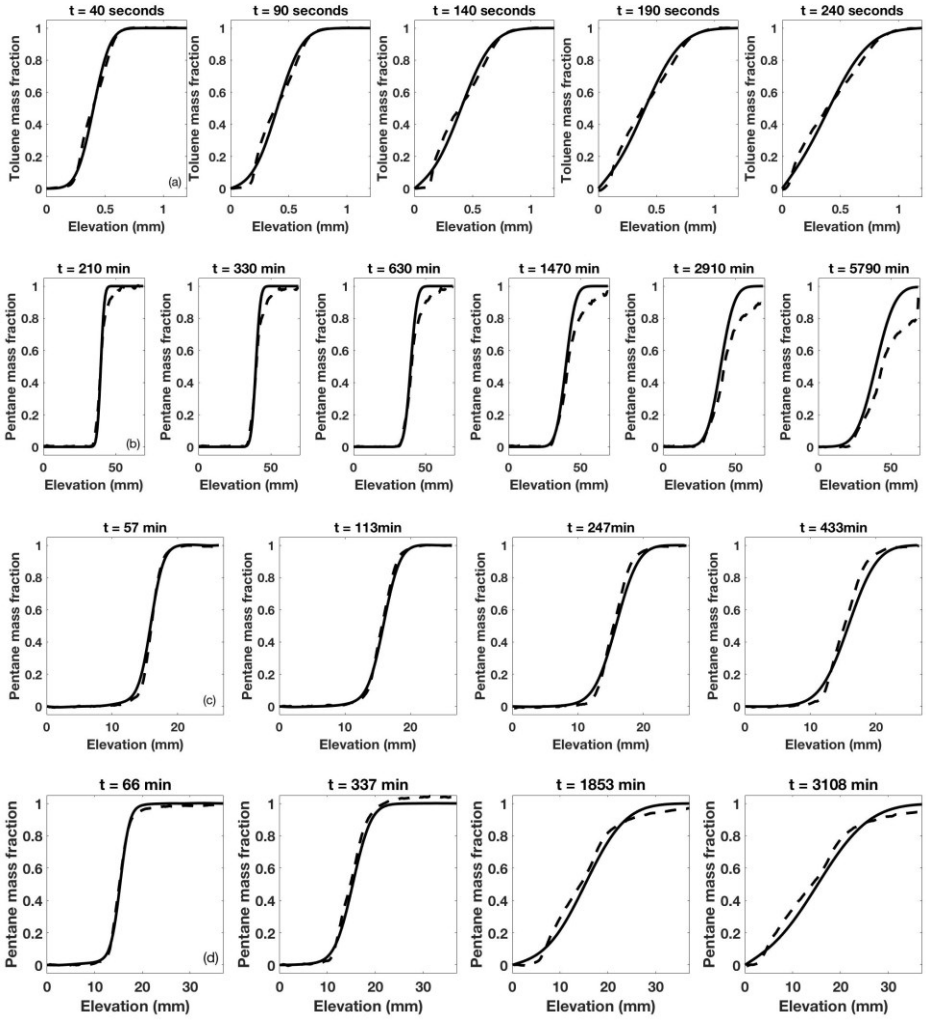

Figure 3.5 Comparison of Fickian diffusion model (solid) with smoothed experimental composition profile data (dashed) for (a) Athabasca bitumen + toluene[26]; (b) Athabasca bitumen + pentane[22,23] (c) Athabasca atmospheric residue + pentane[24]; (d) Athabasca bitumen + pentane[24]. D = 1.6×10^{-10} m^2/s

3.4.2 Fickian diffusion + sorption model

The impact of including sorption is shown in Figure 3.6 and 3.7. In Figure 3.6a-c the Fickian diffusion and Fickian diffusion + sorption models are compared with one another and with data from Fadaie et al.[26] If sorption parameters for carbon black are used, no differences between the two models is detected and large deviations from the experimental composition profiles develop at high bitumen mass fractions. With sorption parameters for activated carbon F-400 and activated carbon F300, deviations from the experimental composition profiles at high bitumen mass fraction are reduced and model outcomes can be discriminated. Other cases are comparable and only outcomes obtained using sorption parameters for activated carbon F300 are reported in Figure 3.8. Even so, the Fickian diffusion and Fickian diffusion + sorption models only begin to diverge from one another and the experimental composition profiles beyond 1800 minutes for Athabasca bitumen + pentane mixtures – Figure 3.7a and beyond 400 minutes for Athabasca atmospheric residue + pentane – Figure 3.7b.

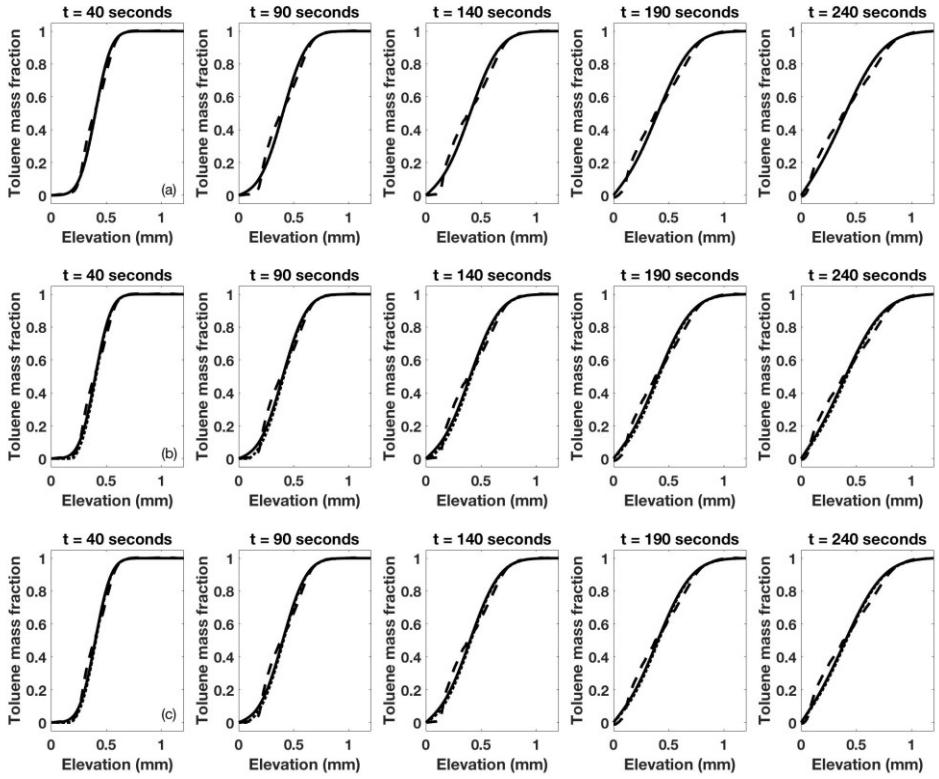

Figure 3.6 Comparison among Fadaie et al.[26] experimental data (dashed), the Fickian diffusion model (D = 1.6×10^{-10} m^2/s) (solid) and a Fickian diffusion (D = 1.6×10^{-10} m^2/s) + sorption model (dotted) using Langmuir sorption parameters for: a) carbon black, b) activated carbon F300, and c) activated carbon F400.

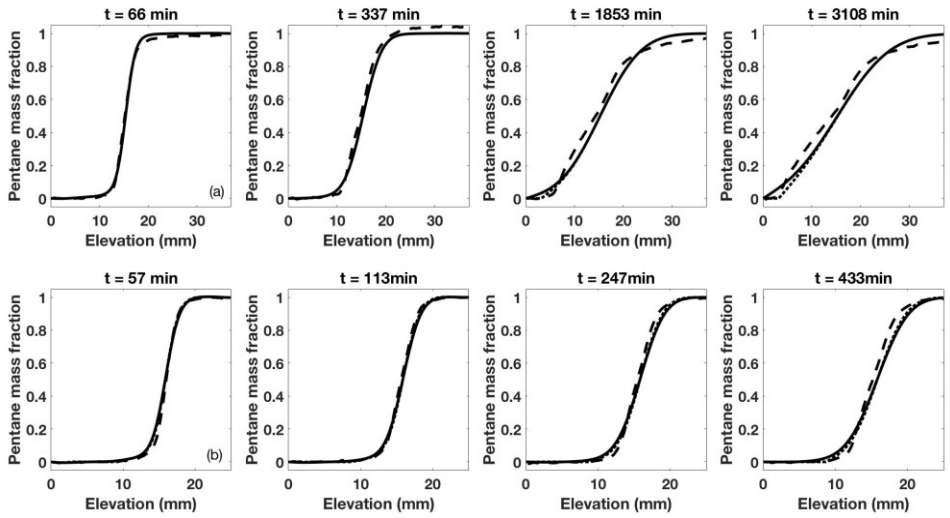

Figure 3.7 Comparison among Athabasca bitumen + pentane[24] (a) and Athabasca atmospheric residue + pentane[24] (b). Experimental data (dashed), a Fickian diffusion only model (D = 1.6×10^{-10} m^2/s) (solid) and Fickian diffusion + sorption model (D = 1.6×10^{-10} m^2/s) (dotted) based on the properties of activated carbon F300.

3.4.3 Comparison of toluene + polybutene and toluene + (0.05 mass fraction carbon nanotube + polybutene)

Composition profile data for the control experiments are shown in Figure 3.8 along with a Fickian diffusion model with a mutual diffusion coefficient of 1.6×10^{-10} m^2/s. Toluene diffusion in polybutene follows a Fickian trend, Figure 3.8a. However, when carbon nanotubes are added, Figure 3.8b, deviation from Fickian diffusion is observed and diffusion is hindered. Average nearest neighbour distance between nanoparticles can be calculated using their dimensions and volume fraction in mixture. For instance, the mean nearest distance between particles in absence of solvent is around 35 nm and at 0.5 mass fraction of solvent the distance would increase to about 50 nm. However, Investigation of

effects of size of particles, their distribution and surface properties on active diffusion mechanism and transition region needs much future work and analysis.

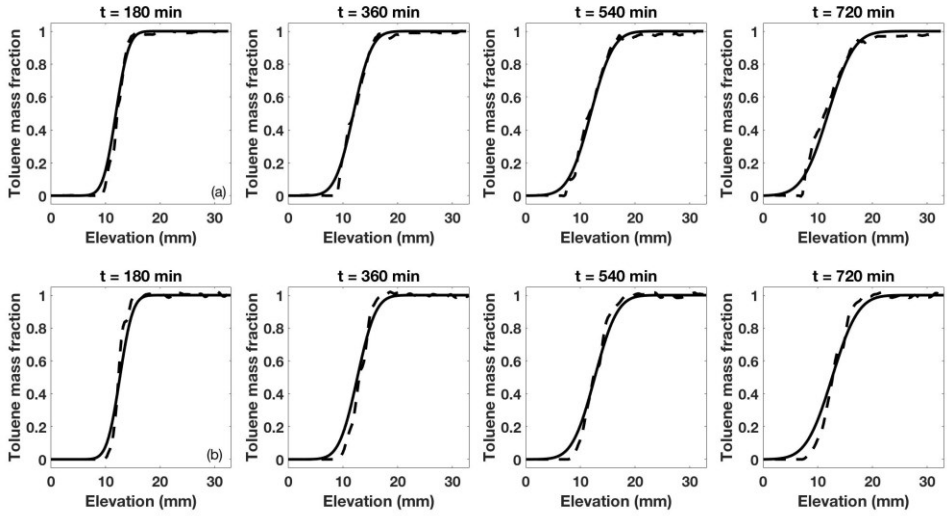

Figure 3.8 Comparison of Fickian diffusion model with D = 1.6×10^{-10} m^2/s (solid line) with experimental data (dashed line) for (a) toluene + polybutene (dashed); (b) toluene + (0.05 mass fraction carbon nanotubes + polybutene)

3.5 Summary

Identification of active diffusion mechanisms in heavy oil + diluent mixtures is important because it impacts mutual penetration rates at interfaces and hence production rates. Six sets of mutual diffusion composition profile data from the literature were modeled in detail to investigate the governing diffusion mechanisms. These data sets all show deviation from Fickian diffusion at high heavy oil mass fractions. These deviations may be attributed to a shift in the dominant mechanism from Fickian to Single-File diffusion.

The impact of sorption on composition profiles can be ignored even when high sorption rates and equilibrium extents of sorption are assumed.

Fickian and Single-File diffusion and sorption are active for the model mixture toluene + (polybutene + carbon nanotubes (0.05 mass fraction), however, based on mathematics alone they cannot be discriminated and analysis of planned experiments with well-defined nanostructured fluids where sorption does/does not occur comprise needed future work.

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Chapter 4. Transport properties in nano-colloids

4.1 Introduction

Colloids comprise a particulate/discrete liquid phase dispersed in a continuous fluid phase. Examples include aerosols, milk, and emulsions[1,2]. Nanocolloids arise in diverse processes, from the manufacturing of solar panels, pharmaceutics and biochemical products, to the production of unconventional hydrocarbon resources, and the treatment of mine tailings[1,3–5]. A detailed understanding of the relative importance of impacts of Fickian diffusion[6–8], Single-File diffusion, and sorption[9] of penetrants on colloid surfaces provides insights regarding the time scales and outcomes that govern process designs for specific cases. Fickian diffusion, Single-File diffusion – in nano-scale constrictions among particles, and penetrant sorption on colloidal particles impact transport of penetrants in colloidal suspensions. Their relative importance is dictated by the size, size distribution, shape, volume fraction and surface properties of particles. Without foreknowledge of active transport mechanisms it is difficult to interpret experimental outcomes and to optimize process designs.

The governing diffusion mechanism(s) are readily identified from composition profiles during diffusion. Profiles obtained at different times superimpose if plotted against a joint time-distance variable[10]:

$$\lambda = \frac{x}{t^{n_w}} \tag{4.1}$$

where x is distance, t is time and n_w falls in the range 0.25 to 0.5[10]. $n_w = 0.25$ corresponds to Single-File diffusion[11–14]. $n_w = 0.5$ corresponds to Fickian diffusion[15]. n_w values

between these limits correspond to a mixed mode diffusion[14,16–18]. The values of n_w and their uncertainties are identified using two complementary methods that minimize the sum of absolute differences and least-squares regression of slopes as explained by Alizadehgiashi and Shaw[10] in detail. Only a brief overview is provided here. The experimental composition profiles at each time step are smoothed[19] within 0.05 mass fraction ranges. There is one elevation where composition profiles at all time steps intersect in free diffusion measurements. This point of intersection, which defines the origin of the spatial coordinate for the interpretation of the data and the determination of local n_w values, is identified using smoothed composition profiles. Best fit n_w values and their uncertainties that fit the composition profiles jointly at each 0.05 mass fraction composition range are identified in the search window $0.2 < n_w < 0.6$ with a resolution of 0.025. Values of n_w with uncertainties greater than 0.1 are ignored. Typically one and frequently both of the two complimentary methods have low local uncertainty. At the composition where all composition profiles intersect, uncertainties typically have high uncertainty. For example, Figure 4.1a shows a Fickian diffusion profile at different times plotted using numerically solving Fick's second law over a 1 mm cell with a mutual diffusion coefficient of $D = 1.6 \times 10^{-10}$ m^2/s. In Figure 4.1b and 4.1c composition profiles are plotted against the joint variable, λ, for two limits of exponent value. When n_w is 0.5, (Figure 4.1b) the composition profiles superimpose, confirming Fickian diffusion. The value and uncertainty of n_w, based on local derivative and absolute difference fits for this case are shown in Figure 4.1d.

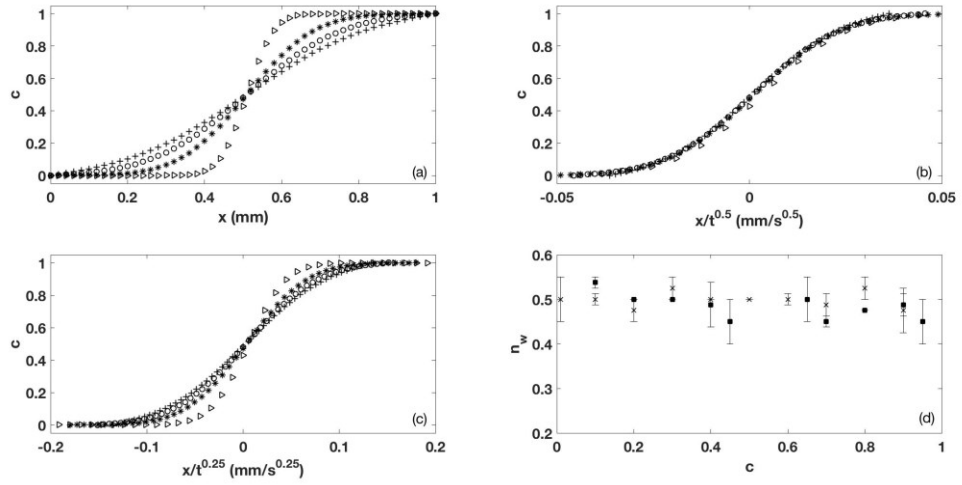

Figure 4.1 Fickian composition profile after 10s (⊳), 60s (∗), 120s (∘), and 190s (+), plotted against (a) distance, (b) λ with n_w = 0.5, and (c) λ with n_w = 0.25. (d) Uncertainties of values of n_w based on absolute difference (■) and derivate fits (×).

Using this approach, Alizadehgiashi and Shaw[10] showed that in mixtures of light hydrocarbons (diluents) and asphaltene-rich heavy oils the dominant diffusion mechanism transitioned from Single-File diffusion at low diluent mass fraction (high nano-dispersed asphaltene-rich fraction) to Fickian diffusion at high diluent mass fraction (low nano-dispersed asphaltene-rich fraction). They also showed that (polybutene + carbon nanotube) + toluene mixtures behaved similarly. They attributed shifts in diffusion mechanism to the corresponding changes in the average distances among adjacent nano-dispersed domains from nano to micro-scopic dimensions. Their interpretation was qualitative and did not include possible impacts of sorption on nano-dispersed phase domains.

In this work, the data analysis approach outlined above is applied to (nanoparticles (carbon nanotubes, nanodiamonds, and nanosilica) + polymer) + toluene mixtures. The surface properties, identified from TAM III solution calorimetry measurements; sizes, identified from dynamic light scattering measurements or particle size distribution charts provided by manufacturer; and shapes differ. Baseline cases including only Fickian diffusion, Fickian diffusion + Single-File diffusion, and Fickian diffusion + Single-File diffusion + sorption are examined. Transitions from Fickian to Single-File diffusion controlled transport are presented and discussed from the perspective of generalizable attributes (nanoparticle volume fraction, nanoparticle shape, and sorption properties) and also from the perspective of the lead example – asphaltene-rich heavy oil + diluent mixtures.

4.2 Average nearest distance calculation among nanoparticles

The average nearest neighbor distances among mono-dispersed uniformly-distributed cylindrical and spherical particles in a matrix can be determined using Figure 4.2. Each particle is assigned a volume in the matrix according to its dimensions and its volume fraction. The distances separating adjacent particle surfaces, L, can be determined from the corresponding geometry. For spheres the geometry possesses spherical symmetry:

$$L \sim D\left[\left(\frac{\pi}{6\emptyset}\right)^{\frac{1}{3}} - 1\right] \tag{4.2}$$

For cylinders, the focus is on the dominant radial symmetry, and the result is a first approximation:

$$L \sim D\left[\left(\frac{\pi}{4\emptyset}\right)^{\frac{1}{2}} - 1\right] \tag{4.3}$$

where D is diameter of particles and ∅ is the volume fraction of particles in the fluid. Equations 4.2 and 4.3 are used to scale data in a transparent manner and illustrate that for particles with one or more nanoscale dimensions, distances among particles reach nanoscopic dimensions at low volume fractions. For example, mono-dispersed spheres with D = 10 nm, occupying ∅ = 0.05, are on average 12 nm apart.

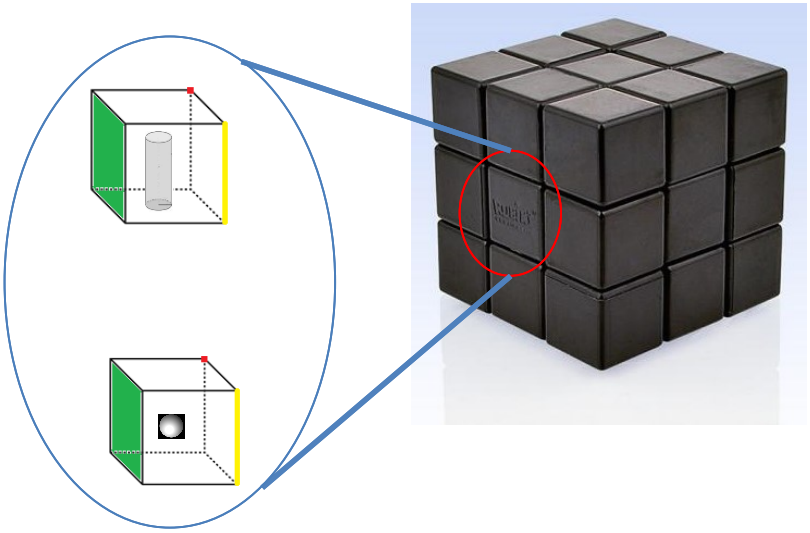

Figure 4.2 Schematic illustrating average nearest distances among evenly distributed cylindrical and spherical particles in matrix.

4.3 Experimental Section

HPLC grade toluene (molar mass of 92.14 g/mol, viscosity of 0.56 mpa.s, and density of 0.865 g/mL at room temperature) and polybutene (mean molar mass of 900 g/mol, viscosity of 58 pa.s, and density of 892 kg/m^3 at room temperature) were obtained from Sigma Aldrich and Cannon Instrument, respectively. Multiwall carbon nanotubes (length 5 μm, median diameter 6.6 nm, and particle density of 2100 kg/m^3) and silica

nanoparticles (average size of 7nm and particle density of 2300 kg/m^3) were purchased from Sigma Aldrich. Microdiamond (original size of 4-8nm, median aggregate diameter of 500 nm, and density of 3100 kg/m^3) were purchased from Microdiamant. Further particle fractionation was done in order to reduce the median size of the microdiamonds. First, a mixture of 10 g of NaCl, 0.25 g of microdiamond and 5mL of DI water was mixed in a vial and sonicated using Branson 1800 with 40 kHz frequency for around 14 hrs. Then the mixture would be centrifuged using Sorvall RC6 Super speed centrifuge two times at 12000 rpm at 4 ℃ and after each time the clear supernatant was discarded. A detailed procedure and workflow is explained elsewhere.[20] After that, remaining particles were redispersed in DI water, with a dilution of 0.2 wt.%, characterized using dynamic light scattering, and then dried for storage. Part of the solution was also passed through a filter with 20 nm pore size as the second round of treatment to achieve nanodiamonds with a smaller mean size. Mean sizes of diamond particles before and after two rounds of treatment are shown in Figure 4.3. Nanodiamond samples with median sizes of 65 nm and 12 nm were prepared and then used to make mixtures with polybutene. Having two samples with different small median diameters helps to compare better the effect of size of particles and go to smaller spacing among particles using less mass/volume fraction of particles.

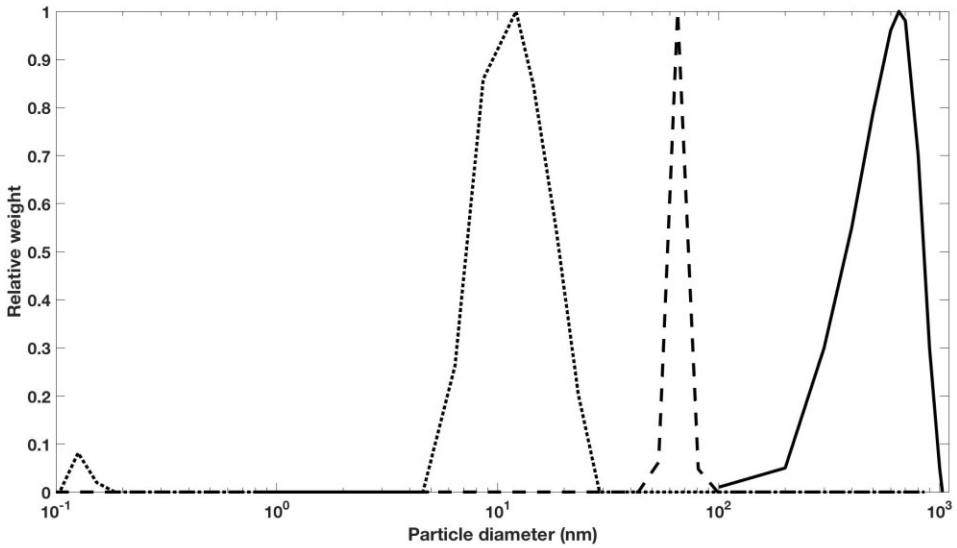

Figure 4.3 Particle size distribution of microdiamond particles before treatment (solid), after first treatment (dashed) and after second treatment with filter (dotted).

Surface properties of nanoparticles were identified using a TAM III calorimeter from TA instruments. Ten experiments were done at 25 °C, details of workflow and calibration are provided elsewhere[21,22], and only a brief explanation is provided here. For each experiment 30 mg of solute was sealed in a crushing ampule and placed in a 25 mL solvent container. The calorimeter was then placed in a TAM III thermostat at 25 °C with an uncertainty of 1 μ°C. Before and after breakage of the ampule, calibrations were done that result in low measurement uncertainty of ±0.5 J/g. Positive enthalpies of solution indicate endothermic behavior. Negative values indicate exothermic behavior. A value of zero indicates no interaction or a balance of competing endothermic and exothermic interactions.

Composition profiles were measured using calibrated speed of sound values and calibrations were done for each experiment (see Appendix C for details). Detailed

explanations of the apparatus, procedures and work flow are provided in a recent publication[10]. In addition to toluene + polybutene and toluene + (polybutene + 0.05 mass fraction of carbon nanotubes) mentioned in the previous chapter, eight more experiments with different volume/mass fractions of nanoparticles were done summary of which is surveyed in Table 4.1. All composition profile data is provided in Appendix B.

Table 4.1 Summary of the experiments done in this work

Experiment #	Mixture of nanoparticles + polybutene
1	0.01 mass fraction carbon nanotubes + polybutene
2	0.01 volume fraction 65 nm nanodiamonds + polybutene
3	0.00135 volume fraction 12 nm nanodiamonds + polybutene
4	0.0027 volume fraction 12 nm nanodiamond + polybutene
5	0.0005 volume fraction nanosilica + polybutene
6	0.00135 volume fraction nanosilica + polybutene
7	0.0027 volume fraction nanosilica + polybutene
8	0.01 volume fraction nanosilica + polybutene

4.4 Results and Discussion

4.4.1 Calorimetric measurements

A summary of calorimetric results is shown in Table 4.2 All of the experiments were done at a solute mass fraction of 0.005. The effect of solute concentration on the enthalpy of solution was within measurement uncertainty in the range of solute mass fraction (0.005 – 0.02).

The enthalpy of solution corresponding to mixing of carbon nanotubes in toluene is a large negative number (-15 J/g). This indicates sorption of solvent molecules on carbon

nanotube surfaces. For microdiamonds and silica nanoparticles the large positive enthalpies of solution indicate dispersion of particles in the solvent without sorption. Other cases, including polybutene in toluene and polybutene with different mass fractions of particles, up to 0.02, in toluene were done to examine the interaction between particles and polybutene. Due to an increase in the viscosity of polybutene by increasing the mass fraction of particles, calorimetry measurements could not be done for higher mass fractions of particles in polybutene. For microdiamond and nanosilica particles, the enthalpy for each mass fraction of particles is almost the same as the case of pure polybutene + toluene. No affinity between particles and polybutene is shown. To assess competitive sorption effects for polybutene + carbon nanotubes in toluene, the composition of two components should be changed. Due to the instrument limitation in the needed amount of solute and solvent for each measurement, the possible impact of polybutene sorption on carbon nanotubes cannot be discriminated from that of toluene sorption within measurement uncertainty.

Table 4.2 Summary of the calorimetric results.

Solute	Solvent	Solute/Solvent (g/g)	Enthalpy (J/g)
Carbon nanotubes	Toluene	0.005	-15.0 ± 0.5
Microdiamond	Toluene	0.005	14.0 ± 0.5
Nanosilica	Toluene	0.005	28.0 ± 0.5
Polybutene	Toluene	0.005	12.7 ± 0.5
Polybutene + 0.001 mass fraction carbon nanotubes	Toluene	0.005	11.9 ± 0.5
Polybutene + 0.02 mass fraction carbon nanotubes	Toluene	0.005	11.5 ± 0.5

Polybutene + 0.01 mass fraction microdiamonds	Toluene	0.005	12.5 ± 0.5
Polybutene + 0.02 mass fraction microdiamonds	Toluene	0.005	12.4 ± 0.5
Polybutene + 0.01 mass fraction nanosilica	Toluene	0.005	12.8 ± 0.5
Polybutene + 0.02 mass fraction nanosilica	Toluene	0.005	13.0 ± 0.5

4.4.2 Local values of n_w and their uncertainty extracted from toluene + (nanoparticles + polybutene) composition profile data

Smoothed composition profile data for all mixtures are presented in Figure 4.4, and local values of n_w and their uncertainties based on smoothed diffusion profile data and the methodology explained above are shown in Figure 4.5. Calculation method for all values of n_w is shown as tables in Appendix D.

For mixtures of toluene + polybutene (Figure 4.4a) and other mixtures with low particle mass/volume fraction (Figures 4.4b, 4.4e, 4.4g) and toluene + (0.01 volume fraction 65 nm nanodiamond + polybutene) (Figure 4.4d), n_w is 0.5 (Fickian diffusion limit). For other mixtures (Figures 4.4c, 4.4f, 4.4h, 4.4i, 4.4j) deviation from Fickian diffusion is observed and especially for toluene + (0.01 mass fraction nanosilica + polybutene), Figure 4.5j, where n_w values approach the Single-File diffusion limit.

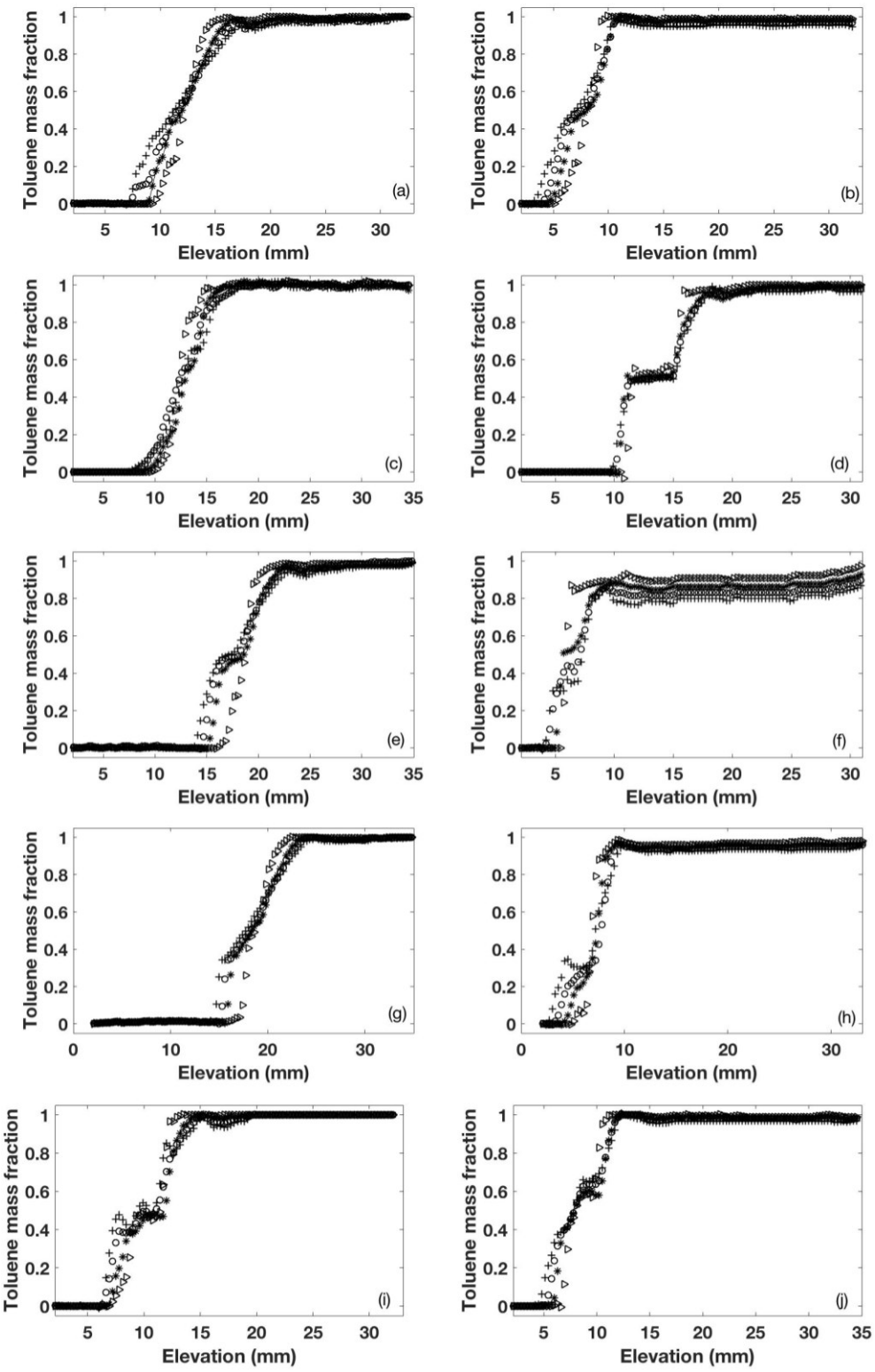
Toluene mass fraction
Elevation (mm)
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)

Figure 4.4 Smoothed composition profile data after 3h (⊳), 6h (∗), 9h (∘), 12h (+), for (a) toluene + polybutene, (b) toluene + (0.01 mass fraction carbon nanotubes + polybutene), (c) toluene + (0.05 mass fraction carbon nanotubes + polybutene), (d) toluene + (0.01 volume fraction 65nm nanodiamond, + polybutene) (e) toluene + (0.00135 volume fraction 12 nm nanodiamond + polybutene), (f) toluene + (0.0027 volume fraction 12 nm nanodiamond + polybutene), (g) toluene + (0.0005 volume fraction nanosilica + polybutene), (h) toluene + (0.00135 volume fraction nanosilica + polybutene), (i) toluene + (0.0027 volume fraction nanosilica + polybutene), (j) toluene + (0.01 volume fraction nanosilica + polybutene).

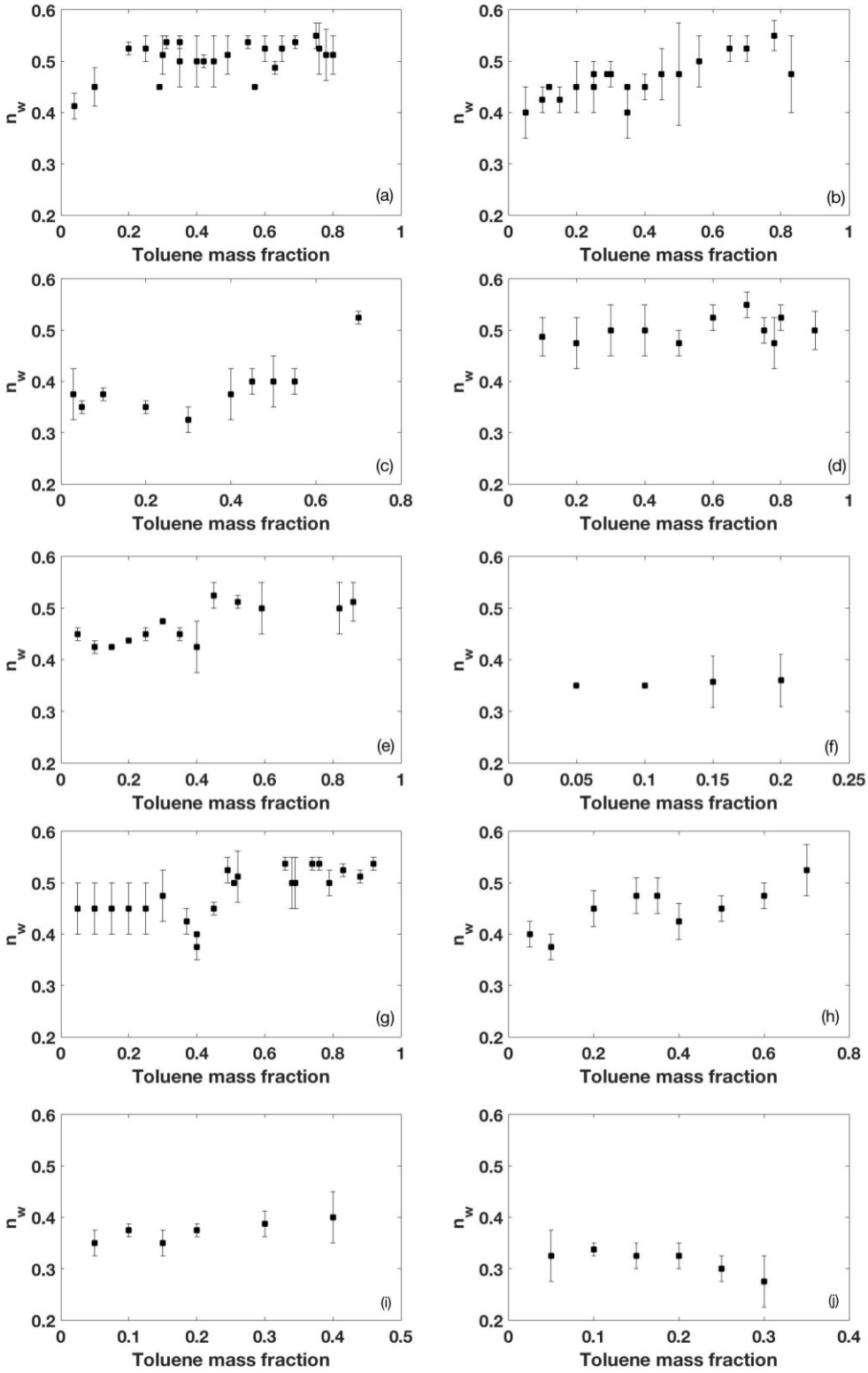
(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
(i)
(j)
n_w
Toluene mass fraction

Figure 4.5 Local values of n_w and their uncertainties for (a) toluene + polybutene, (b) toluene + (0.01 mass fraction carbon nanotubes + polybutene), (c) toluene + (0.05 mass fraction carbon nanotubes + polybutene), (d) toluene + (0.01 volume fraction 65 nm nanodiamond, + polybutene) (e) toluene + (0.00135 volume fraction 12 nm nanodiamond + polybutene), (f) toluene + (0.0027 volume fraction 12nm nanodiamond + polybutene), (g) toluene + (0.0005 volume fraction nanosilica + polybutene), (h) toluene + (0.00135 volume fraction nanosilica + polybutene),(i) toluene + (0.0027 volume fraction nanosilica + polybutene), (j) toluene + (0.01 volume fraction nanosilica + polybutene)

4.4.3 Effect of mass/volume fraction of nanoparticles on local values of n_w

Local values of n_w and their uncertainties based on mass/volume fraction of all nanoparticles is shown in Figure 4.6.

For all three types of nanoparticles, as mass/volume fraction of particles increase values of n_w decrease from the Fickian diffusion limit toward the Single-File diffusion limit. At the same mass/volume fraction of two types of nanodiamonds, 12 nm diamonds have lower values of n_w than 65 nm diamonds, which is consistent with the effect of size and particle spacing on the dominant diffusion mechanism. Figure 4.7 shows the effect of nanoparticle spacing, as calculated from equations 2.2 and 2.3 on local values of n_w.

When the average nearest neighbor distance among nanoparticles is ~120 nm or larger Fickian behavior is observed (n_w = 0.5). At shorter distances the diffusion mechanism shifts to Single-File Diffusion behaviour. When the average nearest neighbour distance among nanoparticles becomes less than ~20 nm, the transition to Single-File diffusion (n_w = 0.25) is complete.

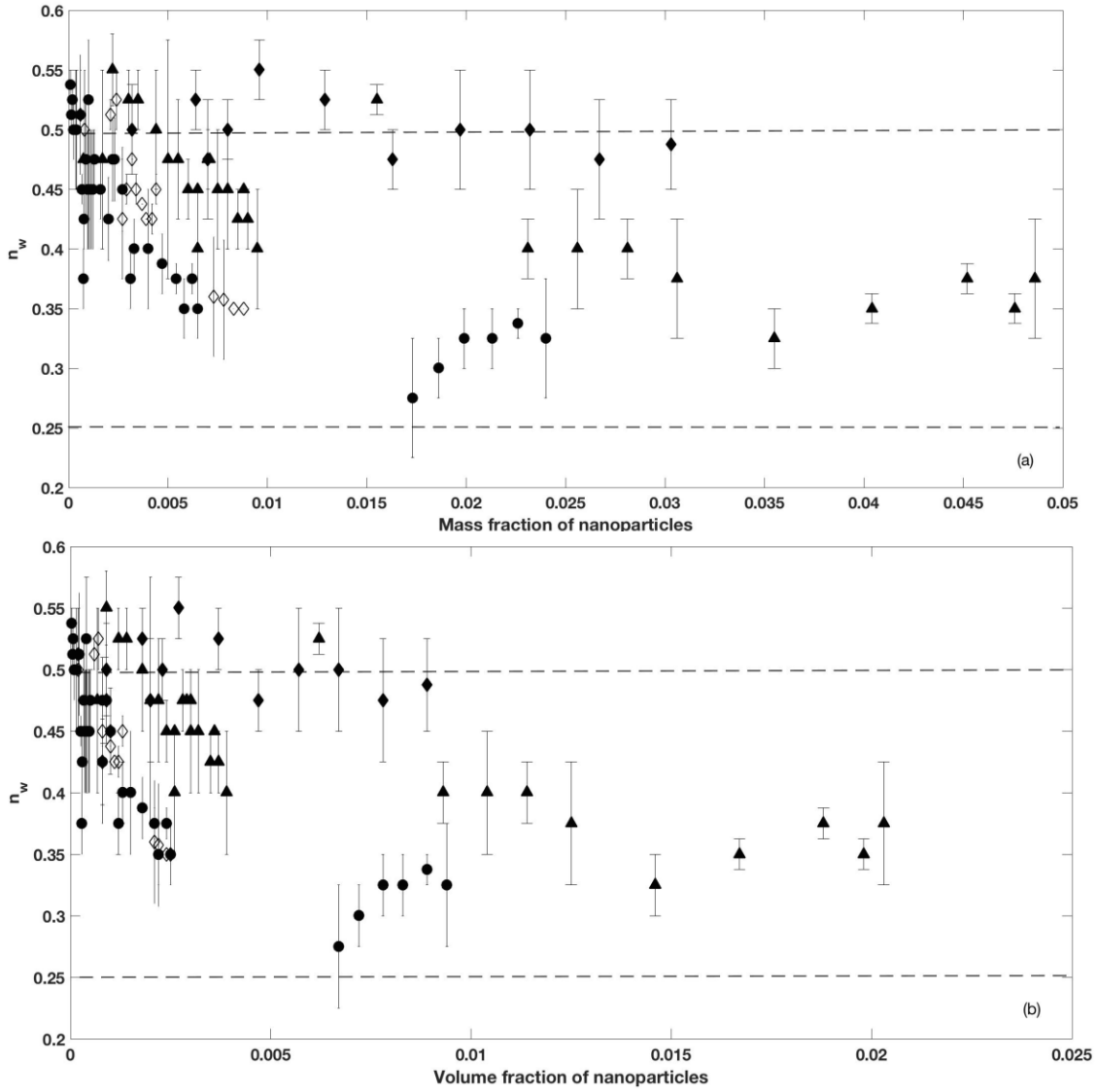

Figure 4.6 Local values of n_w and their uncertainties for carbon nanotubes (▲), 65 nm diamond (◆), 12 nm diamond (◇), and nanosilica (●) at different mass fractions (a) and volume fractions (b) of nanoparticles.

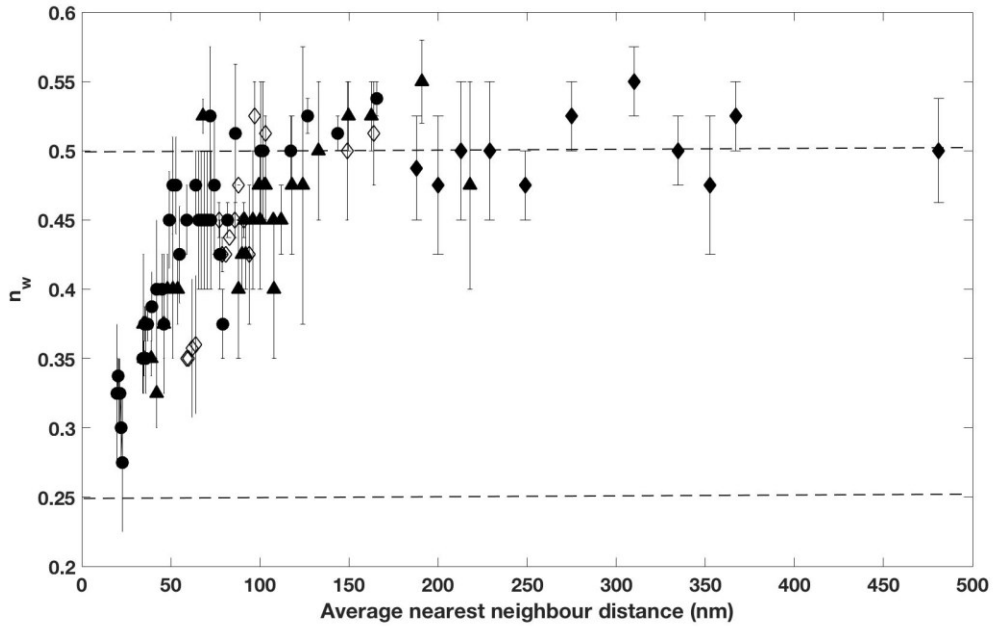

Figure 4.7 Local values of n_w and their uncertainties for carbon nanotubes (▲), 65 nm diamond (◆), 12 nm diamond (◇), and nanosilica (●) at different mass fractions (a) and volume fractions (b) of nanoparticles.

4.5 Summary

Diffusion of toluene into polybutene containing a wide range of mass/volume fractions of nanoparticles with different shapes and surface properties were investigated. Diffusion measurements showed that even at low volume fractions of nanoparticles, the average nearest neighbour distances among them fall within the nanometer length scale. Fickian diffusion is the dominant diffusion mechanism for ~120nm average nearest neighbor distances and higher. As the nearest neighbor distance decreases the active diffusion mechanism trends toward Single-File diffusion and at a distance less than ~20nm the

transition is complete. The impacts of nanoparticle shape and surface properties on the transition from Fickian diffusion to Single-File diffusion are not resolved in the measurements, suggesting that nearest neighbour distance is the primary parameter impacting the diffusion mechanism.

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Chapter 5. Concluding Remarks and Future Work

5.1. Conclusions

Chapter 3 shows that the identification of active diffusion mechanisms in heavy oil + diluent mixtures is important because it impacts mutual penetration rates at interfaces and hence production rates of heavy oils. Six sets of mutual diffusion composition profile data from the literature were modeled in detail to investigate the governing diffusion mechanisms and the influence of sorption. These data sets show deviation from Fickian diffusion at high heavy oil mass fractions. These deviations are attributed to a shift in the dominant mechanism from Fickian to Single-File diffusion. The impact of sorption on composition profiles can be ignored even when high sorption rates and equilibrium extents of sorption are assumed. Identification of Single-File diffusion coefficients at high heavy oil mass fraction could not be resolved with the numerical methodology used in this work and it demands future work.

For the model mixture toluene + (polybutene + carbon nanotubes (0.05 mass fraction)) Fickian and Single-File diffusion mechanisms are active and sorption occurs. These effects cannot be discriminated, based on mathematics alone, because they can equally fit the data and analysis of experiments with well-defined nanostructured fluids where sorption does/does not occur are needed in order to interpret such complex cases.

In chapter 4, diffusion measurements with nanoparticles having different sizes, shapes and surface properties show that when the average nearest neighbor distance among

nanoparticles is ~120 nm or larger Fickian behavior is observed (n_w = 0.5). At shorter nearest neighbor distances the diffusion mechanism transitions to Single-File diffusion. When the average nearest neighbor distance among nanoparticles becomes less than ~20 nm, the transition to Single-File diffusion (n_w = 0.25) is complete. Although sorption on colloid surfaces impedes diffusion of solvent into nanocolloids, it does not appear to interfere with the values of n_w and active diffusion mechanism identification for the cases studied in this work. The impacts of nanoparticle shape and surface properties on the transition from Fickian diffusion to Single-File diffusion are not resolved in the measurements, suggesting that nearest neighbor distance is the primary parameter impacting the diffusion mechanism. Particle shape and surface properties appear to be secondary variables.

5.2. Recommendations for future work

1- More work is required to derive equations for Single-File diffusion front movement and to investigate their solution so that values of Single-File mobility coefficients can be identified that are relevant to mutual diffusion of light hydrocarbon and heavy oils.

2- Development of an experimental technique that will allow high mass/volume fractions of nanoparticles to be explored, is a required enabling technology. The current apparatus cannot be used for high mass/volume fractions of nanoparticles due to either transmitted acoustic signal attenuation, or non-ideal mixing and gas bubbles arising in highly viscous fluids.

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Appendix A. Numerical solutions and codes for equations in Chapter 3

All equations are solved by substituting finite divided differences for the partial derivatives. Time step and grid difference is chosen according to convergence and stability criteria for explicit and implicit methods meaning time step should be smaller than $0.5 \times \frac{\Delta x^2}{D}$.

Diffusion has been studied only in 1D, therefore, gridding would be only in x direction. (Figure A.1)

Figure A.1. Gridding a cell in which diffusion occurs

1-Fickian diffusion equation, constant density, explicit method

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{c}) = \mathrm{D}\frac{\partial^2 c}{\partial x^2}$$

First, both differential terms would be discretized as follows[1,2]:

$$\frac{\partial^2 c}{\partial x^2} = \frac{c_{i+1}^{l} - 2c_i^l + c_{i-1}^l}{\Delta x^2} \quad \text{(A.1)}$$

$$\frac{\partial}{\partial t}(c) = \frac{c_i^{l+\Delta l} - c_i^l}{\Delta t} \quad \text{(A.2)}$$

where c is the solvent mass fraction, *i* corresponds to i^{th} node and *l* corresponds to time. Substituting equations A.1 and A.2 into Fickian diffusion equation:

$$D\frac{C_{i+1}^{l}-2C_{i}^{l}+C_{i-1}^{l}}{\Delta x^2}=\frac{C_{i}^{l+1}-C_{i}^{l}}{\Delta t}\rightarrow c_{i}^{l+1}=c_{i}^{l}+\frac{D\Delta t}{\Delta x^2}\times(c_{i+1}^{l}-2c_{i}^{l}+c_{i-1}^{l}) \quad \text{(A.3)}$$

Equation A.3 gives the mass fraction of solvent at i^{th} node at the next time step, and can be written for nodes number 1 to N-1 and be solved individually.

For all equations if constant concentration boundary condition is assumed, it means concentration is always constant in both ends and is either 0 or 1. However, if zero flux boundary condition is assumed (usually at the end with presence of solvent), concentration at the end would equal the concentration at the previous node or next node depending on which end the boundary condition is for.

$$\frac{\partial c}{\partial x}=0\ \rightarrow\frac{c_i-c_{i-1}}{\Delta x}=0\rightarrow c_i=c_{i-1} \quad \text{(A.4)}$$

2- Fickian diffusion equation, constant density, implicit method

In this method discretization would be done in next time step:

$$\frac{\partial^2 c}{\partial x^2}=\frac{C_{i+1}^{l+\Delta l}-2C_{i}^{l+\Delta l}+C_{i-1}^{l+\Delta l}}{\Delta x^2} \quad \text{(A.5)}$$

$$\frac{\partial}{\partial \mathrm{t}}(\mathrm{c})=\frac{C_{i}^{l+\Delta l}-C_{i}^{l+\Delta l}}{\Delta t} \quad \text{(A.6)}$$

Substituting equations A.5 and A.6 in the Fickian diffusion equation and simplifying:

$$c_{i+1}^{l+\Delta l}\left(\frac{D}{\Delta x^2}\right)+c_{i}^{l+\Delta l}\left(\frac{-2D}{\Delta x^2}-\frac{1}{\Delta t}\right)+c_{i-1}^{l+\Delta l}\left(\frac{D}{\Delta x^2}\right)=\frac{-c_i^t}{\Delta t} \quad \text{(A.7)}$$

In equation A.7 concentrations at next time step are unknown ($c_{i+1}^{l+\Delta l}$, $c_{i+1}^{l+\Delta l}$, $c_{i+1}^{l+\Delta l}$). This equation can be written for all the nodes (i=1→ N-1) and therefore N-1 equation with N-1 unknowns would be achieved that can be easily solved using a matrix system.

$$A \times c = Q \ \rightarrow c = \ A^{-1} \times \ Q$$

(A.8)

Where A is the matrix of coefficients, c is the matrix of concentration at next time step and Q is the source term.

3-Fickian diffusion equation, variant density, explicit method

$$\frac{\partial}{\partial t}(\rho c) = D\frac{\partial}{\partial x}\left[\rho\frac{\partial c}{\partial x}\right]$$

Using discretization we have:

$$\frac{\partial}{\partial t}(\rho c) = \frac{\rho_i^{l+\Delta l}c_i^{l+\Delta l} - \rho_i^l c_i^l}{\Delta t} \qquad \text{(A.9)}$$

$$\frac{\partial}{\partial \mathrm{x}}\left[\rho\frac{\partial \mathrm{c}}{\partial \mathrm{x}}\right] = \frac{\rho_{i+1/2}^l\frac{\partial c^l}{\partial x}_{at\ i+1/2} - \rho_{i-1/2}^l\frac{\partial c^l}{\partial x}_{at\ i-1/2}}{\Delta x} = \frac{\rho_{i+\frac{1}{2}}^l\left(\frac{c_{i+1}^l - c_i^l}{\Delta x}\right) - \rho_{i-\frac{1}{2}}^l\left(\frac{c_i^l - c_{i-1}^l}{\Delta x}\right)}{\Delta x} =$$

$$\frac{\rho_{i+\frac{1}{2}}^l\left(c_{i+1}^l - c_i^l\right) - \rho_{i-\frac{1}{2}}^l\left(c_i^l - c_{i-1}^l\right)}{\Delta x^2} \qquad \text{(A.10)}$$

If Δt is very small, we can assume $\rho_i^{l+\Delta l} \approx \rho_i^l$

In order to make sure the assumption made ($\rho_i^{l+\Delta l} \approx \rho_i^l$) was right, the differential Fickian diffusion equation was solved implicitly and the results were the same as the explicit method explained here.

$$\rightarrow c_i^{l+\Delta l} = c_i^l + \frac{D\,\Delta t}{\rho_i^l \Delta x^2}\left[\rho_{i+\frac{1}{2}}^l\left(c_{i+1}^l - c_i^l\right) - \rho_{i-\frac{1}{2}}^l\left(c_{i+1}^l - c_i^l\right)\right] \qquad \text{(A.11)}$$

There are two unknowns in equation A.11 which can be estimated using equations (A.12) and (A.13)

$$\rho_{i+\frac{1}{2}} = \frac{2\rho_i \times \rho_{i+1}}{\rho_i + \rho_{i+1}} \quad \text{(A.12)}$$

$$\rho_{i-\frac{1}{2}} = \frac{2\rho_{i-1} \times \rho_i}{\rho_{i-1} + \rho_i} \quad \text{(A.13)}$$

Equation A.11 can be solved using equations A.12 and A.13 for all the nodes from 1 to N-1 individually.

4-Fickian diffusion equation, variant density- implicit

$$\frac{\partial}{\partial t}(\rho c) = D\frac{\partial}{\partial x}\left[\rho \frac{\partial c}{\partial x}\right]$$

Discretization is quite similar to the explicit method with the difference that it would be written in the latter time step. After simplifying:

$$\frac{D}{\Delta x^2} \times \rho_{i-1/2}^{l+\Delta l} \times c_{i-1}^{l+\Delta l} + \left[\frac{-D}{\Delta x^2}\left(\rho_{i+\frac{1}{2}}^{l+\Delta l} + \rho_{i-\frac{1}{2}}^{l+\Delta l}\right) - \frac{\rho_i^{l+\Delta l}}{\Delta t}\right] \times c_i^{l+\Delta l} + \frac{D}{\Delta x^2} \times \rho_{i+1/2}^{l+\Delta l} \times c_{i+1}^{l+\Delta l} = \frac{-\rho_i^t c_i^t}{\Delta t} \quad \text{(A.14)}$$

equation (A.14) can be solved using equation (A.8).

5-Fickian + sorption diffusion equation- explicit

$$\frac{\partial}{\partial t}(c) = D\frac{\partial^2 c}{\partial x^2} + \frac{\in -1}{\in} \times \frac{\partial c_p}{\partial t}$$

$$c_p = \frac{K_l q \times c}{1 + K_l \times c} \quad \text{(A.15)}$$

$$\in_i = 0.15c_i + 0.85 \quad \text{(A.16)}$$

All the differential terms would be discretized in addition to $\frac{\partial c_p}{\partial t}$, which would be written as a function of $\frac{\partial c}{\partial t}$ (equation A.16).

$$\frac{\partial c_p}{\partial t} = \frac{\partial c}{\partial t}\left[\frac{k_l q(1+k_l c)-k_l^2 qc}{(1+k_l c)^2}\right] \quad \text{(A.17)}$$

$$\frac{\partial}{\partial t}(c) = D\frac{\partial^2 c}{\partial x^2} + \frac{\epsilon-1}{\epsilon} \times \frac{\partial c_p}{\partial t} \xrightarrow{(16)} \frac{\partial c}{\partial t}\left[1 - \frac{\epsilon-1}{\epsilon} \times \frac{k_l q}{(1+k_l c)^2}\right] = D\frac{\partial^2 c}{\partial x^2} \rightarrow \frac{c_i^{l+\Delta l}-c_i^l}{\Delta t} =$$

$$\frac{D}{1-\frac{\epsilon-1}{\epsilon}\times\frac{k_l q}{(1+k_l c)^2}} \times \frac{c_{i+1}^l-2c_i^l+c_{i-1}^l}{\Delta x^2} \rightarrow c_i^{l+\Delta l} = \frac{D\Delta t}{1-\frac{\epsilon-1}{\epsilon}\times\frac{k_l q}{(1+k_l c)^2}} \times \frac{c_{i+1}^l-2c_i^l+c_{i-1}^l}{\Delta x^2} \quad \text{(A.18)}$$

Equation A.17 can be solved using equation A.15 individually for all the nodes from 1 to N-1 to achieve the concentration at next time step.

6-Fickian + sorption diffusion equation- implicit

$$\frac{\partial}{\partial t}(c) = D\frac{\partial^2 c}{\partial x^2} + \frac{\epsilon - 1}{\epsilon} \times \frac{\partial c_p}{\partial t}$$

All the terms would be discretized. Sorption term would go to the source term.

After discretizing, equation (A.19) would be achieved:

$$\frac{c_i^{l+\Delta l}-c_i^l}{\Delta t} = D \times \frac{c_{i+1}^l-2c_i^l+c_{i-1}^l}{\Delta x^2} + \frac{\epsilon-1}{\epsilon\Delta t}\left[\frac{K_l q c_i^{l+\Delta l}}{1+K_l c_i^{l+\Delta l}} - \frac{K_l q c_i^l}{1+K_l c_i^l}\right] \quad \text{(A.19)}$$

after simplifying:

$$c_{i+1}^{l+\Delta l}\left(\frac{D}{\Delta x^2}\right) + c_i^{l+\Delta l}\left(\frac{-2D}{\Delta x^2} - \frac{1}{\Delta t}\right) + c_{i-1}^{l+\Delta l}\left(\frac{D}{\Delta x^2}\right) = \frac{-c_i^t}{\Delta t} - \frac{\epsilon-1}{\epsilon\Delta t}\left[\frac{K_l q c_i^{l+\Delta l}}{1+K_l c_i^{l+\Delta l}} - \frac{K_l q c_i^l}{1+K_l c_i^l}\right] \quad \text{(A.20)}$$

In equation (A.20) concentrations at next time step are unknown ($c_{i+1}^{l+\Delta l}$, $c_{i+1}^{l+\Delta l}$, $c_{i+1}^{l+\Delta l}$). This equation can be written for all the nodes (i=1→ N-1) and therefore N-1 equation with N-1 unknowns would be achieved that can be easily solved using a matrix system (equation A.8).

Matlab codes

%Diffusion equation-constant density-implicit

```
function [X,Y,time]= const_rho_diff
clc
global A Q
% A = Coefficient matrix and Q = Source vector
global rho D
  % rho = density, D = Diffusion
global DX DT
 % DX = step size in X, DT = step size in time
global N
% N = Number of subintervals
global Qp Qc
 % Coefficients of source term in original equation (Zero in our case)
global Y Y1 YNPLUS1
 % Y = Concentration vector, Y1 = Concentration at first boundary node,
% YNPLUS1 = Concentration at last boundary node
%%% INPUT DATA
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
L = 0.0012;
  % Length of x-axis
rho = 935;
  % rho is taken as average of 869.7 and 1000
D = 1.6e-10;

Qp = 0;
Qc = 0;
time_req = 260;
   % You want results untill t = ???
%
Y1 = 0;
 % Boundary condition at x = 0
YNPLUS1 = 1;
 % Boundary condition at x = L     %%% Comment this if right BC is
Neumann
%
N = 600;
DX = L/N;
DT = rho*(DX^2)/2/D/10;
DT=.1;
nitr = 1e6;
K=linspace(1.09,1,round(260/DT))';
%
%Giving Initial profile to Y
Y = ones(N-1,1);
for ii = 1:0.0004/DX
   % 0.0004 m is the length upto which intial Y has value 0
```

```
    Y(ii) = 0;
end
%%% CALCULATIONS
%Giving dimensions to various vectors and matrices
A = zeros(N-1,N-1);
Q = zeros(N-1,1);
%
%Copying Y to matrix YM which will contain different Y vector at
different times (including boundary Y's)
YM(:,1) = [Y1; Y; YNPLUS1];

for j = 1:nitr
    func_A_Q;
   %%% This function calculates matrix A and source vector Q
        Y = Tridiagonal(A,Q);

    fprintf('Solution for time, t = %3.3f seconds is obtained\n', j*DT)
    % Copying Y to matrix YM which will contain different Y vector at
different times (including boundary Y's)
    YM(:,j+1) = [Y1; Y; YNPLUS1];
   %YM(:,j+1) column vector has Y's at t = j*dt seconds %%% Comment this
if right BC is Neumann
        if j == round(time_req/DT)
        break
    end  %end of IF

end   %end of first FOR

%Generating the vector X
X = 0:DX:L;
%Generating the vector for time
time = 0:DT:j*DT;
save('workspace')
%experimental data
load('exp_data.mat')
C40 = (exp_data(:,2));
C90 = (exp_data(:,3));
C140 = (exp_data(:,4));
C190 = (exp_data(:,5));
C240 = (exp_data(:,6));
x = (exp_data(:,1));
x=x.*1000;
X= 0:DX:L';
X=X.*1000;
plot(x,C40,'--r','LineWidth',1); title('t = 40
seconds');xlabel('Elevation (mm)');ylabel('Toluene mass fraction'); hold
on;plot(X,YM(:,round(40./DT)+1),'LineWidth',1);
subplot(2,5,2)
plot(x,C90,'--r','LineWidth',1); title('t = 90 seconds');
xlabel('Elevation (mm)');ylabel('Toluene mass fraction'); hold
on;plot(X,YM(:,round(90./DT)+1),'LineWidth',1);
subplot(2,5,3)
plot(x,C140,'--r','LineWidth',1); title('t = 140
seconds');xlabel('Elevation (mm)');ylabel('Toluene mass fraction');
hold on;plot(X,YM(:,round(140./DT)+1),'LineWidth',1);
subplot(2,5,4)
```

```
plot(x,C190,'--r','LineWidth',1); title('t = 190
seconds');xlabel('Elevation (mm)');ylabel('Toluene mass fraction');
hold on;plot(X,YM(:,round(190./DT)+1),'LineWidth',1);
subplot(2,5,5)
plot(x,C240,'--r','LineWidth',1); title('t = 240
seconds');xlabel('Elevation (mm)');ylabel('Toluene mass fraction');
hold on;plot(X,YM(:,round(240./DT)+1),'LineWidth',1);
%%% Functions
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Calculates A and Q
function func_A_Q
global A Q rho D DX N DT Qp Qc Y Y1 YNPLUS1
%Generating the matrix A
for i = 1:N-1
    %Generating diagonal elements
    A(i,i) = rho*D/DX/DX  + rho*D/DX/DX + rho/DT - Qp;
    %Generating source vector
    Q(i) = Qc + rho*Y(i)/DT;
end

%Generating off diagonal elements
for i = 2:N-1
    A(i,i-1) =  - rho*D/DX/DX;
end   %end of FOR

for i = 1:N-2
    A(i,i+1) =  - rho*D/DX/DX;
end   %end of FOR

%Implementing the boundary condition at x = 0
Q(1) = Qc + rho*Y(1)/DT + rho*D/DX/DX*Y1;
%Implementing the boundary condition at x = L
Q(N-1) = Qc + rho*Y(N-1)/DT + rho*D/DX/DX*YNPLUS1;
return
%end
```

%Diffusion equation-constant density-explicit

```
function [X,Y,time]= const_rho_diff
clc
clear

global A Q
   % A = Coefficient matrix and Q = Source vector
global rho D
   % rho = density, D = Diffusion
global DX DT
   % DX = step size in X, DT = step size in time
global N                                                    % N = Number
```

```
of subintervals

global Qp Qc
   % Coefficients of source term in original equation (Zero in our case)
global Y Y1 YNPLUS1
 % Y = Concentration vector, Y1 = Concentration at first boundary node,
%
   % YNPLUS1 = Concentration at last boundary node
global YC
  % YC = Concentration at previous time step

%%% INPUT DATA
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
L = 0.0012;
  % Length of x-axis
rho = 935;
    % rho is taken as average of 869.7 and 1000
DNOT = 2e-10;
D = DNOT; %az koja maloom ine?
Qp = 0; rlx=1; eps=1e-5;
Qc = 0;
time_req = 150;
     % You want results untill t = ???
%
Y1 = 0;
  % Boundary condition at x = 0
YNPLUS1 = 1;
 % Boundary condition at x = L     %%% Comment this if right BC is
Neumann
%
N =100;
DX = L/N;
% DT =(DX^4)/2/DNOT;
% DT=0.1*DX*DX/D;
DT=0.1;
% D*DT/(6*DX*DX*DX*DX)

%
%Giving Initial profile to Y
Y = ones(N-1,1);

for ii = 1:0.0004/DX
   Y(ii) = 0;
end
%%% CALCULATIONS
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Giving dimensions to varius vectors and matrices
A = zeros(N-1,N-1);
Q = zeros(N-1,1); nitr = 1e5;

YM(:,1) = [Y1; Y; YNPLUS1];
  %YM(:,1) column vector has Y's at t = 0
%
for j = 1:nitr
%   for iii = 1:nitr
     %iii
```

```
    func_A_Q;

    if j==round(40/DT)
        YM(:,2)=[Y1;Y;YNPLUS1];
    end
    if j==round(90/DT)
        YM(:,3)=[Y1;Y;YNPLUS1];
    end
    if j==round(140/DT)
        YM(:,4)=[Y1;Y;YNPLUS1];
    end

if j == round(time_req/DT)
      break
    end  %end of IF

end   %end of first FOR

%Generating the vector X
X = 0:DX:L;
X=X.*1000;
%Generating the vector for time
time = 0:DT:j*DT;


%%% Experimental results
load('exp_data.mat')
C40 = (exp_data(:,2))';
C90 = (exp_data(:,3))';
C140 = (exp_data(:,4))';
C190 = (exp_data(:,5))';
C240 = (exp_data(:,6))';
x = (exp_data(:,1))';
x=x.*1000;
figure()
subplot(2,3,1);
plot(x,C40,'--r','LineWidth',2); title('t = 40 seconds');xlabel('x
(m)');ylabel('C'); hold on;plot(X,YM(:,2),'LineWidth',2);
  subplot(2,3,2)
plot(x,C90,'--r','LineWidth',2); title('t = 90 seconds'); xlabel('x
(m)');ylabel('C'); hold on;plot(X,YM(:,3),'LineWidth',2);
 subplot(2,3,3)
plot(x,C140,'--r','LineWidth',2); title('t = 140 seconds');xlabel('x
(m)');ylabel('C');  hold on;plot(X,YM(:,4),'LineWidth',2);
%  subplot(2,3,4)
% plot(x,C190,'--r','LineWidth',2); title('t = 190 seconds');xlabel('x
(m)');ylabel('C');  hold
on;plot(X,YM(:,round(190./DT)+1),'LineWidth',2);
% subplot(2,3,5)
% plot(x,C240,'--r','LineWidth',2); title('t = 240 seconds');xlabel('x
(m)');ylabel('C');  hold
on;plot(X,YM(:,round(240./DT)+1),'LineWidth',2);

%function[aaa,bbb] = func_A_Q(rho,D,DX,N,DT,Qp,Qc,Y,Y1,YNPLUS1)   %aaa
is A, bbb is Q
```

```
    function func_A_Q
        global A Q rho D DX N DT Qp Qc Y Y1 YNPLUS1 YC



    for i=2:N-2
        Y(i)=Y(i)+D*DT*(Y(i+1)-2*Y(i)+Y(i-1))/DX^2;
    end
   Y(1)=Y(1)+D*DT*(Y(2)-2*Y(1))/DX^2;

%      Y(N-1)=Y(N-1)+D*DT*(1-2*Y(N-1)+Y(N-2))/DX^2;
     Y(N-1)=Y(N-1)+D*DT*(YNPLUS1-2*Y(N-1)+Y(N-2))/DX^2;


return
%end
```

Fickian diffusion equation-variant density-Explicit

```
function [X,Y,time]= const_rho_diff
clc
clear
global A Q
   % A = Coefficient matrix and Q = Source vector
global rho D
   % rho = density, D = Diffusion
global DX DT
 % DX = step size in X, DT = step size in time
global N
 % N = Number of subintervals
global Qp Qc                                                    %
Coefficients of source term in original equation (Zero in our case)
global Y Y1 YNPLUS1
  % Y = Concentration vector, Y1 = Concentration at first boundary node,
%
  % YNPLUS1 = Concentration at last boundary node
global YC
  % YC = Concentration at previous time step

%%% INPUT DATA
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
L = 0.0012;
      % Length of x-axis

  % rho is taken as average of 869.7 and 1000
DNOT = 1.6e-10;
D = DNOT; %az koja maloom ine?
```

```
        nitr=100000000000000;
time_req = 91;
   % You want results untill t = ???
%
Y1 = 0;
  % Boundary condition at x = 0
YNPLUS1 = 1;
% Boundary condition at x = L     %%% Comment this if right BC is
Neumann
%
N =100;
DX = L/N;
DT=.01;
%
%Giving Initial profile to Y
Y = ones(N-1,1);

for ii = 1:0.0004/DX
   Y(ii) = 0;
end
%%% CALCULATIONS
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Giving dimensions to varius vectors and matrices


YM(:,1) = [Y1; Y; YNPLUS1];
   %YM(:,1) column vector has Y's at t = 0
%
for j = 1:nitr
%   for iii = 1:nitr
     %iii
    func_A_Q;

    if j==round(40/DT)
        YM(:,2)=[Y1;Y;YNPLUS1];
    end
    if j==round(90/DT)
        YM(:,3)=[Y1;Y;YNPLUS1];
    end
    if j==round(140/DT)
        YM(:,4)=[Y1;Y;YNPLUS1];
    end
    if j==round(240/DT)
        YM(:,5)=[Y1;Y;YNPLUS1];
    end
%     YM(:,j+1) = [Y1; Y; YNPLUS1];                          %YM(:,j+1)
column vector has Y's at t = j*dt seconds %%% Comment this if right BC
is Neumann
    if j == round(time_req/DT)
      break
    end  %end of IF

end   %end of first FOR

%Generating the vector X
```

```
X = 0:DX:L;
X=X.*1000;
%Generating the vector for time
%%% Experimental results
load('exp_data.mat')
C40 = (exp_data(:,2))';
C90 = (exp_data(:,3))';
C140 = (exp_data(:,4))';
C190 = (exp_data(:,5))';
C240 = (exp_data(:,6))';
x = (exp_data(:,1))';
x=x.*1000;
% figure(1)
% subplot(2,3,1);
% plot(x,C40,'--r','LineWidth',1); title('t = 40 seconds');xlabel('x
(m)');ylabel('C'); hold on;plot(X,YM(:,2),'LineWidth',1);
%   subplot(2,3,2)
% plot(x,C90,'--r','LineWidth',1); title('t = 90 seconds'); xlabel('x
(m)');ylabel('C'); hold on;plot(X,YM(:,3),'LineWidth',1);
%  subplot(2,3,3)
% plot(x,C140,'--r','LineWidth',1); title('t = 140 seconds');xlabel('x
(m)');ylabel('C');  hold on;plot(X,YM(:,4),'LineWidth',1);
% %  subplot(2,3,4)
% plot(x,C190,'--r','LineWidth',2); title('t = 190 seconds');xlabel('x
(m)');ylabel('C');  hold
on;plot(X,YM(:,round(190./DT)+1),'LineWidth',2);
% subplot(2,3,5)
% plot(x,C240,'--r','LineWidth',2); title('t = 240 seconds');xlabel('x
(m)');ylabel('C');  hold
on;plot(X,YM(:,round(240./DT)+1),'LineWidth',2);
%save('workspace111')
%function[aaa,bbb] = func_A_Q(rho,D,DX,N,DT,Qp,Qc,Y,Y1,YNPLUS1)   %aaa
is A, bbb is Q
    function func_A_Q
        global A Q rho D DX N DT Qp Qc Y Y1 YNPLUS1 YC

        ds=862; %toluene density

 db=1026; %athabasca bitumen density
    for i=2:N-2
        d(i)=1/(Y(i)/ds+(1-Y(i))/db);
    end
    d(1)=1/(Y(1)/ds+(1-Y(1))/db);
    d(N-1)=1/(Y(N-1)/ds+(1-Y(N-1))/db);
    for i=2:N-2
        Y(i)=Y(i)+D*DT*((Y(i+1)-Y(i))*(2*d(i+1)*d(i))/(d(i+1)+d(i))-
(Y(i)-Y(i-1))*(2*d(i-1)*d(i))/(d(i-1)+d(i)))/DX^2/d(i);

%         Y(i)=Y(i)+D*DT*(Y(i+1)-2*Y(i)+Y(i-1))/DX^2;
    end

   Y(1)=Y(1)+D*DT*((Y(1+1)-Y(1))*(2*d(1+1)*d(1))/(d(1+1)+d(1))-(Y(1)-
0)*(2*db*d(1))/(db+d(1)))/DX^2/d(1);


Y(N-1)=Y(N-1)+D*DT*((YNPLUS1-Y(N-1))*(2*ds*d(N-1))/(ds+d(N-1))-(Y(N-1)-
```

```
Y(N-2))*(2*d(N-2)*d(N-1))/(d(N-2)+d(N-1)))/DX^2/d(N-1);
%          Y(N-1)=Y(N-1)+D*DT*(YNPLUS1-2*Y(N-1)+Y(N-2))/DX^2;









return
%end
```

Fickian+sorption-explicit

```
function [X,Y,time]= const_rho_diff
clc
clear

global A Q
 % A = Coefficient matrix and Q = Source vector
global rho D
  % rho = density, D = Diffusion
global DX DT
 % DX = step size in X, DT = step size in time
global N
  % N = Number of subintervals
global Qp Qc
  % Coefficients of source term in original equation (Zero in our case)
global Y Y1 YNPLUS1
  % Y = Concentration vector, Y1 = Concentration at first boundary node,
%
  % YNPLUS1 = Concentration at last boundary node
global YC
   % YC = Concentration at previous time step

%%% INPUT DATA
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
L = 0.0012;
  % Length of x-axis
rho = 935;
   % rho is taken as average of 869.7 and 1000
DNOT = 1.6e-10;
D = DNOT; %az koja maloom ine?
Qp = 0; rlx=.2; eps=1e-5;
Qc = 0;
time_req = 261;
   % You want results untill t = ???
```

```
%


Y1 = 0;
      % Boundary condition at x = 0
YNPLUS1 = 1;
     % Boundary condition at x = L     %%% Comment this if right BC is
Neumann
%
N =100;
DX = L/N;
% DT =(DX^4)/2/DNOT;
% DT=0.1*DX*DX/D;
DT=0.01;
% D*DT/(6*DX*DX*DX*DX)

%
%Giving Initial profile to Y
Y = ones(N-1,1);

for ii = 1:0.0004/DX
   Y(ii) = 0;
end
%%% CALCULATIONS
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Giving dimensions to varius vectors and matrices
A = zeros(N-1,N-1);
Q = zeros(N-1,1); nitr = 1e5;

YM(:,1) = [Y1; Y; YNPLUS1];
      %YM(:,1) column vector has Y's at t = 0
%
for j = 1:nitr
%   for iii = 1:nitr
     %iii
    func_A_Q;

    if j==round(40/DT)
        YM(:,2)=[Y1;Y;YNPLUS1];
    end
    if j==round(90/DT)
        YM(:,3)=[Y1;Y;YNPLUS1];
    end
    if j==round(140/DT)
        YM(:,4)=[Y1;Y;YNPLUS1];
    end
    if j==round(190/DT)
        YM(:,5)=[Y1;Y;YNPLUS1];
    end
    if j==round(240/DT)
        YM(:,6)=[Y1;Y;YNPLUS1];
    end

%     YM(:,j+1) = [Y1; Y; YNPLUS1];
       %YM(:,j+1) column vector has Y's at t = j*dt seconds %%% Comment
```

```
this if right BC is Neumann
    if j == round(time_req/DT)
      break
    end  %end of IF

end   %end of first FOR

%Generating the vector X
X = 0:DX:L;
X=X.*1000;

%Generating the vector for time
time = 0:DT:j*DT;


%%% Experimental results
load('exp_data.mat')
C40 = (exp_data(:,2))';
C90 = (exp_data(:,3))';
C140 = (exp_data(:,4))';
C190 = (exp_data(:,5))';
C240 = (exp_data(:,6))';
x = (exp_data(:,1))';
x=x.*1000;
% figure()
% plot(X,YM(:,2),X,YM(:,3),X,YM(:,4))
% figure()
% X=X-0.0004;
% plot(X/40^0.25,YM(:,2),X/90^0.25,YM(:,3));
% figure()
% subplot(2,5,1);
% plot(x,C40,'--r','LineWidth',2); title('t = 40
seconds');xlabel('Elevation (mm)');ylabel('Toluene mass fraction'); hold
on;plot(X,YM(:,2),'LineWidth',2);
%   subplot(2,5,2)
% plot(x,C90,'--r','LineWidth',2); title('t = 90 seconds');
xlabel('Elevation (mm)');ylabel('Toluene mass fraction'); hold
on;plot(X,YM(:,3),'LineWidth',2);
%  subplot(2,5,3)
% plot(x,C140,'--r','LineWidth',2); title('t = 140
seconds');xlabel('Elevation (mm)');ylabel('Toluene mass fraction');
hold on;plot(X,YM(:,4),'LineWidth',2);
%  subplot(2,5,4)
% plot(x,C190,'--r','LineWidth',2); title('t = 190
seconds');xlabel('Elevation (mm)');ylabel('Toluene mass fraction');
hold on;plot(X,YM(:,5),'LineWidth',2);
% subplot(2,5,5)
% plot(x,C240,'--r','LineWidth',2); title('t = 240
seconds');xlabel('Elevation (mm)');ylabel('Toluene mass fraction');
hold on;plot(X,YM(:,6),'LineWidth',2);

% figure()
% subplot(2,3,1);
% plot(x,C40,'--r','LineWidth',1); title('t = 40
seconds');xlabel('Elevation (mm)');ylabel('Toluene mass fraction'); hold
```

```
on;plot(X,YM(:,2),'LineWidth',1);
%   subplot(2,3,2)
% plot(x,C140,'--r','LineWidth',1); title('t = 140 seconds');
xlabel('Elevation (mm)');ylabel('Toluene mass fraction'); hold
on;plot(X,YM(:,4),'LineWidth',1);
%  subplot(2,3,3)
% plot(x,C240,'--r','LineWidth',1); title('t = 240
seconds');xlabel('Elevation (mm)');ylabel('Toluene mass fraction');
hold on;plot(X,YM(:,6),'LineWidth',1);
%
figure(1)
subplot(2,5,1)
hold on
plot(X,YM(:,2),':','LineWidth',3);
hold on
subplot(2,5,2)
plot(X,YM(:,3),':','LineWidth',3);
subplot(2,5,3)
hold on
plot(X,YM(:,4),':','LineWidth',3)
subplot(2,5,4)
hold on
plot(X,YM(:,5),':','LineWidth',3);
subplot(2,5,5)
hold on
plot(X,YM(:,6),':','LineWidth',3);


% plot(X,YM(:,round(3000./DT)+1));
%save('workspace111')
%variables = whos ;
%   for k=1:length(variables)
%      assignin('base',variables(k).name,eval(variables(k).name))
%   end

%function[aaa,bbb] = func_A_Q(rho,D,DX,N,DT,Qp,Qc,Y,Y1,YNPLUS1)   %aaa
is A, bbb is Q
    function func_A_Q
        global A Q rho D DX N DT Qp Qc Y Y1 YNPLUS1 YC a E b



%a=kl*q
%b=kl

% carbon black
% b=600;
% a=600*2.8e-3;
%
% % F300
a=124899.7;
 b=499000;

%
% % F400
```

```
% b=0.07e6;
% a=b*.18;

    for i=2:N-2
%       %E=porosity
        E=0.15*Y(i)+0.85;
        Y(i)=Y(i)+D*DT*(Y(i+1)-2*Y(i)+Y(i-1))/DX^2/(1+a*(1-
E)/E/(1+b*Y(i))^2);
    end
     E=0.15*Y(1)+0.85;
%     E=(tanh(s*(Y(1)-ycr))+12.34)/(200/15);
   Y(1)=Y(1)+D*DT*(Y(2)-2*Y(1))/DX^2/(1+a*(1-E)/E/(1+b*Y(1))^2);
    E=0.15*Y(N-1)+0.85;
%     Y(N-1)=Y(N-1)+D*DT*(1-2*Y(N-1)+Y(N-2))/DX^2;
%         E=(tanh(s*(Y(N-1)-ycr))+12.34)/(200/15);
     Y(N-1)=Y(N-1)+D*DT*(YNPLUS1-2*Y(N-1)+Y(N-2))/DX^2/(1+a*(1-
E)/E/(1+b*Y(N-1))^2);
%      YNPLUS1=2*Y(N-1)-Y(N-2);

return
%end
```

Appendix B. Literature, simulation, and experimental data

Table B.1 Fadaie et al.[3], experimental data (Tolune mass fraction in athabasca bitumen at different elevations and times)

Elevation (mm)	40s	90s	140s	190s	240s
0	0.001096379	0.001096379	0.001096379	-0.012480149	-0.006677214
0.00191	0.001100974	0.001100974	0.001100974	-0.01237541	-0.006318496
0.00382	0.001107866	0.001107866	0.001107866	-0.012224138	-0.006040865
0.00572	0.001080298	0.001080298	0.001080298	-0.012119425	-0.005821126
0.00763	0.001045836	0.001045836	0.001045836	-0.011968191	-0.005589872
0.00954	0.001015969	0.001015969	0.001015969	-0.011747196	-0.005451144
0.0114	0.000972315	0.000972315	0.000972315	-0.011689047	-0.005150632
0.0134	0.000926361	0.000926361	0.000926361	-0.011584388	-0.004919527
0.0153	0.00091717	0.00091717	0.00091717	-0.011386726	-0.004538318
0.0172	0.000926361	0.000926361	0.000926361	-0.011061247	-0.004226524
0.019077	0.000963124	0.000963124	0.000963124	-0.010573219	-0.003764779
0.021	0.001048134	0.001048134	0.001048134	-0.010027364	-0.003072549
0.0229	0.001137731	0.001137731	0.001137731	-0.009319339	-0.002277057
0.0248	0.001243399	0.001243399	0.001243399	-0.008472664	-0.001459147
0.0267	0.001406475	0.001406475	0.001406475	-0.007580343	-0.000331266
0.0286	0.001571821	0.001571821	0.001571821	-0.006850832	0.00073793
0.0305	0.00172566	0.00172566	0.00172566	-0.005902077	0.001863408
0.0324	0.001890955	0.001890955	0.001890955	-0.004988853	0.003044981
0.0343	0.002056223	0.002056223	0.002056223	-0.004168795	0.004293902
0.0362	0.002212285	0.002212285	0.002212285	-0.003257098	0.005689975
0.038154	0.002395857	0.002395857	0.002395857	-0.002219437	0.007141242
0.0401	0.002561044	0.002561044	0.002561044	-0.001182817	0.008738677
0.042	0.002749141	0.002749141	0.002749141	-0.00017024	0.010424676
0.0439	0.002923445	0.002923445	0.002923445	0.000990696	0.012141976
0.0458	0.003083961	0.003083961	0.003083961	0.002138847	0.013935782
0.0477	0.003239867	0.003239867	0.003239867	0.003262792	0.015975495
0.0496	0.003359073	0.003359073	0.003359073	0.004293902	0.017830323
0.0515	0.003494309	0.003494309	0.003494309	0.005426926	0.020098977
0.0534	0.003643278	0.003643278	0.003643278	0.006684372	0.022621213
0.0553	0.003796808	0.003796808	0.003796808	0.007917451	0.025327805
0.057231	0.003970933	0.003970933	0.003970933	0.009228816	0.028384952
0.0591	0.004135866	0.004135866	0.004135866	0.010697819	0.031722526

0.061	0.004319094	0.004319094	0.004319094	0.012232878	0.035304327
0.063	0.004488551	0.004488551	0.004488551	0.013674855	0.03941515
0.0649	0.00465798	0.00465798	0.00465798	0.015171432	0.043607957
0.0668	0.004813647	0.004813647	0.004813647	0.016609234	0.048177469
0.0687	0.004955558	0.004955558	0.004955558	0.017909417	0.052878319
0.0706	0.005088295	0.005088295	0.005088295	0.01903865	0.057567299
0.0725	0.005191269	0.005191269	0.005191269	0.020155346	0.062579087
0.0744	0.005326264	0.005326264	0.005326264	0.021259541	0.067693624
0.076308	0.0054132	0.0054132	0.0054132	0.022407519	0.072930313
0.0782	0.005536729	0.005536729	0.005536729	0.023689	0.078116886
0.0801	0.005625934	0.005625934	0.005625934	0.024991283	0.083264391
0.082	0.005667104	0.005667104	0.005667104	0.026403913	0.088352124
0.0839	0.00572428	0.00572428	0.00572428	0.02780336	0.093255352
0.0858	0.005758585	0.005758585	0.005758585	0.029256704	0.097955902
0.0878	0.005788315	0.005788315	0.005788315	0.031053677	0.102694496
0.0897	0.005850058	0.005850058	0.005850058	0.033070002	0.107254207
0.0916	0.005911798	0.005911798	0.005911798	0.035304327	0.111606742
0.0935	0.005971247	0.005971247	0.005971247	0.037954503	0.115907752
0.0954	0.006076419	0.006076419	0.006076419	0.041006112	0.120147616
0.0973	0.006197581	0.006197581	0.006197581	0.044510372	0.124417854
0.0992	0.006341586	0.006341586	0.006341586	0.048341836	0.128768046
0.101108	0.006469573	0.006469573	0.006469573	0.052583819	0.133266753
0.103016	0.006615824	0.006615824	0.006615824	0.057219943	0.137682791
0.104924	0.006798609	0.006798609	0.006798609	0.062114732	0.141957801
0.106831	0.006976792	0.006976792	0.006976792	0.067006106	0.146054242
0.108739	0.007175499	0.007175499	0.007175499	0.072342763	0.149974443
0.110647	0.0073833	0.0073833	0.0073833	0.07785133	0.153867013
0.112554	0.0045	0.0045	0.0045	0.083454496	0.157722441
0.114462	0.004598152	0.004788263	0.005632199	0.089087169	0.161599079
0.11637	0.004705738	0.005101167	0.006886364	0.094727511	0.165409838
0.118277	0.00482113	0.00543677	0.008267953	0.100395669	0.169126692
0.120185	0.004946995	0.005796363	0.009792066	0.105925798	0.172769813
0.122093	0.005084123	0.006184574	0.011469933	0.111309714	0.176406511
0.124001	0.005234653	0.00659871	0.013325178	0.116549599	0.180055637
0.125908	0.005395562	0.007044773	0.015417317	0.121607068	0.183509716
0.127816	0.005571861	0.007513302	0.017791526	0.126625839	0.186911755
0.129724	0.005738648	0.008001079	0.020482893	0.131496074	0.190215576
0.131631	0.005920683	0.008516981	0.023519306	0.136309537	0.193450164
0.133539	0.006126076	0.009079395	0.027055891	0.140977701	0.196875653
0.135447	0.006344609	0.009677432	0.031157476	0.145502604	0.200332705
0.137354	0.006578949	0.010303556	0.036032536	0.149876411	0.203728939

0.139262	0.00683129	0.011000027	0.04195898	0.154101174	0.207064998
0.14117	0.00709643	0.01173048	0.049454429	0.158130324	0.210414372
0.143078	0.007379854	0.012504126	0.056714332	0.162034089	0.213667939
0.144985	0.007679641	0.013355606	0.06391993	0.165823638	0.216880961
0.146893	0.008008902	0.014247679	0.071071565	0.169490764	0.220035828
0.148801	0.00834871	0.015209149	0.078169577	0.173275336	0.223088333
0.150708	0.008680534	0.016224234	0.085214305	0.177071191	0.226128835
0.152616	0.009043421	0.01730788	0.092206087	0.180792973	0.229201824
0.154524	0.009461779	0.018461145	0.099145258	0.184573202	0.232085441
0.156431	0.009919138	0.019724131	0.113427737	0.188289201	0.234799381
0.158339	0.010375401	0.021122224	0.119305315	0.191783218	0.237415729
0.160247	0.010890806	0.02255358	0.125406584	0.195382856	0.239935426
0.162155	0.011371914	0.024069295	0.131435988	0.198855579	0.242359373
0.164062	0.01185331	0.025621914	0.137284969	0.202304099	0.244557784
0.16597	0.012368757	0.027232479	0.143094908	0.205884318	0.246940822
0.167878	0.012864541	0.028907514	0.148659881	0.209366369	0.249247029
0.169785	0.013358503	0.030705328	0.153964588	0.212978364	0.251658288
0.171693	0.013863173	0.032548238	0.159217053	0.216609948	0.254199326
0.173601	0.01439619	0.034552747	0.164350349	0.220161756	0.256783066
0.175508	0.014925229	0.036742781	0.169394971	0.223715298	0.259451684
0.177416	0.015432386	0.039068545	0.174361644	0.227288216	0.262161656
0.179324	0.015967115	0.041672427	0.179232442	0.23056957	0.264861602
0.181232	0.016486604	0.044436469	0.183820435	0.233739708	0.267391114
0.183139	0.016949213	0.047560112	0.187961449	0.236685469	0.269911819
0.185047	0.017410612	0.051043804	0.192006919	0.239637363	0.272549528
0.186955	0.01789656	0.055037956	0.195865305	0.242647627	0.275185941
0.188862	0.018401083	0.059859972	0.199677567	0.245445788	0.277704459
0.19077	0.018993722	0.065739603	0.203177691	0.248233524	0.280180924
0.192678	0.01956594	0.072001434	0.206671634	0.25087268	0.282541301
0.194585	0.020187598	0.07822207	0.21006823	0.253304498	0.284646561
0.196493	0.02082281	0.08440174	0.213423028	0.255745508	0.286638696
0.198401	0.021589718	0.090540672	0.216871929	0.258340938	0.288535027
0.200309	0.022387173	0.096639093	0.220386579	0.260876098	0.290458942
0.202216	0.02329341	0.102697228	0.223858533	0.263394005	0.292426491
0.204124	0.024217954	0.108715305	0.227332773	0.265869388	0.294331586
0.206032	0.025221899	0.120238902	0.230800247	0.268319486	0.296377398
0.207939	0.026331563	0.126474783	0.234252068	0.270870576	0.298376766
0.209847	0.027554499	0.132916903	0.237697087	0.2735299	0.300249454
0.211755	0.028915266	0.139540197	0.24115275	0.276304526	0.302253707
0.213662	0.030389855	0.14618225	0.244784238	0.27925949	0.304340268
0.21557	0.031974519	0.15276364	0.248380871	0.282119495	0.306324607

0.217478	0.033629104	0.159372186	0.252020596	0.285091576	0.308534173
0.219385	0.035456323	0.166006415	0.255779831	0.288108594	0.310839756
0.221293	0.037337113	0.172426263	0.259579738	0.29103917	0.313248234
0.223201	0.039268858	0.178635821	0.263309083	0.293924953	0.315687532
0.225109	0.041422466	0.184798897	0.267019432	0.296742086	0.318165102
0.227016	0.043673985	0.190803798	0.270719278	0.299491306	0.320727376
0.228924	0.04605519	0.196551368	0.274416943	0.302213519	0.323170746
0.230832	0.048661355	0.202156874	0.278054013	0.305013029	0.32567501
0.232739	0.051504834	0.207778044	0.28173055	0.307920682	0.328278067
0.234647	0.054619366	0.213087285	0.28553631	0.310927055	0.330970968
0.236555	0.057939586	0.218514074	0.289362549	0.314070216	0.333660504
0.238462	0.061512528	0.224082285	0.293257558	0.317104409	0.336552787
0.24037	0.065702747	0.229521775	0.297260423	0.320132741	0.339401824
0.242278	0.070384208	0.234993494	0.301111436	0.323155162	0.342155092
0.244186	0.074869282	0.240303457	0.304989013	0.326125082	0.344715716
0.246093	0.079333108	0.24550669	0.308733239	0.329089415	0.347213572
0.248001	0.083775771	0.250535736	0.312504425	0.332163415	0.349634352
0.249909	0.088197356	0.255436531	0.316207401	0.335200066	0.352105545
0.251816	0.092597948	0.260347597	0.319835224	0.338275897	0.354648749
0.253724	0.09697763	0.265192039	0.323420042	0.341238644	0.35712258
0.255632	0.101336488	0.269894987	0.326791866	0.344067086	0.359542502
0.257539	0.105379453	0.274575826	0.330077133	0.346702759	0.361938403
0.259447	0.108806692	0.279209649	0.333230922	0.349110507	0.364368943
0.261355	0.11250747	0.283706162	0.336346621	0.351367437	0.366673515
0.263263	0.116559783	0.288083984	0.339226978	0.353497398	0.368838948
0.26517	0.120796557	0.292353113	0.342056693	0.355620186	0.370794347
0.267078	0.125658634	0.296328758	0.344813708	0.357780131	0.372649811
0.268986	0.131015273	0.300249454	0.347588909	0.359940006	0.374571513
0.270893	0.136817296	0.304123882	0.350374481	0.362129091	0.37646567
0.272801	0.143055381	0.307968506	0.35321481	0.364222795	0.378375349
0.274709	0.149552826	0.311878673	0.355842441	0.366200176	0.380271889
0.276617	0.156332222	0.315852989	0.358555007	0.368222068	0.382119895
0.278524	0.163405314	0.319819561	0.361329278	0.370280754	0.383905624
0.280432	0.170629858	0.323723744	0.364200869	0.37253446	0.385636653
0.28234	0.178124087	0.327705658	0.367182859	0.374808606	0.387418949
0.284247	0.185907656	0.331663621	0.370150479	0.377260313	0.389209942
0.286155	0.193831494	0.335651286	0.373103793	0.379752004	0.390876667
0.288063	0.20176107	0.339569024	0.376007023	0.3824037	0.392601462
0.28997	0.20973105	0.343395137	0.378953498	0.385121402	0.394481106
0.291878	0.217494908	0.347296165	0.382013434	0.387939245	0.396569489
0.293786	0.225271554	0.35118091	0.385079033	0.390680825	0.398684948

0.295694	0.232758197	0.35500487	0.388100865	0.393312256	0.400964625
0.297601	0.240110701	0.358842573	0.391135358	0.395952769	0.403242228
0.299509	0.24734015	0.362407683	0.394084792	0.39869875	0.405429047
0.301417	0.254611958	0.365813953	0.396977969	0.401404378	0.407668743
0.303324	0.261846861	0.369158032	0.399911988	0.404172639	0.409906493
0.305232	0.269229821	0.372469566	0.402906639	0.406914076	0.412169214
0.30714	0.276396272	0.375669983	0.405817705	0.409466416	0.414315531
0.309047	0.283384158	0.378825068	0.408558109	0.411771356	0.416393531
0.310955	0.290270878	0.382070215	0.411312463	0.413919174	0.4185439
0.312863	0.296912209	0.385382612	0.414134182	0.415978542	0.420699355
0.314771	0.303394079	0.388725854	0.416841645	0.417997069	0.422813471
0.316678	0.309648192	0.39220388	0.419635968	0.419875406	0.424807567
0.318586	0.315813598	0.395737803	0.422350243	0.42169445	0.426650028
0.320494	0.321930669	0.399326365	0.42503821	0.423520806	0.42846019
0.322401	0.32781399	0.402790164	0.426354331	0.42439217	0.429307483
0.324309	0.33372185	0.406274213	0.42962382	0.426999405	0.431855882
0.326217	0.339531028	0.409750812	0.43284154	0.429558476	0.434395736
0.328124	0.345152794	0.413172736	0.435956502	0.432076444	0.436856128
0.330032	0.350546307	0.416473817	0.438906012	0.434566713	0.439119243
0.33194	0.35574614	0.419635968	0.441644638	0.436961868	0.441206648
0.333848	0.360756303	0.422601758	0.444092719	0.439182811	0.443168108
0.335755	0.365755634	0.425446541	0.446203401	0.441317938	0.44500494
0.337663	0.370678645	0.428237519	0.448122684	0.443460564	0.446794345
0.339571	0.375540855	0.431092667	0.449956415	0.44563591	0.448625084
0.341478	0.380499643	0.433971949	0.451812046	0.447881414	0.45047783
0.343386	0.385657819	0.436887723	0.453711171	0.450076594	0.452308456
0.345294	0.390890653	0.439864893	0.455559888	0.452153065	0.454076565
0.347201	0.396112208	0.442800241	0.457485867	0.454127762	0.455807635
0.349109	0.401273861	0.445789414	0.459590161	0.456101294	0.45757953
0.351017	0.406199289	0.448743041	0.461815193	0.458185144	0.459404157
0.352925	0.410981561	0.451755606	0.460849404	0.460337833	0.461360974
0.354832	0.415817819	0.454850859	0.463046403	0.462598371	0.463494435
0.35674	0.420725914	0.458002356	0.465397535	0.464983615	0.465811456
0.358648	0.425611106	0.461307402	0.467893032	0.467503917	0.468282146
0.360555	0.430518907	0.464664954	0.470577579	0.470226792	0.470928367
0.362463	0.435460879	0.467891356	0.473451091	0.473169938	0.473732244
0.364371	0.440287954	0.470958586	0.476420532	0.476272558	0.476568506
0.366278	0.444983345	0.473767104	0.479381461	0.479356201	0.479406722
0.368186	0.449562341	0.476344917	0.48226292	0.482367813	0.482158028
0.370094	0.453939806	0.478867968	0.485080731	0.485387754	0.484773709
0.372002	0.458058128	0.481123768	0.487899978	0.488476934	0.487323022

0.373909	0.461922843	0.483292767	0.490726245	0.491587441	0.489865049
0.375817	0.465716215	0.485446474	0.493462501	0.494600499	0.492324503
0.377725	0.469433334	0.487368646	0.495969289	0.497383033	0.494555545
0.379632	0.473021289	0.489213438	0.49815859	0.499813384	0.496503797
0.38154	0.47640471	0.490842298	0.499964839	0.501825751	0.498103927
0.383448	0.479409099	0.492222585	0.501329566	0.503416796	0.499242336
0.385355	0.481975945	0.49324658	0.502243629	0.504593491	0.499893767
0.387263	0.484135355	0.493985758	0.502750796	0.505367327	0.500134266
0.389171	0.486215067	0.494550934	0.502941804	0.505790937	0.500092672
0.391079	0.488467013	0.495144238	0.502977215	0.506008792	0.499945639
0.392986	0.491039721	0.495932269	0.503096301	0.506277173	0.499915429
0.394894	0.493916507	0.4969829	0.503461837	0.50674212	0.500181554
0.396802	0.497160651	0.498437384	0.504132522	0.507476001	0.500789044
0.398709	0.500639378	0.500012892	0.505125361	0.50850276	0.501747962
0.400617	0.504239996	0.501782031	0.506389191	0.509764657	0.503013726
0.402525	0.50804346	0.503686076	0.507890936	0.511240316	0.504541556
0.404432	0.524046378	0.5157141	0.512832861	0.520704207	0.517980009
0.40634	0.528266551	0.518336488	0.514952659	0.522337568	0.519530064
0.408248	0.53270297	0.521412708	0.517447523	0.52434409	0.521450827
0.410156	0.537453702	0.524787593	0.520142083	0.526681154	0.52367803
0.412063	0.542466326	0.528443557	0.523119528	0.529241909	0.526207152
0.413971	0.547705236	0.532219271	0.526379574	0.532118213	0.529049148
0.415879	0.55300383	0.536069095	0.529948003	0.535166532	0.532022454
0.417786	0.558263283	0.540069005	0.533642306	0.538278211	0.535092557
0.419694	0.563335	0.544079783	0.537222356	0.541436027	0.537963292
0.421602	0.5680186	0.54780794	0.540486864	0.54418334	0.540481643
0.423509	0.572354844	0.551198958	0.543442369	0.546517247	0.54243514
0.425417	0.576521515	0.554295651	0.546079296	0.548587705	0.543945122
0.427325	0.58055615	0.557134133	0.548408277	0.550347298	0.545305371
0.429233	0.584363046	0.559794154	0.550612665	0.551855684	0.546676862
0.43114	0.587989891	0.562114956	0.55254189	0.553237151	0.547956818
0.433048	0.591283673	0.564190895	0.554315884	0.554568717	0.549181851
0.434956	0.594339352	0.566084504	0.555961689	0.555860901	0.550464692
0.436863	0.597439998	0.567920638	0.55747068	0.557194429	0.551687779
0.438771	0.600633928	0.569812158	0.559109443	0.558633997	0.553079927
0.440679	0.604151433	0.571957208	0.560881429	0.560198466	0.554684971
0.442586	0.607730561	0.574231186	0.562606372	0.561816851	0.556339435
0.444494	0.611342712	0.576483127	0.564274907	0.563364713	0.557902279
0.446402	0.614942871	0.578617799	0.565858114	0.564783563	0.559324471
0.44831	0.618414344	0.580712911	0.567293132	0.566148461	0.560776812
0.450217	0.621841347	0.582792591	0.568811256	0.56751875	0.562318541

0.452125	0.625241526	0.584946287	0.570377461	0.5690556	0.56395854
0.454033	0.628778797	0.587336286	0.572088179	0.570776609	0.565715327
0.45594	0.632544274	0.589944344	0.573922271	0.57258743	0.567528557
0.457848	0.636620755	0.592747613	0.575892461	0.574549513	0.569221672
0.459756	0.641066111	0.595883569	0.578149697	0.576665437	0.571000354
0.461663	0.645865878	0.599171756	0.580655914	0.578818251	0.572897341
0.463571	0.650696785	0.602387651	0.58315627	0.581012015	0.574766413
0.465479	0.655431449	0.605461228	0.585556848	0.583071283	0.576564697
0.467387	0.660083801	0.6085239	0.587896584	0.585035581	0.578211823
0.469294	0.664644339	0.611474543	0.590194941	0.586981027	0.57983332
0.471202	0.669268867	0.614420052	0.59250784	0.589047409	0.581510035
0.47311	0.674053189	0.617533241	0.59508701	0.591214268	0.583411123
0.475017	0.679007398	0.620831097	0.597813357	0.593636277	0.585627238
0.476925	0.684183394	0.624321133	0.600755906	0.596230988	0.587961901
0.478833	0.68960444	0.627921824	0.603806487	0.598949464	0.590348006
0.48074	0.695079921	0.631641904	0.60693114	0.601667278	0.592793706
0.482648	0.700489053	0.635262857	0.610061594	0.604330505	0.595206138
0.484556	0.705698754	0.638799226	0.613136103	0.606988932	0.59773143
0.486464	0.710749501	0.642317567	0.616047136	0.609629187	0.600141111
0.488371	0.71573136	0.645809829	0.618910139	0.61218126	0.602504586
0.490279	0.720741766	0.649307925	0.62174301	0.614681551	0.604804648
0.492187	0.725761935	0.652830749	0.624643742	0.617195805	0.607113376
0.494094	0.730771107	0.656384764	0.627543115	0.619628961	0.609399549
0.496002	0.735771166	0.659818409	0.630457564	0.6219653	0.611667813
0.49791	0.740697886	0.663222286	0.633282813	0.624295652	0.613953265
0.499817	0.745511783	0.666555222	0.635921864	0.626489112	0.61599938
0.501725	0.750260231	0.66980379	0.638435692	0.628526952	0.61782285
0.503633	0.754999282	0.672921745	0.640818545	0.630453387	0.619469819
0.505541	0.759716788	0.676048016	0.643137358	0.632324084	0.621079631
0.507448	0.764404156	0.679138323	0.645381168	0.634065365	0.622665506
0.509356	0.769118994	0.682218455	0.647654798	0.635814857	0.624202207
0.511264	0.77385083	0.685345393	0.650008971	0.637580566	0.625757985
0.513171	0.778571266	0.688524483	0.652359395	0.639284729	0.627244083
0.515079	0.783326747	0.691680275	0.654616158	0.640928145	0.628707459
0.516987	0.788017002	0.694840733	0.656893432	0.642572185	0.630206862
0.518894	0.792727574	0.698063659	0.659182954	0.644265041	0.631729327
0.520802	0.797439231	0.701316168	0.661495809	0.646085984	0.633233071
0.52271	0.802210022	0.70461036	0.663857991	0.647973305	0.634722408
0.524618	0.807007503	0.707951142	0.666370274	0.650016885	0.636312586
0.526525	0.81181548	0.711366215	0.668924278	0.652123482	0.63799406
0.528433	0.816597688	0.714823353	0.671559759	0.654327036	0.639802153

0.530341	0.821384736	0.71830774	0.67430042	0.656621717	0.641763251
0.532248	0.826153185	0.721881659	0.677077615	0.658936161	0.643798288
0.534156	0.830874308	0.725434364	0.679842988	0.661170176	0.645813833
0.536064	0.835609459	0.728947255	0.682582141	0.663427972	0.647778253
0.537971	0.840331644	0.732485772	0.685327547	0.665697584	0.64983087
0.539879	0.845013284	0.736054554	0.688107084	0.668001166	0.651855923
0.541787	0.849643187	0.73957971	0.690838874	0.670244564	0.653775482
0.543695	0.854196159	0.743071065	0.693509878	0.672358315	0.655653472
0.545602	0.858699894	0.74656158	0.696166193	0.674403687	0.657428483
0.54751	0.863129742	0.750039099	0.698756521	0.676381789	0.659136693
0.549418	0.86747231	0.753500652	0.701353559	0.67832649	0.66087109
0.551325	0.871724738	0.757008861	0.703980505	0.680296242	0.662585409
0.553233	0.87590978	0.760463185	0.706579533	0.682229263	0.664287476
0.555141	0.879986895	0.763889972	0.709194193	0.684183394	0.665882894
0.557048	0.88397684	0.767336434	0.711787665	0.686047771	0.667406958
0.558956	0.887889879	0.770801459	0.714370006	0.688011503	0.668972991
0.560864	0.89174518	0.774283973	0.71697038	0.690044584	0.670531881
0.562772	0.895501417	0.7777856	0.719655517	0.692180588	0.672154212
0.564679	0.899183421	0.781318396	0.722423018	0.694410448	0.673872264
0.566587	0.902772931	0.784886061	0.725254685	0.696732112	0.675655135
0.568495	0.906315685	0.788394574	0.728129749	0.699061323	0.677483459
0.570402	0.909810793	0.791909004	0.731077659	0.701418134	0.679494473
0.57231	0.913268001	0.795418748	0.73405312	0.703865853	0.681572928
0.574218	0.916620904	0.798844237	0.737051965	0.706365421	0.683681586
0.576125	0.91985081	0.802281186	0.74001604	0.708835732	0.685776979
0.578033	0.922981144	0.805682826	0.742919179	0.711184952	0.687788374
0.579941	0.926013876	0.809033236	0.745774568	0.713477732	0.68974535
0.581849	0.928979786	0.812345694	0.748545198	0.715737859	0.691715287
0.583756	0.931878221	0.815682302	0.751293942	0.717949727	0.693656084
0.585664	0.934680085	0.818953724	0.754015377	0.7201238	0.695554312
0.587572	0.937392067	0.822246991	0.7567413	0.722388018	0.697410608
0.589479	0.939989354	0.825472404	0.759476991	0.72456022	0.699177689
0.591387	0.942459349	0.828679254	0.762174397	0.726657852	0.700860324
0.593295	0.944806029	0.831838928	0.764845384	0.728713455	0.70250717
0.595202	0.947039662	0.834941626	0.767512412	0.730727732	0.704152406
0.59711	0.949138279	0.838045894	0.770145394	0.732673655	0.705752406
0.599018	0.951166103	0.84117769	0.772763919	0.734708444	0.707354495
0.600926	0.953111577	0.844265175	0.775389592	0.736781643	0.709044883
0.602833	0.954993163	0.847364965	0.778000798	0.738907461	0.710766006
0.604741	0.956836578	0.850436539	0.780681978	0.740991787	0.712520582
0.606649	0.95861907	0.853499474	0.783391986	0.743142515	0.714314516

0.608556	0.960323124	0.856543597	0.786096255	0.745307896	0.716166541
0.610464	0.96197882	0.859577611	0.788833206	0.747434659	0.717969089
0.612372	0.963562615	0.862569119	0.791556066	0.749526391	0.719793508
0.614279	0.965087589	0.865527274	0.794265035	0.751699505	0.721706314
0.616187	0.966545636	0.868468944	0.797017726	0.753831441	0.723648773
0.618095	0.967939232	0.871402476	0.799748505	0.756019995	0.725601342
0.620003	0.969339866	0.874318176	0.802521549	0.758221332	0.727635714
0.62191	0.970723731	0.877261487	0.805294282	0.760488502	0.729743978
0.623818	0.972072	0.880222001	0.808054531	0.762764081	0.731782512
0.625726	0.973421063	0.883135671	0.810802492	0.765067145	0.733866069
0.627633	0.974726266	0.88602458	0.813533633	0.767402438	0.735941839
0.629541	0.975978263	0.888874057	0.81627174	0.769747256	0.737994724
0.631449	0.977203222	0.891692456	0.818997922	0.772066038	0.73999499
0.633356	0.9784182	0.894493469	0.821693941	0.774461357	0.742030191
0.635264	0.979556393	0.897218004	0.824360471	0.776872644	0.744069857
0.637172	0.98061081	0.899862072	0.827023121	0.779235906	0.746048925
0.63908	0.981619905	0.902456513	0.829632423	0.781570492	0.748012406
0.640987	0.982563878	0.904996761	0.832263259	0.78389777	0.750001258
0.642895	0.983476279	0.907528895	0.834952694	0.786222957	0.751954155
0.644803	0.984362903	0.910004505	0.837587278	0.788540855	0.753917675
0.64671	0.985224057	0.912403158	0.84017917	0.790864248	0.755868676
0.648618	0.98603075	0.914747404	0.842753111	0.793210596	0.757830006
0.650526	0.986806297	0.91707679	0.84533094	0.795554195	0.759764725
0.652433	0.987551103	0.919401888	0.84791893	0.797942288	0.761704069
0.654341	0.988276044	0.921651352	0.850556967	0.800336713	0.763723023
0.656249	0.988961802	0.923859171	0.853227111	0.802668618	0.765781225
0.658157	0.98961668	0.925976128	0.85586413	0.804970936	0.767877789
0.660064	0.990207541	0.928046275	0.858468765	0.807229748	0.769910938
0.661972	0.990737799	0.930014253	0.861027383	0.809443523	0.771954988
0.66388	0.991229936	0.931933881	0.863484002	0.811632194	0.773939661
0.665787	0.9917175	0.933814152	0.865929665	0.81385297	0.775964964
0.667695	0.992166257	0.935575455	0.868344517	0.816088686	0.778022044
0.669603	0.992605695	0.937294175	0.870711224	0.818306337	0.780070609
0.67151	0.993034633	0.938959246	0.873034684	0.820517825	0.782095024
0.673418	0.993425559	0.940559825	0.875305872	0.822668048	0.784111304
0.675326	0.993780097	0.942147381	0.877557056	0.824860976	0.786104014
0.677234	0.994109804	0.943695931	0.879792478	0.827009511	0.788112081
0.679141	0.994409914	0.945194569	0.882016272	0.829137036	0.790119819
0.681049	0.99471167	0.946663194	0.88422094	0.831255127	0.792137308
0.682957	0.99500268	0.948154949	0.886416346	0.833415094	0.794184441
0.684864	0.995310152	0.949640628	0.888585533	0.835613878	0.796170476

0.686772	0.995624096	0.951120143	0.890789336	0.837859453	0.798163671
0.68868	0.995949342	0.952590246	0.892968929	0.840089831	0.80017865
0.690587	0.996304088	0.9540603	0.895175065	0.842363742	0.802207568
0.692495	0.996683138	0.955522301	0.897418349	0.844635139	0.804279351
0.694403	0.997036509	0.956943602	0.899644595	0.846861347	0.806334972
0.696311	0.997381366	0.95835859	0.901826539	0.849100525	0.808345818
0.698218	0.997682866	0.959705812	0.903946645	0.851263883	0.810324655
0.700126	0.997938999	0.960952601	0.906005875	0.853352844	0.812245901
0.702034	0.998182466	0.962158028	0.908039396	0.855441647	0.81416962
0.703941	0.998436057	0.963328605	0.910051125	0.857515798	0.816091033
0.705849	0.998669898	0.964454184	0.912023484	0.859614649	0.817998481
0.707757	0.998896018	0.965526315	0.913962322	0.861733661	0.819936248
0.709664	0.99911091	0.966605185	0.915875124	0.863866366	0.821878398
0.711572	0.999333576	0.967647611	0.917758675	0.865994329	0.823815654
0.71348	0.999542713	0.96867758	0.919636026	0.868079463	0.825811837
0.715388	0.999739588	0.969652608	0.921507154	0.87015846	0.827834151
0.717295	0.999920751	0.970633228	0.923342642	0.872265172	0.829884328
0.719203	1.000090988	0.971574201	0.925132589	0.874361604	0.831928307
0.721111	1.000229281	0.972474532	0.926848455	0.876422411	0.833939534
0.723018	1.000360341	0.973315965	0.928503124	0.878442327	0.835953901
0.724926	1.000481861	0.974140773	0.930149912	0.880441427	0.837940622
0.726834	1.000616037	0.974949094	0.931770248	0.882452857	0.839963408
0.728741	1.000736033	0.975741065	0.933382858	0.884464879	0.841982585
0.730649	1.000845398	0.976511162	0.934960985	0.886464094	0.844006819
0.732557	1.000981326	0.977293411	0.936490017	0.888460184	0.846029584
0.734465	1.001103127	0.978014634	0.937963889	0.890413492	0.84801046
0.736372	1.001234011	0.978683914	0.939391475	0.892266375	0.84996075
0.73828	1.001346201	0.979335224	0.940766714	0.894100755	0.851866242
0.740188	1.001417831	0.979975655	0.94210489	0.895918734	0.853761158
0.742095	1.001517086	0.980596999	0.94341777	0.897740901	0.855635262
0.744003	1.001608158	0.981210437	0.944715297	0.89955425	0.857515798
0.745911	1.001677259	0.981800938	0.945952384	0.901340516	0.859342946
0.747818	1.001779653	0.982411047	0.947198791	0.90313292	0.861191284
0.749726	1.00184861	0.982992892	0.948439901	0.904927693	0.863058439
0.751634	1.001907178	0.983521008	0.949677273	0.906690375	0.864909655
0.753542	1.002009285	0.984082358	0.950926709	0.908516795	0.866779453
0.755449	1.002115843	0.984640218	0.952148461	0.910302051	0.868629431
0.757357	1.002184516	0.985119544	0.953298759	0.912009216	0.870404016
0.759265	1.002217687	0.98557455	0.95440816	0.913626867	0.872155958
0.761172	1.002217687	0.985990792	0.955459921	0.91519325	0.873867792
0.76308	1.002213113	0.986393837	0.956482614	0.916689587	0.875553851

0.764988	1.002199388	0.986787756	0.957484241	0.918181576	0.877245821
0.766895	1.002184516	0.987144877	0.95844185	0.919676198	0.878951411
0.768803	1.002216543	0.987537934	0.959438797	0.921206409	0.880722799
0.770711	1.002226835	0.987932458	0.960437835	0.922740519	0.88250498
0.772619	1.00220625	0.988253778	0.961397738	0.9242284	0.884290104
0.774526	1.0022154	0.988622645	0.962358336	0.925704904	0.886078114
0.776434	1.002234839	0.988981341	0.963337668	0.92715642	0.887882269
0.778342	1.002267989	0.989336434	0.964264718	0.928569556	0.889723143
0.780249	1.00231826	0.989685348	0.965207463	0.929978633	0.891554961
0.782157	1.002365075	0.990065578	0.966108938	0.931392071	0.893364708
0.784065	1.002395889	0.990395712	0.967002259	0.932796279	0.89518999
0.785972	1.002424411	0.990718534	0.967871173	0.93417956	0.896971137
0.78788	1.002463183	0.991026405	0.968717377	0.935557104	0.898705046
0.789788	1.002507634	0.991336043	0.969548414	0.936917266	0.900418092
0.791696	1.002555477	0.991635954	0.970367321	0.938261828	0.902095872
0.793603	1.002596462	0.991871518	0.971143597	0.939546406	0.903742468
0.795511	1.002637426	0.992119301	0.97190379	0.940773279	0.905340093
0.797419	1.002660175	0.992345021	0.972604669	0.941916878	0.906862208
0.799326	1.002653351	0.992536156	0.973242506	0.942989459	0.908331312
0.801234	1.002613533	0.992724446	0.973809274	0.944012822	0.909719283
0.803142	1.002566864	0.99292377	0.974332801	0.9450036	0.911078847
0.805049	1.002520167	0.993086248	0.974850569	0.945999179	0.912417411
0.806957	1.002478003	0.993264829	0.975392512	0.947025191	0.913752921
0.808865	1.002410722	0.993443124	0.975924318	0.948042812	0.915115442
0.810773	1.002368499	0.993632407	0.976470118	0.949071232	0.916499355
0.81268	1.002338816	0.993851368	0.977049511	0.950103913	0.917893846
0.814588	1.002345667	0.994081119	0.97762839	0.951134407	0.919333715
0.816496	1.002344526	0.994301672	0.97820953	0.952156357	0.920759172
0.818403	1.002367358	0.99449817	0.978767737	0.953180802	0.922161662
0.820311	1.002338816	0.994655853	0.979293461	0.954174737	0.923556946
0.822219	1.002323971	0.994815782	0.979817517	0.955149362	0.92490891
0.824126	1.002297699	0.994974233	0.980305307	0.956101716	0.926190555
0.826034	1.002272561	0.99510527	0.980780589	0.957056782	0.927447026
0.827942	1.00228056	0.995262053	0.981295716	0.9580052	0.928714299
0.82985	1.002336533	0.995438306	0.981824237	0.958953132	0.929982026
0.831757	1.002391325	0.995609343	0.982360524	0.959897453	0.931275495
0.833665	1.002481423	0.995800961	0.982933039	0.960854926	0.932550586
0.835573	1.00258508	0.996009369	0.983477634	0.96178123	0.933817507
0.83748	1.002662449	0.996196572	0.983975664	0.96267817	0.935037857
0.839388	1.002734062	0.996362684	0.984445076	0.963562615	0.936233731
0.841296	1.002790852	0.996511464	0.984882096	0.964409088	0.937418608

0.843203	1.002853273	0.996663672	0.985282979	0.965232928	0.93856445
0.845111	1.002904308	0.996818078	0.985677391	0.966040299	0.939697967
0.847019	1.002932647	0.996975883	0.986054719	0.966807532	0.940784769
0.848927	1.002949645	0.9971407	0.986435006	0.967558713	0.94183837
0.850834	1.002947378	0.997271386	0.986753317	0.968252608	0.942823185
0.852742	1.00287596	0.997329413	0.987002142	0.96887207	0.943746331
0.85465	1.002805611	0.997349956	0.987222788	0.969397164	0.94458239
0.856557	1.002673821	0.997335456	0.987381113	0.96987989	0.945378949
0.858465	1.002496239	0.997284687	0.987477336	0.97030737	0.946123392
0.860373	1.002274846	0.99717944	0.987527397	0.970693082	0.946806437
0.86228	1.002036797	0.997049842	0.987548469	0.971044542	0.947423675
0.864188	1.001773904	0.996892156	0.987532665	0.971331374	0.948015572
0.866096	1.001494014	0.996708682	0.987499734	0.971600356	0.948564679
0.868004	1.001250213	0.996562632	0.987514225	0.971882028	0.949095179
0.869911	1.001031227	0.996435882	0.987566905	0.972180679	0.949648595
0.871819	1.000825629	0.996329728	0.987616933	0.972526598	0.950237504
0.873727	1.000685958	0.996285769	0.987757698	0.972910865	0.950872777
0.875634	1.000602045	0.996266226	0.98791276	0.973349084	0.951579404
0.877542	1.000543725	0.996266226	0.988091249	0.973804965	0.952322105
0.87945	1.000493537	0.996310193	0.988295688	0.974286962	0.953081679
0.881357	1.000460841	0.996354141	0.988499806	0.974804858	0.953884631
0.883265	1.000439816	0.996409049	0.988727096	0.975349785	0.954674231
0.885173	1.000450329	0.996484651	0.988952682	0.975895919	0.955461481
0.887081	1.000463177	0.996550451	0.989175269	0.976421985	0.956216822
0.888988	1.000511048	0.996638118	0.989431216	0.976918255	0.956959109
0.890896	1.000556559	0.996747592	0.989678872	0.977386369	0.957700794
0.892804	1.000600879	0.99686666	0.989915695	0.977864453	0.958438767
0.894711	1.000656831	0.996995287	0.990185612	0.978349605	0.959194547
0.896619	1.000734869	0.997144332	0.990453651	0.978850122	0.959931166
0.898527	1.00077677	0.997245989	0.990692842	0.979317128	0.960673206
0.900434	1.000811672	0.997333039	0.990912328	0.979784205	0.961394692
0.902342	1.000837258	0.997440534	0.991133974	0.980223649	0.962113998
0.90425	1.000848886	0.997522585	0.991348821	0.980666043	0.962849275
0.906158	1.000859349	0.99759372	0.991554352	0.981126488	0.963592793
0.908065	1.000903513	0.997682866	0.991782441	0.981613043	0.964339922
0.909973	1.00096275	0.997783958	0.992031684	0.982080301	0.965090586
0.911881	1.0010057	0.99788975	0.99226645	0.982531141	0.965817819
0.913788	1.001045148	0.997996624	0.992503268	0.98297385	0.966521812
0.915696	1.001088056	0.998099782	0.992766106	0.983413906	0.967235404
0.917604	1.001123989	0.998188455	0.993014484	0.983872947	0.967949586
0.919511	1.001151798	0.998262685	0.993242208	0.98431843	0.968642199

0.921419	1.001183072	0.998308151	0.993460687	0.98474105	0.969306067
0.923327	1.001212018	0.998377505	0.99367999	0.985138309	0.969929711
0.925235	1.001223594	0.998420527	0.993865117	0.985510403	0.970523694
0.927142	1.001222437	0.998448002	0.994032462	0.985858849	0.971098446
0.92905	1.001246741	0.99849696	0.994224467	0.986230366	0.971645393
0.930958	1.001265254	0.99853754	0.99440494	0.98659956	0.972196614
0.932865	1.001310363	0.99861507	0.994580145	0.986971725	0.97274194
0.934773	1.001376247	0.998724694	0.994792242	0.987373201	0.973328925
0.936681	1.001462856	0.998856784	0.995024937	0.98780371	0.973965769
0.938588	1.001565516	0.999027862	0.995268221	0.988255088	0.974621901
0.940496	1.001703733	0.99922468	0.99554047	0.988729706	0.975309898
0.942404	1.001845164	0.999403343	0.995807097	0.98922468	0.976018002
0.944312	1.002000112	0.999599344	0.996068137	0.989703481	0.976723308
0.946219	1.002114698	0.999761959	0.996302867	0.990145614	0.977392002
0.948127	1.002209682	0.99989842	0.996510245	0.990538579	0.978030065
0.950035	1.002275989	1.000008846	0.996669756	0.990889243	0.978611234
0.951942	1.002313691	1.000080431	0.996801069	0.991226099	0.979155567
0.95385	1.002353659	1.000170709	0.996918859	0.991528839	0.979653669
0.955758	1.002379913	1.000237478	0.99704257	0.991801535	0.980132254
0.957665	1.002391325	1.000299516	0.997168546	0.992055817	0.980595618
0.959573	1.002391325	1.000360341	0.997288314	0.992287999	0.981032853
0.961481	1.002384478	1.000401256	0.997387405	0.992491881	0.981426297
0.963389	1.002374206	1.000411774	0.997491221	0.992681508	0.981799567
0.965296	1.002367358	1.000417617	0.997559968	0.992865775	0.98214596
0.967204	1.002354801	1.000400087	0.99763228	0.993066109	0.982483387
0.969112	1.002328539	1.000356833	0.997676845	0.993253519	0.982859551
0.971019	1.002333107	1.000355663	0.997741849	0.993466959	0.98327008
0.972927	1.002335391	1.000389568	0.997833262	0.993712535	0.983671361
0.974835	1.002374206	1.000463177	0.997967816	0.993968801	0.984087758
0.976742	1.002415285	1.000536723	0.998105776	0.994231941	0.984496242
0.97865	1.002432395	1.000592717	0.998214801	0.994509352	0.984922369
0.980558	1.002433535	1.000607875	0.998323701	0.994742666	0.985328493
0.982466	1.002426692	1.000610207	0.998396628	0.994948254	0.985730786
0.984373	1.002402735	1.000602045	0.998437252	0.995127506	0.986101314
0.986281	1.002371924	1.000579888	0.998467111	0.995297821	0.98643235
0.988189	1.002347951	1.000553059	0.998488603	0.995467858	0.986720194
0.990096	1.002321687	1.000535557	0.998511285	0.995630242	0.987004786
0.992004	1.002283988	1.000529722	0.99854112	0.995775187	0.987284821
0.993912	1.002242842	1.000518051	0.99856856	0.995891732	0.987576122
0.995819	1.002250844	1.000553059	0.998655598	0.996025289	0.987854961
0.997727	1.002257703	1.000605543	0.99875327	0.996177011	0.988131901

0.999635	1.002248558	1.000641681	0.998821103	0.996317519	0.988400404
1.001543	1.002267989	1.000682463	0.998912658	0.996491964	0.988691853
1.00345	1.002338816	1.000756986	0.999020741	0.996686788	0.989016504
1.005358	1.002401594	1.000823303	0.999145293	0.996915219	0.98938708
1.007266	1.002480283	1.000909323	0.999307548	0.997152808	0.989738443
1.009173	1.0025976	1.001024266	0.999496674	0.997401898	0.990124964
1.011081	1.002710199	1.001165699	0.999687759	0.997675641	0.99050899
1.012989	1.002829446	1.00130805	0.999880786	0.997951007	0.990903351
1.014896	1.002914511	1.001405127	1.000045232	0.998178873	0.991278527
1.016804	1.002984762	1.001491706	1.000181255	0.99837631	0.991616834
1.018712	1.003060608	1.001592026	1.000326424	0.998573331	0.991945273
1.02062	1.003127336	1.001674957	1.000438648	0.998749699	0.992279126
1.022527	1.0031861	1.001748603	1.000550725	0.998916223	0.992580413
1.024435	1.003259491	1.001834824	1.000663822	0.999101422	0.992867036
1.026343	1.003289957	1.00190603	1.000750002	0.999248364	0.993125258
1.02825	1.003333941	1.001951937	1.000830281	0.999386793	0.993386653
1.030158	1.003372265	1.001996672	1.000922102	0.999532091	0.993626144
1.032066	1.003411697	1.00207232	1.00100686	0.999680689	0.993868866
1.033973	1.00345336	1.002123858	1.001086897	0.999833745	0.994111051
1.035881	1.00347137	1.002169642	1.001166857	0.999987711	0.994346475
1.037789	1.003485999	1.002213113	1.001239798	1.000150785	0.994586352
1.039697	1.003527622	1.002273704	1.001345045	1.000334612	0.994847987
1.041604	1.003556856	1.002315976	1.001443233	1.000491202	0.995113918
1.043512	1.003553484	1.002334249	1.001505551	1.000648674	0.995340972
1.04542	1.003571469	1.002357084	1.001552835	1.000798877	0.995552772
1.047327	1.003588327	1.002375348	1.00159894	1.000934879	0.9957359
1.049235	1.003565849	1.002331965	1.001593178	1.001047468	0.995881923
1.051143	1.003521998	1.002274846	1.001560905	1.001112399	0.99600692
1.05305	1.003479247	1.002239412	1.001522853	1.001165699	0.996117084
1.054958	1.003412824	1.002160487	1.001467473	1.001172648	0.996181902
1.056866	1.003308004	1.002058571	1.001393576	1.001161065	0.996229572
1.058774	1.00318384	1.001958821	1.001294173	1.001099649	0.996246679
1.060681	1.003057213	1.001829078	1.001180755	1.0010057	0.996210018
1.062589	1.002895238	1.001685317	1.001021945	1.000867486	0.996139102
1.064497	1.002678369	1.001513626	1.000823303	1.000710417	0.996049775
1.066404	1.002476863	1.001324237	1.00063935	1.000541391	0.995935862
1.068312	1.002296556	1.001168015	1.000485364	1.000412943	0.995842677
1.07022	1.002102102	1.000997576	1.000343969	1.000288985	0.995754318
1.072127	1.001945053	1.000852374	1.000237478	1.000189456	0.995739584
1.074035	1.001850908	1.000769788	1.000187113	1.000149613	0.995755546
1.075943	1.001779653	1.000722062	1.000180083	1.000134374	0.99581814

1.077851	1.001727897	1.000712746	1.000214056	1.000157818	0.995934636
1.079758	1.0017348	1.000745346	1.000287814	1.000238649	0.996088942
1.081666	1.001764705	1.00079306	1.000368525	1.000338121	0.996278441
1.083574	1.001821034	1.000853536	1.000455001	1.000446825	0.996471242
1.085481	1.001881919	1.000933717	1.000548392	1.000592717	0.996673406
1.087389	1.001984057	1.001047468	1.000681298	1.000747674	0.996910364
1.089297	1.002104392	1.001177281	1.000827955	1.000930233	0.997144332
1.091204	1.00220625	1.001286077	1.00096275	1.001092693	0.997369286
1.093112	1.002288558	1.001380868	1.001089215	1.00126294	0.997574435
1.09502	1.002375348	1.001460548	1.001195809	1.0013878	0.997755086
1.096928	1.002384478	1.001491706	1.001234011	1.001446696	0.997890951
1.098835	1.002395889	1.001520546	1.001264097	1.001470935	0.997987022
1.100743	1.002384478	1.001555141	1.001272196	1.001473244	0.998065008
1.102651	1.002315976	1.0015217	1.001230539	1.001415521	0.998104577
1.104558	1.002219974	1.001468627	1.001194651	1.001371625	0.998097384
1.106466	1.002136451	1.001413211	1.00115759	1.001362381	0.998114167
1.108374	1.0020643	1.001379713	1.001144846	1.00133233	0.998134542
1.110281	1.002006992	1.001339266	1.001120512	1.001293016	0.998157309
1.112189	1.00190029	1.001259469	1.001059067	1.001244427	0.998151318
1.114097	1.001785402	1.001188862	1.000992933	1.001192336	0.998129748
1.116005	1.001633502	1.001074142	1.000909323	1.001099649	0.99809019
1.117912	1.001494014	1.00094417	1.000810509	1.001010342	0.998031422
1.11982	1.0013878	1.000877947	1.000760478	1.000926748	0.99797862
1.121728	1.001324237	1.000838421	1.000718568	1.000863999	0.997973818
1.123635	1.001247899	1.000789569	1.000670813	1.000801203	0.997961813
1.125543	1.001185388	1.000755822	1.000649839	1.000761642	0.9979402
1.127451	1.001130942	1.000734869	1.000642846	1.000755822	0.997908972
1.129358	1.001069504	1.000674308	1.000612539	1.000736033	0.997881339
1.131266	1.000980165	1.000577555	1.000579888	1.000702265	0.997838071
1.133174	1.000881434	1.00049237	1.000514549	1.000655666	0.997785161
1.135082	1.000762805	1.000419954	1.000424628	1.000556559	0.997729815
1.136989	1.000623031	1.000317066	1.000328764	1.000438648	0.997666007
1.138897	1.000493537	1.000226939	1.000259723	1.000345138	0.997614207
1.140805	1.000408268	1.000197657	1.000231623	1.000278452	0.997584078
1.142712	1.000350986	1.000191799	1.000209371	1.000249187	0.997614207
1.14462	1.000301856	1.000185942	1.0002082	1.000230452	0.997663598
1.146528	1.00025387	1.000192971	1.000204686	1.000223426	0.99772139
1.148435	1.0002	1.0002	1.0002	1.0002	0.997765914

Table B.2 Fickian model for Fadaie et al.[3], considering constant density

Elevation (mm)	40s	90s	140s	190s	240s
0	0	0	0	0	0
0.002	2.71E-05	0.000576684	0.001252297	0.001724045	0.002020764
0.004	5.44E-05	0.001153735	0.002504883	0.003448276	0.004041644
0.006	8.18E-05	0.001731518	0.003758048	0.005172881	0.006062754
0.008	0.000109493	0.002310401	0.005012083	0.006898046	0.00808421
0.01	0.000137588	0.002890749	0.006267275	0.008623957	0.010106126
0.012	0.000166166	0.00347293	0.007523914	0.010350802	0.012128619
0.014	0.000195328	0.004057308	0.008782289	0.012078765	0.014151802
0.016	0.000225172	0.004644252	0.010042689	0.013808033	0.01617579
0.018	0.000255801	0.005234128	0.011305401	0.015538792	0.018200698
0.02	0.000287319	0.005827302	0.012570713	0.017271226	0.02022664
0.022	0.000319832	0.006424141	0.013838912	0.01900552	0.02225373
0.024	0.000353447	0.007025012	0.015110284	0.02074186	0.024282082
0.026	0.000388275	0.007630281	0.016385117	0.022480427	0.026311809
0.028	0.000424428	0.008240316	0.017663694	0.024221407	0.028343025
0.03	0.000462023	0.008855484	0.018946301	0.025964981	0.030375841
0.032	0.000501179	0.009476151	0.02023322	0.027711332	0.03241037
0.034	0.000542017	0.010102686	0.021524736	0.029460641	0.034446724
0.036	0.000584664	0.010735454	0.02282113	0.031213089	0.036485015
0.038	0.000629249	0.011374823	0.024122682	0.032968857	0.038525354
0.04	0.000675907	0.012021161	0.025429674	0.034728123	0.04056785
0.042	0.000724774	0.012674836	0.026742384	0.036491066	0.042612614
0.044	0.000775995	0.013336213	0.028061089	0.038257864	0.044659755
0.046	0.000829715	0.014005662	0.029386067	0.040028693	0.046709382
0.048	0.000886088	0.014683549	0.030717593	0.041803729	0.048761603
0.05	0.000945271	0.015370242	0.03205594	0.043583147	0.050816526
0.052	0.001007426	0.016066109	0.033401382	0.045367121	0.052874257
0.054	0.001072724	0.016771516	0.034754191	0.047155823	0.054934903
0.056	0.001141338	0.017486832	0.036114635	0.048949424	0.056998569
0.058	0.001213449	0.018212424	0.037482983	0.050748096	0.059065359
0.06	0.001289246	0.018948659	0.038859502	0.052552007	0.061135378
0.062	0.001368923	0.019695904	0.040244458	0.054361325	0.063208729
0.064	0.00145268	0.020454527	0.041638113	0.056176217	0.065285513
0.066	0.001540727	0.021224894	0.043040729	0.057996848	0.067365833
0.068	0.001633279	0.022007372	0.044452567	0.059823383	0.069449789
0.07	0.001730561	0.022802327	0.045873884	0.061655984	0.071537481
0.072	0.001832804	0.023610126	0.047304936	0.063494812	0.073629007
0.074	0.001940249	0.024431134	0.048745978	0.065340026	0.075724465
0.076	0.002053145	0.025265717	0.050197261	0.067191786	0.077823952

0.078	0.002171749	0.02611424	0.051659037	0.069050247	0.079927564
0.08	0.002296328	0.026977068	0.053131552	0.070915564	0.082035395
0.082	0.002427158	0.027854565	0.054615053	0.072787892	0.08414754
0.084	0.002564525	0.028747094	0.056109782	0.074667382	0.086264091
0.086	0.002708724	0.029655019	0.057615982	0.076554183	0.088385139
0.088	0.002860062	0.030578701	0.059133891	0.078448445	0.090510776
0.09	0.003018853	0.031518503	0.060663745	0.080350314	0.09264109
0.092	0.003185426	0.032474786	0.062205778	0.082259934	0.094776169
0.094	0.003360117	0.033447908	0.063760222	0.084177448	0.096916102
0.096	0.003543275	0.03443823	0.065327306	0.086102998	0.099060972
0.098	0.00373526	0.03544611	0.066907256	0.088036722	0.101210866
0.1	0.003936444	0.036471903	0.068500295	0.089978759	0.103365865
0.102	0.004147211	0.037515967	0.070106645	0.091929242	0.105526053
0.104	0.004367955	0.038578656	0.071726522	0.093888305	0.10769151
0.106	0.004599084	0.039660323	0.073360143	0.09585608	0.109862316
0.108	0.00484102	0.040761321	0.075007719	0.097832694	0.112038548
0.11	0.005094194	0.041881999	0.07666946	0.099818276	0.114220284
0.112	0.005359053	0.043022706	0.078345573	0.10181295	0.116407598
0.114	0.005636055	0.04418379	0.08003626	0.103816839	0.118600565
0.116	0.005925674	0.045365596	0.081741721	0.105830062	0.120799257
0.118	0.006228393	0.046568467	0.083462154	0.107852739	0.123003746
0.12	0.006544714	0.047792746	0.085197752	0.109884985	0.125214102
0.122	0.006875149	0.049038772	0.086948706	0.111926914	0.127430391
0.124	0.007220224	0.050306882	0.088715202	0.113978637	0.129652682
0.126	0.007580482	0.051597411	0.090497425	0.116040262	0.13188104
0.128	0.007956477	0.052910693	0.092295556	0.118111898	0.134115528
0.13	0.008348778	0.054247056	0.09410977	0.120193646	0.136356208
0.132	0.00875797	0.05560683	0.095940241	0.122285611	0.138603142
0.134	0.00918465	0.056990338	0.097787139	0.12438789	0.140856388
0.136	0.009629432	0.058397902	0.099650631	0.126500581	0.143116003
0.138	0.010092942	0.059829842	0.101530879	0.128623777	0.145382045
0.14	0.010575823	0.061286474	0.103428041	0.130757571	0.147654567
0.142	0.011078731	0.062768109	0.105342272	0.132902051	0.149933622
0.144	0.011602337	0.064275058	0.107273725	0.135057305	0.15221926
0.146	0.012147326	0.065807625	0.109222546	0.137223416	0.154511532
0.148	0.012714399	0.067366114	0.111188879	0.139400465	0.156810485
0.15	0.013304269	0.068950822	0.113172864	0.141588532	0.159116165
0.152	0.013917666	0.070562044	0.115174635	0.143787693	0.161428617
0.154	0.014555332	0.072200071	0.117194325	0.14599802	0.163747883
0.156	0.015218024	0.073865188	0.119232061	0.148219584	0.166074004
0.158	0.015906513	0.075557677	0.121287966	0.150452454	0.16840702

0.16	0.016621583	0.077277816	0.12336216	0.152696694	0.170746967
0.162	0.017364034	0.079025878	0.125454758	0.154952366	0.173093882
0.164	0.018134675	0.08080213	0.12756587	0.157219532	0.175447799
0.166	0.018934331	0.082606836	0.129695603	0.159498246	0.17780875
0.168	0.01976384	0.084440254	0.131844059	0.161788564	0.180176765
0.17	0.020624051	0.086302637	0.134011336	0.164090536	0.182551872
0.172	0.021515825	0.088194232	0.136197528	0.166404211	0.1849341
0.174	0.022440035	0.090115282	0.138402722	0.168729634	0.187323473
0.176	0.023397566	0.092066022	0.140627005	0.171066848	0.189720014
0.178	0.024389313	0.094046684	0.142870456	0.173415892	0.192123744
0.18	0.025416181	0.096057492	0.14513315	0.175776803	0.194534683
0.182	0.026479087	0.098098665	0.147415159	0.178149615	0.19695285
0.184	0.027578955	0.100170416	0.149716548	0.180534359	0.199378259
0.186	0.028716719	0.102272949	0.15203738	0.182931063	0.201810925
0.188	0.02989332	0.104406465	0.154377712	0.185339752	0.20425086
0.19	0.031109709	0.106571156	0.156737597	0.187760448	0.206698075
0.192	0.032366841	0.108767209	0.159117081	0.190193171	0.209152578
0.194	0.03366568	0.110994802	0.161516208	0.192637936	0.211614376
0.196	0.035007194	0.113254107	0.163935016	0.195094756	0.214083473
0.198	0.036392357	0.115545288	0.166373538	0.197563643	0.216559873
0.2	0.037822144	0.117868504	0.168831804	0.200044602	0.219043577
0.202	0.039297538	0.120223902	0.171309836	0.202537639	0.221534583
0.204	0.040819522	0.122611625	0.173807654	0.205042755	0.224032889
0.206	0.042389079	0.125031807	0.176325273	0.207559947	0.22653849
0.208	0.044007195	0.127484575	0.1788627	0.210089212	0.229051381
0.21	0.045674855	0.129970045	0.181419941	0.21263054	0.231571552
0.212	0.047393044	0.132488328	0.183996994	0.215183923	0.234098994
0.214	0.049162743	0.135039524	0.186593855	0.217749345	0.236633695
0.216	0.050984931	0.137623727	0.189210512	0.22032679	0.239175639
0.218	0.052860582	0.14024102	0.19184695	0.222916239	0.241724813
0.22	0.054790666	0.142891479	0.194503149	0.225517668	0.244281197
0.222	0.056776146	0.14557517	0.197179083	0.228131051	0.246844773
0.224	0.058817977	0.148292151	0.199874721	0.230756361	0.249415518
0.226	0.060917106	0.151042469	0.202590029	0.233393565	0.25199341
0.228	0.063074471	0.153826164	0.205324965	0.236042628	0.254578424
0.23	0.065290998	0.156643265	0.208079485	0.238703513	0.257170532
0.232	0.067567603	0.159493792	0.210853538	0.241376179	0.259769705
0.234	0.069905186	0.162377755	0.213647067	0.244060583	0.262375913
0.236	0.072304634	0.165295156	0.216460014	0.246756677	0.264989123
0.238	0.074766819	0.168245986	0.219292311	0.249464412	0.267609301
0.24	0.077292594	0.171230226	0.22214389	0.252183736	0.270236411

0.242	0.079882797	0.174247846	0.225014673	0.254914593	0.272870413
0.244	0.082538243	0.177298808	0.227904581	0.257656925	0.275511269
0.246	0.085259729	0.180383064	0.230813529	0.26041067	0.278158937
0.248	0.088048029	0.183500553	0.233741424	0.263175764	0.280813373
0.25	0.090903893	0.186651206	0.236688173	0.265952141	0.283474532
0.252	0.093828047	0.189834944	0.239653674	0.268739729	0.286142367
0.254	0.096821193	0.193051676	0.242637823	0.271538457	0.288816828
0.256	0.099884003	0.196301302	0.245640508	0.274348249	0.291497865
0.258	0.103017121	0.199583709	0.248661615	0.277169026	0.294185426
0.26	0.106221164	0.202898777	0.251701024	0.280000707	0.296879457
0.262	0.109496714	0.206246372	0.254758609	0.282843208	0.299579901
0.264	0.112844324	0.209626352	0.25783424	0.285696442	0.302286701
0.266	0.116264512	0.213038563	0.260927784	0.288560319	0.304999797
0.268	0.119757762	0.216482839	0.264039099	0.291434747	0.307719129
0.27	0.123324521	0.219959006	0.267168043	0.294319631	0.310444633
0.272	0.1269652	0.223466878	0.270314465	0.297214873	0.313176245
0.274	0.130680172	0.227006257	0.273478213	0.300120372	0.3159139
0.276	0.134469769	0.230576936	0.276659127	0.303036026	0.318657528
0.278	0.138334284	0.234178696	0.279857044	0.305961729	0.321407061
0.28	0.142273967	0.237811308	0.283071798	0.308897372	0.324162428
0.282	0.146289027	0.241474531	0.286303214	0.311842844	0.326923555
0.284	0.150379628	0.245168116	0.289551116	0.314798032	0.329690369
0.286	0.154545889	0.2488918	0.292815324	0.31776282	0.332462794
0.288	0.158787885	0.252645311	0.29609565	0.320737089	0.335240752
0.29	0.163105642	0.256428365	0.299391905	0.323720718	0.338024164
0.292	0.16749914	0.26024067	0.302703893	0.326713583	0.340812949
0.294	0.171968312	0.264081921	0.306031415	0.329715559	0.343607026
0.296	0.176513039	0.267951803	0.309374268	0.332726517	0.346406311
0.298	0.181133154	0.271849991	0.312732245	0.335746327	0.349210719
0.3	0.18582844	0.275776149	0.316105132	0.338774855	0.352020163
0.302	0.190598626	0.279729931	0.319492715	0.341811967	0.354834555
0.304	0.195443394	0.283710981	0.322894772	0.344857523	0.357653805
0.306	0.200362369	0.287718931	0.32631108	0.347911385	0.360477824
0.308	0.205355127	0.291753407	0.329741411	0.350973411	0.363306518
0.31	0.210421189	0.29581402	0.333185531	0.354043455	0.366139794
0.312	0.215560022	0.299900374	0.336643205	0.357121371	0.368977556
0.314	0.220771042	0.304012063	0.340114193	0.360207012	0.371819709
0.316	0.226053608	0.308148671	0.343598251	0.363300226	0.374666155
0.318	0.231407027	0.312309772	0.347095131	0.36640086	0.377516794
0.32	0.236830552	0.316494931	0.350604583	0.369508759	0.380371527
0.322	0.24232338	0.320703703	0.354126352	0.372623768	0.383230251

0.324	0.247884655	0.324935635	0.35766018	0.375745726	0.386092865
0.326	0.253513467	0.329190265	0.361205804	0.378874474	0.388959263
0.328	0.259208853	0.33346712	0.364762961	0.382009849	0.391829341
0.33	0.264969796	0.337765721	0.368331381	0.385151687	0.394702993
0.332	0.270795225	0.342085578	0.371910793	0.388299821	0.39758011
0.334	0.276684016	0.346426194	0.375500922	0.391454084	0.400460584
0.336	0.282634996	0.350787064	0.379101491	0.394614306	0.403344305
0.338	0.288646936	0.355167674	0.382712218	0.397780316	0.406231162
0.34	0.294718558	0.359567502	0.386332819	0.400951941	0.409121044
0.342	0.300848533	0.36398602	0.389963009	0.404129006	0.412013836
0.344	0.307035484	0.36842269	0.393602497	0.407311335	0.414909426
0.346	0.313277983	0.372876969	0.39725099	0.410498751	0.417807698
0.348	0.319574555	0.377348305	0.400908195	0.413691074	0.420708536
0.35	0.325923678	0.38183614	0.404573814	0.416888125	0.423611823
0.352	0.332323784	0.38633991	0.408247547	0.42008972	0.426517442
0.354	0.33877326	0.390859043	0.411929091	0.423295678	0.429425272
0.356	0.34527045	0.395392961	0.415618142	0.426505812	0.432335195
0.358	0.351813655	0.399941081	0.419314394	0.429719938	0.43524709
0.36	0.358401136	0.404502813	0.423017536	0.432937868	0.438160835
0.362	0.365031112	0.409077563	0.426727258	0.436159414	0.441076309
0.364	0.371701766	0.41366473	0.430443248	0.439384386	0.443993389
0.366	0.378411243	0.418263708	0.434165189	0.442612594	0.44691195
0.368	0.385157653	0.422873887	0.437892766	0.445843847	0.449831868
0.37	0.391939073	0.427494652	0.441625659	0.449077952	0.452753018
0.372	0.398753546	0.432125384	0.44536355	0.452314715	0.455675274
0.374	0.405599085	0.436765458	0.449106115	0.455553942	0.45859851
0.376	0.412473677	0.441414247	0.452853033	0.458795437	0.461522598
0.378	0.41937528	0.446071121	0.456603979	0.462039004	0.464447411
0.38	0.426301826	0.450735444	0.460358627	0.465284447	0.46737282
0.382	0.433251225	0.455406579	0.464116651	0.468531568	0.470298697
0.384	0.440221367	0.460083886	0.467877721	0.471780168	0.473224911
0.386	0.447210119	0.464766722	0.471641511	0.475030049	0.476151334
0.388	0.454215335	0.46945444	0.475407689	0.478281009	0.479077834
0.39	0.461234851	0.474146394	0.479175926	0.481532851	0.482004281
0.392	0.468266489	0.478841935	0.482945889	0.484785372	0.484930543
0.394	0.47530806	0.483540412	0.486717248	0.488038372	0.487856489
0.396	0.482357368	0.488241172	0.490489669	0.491291648	0.490781987
0.398	0.489412207	0.492943563	0.49426282	0.494545	0.493706904
0.4	0.496470367	0.497646932	0.498036367	0.497798225	0.496631107
0.402	0.503529633	0.502350624	0.501809978	0.501051119	0.499554464
0.404	0.510587793	0.507053985	0.505583318	0.504303481	0.502476841

0.406	0.517642632	0.511756361	0.509356054	0.507555107	0.505398105
0.408	0.52469194	0.516457098	0.513127852	0.510805795	0.508318122
0.41	0.531733511	0.521155543	0.516898379	0.51405534	0.511236758
0.412	0.538765149	0.525851045	0.520667301	0.51730354	0.514153879
0.414	0.545784665	0.530542952	0.524434286	0.520550191	0.51706935
0.416	0.552789881	0.535230616	0.528199	0.52379509	0.519983038
0.418	0.559778633	0.539913388	0.531961113	0.527038034	0.522894807
0.42	0.566748775	0.544590623	0.535720292	0.53027882	0.525804524
0.422	0.573698174	0.549261677	0.539476207	0.533517244	0.528712054
0.424	0.58062472	0.553925911	0.543228527	0.536753105	0.531617262
0.426	0.587526323	0.558582686	0.546976924	0.539986199	0.534520013
0.428	0.594400915	0.563231368	0.55072107	0.543216325	0.537420174
0.43	0.601246454	0.567871324	0.554460636	0.546443281	0.54031761
0.432	0.608060927	0.572501928	0.558195298	0.549666865	0.543212186
0.434	0.614842347	0.577122556	0.56192473	0.552886877	0.546103769
0.436	0.621588757	0.581732586	0.565648609	0.556103116	0.548992224
0.438	0.628298234	0.586331405	0.569366613	0.559315382	0.551877418
0.44	0.634968888	0.590918401	0.573078421	0.562523475	0.554759216
0.442	0.641598864	0.595492969	0.576783714	0.565727198	0.557637485
0.444	0.648186345	0.600054506	0.580482175	0.568926352	0.560512093
0.446	0.65472955	0.604602419	0.584173488	0.572120739	0.563382905
0.448	0.66122674	0.609136116	0.587857339	0.575310163	0.566249791
0.45	0.667676216	0.613655014	0.591533417	0.578494428	0.569112616
0.452	0.674076322	0.618158534	0.595201412	0.581673338	0.571971249
0.454	0.680425445	0.622646105	0.598861015	0.584846701	0.57482556
0.456	0.686722017	0.627117161	0.602511921	0.588014322	0.577675415
0.458	0.692964516	0.631571144	0.606153826	0.591176008	0.580520685
0.46	0.699151467	0.6360075	0.609786429	0.59433157	0.583361239
0.462	0.705281442	0.640425686	0.613409432	0.597480815	0.586196948
0.464	0.711353064	0.644825164	0.617022538	0.600623556	0.589027681
0.466	0.717365004	0.649205404	0.620625454	0.603759603	0.59185331
0.468	0.723315983	0.653565884	0.624217887	0.60688877	0.594673708
0.47	0.729204775	0.657906088	0.62779955	0.610010871	0.597488744
0.472	0.735030204	0.662225511	0.631370156	0.613125721	0.600298294
0.474	0.740791147	0.666523654	0.634929423	0.616233137	0.603102229
0.476	0.746486533	0.670800027	0.638477071	0.619332936	0.605900425
0.478	0.752115345	0.675054149	0.642012822	0.622424937	0.608692755
0.48	0.75767662	0.679285547	0.645536402	0.625508962	0.611479095
0.482	0.763169448	0.683493756	0.64904754	0.628584832	0.614259321
0.484	0.768592972	0.687678323	0.652545969	0.63165237	0.617033309
0.486	0.773946392	0.691838801	0.656031423	0.634711402	0.619800938

0.488	0.779228958	0.695974754	0.659503641	0.637761753	0.622562085
0.49	0.784439977	0.700085754	0.662962366	0.640803252	0.625316629
0.492	0.789578811	0.704171384	0.666407341	0.643835727	0.62806445
0.494	0.794644872	0.708231236	0.669838317	0.64685901	0.630805429
0.496	0.79963763	0.712264912	0.673255045	0.649872933	0.633539446
0.498	0.804556606	0.716272023	0.67665728	0.65287733	0.636266385
0.5	0.809401373	0.72025219	0.680044783	0.655872038	0.638986129
0.502	0.81417156	0.724205046	0.683417316	0.658856893	0.64169856
0.504	0.818866845	0.728130231	0.686774645	0.661831736	0.644403565
0.506	0.823486961	0.732027398	0.690116542	0.664796408	0.647101029
0.508	0.828031687	0.735896208	0.693442781	0.66775075	0.649790839
0.51	0.832500859	0.739736335	0.696753139	0.670694609	0.652472883
0.512	0.836894357	0.74354746	0.700047398	0.67362783	0.655147049
0.514	0.841212114	0.747329277	0.703325345	0.676550263	0.657813228
0.516	0.84545411	0.751081489	0.706586768	0.679461756	0.660471309
0.518	0.849620371	0.754803812	0.709831463	0.682362164	0.663121185
0.52	0.853710972	0.758495969	0.713059225	0.685251339	0.665762749
0.522	0.857726031	0.762157696	0.716269859	0.688129138	0.668395894
0.524	0.861665715	0.765788739	0.719463168	0.69099542	0.671020516
0.526	0.865530229	0.769388855	0.722638964	0.693850043	0.67363651
0.528	0.869319826	0.772957811	0.72579706	0.696692872	0.676243774
0.53	0.873034798	0.776495385	0.728937275	0.699523769	0.678842206
0.532	0.876675477	0.780001366	0.732059432	0.702342601	0.681431705
0.534	0.880242236	0.783475552	0.735163357	0.705149237	0.684012172
0.536	0.883735485	0.786917755	0.738248881	0.707943547	0.68658351
0.538	0.887155673	0.790327793	0.74131584	0.710725404	0.68914562
0.54	0.890503283	0.793705499	0.744364073	0.713494682	0.691698407
0.542	0.893778833	0.797050714	0.747393425	0.716251259	0.694241776
0.544	0.896982875	0.80036329	0.750403743	0.718995014	0.696775634
0.546	0.900115993	0.80364309	0.75339488	0.721725828	0.699299889
0.548	0.903178802	0.806889987	0.756366693	0.724443584	0.701814449
0.55	0.906171947	0.810103864	0.759319043	0.727148169	0.704319226
0.552	0.909096101	0.813284616	0.762251797	0.729839471	0.70681413
0.554	0.911951965	0.816432145	0.765164823	0.732517379	0.709299075
0.556	0.914740264	0.819546368	0.768057996	0.735181787	0.711773974
0.558	0.917461749	0.822627207	0.770931196	0.737832588	0.714238743
0.56	0.920117194	0.825674598	0.773784305	0.740469681	0.716693299
0.562	0.922707396	0.828688485	0.776617211	0.743092964	0.71913756
0.564	0.92523317	0.831668822	0.779429805	0.74570234	0.721571444
0.566	0.927695354	0.834615573	0.782221985	0.748297711	0.723994874
0.568	0.930094801	0.837528712	0.784993651	0.750878985	0.726407771

0.57	0.932432382	0.840408223	0.787744708	0.753446071	0.728810058
0.572	0.934708985	0.843254099	0.790475066	0.755998878	0.73120166
0.574	0.936925511	0.846066341	0.793184638	0.75853732	0.733582503
0.576	0.939082875	0.848844961	0.795873343	0.761061314	0.735952515
0.578	0.941182002	0.851589981	0.798541102	0.763570776	0.738311625
0.58	0.94322383	0.854301429	0.801187844	0.766065628	0.740659763
0.582	0.945209308	0.856979344	0.803813499	0.768545791	0.74299686
0.584	0.947139389	0.859623775	0.806418002	0.771011192	0.74532285
0.586	0.949015037	0.862234777	0.809001294	0.773461756	0.747637667
0.588	0.950837222	0.864812414	0.811563318	0.775897415	0.749941247
0.59	0.952606917	0.86735676	0.814104023	0.7783181	0.752233527
0.592	0.954325102	0.869867896	0.816623361	0.780723745	0.754514447
0.594	0.955992759	0.872345912	0.819121289	0.783114288	0.756783945
0.596	0.95761087	0.874790904	0.821597768	0.785489667	0.759041965
0.598	0.959180422	0.877202979	0.824052763	0.787849824	0.761288448
0.6	0.9607024	0.879582249	0.826486242	0.790194702	0.763523339
0.602	0.962177788	0.881928834	0.828898179	0.792524249	0.765746584
0.604	0.963607569	0.884242863	0.831288552	0.794838413	0.76795813
0.606	0.964992724	0.88652447	0.833657342	0.797137143	0.770157926
0.608	0.96633423	0.888773797	0.836004533	0.799420395	0.772345923
0.61	0.96763306	0.890990994	0.838330116	0.801688122	0.774522071
0.612	0.968890183	0.893176215	0.840634084	0.803940284	0.776686324
0.614	0.970106561	0.895329624	0.842916434	0.80617684	0.778838636
0.616	0.971283151	0.897451389	0.845177166	0.808397752	0.780978964
0.618	0.972420902	0.899541686	0.847416286	0.810602986	0.783107264
0.62	0.973520756	0.901600694	0.849633803	0.812792508	0.785223495
0.622	0.974583647	0.903628601	0.851829728	0.814966288	0.787327618
0.624	0.975610499	0.9056256	0.854004079	0.817124298	0.789419595
0.626	0.976602228	0.907591889	0.856156874	0.81926651	0.791499388
0.628	0.97755974	0.909527672	0.858288137	0.821392902	0.793566962
0.63	0.978483928	0.911433158	0.860397896	0.823503452	0.795622284
0.632	0.979375679	0.91330856	0.86248618	0.82559814	0.79766532
0.634	0.980235864	0.915154099	0.864553024	0.827676949	0.799696039
0.636	0.981065345	0.916969997	0.866598466	0.829739864	0.801714412
0.638	0.981864972	0.918756482	0.868622547	0.831786872	0.803720411
0.64	0.98263558	0.920513789	0.87062531	0.833817963	0.805714008
0.642	0.983377995	0.922242152	0.872606804	0.835833128	0.807695179
0.644	0.984093027	0.923941815	0.874567079	0.83783236	0.809663899
0.646	0.984781473	0.92561302	0.87650619	0.839815656	0.811620146
0.648	0.985444119	0.927256018	0.878424193	0.841783013	0.813563898
0.65	0.986081735	0.92887106	0.88032115	0.843734432	0.815495136

0.652	0.986695077	0.930458402	0.882197124	0.845669914	0.817413841
0.654	0.987284888	0.932018302	0.884052182	0.847589463	0.819319996
0.656	0.987851896	0.933551024	0.885886392	0.849493086	0.821213586
0.658	0.988396815	0.93505683	0.887699828	0.85138079	0.823094597
0.66	0.988920344	0.93653599	0.889492565	0.853252587	0.824963015
0.662	0.989423169	0.937988774	0.891264681	0.855108488	0.826818829
0.664	0.98990596	0.939415453	0.893016256	0.856948507	0.82866203
0.666	0.990369373	0.940816304	0.894747375	0.85877266	0.830492607
0.668	0.990814049	0.942191602	0.896458124	0.860580966	0.832310554
0.67	0.991240614	0.943541628	0.898148591	0.862373445	0.834115865
0.672	0.991649681	0.944866661	0.899818868	0.864150118	0.835908535
0.674	0.992041847	0.946166985	0.901469049	0.865911009	0.83768856
0.676	0.992417695	0.947442884	0.90309923	0.867656143	0.839455939
0.678	0.992777794	0.948694642	0.904709511	0.869385549	0.841210669
0.68	0.993122697	0.949922547	0.906299991	0.871099254	0.842952753
0.682	0.993452946	0.951126887	0.907870775	0.872797291	0.844682192
0.684	0.993769064	0.952307949	0.909421968	0.874479692	0.846398988
0.686	0.994071566	0.953466024	0.910953677	0.876146491	0.848103147
0.688	0.994360947	0.954601402	0.912466013	0.877797725	0.849794673
0.69	0.994637694	0.955714374	0.913959087	0.879433432	0.851473573
0.692	0.994902276	0.95680523	0.915433013	0.88105365	0.853139857
0.694	0.995155151	0.957874262	0.916887907	0.882658422	0.854793532
0.696	0.995396762	0.958921762	0.918323887	0.884247791	0.856434609
0.698	0.995627542	0.959948022	0.919741072	0.8858218	0.8580631
0.7	0.995847909	0.960953332	0.921139583	0.887380495	0.859679019
0.702	0.996058267	0.961937985	0.922519544	0.888923925	0.861282379
0.704	0.996259011	0.962902271	0.923881079	0.890452139	0.862873195
0.706	0.996450521	0.963846482	0.925224314	0.891965186	0.864451484
0.708	0.996633166	0.964770906	0.926549377	0.89346312	0.866017263
0.71	0.996807304	0.965675834	0.927856397	0.894945993	0.867570552
0.712	0.996973279	0.966561553	0.929145505	0.896413862	0.869111371
0.714	0.997131428	0.967428353	0.930416833	0.897866781	0.870639739
0.716	0.997282072	0.96827652	0.931670515	0.899304809	0.87215568
0.718	0.997425524	0.969106339	0.932906686	0.900728005	0.873659217
0.72	0.997562086	0.969918095	0.93412548	0.90213643	0.875150374
0.722	0.99769205	0.970712072	0.935327036	0.903530144	0.876629176
0.724	0.997815696	0.971488551	0.936511491	0.904909213	0.87809565
0.726	0.997933296	0.972247813	0.937678986	0.906273698	0.879549823
0.728	0.998045111	0.972990138	0.938829659	0.907623667	0.880991724
0.73	0.998151394	0.973715803	0.939963653	0.908959185	0.882421383
0.732	0.998252388	0.974425083	0.941081109	0.910280321	0.88383883

0.734	0.998348327	0.975118253	0.942182171	0.911587144	0.885244096
0.736	0.998439437	0.975795585	0.943266982	0.912879724	0.886637215
0.738	0.998525933	0.97645735	0.944335687	0.914158132	0.888018219
0.74	0.998608025	0.977103815	0.945388432	0.91542244	0.889387144
0.742	0.998685914	0.977735248	0.946425361	0.916672722	0.890744024
0.744	0.998759792	0.978351913	0.947446623	0.917909052	0.892088896
0.746	0.998829844	0.978954072	0.948452363	0.919131506	0.893421798
0.748	0.998896249	0.979541984	0.94944273	0.92034016	0.894742767
0.75	0.998959178	0.980115909	0.950417871	0.921535091	0.896051843
0.752	0.999018794	0.980676101	0.951377936	0.922716378	0.897349065
0.754	0.999075254	0.981222812	0.952323072	0.923884099	0.898634475
0.756	0.999128711	0.981756295	0.95325343	0.925038335	0.899908114
0.758	0.999179307	0.982276797	0.954169158	0.926179166	0.901170024
0.76	0.999227182	0.982784564	0.955070407	0.927306674	0.90242025
0.762	0.999272469	0.983279839	0.955957326	0.928420942	0.903658834
0.764	0.999315294	0.983762863	0.956830066	0.929522052	0.904885823
0.766	0.999355779	0.984233873	0.957688776	0.930610089	0.906101261
0.768	0.99939404	0.984693106	0.958533607	0.931685137	0.907305195
0.77	0.999430189	0.985140794	0.959364709	0.932747281	0.908497673
0.772	0.999464332	0.985577166	0.960182232	0.933796607	0.909678742
0.774	0.99949657	0.986002451	0.960986327	0.934833203	0.910848451
0.776	0.999527001	0.986416873	0.961777144	0.935857155	0.912006849
0.778	0.999555717	0.986820653	0.962554833	0.936868551	0.913153988
0.78	0.999582807	0.98721401	0.963319543	0.937867479	0.914289916
0.782	0.999608355	0.987597162	0.964071425	0.938854029	0.915414686
0.784	0.999632442	0.98797032	0.964810627	0.93982829	0.91652835
0.786	0.999655145	0.988333696	0.965537299	0.940790351	0.917630961
0.788	0.999676536	0.988687497	0.966251589	0.941740304	0.918722572
0.79	0.999696685	0.989031928	0.966953646	0.942678238	0.919803236
0.792	0.999715659	0.989367191	0.967643618	0.943604246	0.920873009
0.794	0.999733521	0.989693485	0.968321653	0.944518419	0.921931946
0.796	0.999750331	0.990011006	0.968987897	0.945420848	0.922980102
0.798	0.999766146	0.990319947	0.969642498	0.946311627	0.924017534
0.8	0.999781021	0.9906205	0.970285602	0.947190848	0.925044298
0.802	0.999795008	0.99091285	0.970917355	0.948058604	0.926060451
0.804	0.999808155	0.991197184	0.971537901	0.948914989	0.927066053
0.806	0.999820509	0.991473683	0.972147385	0.949760095	0.92806116
0.808	0.999832114	0.991742524	0.972745951	0.950594018	0.929045832
0.81	0.999843014	0.992003886	0.973333742	0.95141685	0.930020128
0.812	0.999853247	0.99225794	0.973910901	0.952228686	0.930984108
0.814	0.999862851	0.992504858	0.97447757	0.953029621	0.931937832

0.816	0.999871863	0.992744805	0.97503389	0.953819749	0.93288136
0.818	0.999880317	0.992977948	0.975580001	0.954599165	0.933814754
0.82	0.999888244	0.993204448	0.976116043	0.955367963	0.934738075
0.822	0.999895675	0.993424464	0.976642155	0.956126239	0.935651385
0.824	0.999902639	0.993638151	0.977158475	0.956874087	0.936554746
0.826	0.999909164	0.993845665	0.977665139	0.957611604	0.937448221
0.828	0.999915276	0.994047154	0.978162285	0.958338882	0.938331872
0.83	0.999920998	0.994242768	0.978650048	0.959056019	0.939205763
0.832	0.999926355	0.99443265	0.979128561	0.959763109	0.940069958
0.834	0.999931367	0.994616945	0.97959796	0.960460247	0.94092452
0.836	0.999936057	0.994795792	0.980058376	0.961147527	0.941769513
0.838	0.999940443	0.994969327	0.980509941	0.961825047	0.942605002
0.84	0.999944543	0.995137686	0.980952786	0.962492899	0.943431052
0.842	0.999948376	0.995301001	0.981387041	0.963151179	0.944247727
0.844	0.999951957	0.9954594	0.981812834	0.963799981	0.945055093
0.846	0.999955302	0.995613011	0.982230294	0.964439401	0.945853216
0.848	0.999958426	0.995761957	0.982639546	0.965069533	0.94664216
0.85	0.999961343	0.995906361	0.983040718	0.96569047	0.947421993
0.852	0.999964065	0.996046343	0.983433932	0.966302308	0.948192779
0.854	0.999966604	0.996182018	0.983819313	0.96690514	0.948954586
0.856	0.999968973	0.996313501	0.984196983	0.96749906	0.949707479
0.858	0.999971182	0.996440904	0.984567064	0.968084162	0.950451526
0.86	0.999973241	0.996564337	0.984929676	0.968660538	0.951186792
0.862	0.99997516	0.996683907	0.985284938	0.969228281	0.951913346
0.864	0.999976948	0.99679972	0.985632968	0.969787486	0.952631254
0.866	0.999978613	0.996911877	0.985973883	0.970338243	0.953340582
0.868	0.999980163	0.997020479	0.986307799	0.970880646	0.954041399
0.87	0.999981606	0.997125625	0.986634831	0.971414786	0.954733772
0.872	0.999982949	0.99722741	0.986955091	0.971940754	0.955417768
0.874	0.999984199	0.997325928	0.987268692	0.972458643	0.956093454
0.876	0.99998536	0.997421272	0.987575746	0.972968543	0.956760899
0.878	0.999986441	0.99751353	0.987876362	0.973470544	0.957420169
0.88	0.999987445	0.997602791	0.98817065	0.973964737	0.958071333
0.882	0.999988377	0.99768914	0.988458716	0.974451211	0.958714457
0.884	0.999989244	0.99777266	0.988740668	0.974930057	0.959349611
0.886	0.999990049	0.997853433	0.98901661	0.975401362	0.95997686
0.888	0.999990796	0.997931538	0.989286647	0.975865216	0.960596274
0.89	0.999991489	0.998007055	0.989550882	0.976321707	0.96120792
0.892	0.999992133	0.998080057	0.989809416	0.976770922	0.961811865
0.894	0.999992729	0.998150619	0.99006235	0.977212949	0.962408177
0.896	0.999993283	0.998218814	0.990309784	0.977647875	0.962996923

0.898	0.999993796	0.998284712	0.990551814	0.978075786	0.963578172
0.9	0.999994271	0.998348381	0.990788539	0.978496768	0.964151991
0.902	0.999994712	0.998409889	0.991020054	0.978910907	0.964718446
0.904	0.999995119	0.9984693	0.991246454	0.979318287	0.965277606
0.906	0.999995497	0.998526678	0.991467832	0.979718992	0.965829538
0.908	0.999995847	0.998582086	0.99168428	0.980113108	0.966374308
0.91	0.99999617	0.998635583	0.99189589	0.980500717	0.966911985
0.912	0.99999647	0.998687229	0.992102751	0.980881903	0.967442634
0.914	0.999996747	0.99873708	0.992304951	0.981256747	0.967966323
0.916	0.999997002	0.998785192	0.992502579	0.981625331	0.968483118
0.918	0.999997239	0.99883162	0.99269572	0.981987737	0.968993086
0.92	0.999997458	0.998876417	0.99288446	0.982344046	0.969496294
0.922	0.99999766	0.998919633	0.993068882	0.982694337	0.969992808
0.924	0.999997846	0.99896132	0.99324907	0.983038691	0.970482693
0.926	0.999998018	0.999001525	0.993425105	0.983377187	0.970966017
0.928	0.999998177	0.999040296	0.993597068	0.983709903	0.971442844
0.93	0.999998324	0.999077679	0.993765038	0.984036916	0.97191324
0.932	0.999998459	0.999113718	0.993929092	0.984358305	0.972377272
0.934	0.999998584	0.999148458	0.994089309	0.984674146	0.972835003
0.936	0.999998699	0.99918194	0.994245765	0.984984515	0.9732865
0.938	0.999998805	0.999214206	0.994398533	0.985289489	0.973731826
0.94	0.999998903	0.999245296	0.994547688	0.985589141	0.974171048
0.942	0.999998993	0.999275248	0.994693302	0.985883546	0.974604228
0.944	0.999999076	0.9993041	0.994835447	0.986172779	0.975031432
0.946	0.999999152	0.999331889	0.994974194	0.986456911	0.975452723
0.948	0.999999222	0.99935865	0.995109611	0.986736017	0.975868166
0.95	0.999999287	0.999384417	0.995241767	0.987010167	0.976277823
0.952	0.999999346	0.999409225	0.995370728	0.987279434	0.976681759
0.954	0.999999401	0.999433105	0.995496562	0.987543887	0.977080036
0.956	0.999999451	0.99945609	0.995619334	0.987803597	0.977472716
0.958	0.999999497	0.999478209	0.995739106	0.988058634	0.977859864
0.96	0.999999539	0.999499493	0.995855943	0.988309066	0.97824154
0.962	0.999999578	0.999519969	0.995969906	0.988554962	0.978617807
0.964	0.999999614	0.999539667	0.996081056	0.988796388	0.978988727
0.966	0.999999647	0.999558614	0.996189453	0.989033413	0.979354361
0.968	0.999999677	0.999576834	0.996295156	0.989266102	0.979714771
0.97	0.999999705	0.999594354	0.996398223	0.989494521	0.980070017
0.972	0.99999973	0.999611199	0.996498711	0.989718736	0.98042016
0.974	0.999999753	0.999627391	0.996596675	0.98993881	0.980765261
0.976	0.999999774	0.999642955	0.996692172	0.990154808	0.981105379
0.978	0.999999794	0.999657913	0.996785255	0.990366792	0.981440575

0.98	0.999999812	0.999672286	0.996875977	0.990574826	0.981770907
0.982	0.999999828	0.999686096	0.99696439	0.990778971	0.982096436
0.984	0.999999843	0.999699362	0.997050546	0.990979289	0.98241722
0.986	0.999999857	0.999712104	0.997134495	0.99117584	0.982733318
0.988	0.999999869	0.999724341	0.997216287	0.991368684	0.983044788
0.99	0.999999881	0.999736092	0.99729597	0.991557881	0.983351687
0.992	0.999999891	0.999747375	0.997373591	0.991743489	0.983654075
0.994	0.999999901	0.999758206	0.997449199	0.991925568	0.983952007
0.996	0.99999991	0.999768603	0.997522838	0.992104173	0.984245542
0.998	0.999999918	0.999778581	0.997594553	0.992279363	0.984534736
1	0.999999925	0.999788155	0.99766439	0.992451194	0.984819645
1.002	0.999999932	0.999797342	0.997732392	0.992619721	0.985100325
1.004	0.999999938	0.999806156	0.9977986	0.992784999	0.985376833
1.006	0.999999944	0.999814609	0.997863058	0.992947084	0.985649223
1.008	0.999999949	0.999822717	0.997925806	0.993106028	0.985917552
1.01	0.999999953	0.999830492	0.997986885	0.993261886	0.986181873
1.012	0.999999958	0.999837947	0.998046333	0.99341471	0.986442241
1.014	0.999999961	0.999845094	0.99810419	0.993564551	0.986698711
1.016	0.999999965	0.999851945	0.998160493	0.993711462	0.986951336
1.018	0.999999968	0.999858511	0.998215281	0.993855494	0.987200169
1.02	0.999999971	0.999864804	0.998268589	0.993996696	0.987445265
1.022	0.999999974	0.999870833	0.998320452	0.994135119	0.987686676
1.024	0.999999976	0.999876609	0.998370908	0.994270812	0.987924454
1.026	0.999999978	0.999882142	0.998419989	0.994403823	0.988158651
1.028	0.99999998	0.999887441	0.998467729	0.994534201	0.988389321
1.03	0.999999982	0.999892517	0.998514161	0.994661992	0.988616513
1.032	0.999999984	0.999897376	0.998559318	0.994787244	0.988840279
1.034	0.999999985	0.999902028	0.998603232	0.994910003	0.989060671
1.036	0.999999987	0.999906482	0.998645933	0.995030315	0.989277739
1.038	0.999999988	0.999910745	0.998687451	0.995148225	0.989491532
1.04	0.999999989	0.999914824	0.998727818	0.995263778	0.989702102
1.042	0.99999999	0.999918728	0.998767061	0.995377018	0.989909498
1.044	0.999999991	0.999922463	0.998805209	0.995487988	0.990113768
1.046	0.999999992	0.999926036	0.998842291	0.995596732	0.990314963
1.048	0.999999993	0.999929453	0.998878333	0.995703292	0.99051313
1.05	0.999999993	0.999932721	0.998913363	0.99580771	0.990708318
1.052	0.999999994	0.999935847	0.998947406	0.995910028	0.990900575
1.054	0.999999995	0.999938835	0.998980489	0.996010286	0.991089948
1.056	0.999999995	0.999941691	0.999012636	0.996108526	0.991276486
1.058	0.999999996	0.999944422	0.999043872	0.996204787	0.991460235
1.06	0.999999996	0.999947032	0.999074221	0.996299109	0.991641243

1.062	0.999999996	0.999949526	0.999103707	0.996391531	0.991819554
1.064	0.999999997	0.999951908	0.999132353	0.99648209	0.991995216
1.066	0.999999997	0.999954185	0.999160181	0.996570826	0.992168275
1.068	0.999999997	0.99995636	0.999187213	0.996657776	0.992338776
1.07	0.999999998	0.999958437	0.999213472	0.996742977	0.992506764
1.072	0.999999998	0.99996042	0.999238977	0.996826466	0.992672285
1.074	0.999999998	0.999962315	0.99926375	0.996908279	0.992835383
1.076	0.999999998	0.999964123	0.999287811	0.996988451	0.992996102
1.078	0.999999998	0.999965849	0.99931118	0.997067018	0.993154486
1.08	0.999999999	0.999967497	0.999333876	0.997144016	0.99331058
1.082	0.999999999	0.99996907	0.999355917	0.997219477	0.993464427
1.084	0.999999999	0.999970571	0.999377323	0.997293437	0.993616071
1.086	0.999999999	0.999972003	0.999398112	0.997365928	0.993765553
1.088	0.999999999	0.99997337	0.9994183	0.997436985	0.993912917
1.09	0.999999999	0.999974673	0.999437906	0.99750664	0.994058206
1.092	0.999999999	0.999975917	0.999456947	0.997574925	0.994201461
1.094	0.999999999	0.999977103	0.999475438	0.997641872	0.994342724
1.096	0.999999999	0.999978234	0.999493397	0.997707513	0.994482038
1.098	0.999999999	0.999979313	0.999510838	0.99777188	0.994619443
1.1	1	0.999980341	0.999527778	0.997835002	0.994754981
1.102	1	0.999981321	0.999544232	0.997896911	0.994888693
1.104	1	0.999982256	0.999560214	0.997957637	0.995020618
1.106	1	0.999983147	0.999575739	0.998017209	0.995150799
1.108	1	0.999983997	0.999590821	0.998075657	0.995279274
1.11	1	0.999984806	0.999605474	0.99813301	0.995406084
1.112	1	0.999985578	0.999619711	0.998189297	0.995531268
1.114	1	0.999986313	0.999633546	0.998244546	0.995654867
1.116	1	0.999987014	0.999646992	0.998298785	0.995776919
1.118	1	0.999987682	0.999660062	0.998352043	0.995897463
1.12	1	0.999988318	0.999672767	0.998404346	0.996016539
1.122	1	0.999988925	0.999685121	0.998455722	0.996134184
1.124	1	0.999989503	0.999697135	0.998506198	0.996250438
1.126	1	0.999990054	0.999708821	0.998555801	0.996365338
1.128	1	0.999990579	0.99972019	0.998604557	0.996478923
1.13	1	0.999991079	0.999731253	0.998652491	0.99659123
1.132	1	0.999991556	0.999742022	0.99869963	0.996702297
1.134	1	0.999992011	0.999752507	0.998746	0.996812162
1.136	1	0.999992444	0.999762719	0.998791625	0.996920862
1.138	1	0.999992858	0.999772668	0.998836531	0.997028434
1.14	1	0.999993253	0.999782365	0.998880743	0.997134915
1.142	1	0.999993629	0.999791819	0.998924285	0.997240342

1.144	1	0.999993988	0.99980104	0.998967182	0.997344752
1.146	1	0.999994331	0.999810038	0.999009458	0.99744818
1.148	1	0.999994659	0.999818822	0.999051137	0.997550664
1.15	1	0.999994972	0.999827402	0.999092243	0.997652239
1.152	1	0.999995271	0.999835786	0.999132798	0.997752942
1.154	1	0.999995558	0.999843984	0.999172828	0.997852809
1.156	1	0.999995832	0.999852005	0.999212355	0.997951875
1.158	1	0.999996095	0.999859856	0.999251401	0.998050176
1.16	1	0.999996346	0.999867547	0.999289991	0.998147748
1.162	1	0.999996588	0.999875087	0.999328147	0.998244626
1.164	1	0.99999682	0.999882483	0.999365891	0.998340845
1.166	1	0.999997043	0.999889743	0.999403246	0.998436441
1.168	1	0.999997258	0.999896877	0.999440234	0.99853145
1.17	1	0.999997466	0.999903891	0.999476877	0.998625905
1.172	1	0.999997666	0.999910794	0.999513199	0.998719842
1.174	1	0.999997859	0.999917593	0.999549219	0.998813296
1.176	1	0.999998047	0.999924297	0.999584961	0.998906302
1.178	1	0.999998228	0.999930912	0.999620447	0.998998894
1.18	1	0.999998405	0.999937447	0.999655697	0.999091107
1.182	1	0.999998577	0.999943909	0.999690734	0.999182976
1.184	1	0.999998746	0.999950306	0.999725579	0.999274536
1.186	1	0.99999891	0.999956644	0.999760254	0.99936582
1.188	1	0.999999072	0.999962932	0.99979478	0.999456864
1.19	1	0.99999923	0.999969176	0.999829178	0.999547701
1.192	1	0.999999387	0.999975384	0.99986347	0.999638367
1.194	1	0.999999542	0.999981563	0.999897676	0.999728896
1.196	1	0.999999695	0.999987721	0.99993182	0.999819321
1.198	1	0.999999848	0.999993864	0.99996592	0.999909678
1.2	1	1	1	1	1

Table B.3 Fickian model for Fadaie et al.[3], considering variations in density

Elevation (mm)	40 s	90 s	140 s	190 s	240 s
0	0	0	0	0	0
0.012	0	0.000231344	0.003925128	0.007807873	0.011717437
0.024	0	0.000484415	0.007916005	0.015671442	0.023476126
0.036	0	0.000795403	0.01207141	0.023659856	0.035299872
0.048	0	0.001191773	0.016454147	0.031816536	0.047203652
0.06	0	0.001709445	0.021135714	0.040190249	0.059204245
0.072	0	0.002391373	0.026187126	0.048828456	0.071317929
0.084	0	0.003289215	0.031678655	0.057776938	0.083560328
0.096	0	0.004464956	0.037679511	0.06707945	0.095946272
0.108	0	0.005992401	0.044257454	0.076777367	0.108489662
0.12	0	0.007958478	0.051478342	0.086909351	0.121203335
0.132	0	0.010464219	0.059405604	0.097511026	0.134098948
0.144	0	0.013625327	0.068099651	0.108614672	0.147186861
0.156	0	0.017572183	0.077617217	0.120248926	0.160476037
0.168	0	0.022449178	0.088010663	0.132438519	0.173973948
0.18	0	0.028413251	0.09932722	0.145204015	0.187686494
0.192	0	0.035631554	0.111608223	0.15856159	0.201617934
0.204	0	0.04427817	0.124888326	0.172522832	0.215770829
0.216	0	0.054529896	0.139194727	0.18709457	0.230145994
0.228	0	0.066561118	0.154546428	0.20227874	0.244742472
0.24	0	0.080537896	0.170953537	0.218072289	0.259557511
0.252	0	0.096611419	0.188416652	0.234467109	0.274586562
0.264	0	0.114911062	0.206926332	0.251450024	0.289823285
0.276	0	0.135537331	0.226462686	0.269002816	0.30525957
0.288	0	0.15855502	0.246995098	0.287102298	0.320885577
0.3	0	0.183986941	0.268482104	0.305720433	0.336689777
0.312	0	0.211808599	0.290871429	0.324824505	0.352659017
0.324	0	0.24194418	0.314100216	0.344377335	0.368778591
0.336	0	0.274264172	0.33809543	0.364337552	0.385032326
0.348	0	0.308584915	0.36277445	0.384659899	0.401402673
0.36	0	0.344670266	0.38804586	0.405295599	0.417870818
0.372	0	0.382235481	0.413810403	0.426192754	0.434416793
0.384	0	0.420953288	0.439962118	0.447296782	0.451019603
0.396	0	0.460462002	0.466389615	0.468550894	0.467657351
0.408	1	0.500375383	0.492977485	0.489896593	0.484307383
0.42	1	0.540293828	0.519607805	0.511274202	0.500946425
0.432	1	0.579816371	0.546161712	0.532623403	0.517550732
0.444	1	0.618552882	0.572521011	0.553883787	0.53409624

0.456	1	0.656135851	0.598569785	0.574995404	0.55055871
0.468	1	0.692231121	0.624195958	0.59589931	0.566913889
0.48	1	0.726547027	0.649292789	0.616538092	0.583137654
0.492	1	0.758841484	0.673760251	0.636856384	0.599206162
0.504	1	0.788926731	0.697506273	0.656801338	0.615095995
0.516	1	0.81667158	0.720447804	0.676323072	0.6307843
0.528	1	0.842001204	0.74251169	0.695375068	0.64624892
0.54	1	0.864894652	0.763635347	0.713914527	0.661468526
0.552	1	0.885380407	0.783767205	0.731902668	0.67642273
0.564	1	0.903530401	0.802866938	0.749304974	0.691092199
0.576	1	0.919452966	0.820905474	0.766091376	0.705458748
0.588	1	0.93328519	0.837864798	0.782236382	0.719505437
0.6	1	0.945185153	0.85373756	0.797719147	0.733216643
0.612	1	0.955324431	0.868526509	0.812523477	0.746578126
0.624	1	0.963881208	0.882243785	0.826637784	0.759577086
0.636	1	0.971034226	0.894910079	0.840054987	0.7722022
0.648	1	0.976957726	0.90655371	0.852772358	0.784443659
0.66	1	0.981817443	0.917209629	0.86479133	0.796293176
0.672	1	0.985767653	0.92691839	0.876117257	0.807743999
0.684	1	0.988949196	0.935725113	0.886759155	0.818790901
0.696	1	0.991488389	0.943678459	0.896729394	0.829430164
0.708	1	0.993496666	0.950829646	0.906043389	0.839659551
0.72	1	0.995070834	0.957231515	0.914719263	0.84947827
0.732	1	0.996293779	0.962937669	0.922777506	0.858886924
0.744	1	0.997235493	0.968001698	0.930240629	0.867887462
0.756	1	0.997954301	0.972476488	0.937132817	0.876483111
0.768	1	0.998498198	0.976413625	0.943479599	0.884678313
0.78	1	0.998906193	0.979862897	0.949307515	0.892478645
0.792	1	0.999209619	0.982871886	0.95464381	0.899890748
0.804	1	0.999433354	0.985485658	0.959516144	0.90692224
0.816	1	0.999596932	0.987746526	0.963952314	0.913581634
0.828	1	0.999715523	0.989693906	0.967980015	0.919878251
0.84	1	0.99980078	0.99136423	0.971626613	0.925822137
0.852	1	0.999861564	0.992790925	0.974918945	0.931423974
0.864	1	0.999904543	0.994004451	0.977883152	0.936694996
0.876	1	0.999934683	0.995032374	0.980544528	0.941646905
0.888	1	0.999955648	0.995899477	0.982927402	0.946291795
0.9	1	0.999970112	0.996627905	0.985055036	0.950642068
0.912	1	0.999980012	0.99723732	0.986949555	0.954710367
0.924	1	0.999986733	0.997745077	0.988631888	0.958509505
0.936	1	0.99999126	0.998166404	0.990121738	0.962052397

0.948	1	0.999994285	0.99851459	0.991437561	0.965352007
0.96	1	0.999996291	0.998801163	0.99259657	0.968421289
0.972	1	0.999997611	0.99903607	0.993614746	0.97127314
0.984	1	0.999998472	0.999227849	0.994506862	0.973920359
0.996	1	0.99999903	0.999383789	0.995286522	0.976375607
1.008	1	0.999999389	0.99951008	0.995966205	0.978651377
1.02	1	0.999999617	0.999611952	0.996557315	0.98075997
1.032	1	0.999999762	0.999693802	0.997070242	0.98271347
1.044	1	0.999999853	0.999759309	0.997514419	0.984523734
1.056	1	0.99999991	0.999811536	0.997898389	0.986202383
1.068	1	0.999999945	0.999853023	0.998229875	0.987760792
1.08	1	0.999999967	0.999885863	0.998515841	0.989210096
1.092	1	0.99999998	0.99991178	0.998762567	0.990561192
1.104	1	0.999999988	0.999932185	0.998975715	0.99182475
1.116	1	0.999999993	0.99994823	0.999160393	0.993011224
1.128	1	0.999999996	0.999960857	0.999321229	0.994130868
1.14	1	0.999999998	0.999970837	0.999462431	0.995193758
1.152	1	0.999999999	0.999978804	0.999587853	0.996209813
1.164	1	0.999999999	0.999985283	0.999701061	0.99718882
1.176	1	1	0.999990722	0.999805392	0.998140459
1.188	1	1	0.999995509	0.999904016	0.999074333
1.2	1	1	1	1	1

Table B.4 Fickian + sorption model for Fadaie et al.[3]

Elevation (mm)	40s	90s	140s	190s	240s
0	0	0	0	0	0
0.012	2.20E-78	7.55E-37	5.36E-09	0.008373102	0.010768805
0.024	1.14E-73	2.56E-32	0.000626981	0.016803175	0.02156954
0.036	6.10E-69	8.09E-28	0.006012017	0.025347637	0.032434513
0.048	3.26E-64	2.28E-23	0.012040902	0.034061237	0.04339472
0.06	1.71E-59	5.59E-19	0.018416704	0.042996977	0.054480448
0.072	8.67E-55	1.16E-14	0.025216512	0.052205181	0.06572081
0.084	4.17E-50	2.00E-10	0.032536017	0.061732945	0.077143482
0.096	1.88E-45	2.92E-06	0.040452834	0.071623663	0.088774448
0.108	7.83E-41	0.006730458	0.049025224	0.081916632	0.100637763
0.12	3.01E-36	0.013812389	0.058295772	0.09264673	0.112755345
0.132	1.07E-31	0.021546546	0.0682957	0.103844182	0.125146778
0.144	3.83E-27	0.03015	0.079048482	0.115534387	0.13782915
0.156	1.80E-22	0.039759502	0.090572249	0.127737834	0.150816907
0.168	1.42E-17	0.050452948	0.102880988	0.140470056	0.164121735
0.18	1.37E-12	0.062275829	0.115984841	0.15374166	0.177752475
0.192	1.10E-07	0.075260754	0.129889882	0.167558383	0.191715058
0.204	0.005192522	0.089436422	0.144597668	0.181921198	0.206012468
0.216	0.014379	0.104828565	0.16010478	0.196826444	0.220644733
0.228	0.02687787	0.121457135	0.17640244	0.212265981	0.23560894
0.24	0.041717474	0.139332923	0.193476242	0.228227363	0.250899277
0.252	0.058767405	0.158455028	0.211305986	0.244694029	0.266507096
0.264	0.078242271	0.178809355	0.229865613	0.261645506	0.282421
0.276	0.100359207	0.200367869	0.249123211	0.279057624	0.298626953
0.288	0.125251274	0.223088289	0.269041111	0.296902745	0.315108404
0.3	0.152966625	0.246914071	0.289576055	0.315150002	0.331846433
0.312	0.183478292	0.271774623	0.310679433	0.333765548	0.348819914
0.324	0.216688562	0.29758577	0.332297604	0.352712825	0.366005688
0.336	0.252429277	0.324250491	0.354372287	0.371952839	0.383378751
0.348	0.290461975	0.351659926	0.376841021	0.39144445	0.400912454
0.36	0.330480513	0.379694662	0.399637688	0.41114468	0.418578707
0.372	0.372117187	0.408226273	0.422693095	0.43100902	0.436348194
0.384	0.414952342	0.43711907	0.4459356	0.450991761	0.454190592
0.396	0.458526922	0.466232037	0.469291784	0.471046323	0.472074792

0.408	0.502357245	0.495420896	0.492687143	0.491125595	0.48996912
0.42	0.545951124	0.52454025	0.516046803	0.511182276	0.50784156
0.432	0.588824464	0.553445756	0.539296238	0.531169212	0.525659974
0.444	0.630517373	0.581996272	0.562361981	0.551039738	0.543392314
0.456	0.67060893	0.610055924	0.585172326	0.570748005	0.561006838
0.468	0.7087298	0.637496039	0.607657989	0.590249298	0.578472305
0.48	0.74457209	0.664196906	0.629752744	0.609500345	0.595758174
0.492	0.777896027	0.690049321	0.651394	0.628459599	0.612834785
0.504	0.80853326	0.714955882	0.672523331	0.647087513	0.62967353
0.516	0.836386852	0.738832011	0.693086932	0.665346781	0.646247016
0.528	0.861428192	0.761606688	0.713036018	0.683202557	0.66252921
0.54	0.883691286	0.783222892	0.732327138	0.700622648	0.678495567
0.552	0.903264965	0.803637748	0.750922418	0.717577677	0.694123154
0.564	0.920283669	0.822822391	0.768789725	0.734041217	0.709390745
0.576	0.934917437	0.840761565	0.785902753	0.749989891	0.72427891
0.588	0.947361741	0.857452993	0.80224103	0.765403443	0.738770082
0.6	0.957827713	0.872906527	0.817789855	0.780264777	0.75284861
0.612	0.966533203	0.887143133	0.832540164	0.794559966	0.766500797
0.624	0.973695005	0.900193732	0.846488335	0.808278233	0.779714919
0.636	0.979522449	0.912097954	0.859635928	0.821411898	0.79248123
0.648	0.984212446	0.922902817	0.871989385	0.833956304	0.804791954
0.66	0.987945959	0.932661392	0.883559677	0.845909717	0.816641256
0.672	0.990885817	0.941431477	0.894361925	0.857273204	0.828025209
0.684	0.993175693	0.949274307	0.904414985	0.868050488	0.83894174
0.696	0.994940055	0.95625333	0.913741023	0.878247789	0.849390569
0.708	0.996284888	0.96243308	0.922365073	0.887873648	0.859373135
0.72	0.997298958	0.967878145	0.930314594	0.896938744	0.868892515
0.732	0.998055446	0.972652257	0.93761903	0.905455696	0.877953331
0.744	0.998613769	0.976817507	0.94430938	0.913438858	0.886561655
0.756	0.999021462	0.980433688	0.950417788	0.920904122	0.894724905
0.768	0.999316016	0.983557763	0.955977146	0.927868703	0.902451735
0.78	0.999526584	0.98624346	0.961020729	0.934350938	0.909751926
0.792	0.999675532	0.988540974	0.965581857	0.940370085	0.916636271
0.804	0.99977979	0.990496785	0.969693584	0.945946127	0.923116465
0.816	0.999852007	0.992153566	0.973388426	0.951099582	0.929204985
0.828	0.999901509	0.993550175	0.976698118	0.955851326	0.934914984
0.84	0.999935091	0.994721717	0.979653408	0.960222423	0.940260175
0.852	0.999957638	0.995699666	0.982283881	0.964233971	0.94525473

0.864	0.999972621	0.996512033	0.984617822	0.967906954	0.949913169
0.876	0.999982476	0.997183566	0.986682102	0.971262113	0.954250273
0.888	0.999988891	0.99773598	0.9885021	0.974319828	0.958280979
0.9	0.999993026	0.998188196	0.990101652	0.977100013	0.962020302
0.912	0.999995664	0.99855659	0.991503017	0.979622027	0.965483253
0.924	0.99999733	0.998855243	0.992726878	0.981904598	0.96868476
0.936	0.999998371	0.999096186	0.993792349	0.983965757	0.971639607
0.948	0.999999016	0.999289629	0.994717014	0.985822791	0.974362374
0.96	0.999999411	0.999444186	0.995516962	0.987492203	0.97686738
0.972	0.999999651	0.999567078	0.996206855	0.988989686	0.979168643
0.984	0.999999795	0.99966432	0.996799986	0.990330105	0.98127984
0.996	0.999999881	0.999740896	0.997308357	0.991527494	0.983214276
1.008	0.999999931	0.999800909	0.997742756	0.992595061	0.984984864
1.02	0.999999961	0.999847714	0.998112841	0.993545193	0.986604101
1.032	0.999999978	0.999884045	0.998427224	0.994389483	0.988084065
1.044	0.999999988	0.999912111	0.998693555	0.995138751	0.989436407
1.056	0.999999993	0.99993369	0.998918604	0.995803077	0.990672353
1.068	0.999999996	0.999950205	0.999108346	0.99639184	0.991802712
1.08	0.999999998	0.999962786	0.999268041	0.996913758	0.992837887
1.092	0.999999999	0.999972329	0.999402306	0.997376931	0.993787896
1.104	0.999999999	0.99997954	0.999515193	0.997788894	0.994662388
1.116	1	0.999984973	0.999610258	0.998156666	0.995470673
1.128	1	0.999989059	0.999690624	0.998486799	0.996221747
1.14	1	0.999992138	0.999759049	0.998785441	0.996924329
1.152	1	0.999994473	0.999817978	0.999058387	0.997586892
1.164	1	0.999996273	0.999869609	0.999311135	0.998217702
1.176	1	0.999997705	0.999915939	0.999548949	0.998824857
1.188	1	0.999998908	0.999958818	0.999776915	0.999416328
1.2	1	1	1	1	1

Table B.5 Zhang el al.[4], experimental data (Pentane mass in athabasca bitumen fraction at different elevations and times)

Elevation (cm)	210 min	330 min	630 min	1470 min	2910 min	5790 min
0.01927875	0.004788154	0.003924696	0.000308726	0.00731389	0.008489406	0.002770939
0.05783625	0.004772348	0.003800468	0.001075555	0.007459878	0.006527902	0.001438294
0.09639375	0.00353508	0.00351532	0.000356469	0.005442936	0.004614154	-0.000292301
0.13495125	0.002784074	0.003126279	0.000423141	0.005281058	0.003371727	-0.001260124
0.17350875	0.005444675	0.004889601	0.001782752	0.006770728	0.003285579	-0.001211559
0.21206625	0.007182006	0.005749618	0.0026805	0.006560866	0.003638319	-7.64E-05
0.25062375	0.008866467	0.005881878	0.00307728	0.007113332	0.003709012	0.000643678
0.28918125	0.007778201	0.006716525	0.003967338	0.006745873	0.003546454	-2.98E-05
0.32773875	0.006345854	0.005463548	0.002978246	0.005931	0.003146376	0.001137138
0.36629625	0.006653526	0.006458942	0.005077894	0.00541749	0.004589251	1.94E-03
0.40485375	0.004930039	0.005580877	0.002587128	0.004160068	0.004243535	-0.000399217
0.44341125	0.004408659	0.005222863	0.001599785	0.00248845	0.003097677	-1.85E-03
0.48196875	0.00356875	0.005378393	0.000330121	0.002942565	0.002895738	-0.001234123
0.52052625	0.005049137	0.005519865	0.001688561	0.004122868	0.00391472	-5.17E-04
0.55908375	0.004222782	0.005020216	0.00195953	0.003737533	0.002885369	-0.00127557
0.59764125	0.004211913	0.003525284	0.00232066	0.00460392	0.001916696	1.95E-04
0.63619875	0.003564987	0.004681262	0.002246833	0.004548307	0.002577191	0.000955745
0.67475625	0.003075699	0.003534861	0.000140848	0.00510085	0.003327098	-2.70E-04
0.71331375	0.005679639	0.00532354	0.001194455	0.006980609	0.005079813	0.002422908
0.75187125	0.005973373	0.005296106	0.002000811	0.007757831	0.006365401	1.04E-03
0.79042875	0.006134754	0.006102489	0.00239589	0.006681252	0.00563908	0.000547694
0.82898625	0.003864295	0.006237507	0.000925341	0.005843281	0.004638037	8.94E-04
0.86754375	0.004037389	0.004484644	0.000196491	0.003656557	0.004271641	0.000765875
0.90610125	0.003534308	0.004457524	-0.000472654	0.003612284	0.003891416	1.04E-03
0.94465875	0.004965582	0.004297655	0.001353086	0.00528251	0.005097854	0.002548882
0.98321625	0.005103631	0.003964287	0.001029363	0.00526416	0.003785317	6.70E-04
1.02177375	0.007941941	0.004441743	0.001725462	0.005004155	0.00435357	0.001465772
1.06033125	0.006958343	0.004258788	0.001537735	0.003835316	0.004139774	1.25E-03
1.09888875	0.005694398	0.005504322	0.002199776	0.005138985	0.004177565	0.00229641
1.13744625	0.002858933	0.004539261	0.001376443	0.004133975	0.003004166	9.33E-04
1.17600375	0.001621803	0.004541159	0.001109582	0.003398638	0.002920239	0.00057074
1.21456125	0.001918057	0.003896561	0.001395598	0.002723512	0.003821631	1.64E-03
1.25311875	0.002852847	0.004516455	0.001284339	0.002307406	0.003573863	0.001271427
1.29167625	0.005132664	0.004792554	0.002020314	0.00381412	0.003655223	1.98E-03
1.33023375	0.00528938	0.003877125	0.001448125	0.003250604	0.002948401	0.001463295
1.36879125	0.00389672	0.003557947	0.000978134	0.003083385	0.003250859	5.04E-04
1.40734875	0.001626829	0.002050712	0.000176312	0.002256558	0.00181972	-0.000562101
1.44590625	0.002526989	0.00310094	0.000884024	0.004079786	0.004427799	-2.91E-04

1.48446375	0.00284909	0.002055011	0.001113505	0.004792573	0.004079173	-0.000739456
1.52302125	0.00254389	0.00235749	0.00051582	0.00403388	0.00285847	-1.01E-03
1.56157875	0.003313597	0.002218869	0.000881252	0.00441353	0.003259752	-0.000232176
1.60013625	0.00435306	0.00371462	0.001172462	0.004382649	0.003538543	1.31E-03
1.63869375	0.00436799	0.003277244	0.00077792	0.003848901	0.003639279	0.00193368
1.67725125	0.002263219	0.001926026	-0.000870158	0.00265569	0.001832677	1.69E-03
1.71580875	0.002122563	0.002839685	0.000402705	0.004558694	0.003763717	0.003223507
1.75436625	0.001673502	0.003584438	-4.30551E-05	0.003645193	0.004232503	2.15E-03
1.79292375	0.00289015	0.004650242	0.001388661	0.004185797	0.004796038	0.001058601
1.83148125	0.001992029	0.003449481	0.000647164	0.003745128	0.004051103	-1.41E-04
1.87003875	0.002007003	0.003613282	0.001915735	0.003663928	0.003066853	0.00014817
1.90859625	0.002596692	0.002856044	0.00054671	0.002585618	0.003664341	-6.34E-04
1.94715375	0.003350406	0.002863918	0.000736146	0.00324074	0.00311276	0.000234179
1.98571125	0.002895246	0.003153116	-0.000169632	0.002474695	0.001733627	1.16E-03
2.02426875	0.003801982	0.002870078	0.000334847	0.002088184	0.00090403	0.002214026
2.06282625	0.004819192	0.004038809	0.000614475	0.003413498	0.001021591	2.31E-03
2.10138375	0.003789978	0.003601765	0.001249856	0.003758961	0.001229763	0.003475044
2.13994125	0.004651521	0.004464216	0.002113698	0.003408129	0.003144336	5.39E-03
2.17849875	0.003046823	0.005661236	0.001571906	0.003330325	0.003989604	0.00552269
2.21705625	0.003633284	0.005359465	0.001580041	0.003938441	0.005961638	9.06E-03
2.25561375	0.003809804	0.004948731	0.001510785	0.0038954	0.005341669	0.012342118
2.29417125	0.004692148	0.004208142	0.000925021	0.004808117	0.004902508	1.84E-02
2.33272875	0.004869979	0.002907099	-4.87858E-05	0.004007585	0.003816761	0.02336373
2.37128625	0.004119084	0.002898168	-0.000650948	0.00444052	0.005308026	3.09E-02
2.40984375	0.00325863	0.00232997	-0.001336308	0.002725446	0.005570952	0.039515747
2.44840125	0.002083659	0.001892873	-0.001759024	0.002154796	0.004246586	4.82E-02
2.48695875	0.001511162	0.001762576	-0.000958845	0.002078376	0.003432855	0.056532113
2.52551625	0.001951524	0.002202369	-0.000655647	0.003580928	0.003884511	6.41E-02
2.56407375	0.001527986	0.00163095	-0.000299914	0.00351195	0.004591263	0.072804212
2.60263125	0.002992239	0.001327147	0.000579979	0.00528269	0.00802828	8.08E-02
2.64118875	0.004922042	0.001632028	0.000765397	0.004881148	0.011122118	0.089147409
2.67974625	0.00562399	0.002495224	0.001318591	0.004959636	0.016448969	9.56E-02
2.71830375	0.005190048	0.003235537	0.002235681	0.005141048	0.022402309	0.102327246
2.75686125	0.003701792	0.002340595	0.001462403	0.005092124	0.029255286	1.09E-01
2.79541875	0.004146609	0.003370008	0.001335858	0.005567411	0.038899199	0.117111555
2.83397625	0.003406832	0.002778145	0.001475821	0.005549755	0.048620206	1.20E-01
2.87253375	0.002686506	0.003810486	0.00343178	0.006635255	0.058781026	0.1274133
2.91109125	0.004706457	0.004370369	0.003829337	0.009689322	0.069200057	1.31E-01
2.94964875	0.004287136	0.003950132	0.003580281	0.01214198	0.078880408	0.13759571
2.98820625	0.003696	0.00394213	0.001946033	0.015988463	0.088091105	1.42E-01
3.02676375	0.002834438	0.003954932	0.003014473	0.022934231	0.09860961	0.148977331

3.06532125	0.00281578	0.003787509	0.003118757	0.032694835	0.107340447	1.53E-01
3.10387875	0.002393056	0.003801975	0.003158332	0.044751494	0.116357346	0.16097335
3.14243625	0.002097799	0.00335947	0.003442822	0.056114684	0.123763023	1.66E-01
3.18099375	0.002558055	0.000338621	0.005287396	0.068527789	0.132425015	0.174525062
3.21955125	0.002996395	0.0023678	0.009583814	0.080606564	0.138360862	1.80E-01
3.25810875	0.004759692	0.00442078	0.016461935	0.094690383	0.145948415	0.188477163
3.29666625	0.005333851	0.007182688	0.026119896	0.106809973	0.153636636	1.93E-01
3.33522375	0.005940239	0.011160244	0.037817585	0.11922756	0.165698176	0.20072396
3.37378125	0.007823989	0.016410128	0.053386568	0.130290546	0.173842371	2.06E-01
3.41233875	0.01064837	0.02429979	0.07116622	0.14169035	0.18370365	0.21365626
3.45089625	0.019424323	0.03698904	0.090025024	0.150682556	0.19149633	2.18E-01
3.48945375	0.035155503	0.059181591	0.113508784	0.168613437	0.208098625	0.229114651
3.52801125	0.050231627	0.080456133	0.130183004	0.180757442	0.216846292	2.35E-01
3.56656875	0.073800313	0.105770318	0.151881413	0.199948906	0.228452322	0.244186763
3.60512625	0.097534956	0.129135869	0.165665873	0.210485562	0.236568786	2.50E-01
3.64368375	0.124437831	0.154464746	0.18441297	0.226774122	0.245619421	0.255870355
3.68224125	0.154386098	0.176184419	0.201506846	0.2356778	0.252623521	2.60E-01
3.72079875	0.186911019	0.201719948	0.226489374	0.253481868	0.26586136	0.271902853
3.75935625	0.221455398	0.231320277	0.252680123	0.272026662	0.279413641	2.80E-01
3.79791375	0.258110964	0.265924816	0.281859467	0.294549188	0.296292875	0.29196046
3.83647125	0.314381289	0.308433916	0.309616946	0.312210133	0.307523248	3.03E-01
3.87502875	0.363553426	0.352103771	0.344103378	0.336049977	0.32545897	0.315294487
3.91358625	0.423032464	0.396965835	0.380064136	0.357714743	0.340289234	3.21E-01
3.95214375	0.477816345	0.444596123	0.418396052	0.386400937	0.357617717	0.329296006
3.99070125	0.538014337	0.493638066	0.455326534	0.409743375	0.370162888	3.37E-01
4.02925875	0.597043868	0.546799646	0.50017443	0.44191523	0.391134317	0.35157182
4.06781625	0.652219045	0.593595808	0.539624246	0.46964274	0.409526319	3.64E-01
4.10637375	0.704353184	0.643715106	0.581814795	0.503537087	0.437471264	0.381502235
4.14493125	0.738901768	0.682083066	0.614118478	0.529222232	0.460340113	3.95E-01
4.18348875	0.769834649	0.723374901	0.65333184	0.561309323	0.488353537	0.411781987
4.22204625	0.789474039	0.741857623	0.676234211	0.579931016	0.508137087	4.23E-01
4.26060375	0.814463939	0.765355204	0.701851036	0.603472991	0.531616767	0.440759227
4.29916125	0.8270894	0.776792889	0.712882067	0.61655094	0.544409769	4.54E-01
4.33771875	0.844058129	0.794814181	0.727702743	0.635183909	0.563551306	0.473860436
4.37627625	0.855116652	0.801354649	0.740113794	0.646175848	0.575799933	4.85E-01
4.41483375	0.866112129	0.812231173	0.755008063	0.661505876	0.589701097	0.501570682
4.45339125	0.873651514	0.821343069	0.76588315	0.670946431	0.600470602	5.10E-01
4.49194875	0.887283523	0.839488161	0.77844896	0.689265122	0.616565242	0.52414304
4.53050625	0.89814298	0.852222362	0.792977093	0.700638201	0.626176732	5.39E-01
4.56906375	0.909777554	0.864166863	0.806860992	0.718930807	0.640003248	0.553778655
4.60762125	0.917147826	0.874668944	0.818585852	0.731391151	0.648674881	5.66E-01

4.64617875	0.921368076	0.879281782	0.824530444	0.738246592	0.658790587	0.573788943
4.68473625	0.924187774	0.884261518	0.82730484	0.74677765	0.663704144	5.83E-01
4.72329375	0.929397633	0.894596865	0.83912519	0.753977847	0.67427031	0.587893306
4.76185125	0.934999253	0.905133746	0.85144078	0.761678738	0.687226309	5.97E-01
4.80040875	0.948073141	0.914220111	0.858467352	0.772414659	0.70187954	0.604283737
4.83896625	0.95692662	0.918441664	0.862258445	0.780235129	0.714371363	6.14E-01
4.87752375	0.96625415	0.92521774	0.871780767	0.79211866	0.722695264	0.623626498
4.91608125	0.961239012	0.928367561	0.878260175	0.797148112	0.725306002	6.29E-01
4.95463875	0.963366434	0.929402487	0.888580759	0.802087042	0.729046067	0.635685827
4.99319625	0.959842072	0.935583783	0.898094441	0.810527438	0.736661106	6.41E-01
5.03175375	0.959426194	0.936271839	0.902925018	0.816497765	0.741084704	0.646017989
5.07031125	0.968885772	0.944877402	0.909548774	0.826335002	0.746407102	6.50E-01
5.10886875	0.967063017	0.943284424	0.906947656	0.826501223	0.753131616	0.65503535
5.14742625	0.971762713	0.948841932	0.911133545	0.83240329	0.76217302	6.60E-01
5.18598375	0.974513463	0.953137231	0.913361162	0.83973055	0.764771805	0.665708571
5.22454125	0.975977083	0.958188226	0.920003797	0.847876486	0.771459075	6.71E-01
5.26309875	0.971848442	0.958446959	0.922625816	0.851656968	0.774495191	0.675679419
5.30165625	0.9799047	0.962649619	0.93287232	0.8572481	0.78175333	6.86E-01
5.34021375	0.985504461	0.958756437	0.937179863	0.856548205	0.790423343	0.689482631
5.37877125	0.99359397	0.96122808	0.944150641	0.865521412	0.798510704	6.95E-01
5.41732875	0.995294482	0.963522324	0.942410248	0.871470698	0.803439824	0.696857901
5.45588625	0.996854956	0.971807462	0.944545607	0.880380673	0.806814412	7.02E-01
5.49444375	1.000724041	0.976688846	0.948897504	0.88408674	0.811288984	0.70707438
5.53300125	0.99134664	0.97714788	0.94973154	0.88422256	0.81080373	7.06E-01
5.57155875	0.99353033	0.984165309	0.952898191	0.886208865	0.817655954	0.708915205
5.61011625	0.993391016	0.985605832	0.954919687	0.892539623	0.8151665	7.11E-01
5.64867375	0.993907789	0.983923323	0.954235715	0.890812093	0.814856646	0.715565049
5.68723125	0.990964215	0.97929232	0.957249232	0.892507252	0.818478339	7.19E-01
5.72578875	0.9837642	0.974366243	0.954501928	0.887939465	0.822619026	0.723579865
5.76434625	0.980806391	0.974668368	0.954985732	0.896518452	0.825855801	7.27E-01
5.80290375	0.985210088	0.979038848	0.960898516	0.909762783	0.836131362	0.734829267
5.84146125	0.986230024	0.982251671	0.961152592	0.909811007	0.842157712	7.36E-01
5.88001875	0.982997646	0.977400738	0.95979801	0.90517151	0.841047008	0.736383057
5.91857625	0.990681586	0.978919047	0.962185318	0.907693682	0.841196432	7.39E-01
5.95713375	0.989582752	0.979508502	0.961162849	0.91356296	0.841473476	0.742058855
5.99569125	0.991686038	0.981532917	0.97060427	0.915339731	0.846506782	7.45E-01
6.03424875	0.996157067	0.983699076	0.977702939	0.916627639	0.848537575	0.750506515
6.07280625	1.000600341	0.985730843	0.98687312	0.918756336	0.850413325	7.53E-01
6.11136375	0.997701313	0.985685143	0.97871538	0.92280128	0.850610365	0.754408664
6.14992125	0.99701394	0.987777976	0.97947635	0.929462853	0.859707042	7.54E-01
6.18847875	0.991859608	0.990075739	0.976558867	0.934463428	0.861437969	0.758157072

6.22703625	0.989501032	0.986581038	0.978035486	0.93791676	0.862387887	7.59E-01
6.26559375	0.986102979	0.987741192	0.977502273	0.939664362	0.864127879	0.75953573
6.30415125	0.984762772	0.987560002	0.976979471	0.9360574	0.861236743	7.63E-01
6.34270875	0.988077928	0.981136859	0.978360036	0.941578838	0.86645486	0.769736961
6.38126625	0.996011653	0.985463729	0.982945819	0.941041283	0.871368188	7.70E-01
6.41982375	0.998278994	0.985329659	0.989684754	0.945536068	0.879348978	0.776818491
6.45838125	0.998161259	0.985714654	0.993415549	0.948122786	0.880677562	7.80E-01
6.49693875	1.001700222	0.98448583	0.990865773	0.947881499	0.884054729	0.78232143
6.53549625	1.004015115	0.984861933	0.994024169	0.948758622	0.883788515	7.84E-01
6.57405375	1.003976827	0.988942501	0.995059389	0.951358454	0.893083998	0.785822581
6.61261125	1.001489938	0.990016839	0.991109126	0.946749799	0.88736601	7.84E-01
6.65116875	0.997305238	0.980043012	0.984057686	0.940268665	0.886453196	0.780456524
6.68972625	0.997841708	0.979344958	0.987413768	0.94214955	0.891280724	7.86E-01
6.72828375	0.996086066	0.977127186	0.993001403	0.942549572	0.893553708	0.79080234
6.76684125	0.993101196	0.97831901	0.99056875	0.946595879	0.891497298	7.96E-01
6.80539875	1.000314334	0.982561621	0.993172149	0.95684139	0.897698881	0.808916629
6.84395625	1.003276469	0.988398212	0.996076826	0.96542256	0.90461184	8.30E-01
6.88251375	1.005088187	0.990847593	0.995056795	0.967552086	0.906449016	0.866119711
6.92107125	0.999670282	0.99252725	0.996010252	0.966586017	0.9135051	9.42E-01

Table B.6 Fickian model for Zhang et al.[4], considering constant density

Elevation (mm)	210 min	330 min	630 min	1470 min	2910 min	5790 min
0	0	0	0	0	0	0
0.69	1.63E-45	5.02E-36	3.05E-24	4.29E-13	7.29E-08	4.60E-05
1.38	2.22E-44	4.41E-35	1.50E-23	1.19E-12	1.62E-07	9.45E-05
2.07	3.07E-43	3.85E-34	7.03E-23	2.85E-12	2.85E-07	0.000148211
2.76	4.17E-42	3.31E-33	3.24E-22	6.60E-12	4.69E-07	0.000209948
3.45	5.56E-41	2.79E-32	1.46E-21	1.51E-11	7.50E-07	0.000282837
4.14	7.26E-40	2.30E-31	6.52E-21	3.40E-11	1.18E-06	0.000370405
4.83	9.31E-39	1.87E-30	2.85E-20	7.57E-11	1.83E-06	0.000476692
5.52	1.17E-37	1.49E-29	1.23E-19	1.67E-10	2.83E-06	0.000606366
6.21	1.44E-36	1.16E-28	5.18E-19	3.62E-10	4.33E-06	0.000764847
6.9	1.74E-35	8.90E-28	2.15E-18	7.75E-10	6.58E-06	0.000958443
7.59	2.05E-34	6.67E-27	8.74E-18	1.64E-09	9.91E-06	0.001194487
8.28	2.37E-33	4.90E-26	3.49E-17	3.43E-09	1.48E-05	0.001481493
8.97	2.68E-32	3.53E-25	1.37E-16	7.06E-09	2.20E-05	0.001829305
9.66	2.96E-31	2.48E-24	5.27E-16	1.44E-08	3.24E-05	0.002249264
10.35	3.20E-30	1.71E-23	1.99E-15	2.89E-08	4.74E-05	0.002754376

11.04	3.38E-29	1.15E-22	7.35E-15	5.72E-08	6.88E-05	0.003359475
11.73	3.48E-28	7.58E-22	2.67E-14	1.12E-07	9.90E-05	0.004081396
12.42	3.51E-27	4.87E-21	9.47E-14	2.16E-07	0.000141513	0.004939132
13.11	3.44E-26	3.06E-20	3.29E-13	4.11E-07	0.000200673	0.005953988
13.8	3.29E-25	1.88E-19	1.12E-12	7.71E-07	0.000282401	0.007149717
14.49	3.07E-24	1.12E-18	3.73E-12	1.43E-06	0.000394391	0.008552635
15.18	2.79E-23	6.54E-18	1.22E-11	2.61E-06	0.000546602	0.010191712
15.87	2.46E-22	3.71E-17	3.88E-11	4.70E-06	0.000751796	0.012098624
16.56	2.11E-21	2.05E-16	1.21E-10	8.35E-06	0.001026157	0.014307767
17.25	1.76E-20	1.11E-15	3.68E-10	1.46E-05	0.001390002	0.016856223
17.94	1.43E-19	5.79E-15	1.09E-09	2.52E-05	0.00186856	0.019783673
18.63	1.12E-18	2.94E-14	3.18E-09	4.30E-05	0.002492831	0.02313224
19.32	8.56E-18	1.45E-13	9.00E-09	7.21E-05	0.003300479	0.026946279
20.01	6.31E-17	6.96E-13	2.49E-08	0.000119332	0.004336754	0.031272078
20.7	4.51E-16	3.23E-12	6.70E-08	0.000194623	0.005655388	0.0361575
21.39	3.11E-15	1.45E-11	1.76E-07	0.000312871	0.007319427	0.041651531
22.08	2.07E-14	6.34E-11	4.50E-07	0.00049574	0.009401933	0.047803764
22.77	1.33E-13	2.67E-10	1.12E-06	0.00077418	0.011986488	0.054663797
23.46	8.22E-13	1.08E-09	2.72E-06	0.001191555	0.01516743	0.06228056
24.15	4.89E-12	4.26E-09	6.41E-06	0.001807421	0.019049742	0.070701585
24.84	2.79E-11	1.61E-08	1.47E-05	0.002701901	0.023748512	0.079972209
25.53	1.53E-10	5.87E-08	3.28E-05	0.00398052	0.02938789	0.090134737
26.22	8.03E-10	2.05E-07	7.09E-05	0.005779225	0.036099495	0.101227575
26.91	4.03E-09	6.91E-07	0.000149102	0.008269175	0.044020214	0.113284349
27.6	1.93E-08	2.23E-06	0.000304212	0.011660727	0.053289389	0.126333027
28.29	8.78E-08	6.89E-06	0.000602159	0.016205893	0.064045402	0.140395066
28.98	3.80E-07	2.04E-05	0.001155879	0.022198447	0.076421704	0.155484606
29.67	1.56E-06	5.76E-05	0.002150891	0.029970836	0.09054239	0.171607726
30.36	6.06E-06	0.000155077	0.003878652	0.039887099	0.10651744	0.188761795
31.05	2.22E-05	0.000397744	0.006775948	0.05233124	0.124437794	0.206934925
31.74	7.64E-05	0.000969909	0.011465123	0.067690816	0.14437047	0.226105559
32.43	0.000246745	0.002245195	0.018785642	0.086336	0.16635394	0.246242201
33.12	0.0007447	0.004926194	0.02980319	0.108594962	0.190394007	0.267303305
33.81	0.002093451	0.010229987	0.045780086	0.134727005	0.21646043	0.289237336
34.5	0.005461984	0.020080349	0.068092375	0.164895483	0.244484502	0.311983006
35.19	0.013178887	0.03721442	0.09808644	0.199142942	0.274357798	0.335469694
35.88	0.029303305	0.065062086	0.13688174	0.237371114	0.305932217	0.359618044
36.57	0.059849248	0.107255858	0.185144113	0.279328296	0.339021435	0.384340726
37.26	0.111985765	0.16672808	0.242871199	0.324606183	0.373403771	0.409543365
37.95	0.191664944	0.244560298	0.309241232	0.372647467	0.408826423	0.435125617
38.64	0.30006546	0.338986545	0.382573002	0.422764502	0.445010954	0.460982354

39.33	0.430708111	0.445057177	0.460425761	0.47416819	0.481659827	0.487004967
40.02	0.569732159	0.555300357	0.539836705	0.526005127	0.518463746	0.513082731
40.71	0.70022459	0.661292292	0.617658892	0.577400111	0.555109478	0.539104216
41.4	0.808409865	0.755589989	0.69093545	0.627500466	0.591287859	0.564958719
42.09	0.887911742	0.833286706	0.75723589	0.675518467	0.62670161	0.590537677
42.78	0.939963111	0.892653598	0.814890916	0.720768324	0.661072664	0.615736031
43.47	0.970508377	0.934790312	0.863089515	0.762694864	0.694148675	0.640453519
44.16	0.986677205	0.96262695	0.901836777	0.800891969	0.725708483	0.664595868
44.85	0.994446672	0.979781161	0.931801739	0.835109959	0.755566315	0.688075863
45.54	0.997856447	0.989665311	0.954103088	0.86525225	0.783574634	0.710814268
46.23	0.999230999	0.995003195	0.970083625	0.891362607	0.809625546	0.732740588
46.92	0.99974267	0.997711595	0.981114491	0.913605088	0.833650837	0.75379366
47.61	0.999919402	0.999005824	0.988453136	0.932239193	0.855620682	0.773922069
48.3	0.999976295	0.999589648	0.99316131	0.947592842	0.875541224	0.793084375
48.99	0.999993433	0.999838824	0.996075863	0.960035613	0.89345118	0.811249175
49.68	0.999998281	0.999939664	0.997817811	0.96995424	0.909417719	0.828394982
50.37	0.999999574	0.999978439	0.998823602	0.977731796	0.923531839	0.844509949
51.06	0.9999999	0.999992634	0.999384987	0.983731386	0.935903494	0.859591454
51.75	0.999999978	0.999997591	0.999688075	0.988284603	0.94665668	0.873645541
52.44	0.999999995	0.999999244	0.999846456	0.991684504	0.955924693	0.886686267
53.13	0.999999999	0.999999772	0.999926613	0.994182546	0.963845712	0.898734949
53.82	1	0.999999934	0.999965927	0.995988698	0.97055885	0.909819347
54.51	1	0.999999982	0.999984625	0.997273888	0.976200753	0.919972799
55.2	1	0.999999995	0.999993255	0.998173958	0.980902797	0.929233327
55.89	1	0.999999999	0.999997121	0.998794429	0.984788904	0.93764274
56.58	1	1	0.999998804	0.999215487	0.987973948	0.945245749
57.27	1	1	0.999999516	0.999496794	0.990562727	0.952089095
57.96	1	1	0.999999809	0.99968184	0.992649423	0.958220735
58.65	1	1	0.999999927	0.999801702	0.994317487	0.963689067
59.34	1	1	0.999999973	0.999878161	0.995639879	0.968542214
60.03	1	1	0.99999999	0.999926197	0.996679566	0.97282738
60.72	1	1	0.999999996	0.999955924	0.997490218	0.976590266
61.41	1	1	0.999999999	0.999974046	0.998117033	0.979874558
62.1	1	1	1	0.99998493	0.998597621	0.982721488
62.79	1	1	1	0.999991371	0.998962916	0.985169453
63.48	1	1	1	0.999995127	0.999238057	0.987253698
64.17	1	1	1	0.999997286	0.999443219	0.989006059
64.86	1	1	1	0.999998509	0.999594377	0.990454755
65.55	1	1	1	0.999999191	0.999703976	0.991624215
66.24	1	1	1	0.999999565	0.999781514	0.992534959
66.93	1	1	1	0.999999765	0.999834016	0.993203498

67.62	1	1	1	0.999999866	0.999866421	0.993642267
68.31	1	1	1	0.999999908	0.999881865	0.993859575
69	1	1	1	0.999999908	0.999881865	0.993859575

Table B.7 Fickian model for Zhang et al.[4], considering variations in density

Elevation (mm)	210 min	330 min	630 min	5790 min
0	0	0	0	0
0.69	1.30E-45	3.97E-36	2.40E-24	3.56E-05
1.38	1.76E-44	3.49E-35	1.18E-23	7.31E-05
2.07	2.44E-43	3.05E-34	5.51E-23	0.000114674
2.76	3.31E-42	2.61E-33	2.54E-22	0.000162441
3.45	4.41E-41	2.20E-32	1.15E-21	0.000218838
4.14	5.76E-40	1.82E-31	5.11E-21	0.000286593
4.83	7.39E-39	1.48E-30	2.24E-20	0.000368835
5.52	9.28E-38	1.18E-29	9.61E-20	0.000469175
6.21	1.14E-36	9.18E-29	4.06E-19	0.000591813
6.9	1.38E-35	7.02E-28	1.68E-18	0.000741633
7.59	1.63E-34	5.27E-27	6.85E-18	0.000924319
8.28	1.88E-33	3.87E-26	2.74E-17	0.00114647
8.97	2.12E-32	2.78E-25	1.07E-16	0.001415725
9.66	2.35E-31	1.96E-24	4.13E-16	0.001740888
10.35	2.54E-30	1.35E-23	1.56E-15	0.002132063
11.04	2.68E-29	9.07E-23	5.75E-15	0.002600793
11.73	2.76E-28	5.97E-22	2.08E-14	0.003160191
12.42	2.78E-27	3.84E-21	7.40E-14	0.003825076
13.11	2.72E-26	2.41E-20	2.57E-13	0.004612105
13.8	2.61E-25	1.48E-19	8.76E-13	0.005539895
14.49	2.43E-24	8.83E-19	2.92E-12	0.006629129
15.18	2.20E-23	5.15E-18	9.50E-12	0.007902656
15.87	1.95E-22	2.92E-17	3.03E-11	0.00938556
16.56	1.67E-21	1.62E-16	9.43E-11	0.011105217
17.25	1.39E-20	8.69E-16	2.87E-10	0.013091309
17.94	1.13E-19	4.55E-15	8.53E-10	0.015375819
18.63	8.87E-19	2.31E-14	2.48E-09	0.017992978
19.32	6.75E-18	1.14E-13	7.01E-09	0.02097918
20.01	4.98E-17	5.46E-13	1.94E-08	0.024372838
20.7	3.55E-16	2.54E-12	5.22E-08	0.028214214
21.39	2.45E-15	1.14E-11	1.37E-07	0.032545175
22.08	1.63E-14	4.97E-11	3.50E-07	0.037408916

22.77	1.05E-13	2.09E-10	8.73E-07	0.042849619
23.46	6.47E-13	8.50E-10	2.12E-06	0.048912063
24.15	3.85E-12	3.33E-09	4.99E-06	0.055641185
24.84	2.20E-11	1.26E-08	1.14E-05	0.063081581
25.53	1.20E-10	4.59E-08	2.55E-05	0.071276968
26.22	6.31E-10	1.61E-07	5.51E-05	0.080269597
26.91	3.16E-09	5.40E-07	0.000115825	0.090099625
27.6	1.51E-08	1.74E-06	0.000236248	0.100804455
28.29	6.88E-08	5.38E-06	0.000467513	0.112418044
28.98	2.98E-07	1.59E-05	0.000897253	0.124970194
29.67	1.22E-06	4.49E-05	0.001669514	0.138485829
30.36	4.74E-06	0.000120796	0.003010945	0.152984273
31.05	1.73E-05	0.00030965	0.005262246	0.168478537
31.74	5.97E-05	0.000754729	0.00891159	0.184974633
32.43	0.000192618	0.001746546	0.014623964	0.202470929
33.12	0.000580894	0.003832258	0.023257728	0.220957549
33.81	0.001632007	0.007963778	0.035858059	0.240415864
34.5	0.004257539	0.015660638	0.053617316	0.260818059
35.19	0.010282427	0.029129617	0.077795056	0.282126819
35.88	0.022932102	0.051251031	0.10959542	0.30429514
36.57	0.047146938	0.085332358	0.15000638	0.327266293
37.26	0.089283336	0.134561754	0.199613688	0.350973947
37.95	0.155735269	0.201172835	0.258412308	0.37534247
38.64	0.250335042	0.285455124	0.325649116	0.400287417
39.33	0.371172805	0.384901079	0.399739852	0.425716214
40.02	0.508568829	0.493916254	0.478304371	0.451529031
40.71	0.646455051	0.604492296	0.558349459	0.477619841
41.4	0.767823227	0.707897541	0.636594213	0.503877656
42.09	0.861360181	0.796846954	0.709886367	0.530187909
42.78	0.924706463	0.867199893	0.775618151	0.556433972
43.47	0.962695029	0.918438914	0.832039529	0.582498755
44.16	0.983062445	0.952904249	0.878395252	0.608266368
44.85	0.992919134	0.97439654	0.914868954	0.633623793
45.54	0.997261807	0.986872412	0.942375839	0.658462519
46.23	0.999016398	0.993640263	0.962280244	0.682680109
46.92	0.999670514	0.997083539	0.976116202	0.706181631
47.61	0.999896707	0.998731739	0.985366018	0.728880944
48.3	0.999969594	0.999476105	0.99132006	0.750701771
48.99	0.999991569	0.999794085	0.995014098	0.771578564
49.68	0.999997792	0.999922866	0.997225246	0.791457115
50.37	0.999999452	0.999972419	0.998503277	0.810294915

51.06	0.999999871	0.999990572	0.999217147	0.828061258
51.75	0.999999971	0.999996914	0.999602782	0.8447371
52.44	0.999999994	0.999999032	0.999804396	0.860314676
53.13	0.999999999	0.999999708	0.999906475	0.874796911
53.82	1	0.999999915	0.999956562	0.888196652
54.51	1	0.999999976	0.999980393	0.900535738
55.2	1	0.999999994	0.999991395	0.911843966
55.89	1	0.999999998	0.999996326	0.922157963
56.58	1	1	0.999998474	0.931520024
57.27	1	1	0.999999382	0.939976928
57.96	1	1	0.999999757	0.947578766
58.65	1	1	0.999999907	0.954377818
59.34	1	1	0.999999965	0.960427485
60.03	1	1	0.999999987	0.965781297
60.72	1	1	0.999999995	0.970492014
61.41	1	1	0.999999998	0.974610815
62.1	1	1	0.999999999	0.978186592
62.79	1	1	1	0.981265334
63.48	1	1	1	0.98388961
64.17	1	1	1	0.986098134
64.86	1	1	1	0.987925409
65.55	1	1	1	0.989401449
66.24	1	1	1	0.990551552
66.93	1	1	1	0.99139613
67.62	1	1	1	0.991950589
68.31	1	1	1	0.992225239
69	1	1	1	0.992225239

Table B.8 Sadighian et al.[5], experimental data (Pentane mass fraction in athabasca bitumen at different times)

Elevation (mm)	0 min	66 min	164 min	337 min	1381 min	1853 min	2814 min	3108 min
0.368	-0.0000711	0.00193	0.000511	0.000649	0.00113	0.000127	-0.0032	-0.00717
0.46	0.000356	0.00233	0.000516	0.00116	0.00142	0.000126	-0.00299	-0.00648
0.552	0.0012	0.00301	0.00132	0.00236	0.00259	0.000917	-0.00228	-0.00506
0.644	0.00146	0.00307	0.00194	0.00305	0.00304	0.0013	-0.00167	-0.00354
0.736	0.00113	0.00286	0.00223	0.00325	0.0029	0.00131	-0.00157	-0.00243
0.92	0.00123	0.00207	0.0025	0.0029	0.00172	0.000815	-0.00101	-0.00115
1.1	0.00207	0.00147	0.0024	0.002	0.000645	0.00128	0.00108	0.000397

1.29	0.0016	0.00166	0.00237	0.00101	-0.00103	0.00107	0.00341	0.00171
1.47	0.000462	0.00102	0.00067	-0.00268	-0.00387	-0.000518	0.00371	0.00118
1.66	0.00131	0.000709	0.00033	-0.00427	-0.00388	-0.00131	0.00384	0.00119
1.84	0.00163	0.000587	0.000918	-0.00441	-0.00264	-0.00212	0.0029	0.00197
2.58	0.00175	-0.0018	-0.00156	0.00105	0.000172	-0.00282	0.00489	0.00859
2.67	0.00108	-0.00218	-0.00219	0.000986	-0.000418	-0.00296	0.00556	0.01007
2.76	-0.00017	-0.00268	-0.0028	0.000602	-0.0016	-0.00346	0.00535	0.01167
2.85	-0.00143	-0.00224	-0.00288	0.000104	-0.00219	-0.00385	0.00527	0.01394
2.94	-0.00217	-0.00145	-0.00276	-0.000356	-0.00204	-0.00386	0.00545	0.01718
3.04	-0.0026	-0.00081	-0.00246	-0.000664	-0.00152	-0.00392	0.00609	0.02088
3.13	-0.00294	-0.000668	-0.00196	-0.00112	-0.000936	-0.00397	0.0071	0.02464
3.22	-0.00337	-0.00151	-0.00188	-0.00172	-0.000731	-0.0043	0.00796	0.02844
3.31	-0.00386	-0.00252	-0.00213	-0.00238	-0.000745	-0.00458	0.00876	0.03232
3.4	-0.00447	-0.00277	-0.00205	-0.00281	-0.000786	-0.00381	0.01022	0.03662
3.5	-0.00493	-0.00275	-0.00168	-0.00346	-0.00111	-0.00274	0.01237	0.04076
3.59	-0.00499	-0.00295	-0.00143	-0.00403	-0.000795	-0.00177	0.01563	0.04489
3.68	-0.00486	-0.00351	-0.00117	-0.00385	-0.000228	-0.000843	0.02029	0.04969
3.77	-0.00471	-0.00376	-0.000437	-0.00306	0.000413	0.000769	0.02623	0.05473
3.86	-0.00456	-0.00404	0.000549	-0.00236	0.000884	0.00319	0.03293	0.06008
3.96	-0.004	-0.00408	0.00108	-0.0021	0.000962	0.00534	0.0396	0.06576
4.05	-0.00316	-0.00361	0.000963	-0.00223	0.0011	0.00714	0.04566	0.07109
4.14	-0.00229	-0.00319	0.000611	-0.00221	0.00151	0.00854	0.05117	0.07616
4.23	-0.00126	-0.00311	0.000567	-0.0013	0.00252	0.00976	0.05665	0.08124
4.32	-0.000294	-0.00319	0.000904	0.000449	0.00404	0.01111	0.06245	0.08681
4.42	0.000449	-0.00263	0.00177	0.00203	0.00534	0.01238	0.06858	0.09308
4.51	0.000981	-0.00177	0.00223	0.00235	0.00571	0.01319	0.07393	0.0992
4.6	0.00131	-0.00164	0.00196	0.00223	0.00539	0.01358	0.07842	0.105
4.69	0.00207	-0.00155	0.00169	0.00281	0.00542	0.01432	0.08249	0.11086
4.78	0.00261	-0.00142	0.00141	0.00388	0.00612	0.01552	0.08618	0.11635
4.88	0.00301	-0.00128	0.00147	0.00495	0.00732	0.01673	0.09037	0.12183
4.97	0.00365	-0.000567	0.00217	0.00633	0.00886	0.01805	0.09568	0.12761
5.06	0.00433	0.000644	0.00323	0.00732	0.0103	0.01916	0.1016	0.13357
5.15	0.0045	0.00177	0.00375	0.00713	0.01128	0.02002	0.10686	0.13932
5.24	0.00426	0.00209	0.00353	0.00638	0.01167	0.02158	0.11128	0.14485
5.34	0.00386	0.00152	0.00337	0.00621	0.01177	0.0235	0.11559	0.14986
5.43	0.00345	0.00095	0.00331	0.0062	0.01184	0.0253	0.11985	0.15456
5.52	0.00283	0.000722	0.00326	0.00565	0.01171	0.02687	0.12417	0.15891
5.61	0.00261	0.000978	0.00371	0.00544	0.01133	0.02903	0.12948	0.16337
5.7	0.0024	0.00146	0.00444	0.00604	0.0111	0.032	0.13505	0.1679
5.8	0.00152	0.00143	0.0049	0.0062	0.01091	0.03557	0.13963	0.17196

5.89	0.000421	0.000572	0.00438	0.00547	0.01031	0.03966	0.14351	0.17568
5.98	0.0000799	-0.000351	0.00393	0.00501	0.01015	0.0445	0.1482	0.17954
6.07	0.000175	-0.000854	0.00388	0.00478	0.01075	0.04956	0.15351	0.18334
6.16	0.000504	-0.000864	0.00404	0.00453	0.01234	0.05505	0.15863	0.18701
6.26	0.00106	-0.000622	0.00439	0.00415	0.01469	0.06088	0.1637	0.19061
6.35	0.00175	-0.00034	0.00447	0.00449	0.01725	0.06689	0.16868	0.19404
6.44	0.0022	-0.000288	0.00387	0.00522	0.02014	0.0728	0.1733	0.19715
6.53	0.00285	-0.0000783	0.00344	0.00573	0.02261	0.07863	0.17779	0.20062
6.62	0.00394	0.000292	0.00359	0.00581	0.02456	0.08462	0.18271	0.20479
6.72	0.00545	0.00166	0.0044	0.00654	0.02752	0.09125	0.18818	0.2097
6.81	0.00628	0.00318	0.00459	0.00731	0.03106	0.09738	0.19322	0.21454
6.9	0.00647	0.00393	0.00395	0.00798	0.03455	0.10282	0.1977	0.21864
6.99	0.00641	0.00441	0.00321	0.00893	0.03801	0.10801	0.20227	0.22251
7.08	0.00641	0.00497	0.00305	0.01025	0.04214	0.11359	0.20698	0.22668
7.18	0.00681	0.00559	0.00382	0.01125	0.04735	0.11981	0.21204	0.23165
7.27	0.00789	0.00625	0.00546	0.01178	0.05313	0.12629	0.21734	0.23703
7.36	0.00944	0.00689	0.00713	0.01198	0.05957	0.13321	0.22274	0.24203
7.45	0.01056	0.00762	0.00836	0.01199	0.06691	0.14037	0.22807	0.24675
7.54	0.01088	0.00801	0.00905	0.01177	0.07454	0.14717	0.23274	0.25112
7.64	0.01086	0.00819	0.00967	0.01212	0.08187	0.15404	0.23702	0.25529
7.73	0.0107	0.00855	0.01061	0.01267	0.08905	0.1608	0.24131	0.25957
7.82	0.0105	0.00931	0.01155	0.01278	0.09634	0.16771	0.24577	0.26411
7.91	0.01022	0.00978	0.01157	0.01235	0.10318	0.17432	0.25027	0.26838
8	0.00963	0.0096	0.01078	0.01173	0.10911	0.18009	0.25435	0.27189
8.1	0.0082	0.00874	0.00964	0.01067	0.11457	0.18553	0.25774	0.27514
8.19	0.00667	0.0079	0.00861	0.00999	0.12034	0.19055	0.26105	0.27872
8.28	0.00582	0.00749	0.00806	0.01069	0.12629	0.19552	0.26448	0.28256
8.37	0.00504	0.00706	0.00788	0.01141	0.13171	0.20057	0.26791	0.28573
8.46	0.00442	0.00626	0.008	0.01099	0.13702	0.20548	0.27154	0.2883
8.56	0.005	0.00566	0.00853	0.01093	0.14305	0.21087	0.27537	0.2911
8.65	0.00642	0.00531	0.00953	0.01169	0.14981	0.21629	0.27938	0.29436
8.74	0.00802	0.00506	0.01104	0.01261	0.15692	0.22139	0.28339	0.29778
8.83	0.00926	0.00508	0.01269	0.01382	0.16473	0.22681	0.28743	0.30166
8.92	0.01022	0.00535	0.01391	0.01522	0.1728	0.23209	0.29148	0.30541
9.02	0.01108	0.0054	0.0144	0.0166	0.18053	0.23723	0.29528	0.30882
9.11	0.01198	0.00495	0.01457	0.01785	0.18747	0.24215	0.29904	0.31206
9.2	0.01327	0.00431	0.01459	0.01922	0.194	0.24696	0.30286	0.31569
9.29	0.0149	0.00443	0.01479	0.02095	0.20052	0.25222	0.30664	0.31977
9.38	0.01613	0.0054	0.01547	0.02222	0.20728	0.25766	0.31091	0.32392
9.48	0.01662	0.00615	0.01632	0.02325	0.21404	0.2632	0.31514	0.32764
9.57	0.01615	0.00662	0.01711	0.02432	0.22033	0.26865	0.31926	0.33107

9.66	0.01536	0.00692	0.01771	0.02438	0.22597	0.27327	0.32301	0.3343
9.75	0.01505	0.00787	0.01859	0.02471	0.23162	0.27805	0.32703	0.33796
9.84	0.01445	0.00886	0.02008	0.02526	0.23741	0.28324	0.33115	0.34167
9.94	0.01325	0.0095	0.02086	0.02539	0.24334	0.28822	0.33484	0.34484
10.03	0.01187	0.01021	0.02076	0.02532	0.24913	0.29278	0.3383	0.34783
10.12	0.01062	0.0113	0.02064	0.02565	0.25506	0.29682	0.34205	0.35126
10.21	0.00947	0.0123	0.0208	0.02665	0.26084	0.30086	0.34572	0.35497
10.3	0.00919	0.01347	0.02098	0.0282	0.26618	0.30523	0.34898	0.3589
10.4	0.01055	0.01541	0.02139	0.03045	0.27162	0.31025	0.35196	0.36313
10.49	0.0124	0.01725	0.02188	0.03346	0.27692	0.31602	0.35525	0.36731
10.58	0.0141	0.01835	0.02263	0.03659	0.28214	0.32179	0.35862	0.37107
10.67	0.0158	0.01912	0.02314	0.04015	0.28733	0.32696	0.36211	0.37456
10.76	0.01725	0.01995	0.02423	0.04465	0.29254	0.33192	0.36594	0.37868
10.86	0.01841	0.02045	0.02656	0.05023	0.29841	0.33659	0.36991	0.38295
10.95	0.01952	0.0205	0.02907	0.05649	0.30438	0.34122	0.37377	0.38659
11.04	0.02102	0.02068	0.0307	0.06336	0.30975	0.34619	0.37751	0.39
11.13	0.0223	0.02064	0.03183	0.07049	0.31501	0.35119	0.38174	0.39338
11.22	0.02281	0.02039	0.03312	0.07774	0.32055	0.35578	0.38615	0.39618
11.32	0.02313	0.02105	0.03461	0.08551	0.32636	0.35971	0.39035	0.39874
11.41	0.02307	0.02209	0.03581	0.09348	0.33167	0.36319	0.39407	0.40125
11.5	0.02244	0.02307	0.03722	0.10178	0.33642	0.36679	0.39732	0.40389
11.59	0.02268	0.02474	0.03959	0.11099	0.34131	0.37071	0.40063	0.40666
11.68	0.02427	0.02754	0.04273	0.1212	0.3466	0.37526	0.40418	0.40981
11.78	0.02638	0.03062	0.04656	0.13219	0.35244	0.38025	0.40758	0.41354
11.87	0.02809	0.03294	0.05109	0.14313	0.35886	0.38494	0.41096	0.41757
11.96	0.02935	0.03496	0.05639	0.15439	0.36509	0.38887	0.41404	0.4214
12.05	0.03037	0.03686	0.06254	0.16583	0.37064	0.39247	0.41689	0.42501
12.14	0.03128	0.03877	0.06989	0.17747	0.37581	0.39666	0.42008	0.42828
12.24	0.03262	0.04107	0.07849	0.18996	0.38069	0.4015	0.42383	0.43161
12.33	0.0351	0.04409	0.08829	0.20309	0.38597	0.40664	0.42788	0.43514
12.42	0.03796	0.04712	0.09888	0.21581	0.39151	0.4115	0.43182	0.4385
12.51	0.03977	0.04937	0.10951	0.22769	0.39656	0.41581	0.43538	0.44122
12.6	0.04091	0.05218	0.12125	0.23942	0.40138	0.41984	0.43909	0.44326
12.7	0.04243	0.05683	0.13439	0.25187	0.40618	0.42366	0.44267	0.44479
12.79	0.0449	0.06297	0.14884	0.26477	0.41116	0.42812	0.44607	0.44658
12.88	0.04798	0.06981	0.16411	0.27769	0.41598	0.43317	0.44928	0.44941
12.97	0.05172	0.07754	0.17968	0.29082	0.42084	0.43805	0.45253	0.453
13.06	0.05561	0.08652	0.19541	0.30393	0.4262	0.44224	0.45612	0.45691
13.16	0.05963	0.09734	0.2113	0.31632	0.43169	0.44603	0.45993	0.46081
13.25	0.06401	0.11008	0.22726	0.32827	0.43705	0.45011	0.4636	0.46436
13.34	0.06913	0.1246	0.24389	0.34021	0.44219	0.45447	0.46716	0.46795

13.43	0.0744	0.13962	0.2604	0.35109	0.44671	0.45893	0.47029	0.47187
13.52	0.07939	0.15499	0.27682	0.36079	0.45076	0.46372	0.47347	0.47633
13.62	0.08481	0.1716	0.29244	0.37	0.45482	0.46827	0.47696	0.48075
13.71	0.09098	0.1893	0.30692	0.37926	0.45939	0.47241	0.48074	0.48441
13.8	0.098	0.2075	0.32072	0.38858	0.46437	0.4764	0.48451	0.48795
13.89	0.10607	0.22638	0.33461	0.39801	0.46967	0.4809	0.48805	0.49168
13.98	0.11453	0.24523	0.34826	0.40738	0.47454	0.4854	0.49099	0.49532
14.08	0.12335	0.26394	0.36137	0.41664	0.47873	0.48931	0.49371	0.49879
14.17	0.13405	0.28346	0.37436	0.42615	0.48339	0.4934	0.497	0.50233
14.26	0.14807	0.30385	0.38698	0.43646	0.48893	0.49768	0.50088	0.50598
14.35	0.16566	0.32409	0.39919	0.4473	0.49482	0.50145	0.50464	0.50899
14.44	0.18665	0.34412	0.41162	0.4578	0.50028	0.50535	0.50806	0.5122
14.54	0.21091	0.36438	0.42455	0.4683	0.50505	0.50966	0.51148	0.51623
14.63	0.23871	0.38483	0.43786	0.47914	0.50974	0.51431	0.51494	0.52042
14.72	0.27047	0.40503	0.45121	0.48988	0.51464	0.51858	0.5179	0.52371
14.81	0.30616	0.4248	0.46487	0.50069	0.52021	0.52278	0.52089	0.52623
14.9	0.3456	0.44425	0.47858	0.5115	0.52662	0.52725	0.52422	0.52895
15	0.38781	0.46354	0.49207	0.52227	0.53297	0.53174	0.5281	0.53213
15.09	0.43203	0.48271	0.5054	0.5334	0.53848	0.53659	0.53204	0.53536
15.18	0.47742	0.50213	0.51855	0.5449	0.54361	0.54189	0.53586	0.53911
15.27	0.52229	0.52157	0.53161	0.55685	0.54869	0.54718	0.53982	0.54271
15.36	0.56638	0.54119	0.54498	0.56882	0.55438	0.55245	0.54412	0.546
15.46	0.6093	0.56057	0.55867	0.58037	0.56021	0.55759	0.54825	0.54903
15.55	0.65038	0.58011	0.57248	0.59157	0.5658	0.56288	0.55236	0.55237
15.64	0.68935	0.59986	0.58607	0.60302	0.57128	0.56842	0.55661	0.55639
15.73	0.72538	0.61974	0.60001	0.61542	0.57687	0.57437	0.56127	0.56064
15.82	0.75821	0.63925	0.61449	0.62849	0.58278	0.58026	0.56559	0.56494
15.92	0.78774	0.65852	0.6298	0.64165	0.58919	0.58577	0.56976	0.56958
16.01	0.81405	0.6774	0.6457	0.65481	0.59579	0.59102	0.57431	0.57404
16.1	0.83771	0.69605	0.66169	0.66771	0.60293	0.59625	0.57904	0.57881
16.19	0.8586	0.714	0.67708	0.68058	0.61015	0.6017	0.58313	0.58354
16.28	0.87649	0.73096	0.69174	0.69348	0.61721	0.60746	0.58682	0.58806
16.38	0.89171	0.7466	0.70621	0.70645	0.62435	0.61311	0.59114	0.59264
16.47	0.90496	0.76175	0.72111	0.71951	0.63158	0.61875	0.59649	0.59754
16.56	0.91648	0.77654	0.73577	0.73189	0.63851	0.62432	0.60199	0.6026
16.65	0.92623	0.79076	0.74926	0.74339	0.64483	0.63009	0.60704	0.60746
16.74	0.93419	0.80429	0.76167	0.75453	0.65094	0.63604	0.61183	0.61216
16.84	0.94057	0.81714	0.7736	0.76517	0.65747	0.64228	0.61681	0.6172
16.93	0.94571	0.82884	0.78505	0.77554	0.66427	0.64879	0.62194	0.62207
17.02	0.94994	0.83961	0.79606	0.78571	0.6714	0.65524	0.62741	0.62656
17.11	0.95375	0.84986	0.80691	0.79563	0.67881	0.66151	0.6334	0.63139

17.2	0.95738	0.86009	0.81737	0.80531	0.68615	0.66819	0.63932	0.63659
17.3	0.96034	0.86975	0.82715	0.81457	0.69335	0.67538	0.64482	0.64206
17.39	0.96313	0.87847	0.83621	0.82347	0.70065	0.68259	0.65043	0.64774
17.48	0.96593	0.88612	0.84476	0.83196	0.70791	0.68986	0.65634	0.65353
17.57	0.96869	0.89284	0.85278	0.83992	0.71532	0.69708	0.66227	0.65912
17.66	0.97135	0.8988	0.86004	0.84756	0.72241	0.70401	0.66807	0.66427
17.76	0.97364	0.90423	0.86648	0.85501	0.72894	0.71046	0.67384	0.6691
17.85	0.97578	0.90926	0.87234	0.8625	0.73483	0.71656	0.67977	0.67449
17.94	0.97761	0.91387	0.8774	0.86942	0.74031	0.7224	0.68552	0.68009
18.03	0.97911	0.9178	0.8817	0.87555	0.74589	0.72786	0.69095	0.68558
18.12	0.98068	0.92099	0.88529	0.88128	0.75129	0.7332	0.69608	0.69084
18.22	0.98223	0.92365	0.88883	0.88704	0.75654	0.73852	0.70097	0.69581
18.31	0.98366	0.92635	0.89294	0.89285	0.76226	0.74375	0.70613	0.70075
18.4	0.98483	0.92925	0.89694	0.89838	0.76771	0.74884	0.71162	0.70591
18.49	0.98595	0.93204	0.90064	0.90374	0.77277	0.75386	0.71695	0.71131
18.58	0.98723	0.93434	0.90425	0.9088	0.77785	0.75887	0.72204	0.71685
18.68	0.98807	0.93616	0.90742	0.91285	0.78277	0.76372	0.72662	0.72158
18.77	0.98874	0.93783	0.91032	0.91663	0.78753	0.76851	0.73103	0.72547
18.86	0.98938	0.93952	0.91339	0.92077	0.79193	0.77327	0.73606	0.7294
18.95	0.98992	0.94135	0.91664	0.9252	0.79642	0.77787	0.74157	0.73368
19.04	0.98998	0.94303	0.91936	0.929	0.80069	0.78207	0.7465	0.73801
19.14	0.98992	0.94455	0.92143	0.93245	0.80446	0.78573	0.75061	0.74208
19.23	0.9902	0.94586	0.92342	0.93616	0.80829	0.78941	0.75457	0.74592
19.32	0.99048	0.94713	0.92534	0.93987	0.8121	0.79323	0.75839	0.74971
19.41	0.99055	0.94853	0.92705	0.94301	0.81535	0.79696	0.76215	0.75349
19.5	0.99119	0.95014	0.92909	0.94614	0.81848	0.80095	0.76626	0.75743
19.6	0.9922	0.95203	0.93187	0.94951	0.82183	0.80495	0.7703	0.76149
19.69	0.99296	0.95359	0.93459	0.95269	0.82527	0.80834	0.77321	0.76532
19.78	0.99352	0.955	0.93692	0.95529	0.82842	0.81095	0.77551	0.7687
19.87	0.99422	0.95647	0.93918	0.95792	0.83152	0.81369	0.77825	0.77207
19.96	0.99487	0.95793	0.94113	0.96091	0.83443	0.81694	0.78137	0.77568
20.06	0.99528	0.95935	0.94258	0.96386	0.83676	0.81998	0.7844	0.77913
20.15	0.99564	0.96071	0.94386	0.96645	0.83883	0.82254	0.78736	0.78245
20.24	0.99596	0.96193	0.94507	0.96925	0.84118	0.82482	0.78986	0.78555
20.33	0.99602	0.96301	0.94612	0.97239	0.84376	0.82702	0.79203	0.78853
20.42	0.99609	0.96395	0.94694	0.97539	0.84617	0.82934	0.79438	0.7917
20.52	0.99611	0.96491	0.94753	0.97792	0.84826	0.83199	0.79712	0.79479
20.61	0.99587	0.96561	0.94789	0.98022	0.84992	0.83475	0.79975	0.79787
20.7	0.99581	0.96613	0.94813	0.98263	0.85124	0.83723	0.80206	0.80041
20.79	0.99584	0.96653	0.94851	0.98437	0.85242	0.83907	0.80403	0.80241
20.88	0.99574	0.9668	0.94904	0.98561	0.85411	0.84054	0.80581	0.80438

20.98	0.99564	0.96712	0.94967	0.98671	0.85625	0.84223	0.80767	0.80632
21.07	0.99581	0.96762	0.95065	0.9879	0.8584	0.84419	0.80983	0.80835
21.16	0.99632	0.96812	0.95202	0.98937	0.86052	0.84614	0.81232	0.81083
21.25	0.99661	0.96839	0.95322	0.9908	0.86253	0.84806	0.8146	0.81333
21.34	0.99684	0.96849	0.95429	0.99231	0.86435	0.85002	0.81662	0.81569
21.44	0.99733	0.96894	0.95545	0.9939	0.86655	0.85204	0.81864	0.81815
21.53	0.9977	0.96972	0.95657	0.99519	0.86894	0.85396	0.82075	0.82093
21.62	0.99778	0.97012	0.95728	0.99651	0.87114	0.85605	0.82293	0.82344
21.71	0.99788	0.97033	0.9582	0.99785	0.873	0.85852	0.82492	0.82554
21.8	0.99807	0.97071	0.95945	0.99942	0.87465	0.86096	0.82676	0.82752
21.9	0.99814	0.97125	0.96055	1.00083	0.87601	0.86315	0.82848	0.82952
21.99	0.99783	0.97174	0.9611	1.00168	0.87709	0.86487	0.82983	0.83134
22.08	0.9975	0.972	0.96118	1.00254	0.87794	0.86637	0.83115	0.83309
22.17	0.99739	0.97237	0.96131	1.00388	0.87928	0.86808	0.83296	0.83501
22.26	0.99734	0.97299	0.96178	1.00549	0.88086	0.86982	0.83495	0.83694
22.36	0.99731	0.97376	0.9624	1.00699	0.88247	0.87181	0.83679	0.8387
22.45	0.99743	0.97484	0.96353	1.0084	0.88436	0.8737	0.8388	0.84082
22.54	0.99776	0.97607	0.96463	1.00995	0.88608	0.87539	0.84095	0.84314
22.63	0.99825	0.97691	0.96543	1.01164	0.8877	0.87711	0.84294	0.84555
22.72	0.99862	0.97743	0.96619	1.0131	0.88965	0.87886	0.84468	0.84778
22.82	0.99888	0.97783	0.9669	1.01419	0.89173	0.88042	0.84624	0.84937
22.91	0.99902	0.97833	0.96761	1.01539	0.89369	0.88161	0.84764	0.85035
23	0.99901	0.97884	0.96805	1.01614	0.89494	0.88239	0.84883	0.85118
23.09	0.99885	0.9789	0.9681	1.01599	0.89567	0.88325	0.84982	0.85212
23.18	0.99877	0.97858	0.96827	1.01573	0.89645	0.88402	0.8507	0.85318
23.28	0.99893	0.97831	0.96851	1.01603	0.89734	0.885	0.85144	0.85426
23.37	0.99892	0.97801	0.96883	1.01663	0.89851	0.88618	0.85259	0.85549
23.46	0.99841	0.97757	0.96891	1.01694	0.89961	0.88713	0.85396	0.85626
23.55	0.99786	0.97734	0.96886	1.01732	0.90041	0.88782	0.85548	0.8568
23.64	0.99777	0.97746	0.96913	1.01811	0.90122	0.88874	0.85734	0.85794
23.74	0.99809	0.97781	0.96989	1.01887	0.90229	0.89006	0.85923	0.86015
23.83	0.99862	0.97824	0.97106	1.0199	0.90392	0.89193	0.86098	0.86279
23.92	0.99925	0.97879	0.97237	1.02141	0.90591	0.89406	0.8625	0.86491
24.01	0.99969	0.97924	0.97336	1.02296	0.90746	0.89616	0.8641	0.86656
24.1	0.99964	0.97936	0.97359	1.02369	0.90843	0.89748	0.8657	0.86784
24.2	0.99936	0.97942	0.97362	1.02355	0.90919	0.89795	0.86667	0.86883
24.29	0.99936	0.98001	0.97393	1.02348	0.91014	0.89846	0.8674	0.8703
24.38	0.99959	0.98065	0.9744	1.0239	0.91116	0.89962	0.86835	0.87204
24.47	0.99986	0.98103	0.97493	1.02442	0.91224	0.90122	0.8693	0.87354
24.56	0.99981	0.98092	0.97502	1.02454	0.91325	0.90248	0.87014	0.8743
24.66	0.99956	0.98038	0.97489	1.0246	0.9137	0.90293	0.87091	0.87454

24.75	0.99928	0.97981	0.97491	1.02483	0.91397	0.90311	0.87198	0.87489
24.84	0.99926	0.97972	0.97539	1.02557	0.91477	0.90341	0.87326	0.87562
24.93	0.99974	0.98017	0.97644	1.02696	0.91617	0.90438	0.87457	0.87665
25.02	1.00037	0.98062	0.97718	1.02847	0.91756	0.90591	0.8758	0.87776
25.12	1.00094	0.9808	0.97774	1.02958	0.9186	0.90734	0.87714	0.87876
25.21	1.00139	0.98105	0.97843	1.03034	0.91951	0.90841	0.87853	0.87998
25.3	1.00137	0.98136	0.97884	1.03082	0.92017	0.90908	0.87947	0.8811
25.39	1.00133	0.98198	0.97932	1.03111	0.92067	0.91002	0.88026	0.88204
25.48	1.00135	0.98282	0.97972	1.03148	0.9215	0.91137	0.88131	0.88308
25.58	1.00124	0.98333	0.97986	1.03186	0.92244	0.91256	0.88228	0.88401
25.67	1.00091	0.98348	0.98006	1.03175	0.9233	0.91345	0.88304	0.88496
25.76	1.00039	0.98327	0.98024	1.03127	0.92362	0.914	0.88361	0.88608
25.85	0.99994	0.98288	0.98038	1.0307	0.92362	0.91422	0.88428	0.88718
25.94	0.9994	0.98236	0.98033	1.03036	0.92365	0.9144	0.88511	0.88819
26.04	0.99897	0.98162	0.97992	1.02997	0.92379	0.91462	0.88576	0.88858
26.13	0.99891	0.98107	0.97958	1.03001	0.92423	0.91514	0.88672	0.88898
26.22	0.99892	0.98072	0.97958	1.03068	0.92499	0.91563	0.88791	0.88959
26.31	0.99892	0.98035	0.97983	1.03128	0.92576	0.91592	0.88864	0.89031
26.4	0.99889	0.98017	0.98008	1.03144	0.92607	0.91605	0.8889	0.89114
26.5	0.99869	0.97986	0.97969	1.03155	0.92576	0.91602	0.88891	0.89163
26.59	0.99847	0.97966	0.97909	1.03159	0.92564	0.91609	0.88917	0.89179
26.68	0.99836	0.9799	0.97899	1.03205	0.92602	0.91673	0.88991	0.89189
26.77	0.99823	0.98021	0.97927	1.03267	0.92678	0.91773	0.89059	0.89205
26.86	0.99795	0.98049	0.97981	1.03317	0.92771	0.91883	0.89108	0.89264
26.96	0.99757	0.98073	0.98047	1.03341	0.92856	0.9196	0.8916	0.89346
27.05	0.99722	0.98091	0.98097	1.03355	0.92918	0.92033	0.89235	0.89459
27.14	0.99734	0.98163	0.98168	1.03392	0.92986	0.92138	0.89356	0.89597
27.23	0.99779	0.9824	0.9823	1.03464	0.93071	0.92265	0.89485	0.89717
27.32	0.99833	0.98293	0.98273	1.03532	0.9317	0.92388	0.89583	0.89804
27.42	0.99866	0.98316	0.98298	1.03588	0.93277	0.9251	0.89676	0.89891
27.51	0.99856	0.98302	0.98302	1.03618	0.93366	0.92602	0.89777	0.90005
27.6	0.99872	0.98303	0.98304	1.03644	0.93429	0.92696	0.89873	0.90119
27.69	0.99921	0.98317	0.98294	1.03692	0.93484	0.9277	0.89961	0.90223
27.78	0.99967	0.98326	0.98293	1.03736	0.93532	0.92832	0.90035	0.90321
27.88	1.0001	0.9834	0.98269	1.03752	0.93574	0.92887	0.9008	0.90369
27.97	1.00015	0.98328	0.98194	1.03741	0.93608	0.9292	0.90109	0.90365
28.06	1	0.98325	0.98145	1.03754	0.93664	0.92984	0.90184	0.90372
28.15	0.99992	0.98363	0.98162	1.0382	0.93747	0.931	0.90314	0.90448
28.24	1.00011	0.98426	0.98236	1.03914	0.93854	0.93227	0.9042	0.90576
28.34	1.00078	0.98498	0.98339	1.04031	0.94	0.93354	0.90493	0.90748
28.43	1.00104	0.98538	0.98409	1.04114	0.94121	0.93424	0.90549	0.90906

28.52	1.00095	0.98562	0.9845	1.04142	0.9421	0.93476	0.90634	0.91019
28.61	1.00082	0.98572	0.98453	1.04172	0.94284	0.93558	0.90721	0.91102
28.7	1.00063	0.98579	0.98473	1.0421	0.94384	0.9366	0.90825	0.91216
28.8	1.00044	0.98595	0.98525	1.04227	0.94487	0.93773	0.90939	0.91359
28.89	1.0004	0.98602	0.9857	1.04213	0.94561	0.93853	0.91031	0.91505
28.98	1.00057	0.98612	0.98605	1.04168	0.94637	0.93892	0.91094	0.91616
29.07	1.00071	0.9861	0.98592	1.04092	0.94684	0.93905	0.91133	0.9168
29.16	1.00068	0.98607	0.98548	1.03971	0.94714	0.93929	0.91158	0.91708
29.26	1.00062	0.98586	0.98509	1.03849	0.9477	0.93984	0.91175	0.91696
29.35	1.0007	0.98555	0.98517	1.03797	0.94843	0.94034	0.91172	0.91693
29.44	1.00101	0.98541	0.9856	1.03752	0.9489	0.94046	0.9119	0.91719
29.53	1.0014	0.98545	0.98618	1.03737	0.94919	0.94037	0.91247	0.91773
29.62	1.00159	0.98553	0.98659	1.03755	0.94967	0.94031	0.91295	0.91809
29.72	1.00155	0.9856	0.98678	1.03781	0.95003	0.94057	0.91317	0.91823
29.81	1.00132	0.98539	0.98666	1.03796	0.94982	0.94093	0.91348	0.91822
29.9	1.00117	0.98508	0.98662	1.03811	0.94961	0.94127	0.91412	0.9182
29.99	1.00107	0.98469	0.98676	1.03854	0.94949	0.94142	0.91487	0.91811
30.08	1.00124	0.98473	0.98726	1.03943	0.94952	0.9416	0.91587	0.91855
30.18	1.00136	0.98506	0.98757	1.04009	0.94973	0.94204	0.91702	0.91936
30.27	1.00107	0.98517	0.98733	1.04057	0.95023	0.94245	0.91765	0.91983
30.36	1.00063	0.98489	0.98665	1.0406	0.95067	0.94279	0.91755	0.91989
30.45	1.00029	0.98418	0.98591	1.04011	0.95072	0.94283	0.91743	0.91981
30.54	0.99988	0.98338	0.9852	1.03924	0.95085	0.94242	0.91764	0.91958
30.64	0.99952	0.98292	0.98475	1.03854	0.95159	0.94223	0.91812	0.91971
30.73	0.99932	0.98276	0.98486	1.03844	0.95251	0.9428	0.91867	0.9203
30.82	0.99934	0.9829	0.98509	1.03847	0.95309	0.9435	0.91927	0.92099
30.91	0.99984	0.98332	0.98508	1.03856	0.95355	0.94415	0.92017	0.9219
31	1.00047	0.98374	0.9852	1.03915	0.95416	0.94515	0.9212	0.92294
31.1	1.0013	0.98432	0.98602	1.04008	0.95503	0.94664	0.92247	0.92442
31.19	1.00224	0.9851	0.98719	1.04111	0.95615	0.94827	0.92401	0.92609
31.28	1.00299	0.98615	0.98818	1.04247	0.95736	0.94977	0.92536	0.92768
31.37	1.00378	0.98713	0.989	1.04386	0.95846	0.95097	0.92634	0.92916
31.46	1.00432	0.98772	0.9896	1.04462	0.95922	0.95182	0.92671	0.93024
31.56	1.00463	0.98823	0.99007	1.04473	0.95976	0.95226	0.92699	0.93102
31.65	1.00437	0.98841	0.99027	1.04467	0.9601	0.95258	0.92717	0.93144
31.74	1.00349	0.98799	0.99014	1.04428	0.96023	0.95255	0.92686	0.9312
31.83	1.00248	0.98754	0.98965	1.04336	0.96018	0.95198	0.92639	0.93052
31.92	1.00145	0.98723	0.98897	1.04226	0.95999	0.95136	0.92616	0.92993
32.02	1.00057	0.98686	0.98827	1.04154	0.95952	0.95107	0.92589	0.92953
32.11	0.99991	0.98632	0.98776	1.04073	0.95906	0.95091	0.92531	0.92916
32.2	0.99933	0.98578	0.98765	1.03962	0.95878	0.95101	0.92485	0.92875

32.29	0.99894	0.98536	0.98774	1.03873	0.95852	0.95125	0.9251	0.92848
32.38	0.99867	0.98514	0.98771	1.03842	0.95838	0.95137	0.92548	0.9284
32.48	0.99888	0.98545	0.9877	1.03848	0.95865	0.95164	0.9259	0.92877
32.57	0.99922	0.98588	0.98768	1.0385	0.95914	0.95222	0.9262	0.9295
32.66	0.99979	0.9863	0.98797	1.03867	0.95968	0.95311	0.92653	0.93053
32.75	1.00047	0.98647	0.98826	1.03886	0.96006	0.95383	0.92683	0.93161
32.84	1.0008	0.98639	0.98827	1.03873	0.96029	0.95406	0.92704	0.93247
32.94	1.0009	0.9862	0.98807	1.03861	0.96033	0.95435	0.92746	0.93316
33.03	1.00089	0.98611	0.98777	1.03881	0.96058	0.95489	0.92801	0.93422
33.12	1.00083	0.98655	0.9875	1.03923	0.96115	0.95542	0.92828	0.93544
33.21	1.00073	0.98708	0.98717	1.03939	0.96161	0.9559	0.92827	0.93641
33.3	1.0005	0.98728	0.98709	1.03945	0.96222	0.95646	0.9282	0.93707
33.4	1.00023	0.98755	0.9874	1.03953	0.96303	0.95714	0.92856	0.93778
33.49	0.99972	0.98766	0.98762	1.03924	0.96356	0.95744	0.92904	0.9383
33.58	0.99899	0.98746	0.98767	1.03867	0.96398	0.95741	0.92929	0.9382
33.67	0.99851	0.98775	0.98806	1.03824	0.96449	0.95759	0.92968	0.93816
33.76	0.99829	0.98855	0.98896	1.03819	0.96513	0.95798	0.93043	0.9385
33.86	0.99823	0.98943	0.9898	1.03841	0.96559	0.95845	0.93117	0.93882
33.95	0.99847	0.98991	0.99055	1.03854	0.96594	0.95929	0.932	0.93925
34.04	0.9987	0.98998	0.99115	1.03873	0.96628	0.95996	0.93298	0.93964
34.13	0.99904	0.9898	0.99152	1.03918	0.96625	0.96012	0.93399	0.93983
34.22	0.99958	0.98964	0.99188	1.0398	0.96596	0.96	0.9352	0.9398
34.32	1.00007	0.98975	0.99217	1.04046	0.96581	0.96009	0.93634	0.94001
34.41	1.00059	0.99017	0.99235	1.04103	0.96579	0.96051	0.9372	0.94058
34.5	1.00082	0.99033	0.99239	1.04106	0.96592	0.96098	0.93772	0.94098
34.59	1.00078	0.99027	0.9923	1.04049	0.96606	0.96126	0.93785	0.94124
34.68	1.00089	0.99032	0.99246	1.03989	0.96625	0.96137	0.93795	0.94158
34.78	1.00082	0.99026	0.9924	1.03955	0.96632	0.96121	0.938	0.94185
34.87	1.00049	0.99021	0.99207	1.03927	0.96636	0.96139	0.93817	0.94201
34.96	0.99984	0.99017	0.99163	1.03861	0.96634	0.96188	0.93838	0.94222
35.05	0.99916	0.99015	0.99127	1.03775	0.96623	0.96248	0.93828	0.94252
35.14	0.99877	0.99019	0.99126	1.03709	0.96644	0.96321	0.93836	0.94276
35.24	0.99855	0.99048	0.99186	1.03682	0.96692	0.96414	0.93902	0.94312
35.33	0.99836	0.99043	0.99243	1.03673	0.96722	0.96464	0.9396	0.94351
35.42	0.99829	0.99001	0.99282	1.03687	0.96739	0.9649	0.94015	0.94401
35.51	0.99809	0.98945	0.99281	1.03738	0.96752	0.96519	0.94095	0.9442
35.6	0.99788	0.98929	0.99276	1.03813	0.96785	0.96529	0.94178	0.94425
35.7	0.998	0.98946	0.9931	1.03873	0.96852	0.96521	0.94232	0.9447
35.79	0.9985	0.98971	0.99363	1.039	0.96922	0.96521	0.94249	0.94537
35.88	0.99888	0.98983	0.99403	1.03895	0.96979	0.9653	0.94252	0.94585
35.97	0.99884	0.98967	0.99406	1.03878	0.97009	0.96526	0.94247	0.94608

36.06	0.99864	0.98944	0.99369	1.03852	0.97021	0.96515	0.94217	0.94613
36.16	0.99872	0.98977	0.99343	1.03849	0.97052	0.96533	0.94226	0.94603
36.25	0.99892	0.99035	0.99309	1.03838	0.9709	0.96569	0.94264	0.94579
36.34	0.99882	0.99067	0.99287	1.0379	0.97131	0.96584	0.94263	0.94593
36.43	0.99862	0.99067	0.99312	1.03732	0.97176	0.96619	0.94256	0.9461
36.52	0.99859	0.99078	0.99347	1.03678	0.97222	0.96702	0.9428	0.94616
36.62	0.9987	0.99119	0.9935	1.03649	0.97272	0.96807	0.94335	0.94605
36.71	0.99893	0.99177	0.99334	1.0365	0.97321	0.96904	0.94387	0.94593
36.8	0.99929	0.99215	0.99314	1.03637	0.97343	0.96962	0.94392	0.94578
36.89	0.99956	0.99234	0.99291	1.03617	0.97366	0.96966	0.94399	0.94572
36.98	0.99963	0.99256	0.99272	1.03622	0.97413	0.96959	0.94431	0.94587
37.08	0.99983	0.99307	0.9928	1.0367	0.97498	0.96982	0.9448	0.9463
37.17	1.00021	0.99383	0.99301	1.03742	0.97593	0.97049	0.94549	0.94679
37.26	1.00064	0.99453	0.99299	1.03792	0.97648	0.97103	0.94598	0.94737

Table B.9 Fickian model for Sadighian et al.[5], (athabasca bitumen + pentane) considering constant density

Elevation (mm)	66 min	337 min	1853 min	3108 min
0	0	0	0	0
0.102472527	-5.56E-05	2.32E-05	0.000921188	0.001950779
0.204945055	-0.000111843	4.67E-05	0.001843091	0.00390206
0.307417582	-0.000169698	7.06E-05	0.002767051	0.00585478
0.40989011	-0.000229587	9.53E-05	0.003693782	0.00780944
0.512362637	-0.000291874	0.000120827	0.004624157	0.009766649
0.614835165	-0.000356719	0.000147524	0.005559048	0.011727015
0.717307692	-0.000424051	0.000175564	0.006499325	0.013691143
0.81978022	-0.000493552	0.000205157	0.00744586	0.01565964
0.922252747	-0.000564644	0.000236504	0.008399524	0.017633109
1.024725275	-0.0006365	0.000269806	0.009361189	0.01961215
1.127197802	-0.000708053	0.000305257	0.010331725	0.021597363
1.22967033	-0.000778026	0.000343045	0.011312002	0.023589346
1.332142857	-0.000844964	0.000383354	0.01230289	0.025588691
1.434615385	-0.000907281	0.00042636	0.01330526	0.02759599
1.537087912	-0.000963307	0.000472235	0.01431998	0.029611831
1.63956044	-0.001011344	0.000521141	0.015347919	0.0316368
1.742032967	-0.001049723	0.000573236	0.016389945	0.033671476
1.844505495	-0.001076864	0.000628671	0.017446925	0.035716437
1.946978022	-0.001091324	0.000687589	0.018519725	0.037772256
2.049450549	-0.001091856	0.000750127	0.019609212	0.039839503

2.151923077	-0.001077443	0.000816414	0.020716249	0.041918742
2.254395604	-0.001047342	0.000886575	0.0218417	0.044010532
2.356868132	-0.0010011	0.000960725	0.022986427	0.046115428
2.459340659	-0.000938573	0.001038975	0.02415129	0.04823398
2.561813187	-0.000859927	0.001121431	0.025337148	0.050366731
2.664285714	-0.000765623	0.001208191	0.026544857	0.052514221
2.766758242	-0.000656401	0.001299351	0.027775274	0.054676981
2.869230769	-0.000533245	0.001395002	0.029029251	0.056855539
2.971703297	-0.00039734	0.001495229	0.030307638	0.059050415
3.074175824	-0.000250027	0.001600118	0.031611283	0.061262122
3.176648352	-9.27E-05	0.001709751	0.032941032	0.063491168
3.279120879	7.30E-05	0.00182421	0.034297725	0.065738052
3.381593407	0.000245781	0.001943577	0.035682202	0.068003267
3.484065934	0.000424147	0.002067935	0.037095297	0.070287299
3.586538462	0.000606815	0.002197371	0.038537842	0.072590627
3.689010989	0.000792648	0.002331973	0.040010663	0.074913719
3.791483516	0.000980696	0.002471838	0.041514583	0.077257039
3.893956044	0.001170224	0.002617068	0.043050419	0.079621041
3.996428571	0.001360719	0.002767775	0.044618983	0.082006169
4.098901099	0.001551895	0.002924081	0.046221081	0.084412861
4.201373626	0.001743681	0.003086121	0.047857516	0.086841546
4.303846154	0.0019362	0.003254044	0.04952908	0.089292642
4.406318681	0.002129741	0.003428017	0.051236563	0.09176656
4.508791209	0.002324721	0.003608226	0.052980745	0.0942637
4.611263736	0.002521644	0.003794879	0.054762398	0.096784454
4.713736264	0.002721057	0.003988207	0.056582289	0.099329202
4.816208791	0.002923503	0.004188471	0.058441175	0.101898317
4.918681319	0.003129479	0.004395962	0.060339804	0.10449216
5.021153846	0.003339399	0.004611001	0.062278914	0.107111082
5.123626374	0.003553561	0.004833951	0.064259235	0.109755424
5.226098901	0.003772122	0.005065211	0.066281487	0.112425515
5.328571429	0.003995085	0.005305226	0.068346376	0.115121676
5.431043956	0.004222289	0.005554488	0.070454602	0.117844214
5.533516484	0.004453422	0.005813543	0.072606848	0.120593427
5.635989011	0.004688029	0.00608299	0.074803788	0.123369601
5.738461538	0.004925533	0.00636349	0.077046084	0.126173011
5.840934066	0.005165273	0.006655768	0.07933438	0.129003919
5.943406593	0.005406529	0.006960621	0.081669312	0.131862578
6.045879121	0.005648567	0.007278919	0.084051498	0.134749226
6.148351648	0.005890673	0.007611611	0.086481542	0.137664091
6.250824176	0.00613219	0.007959734	0.088960033	0.14060739

6.353296703	0.006372556	0.008324412	0.091487542	0.143579324
6.455769231	0.006611328	0.008706869	0.094064627	0.146580086
6.558241758	0.006848201	0.009108427	0.096691825	0.149609853
6.660714286	0.007083029	0.009530519	0.099369659	0.152668793
6.763186813	0.007315823	0.009974691	0.102098629	0.155757057
6.865659341	0.007546753	0.010442609	0.104879221	0.158874786
6.968131868	0.007776135	0.010936062	0.107711899	0.162022109
7.070604396	0.008004417	0.011456977	0.110597107	0.16519914
7.173076923	0.008232156	0.012007413	0.113535268	0.168405981
7.275549451	0.008459996	0.012589578	0.116526787	0.171642719
7.378021978	0.00868864	0.013205829	0.119572043	0.174909431
7.480494505	0.008918832	0.013858678	0.122671397	0.178206178
7.582967033	0.00915133	0.014550802	0.125825182	0.181533009
7.68543956	0.009386896	0.015285042	0.129033714	0.18488996
7.787912088	0.00962628	0.016064415	0.13229728	0.188277052
7.890384615	0.00987022	0.016892114	0.135616145	0.191694294
7.992857143	0.010119442	0.017771516	0.138990549	0.19514168
8.09532967	0.010374674	0.018706183	0.142420706	0.198619191
8.197802198	0.010636655	0.019699868	0.145906805	0.202126796
8.300274725	0.010906162	0.020756517	0.149449008	0.205664449
8.402747253	0.011184026	0.021880271	0.153047451	0.209232089
8.50521978	0.011471165	0.023075469	0.156702241	0.212829644
8.607692308	0.011768603	0.024346646	0.16041346	0.216457026
8.710164835	0.012077497	0.025698536	0.164181159	0.220114136
8.812637363	0.012399154	0.027136068	0.168005363	0.223800858
8.91510989	0.012735056	0.028664366	0.171886067	0.227517065
9.017582418	0.013086866	0.030288746	0.175823236	0.231262615
9.120054945	0.013456439	0.032014708	0.179816808	0.235037355
9.222527473	0.01384583	0.033847934	0.183866688	0.238841114
9.325	0.014257289	0.035794279	0.187972753	0.242673711
9.427472527	0.014693269	0.037859762	0.192134849	0.24653495
9.529945055	0.01515642	0.040050558	0.196352791	0.250424624
9.632417582	0.015649591	0.042372983	0.200626362	0.254342508
9.73489011	0.016175837	0.044833485	0.204955316	0.258288369
9.837362637	0.016738427	0.047438625	0.209339375	0.262261957
9.939835165	0.017340861	0.050195064	0.213778229	0.266263011
10.04230769	0.017986897	0.053109543	0.218271535	0.270291256
10.14478022	0.018680584	0.056188864	0.222818922	0.274346404
10.24725275	0.019426314	0.05943987	0.227419983	0.278428155
10.34972527	0.020228878	0.062869417	0.232074283	0.282536195
10.4521978	0.02109354	0.066484356	0.236781351	0.2866702

10.55467033	0.022026121	0.070291502	0.241540687	0.290829831
10.65714286	0.023033096	0.074297611	0.24635176	0.295014738
10.75961538	0.024121708	0.078509345	0.251214003	0.299224557
10.86208791	0.025300087	0.082933248	0.256126823	0.303458915
10.96456044	0.026577386	0.087575711	0.261089589	0.307717424
11.06703297	0.027963923	0.092442939	0.266101645	0.311999687
11.16950549	0.029471339	0.097540921	0.271162299	0.316305294
11.27197802	0.031112751	0.102875393	0.276270831	0.320633822
11.37445055	0.032902923	0.108451805	0.281426488	0.324984841
11.47692308	0.03485843	0.114275285	0.286628488	0.329357907
11.5793956	0.036997824	0.120350604	0.291876018	0.333752564
11.68186813	0.039341795	0.126682143	0.297168236	0.338168349
11.78434066	0.041913318	0.133273853	0.30250427	0.342604786
11.88681319	0.044737782	0.140129228	0.307883219	0.347061388
11.98928571	0.047843099	0.147251265	0.313304154	0.351537662
12.09175824	0.051259773	0.154642435	0.318766117	0.3560331
12.19423077	0.05502093	0.162304648	0.324268122	0.360547189
12.2967033	0.059162294	0.170239231	0.329809158	0.365079403
12.39917582	0.063722103	0.178446888	0.335388184	0.36962921
12.50164835	0.068740951	0.186927687	0.341004137	0.374196066
12.60412088	0.074261544	0.195681024	0.346655925	0.378779421
12.70659341	0.080328376	0.204705611	0.352342434	0.383378715
12.80906593	0.086987295	0.213999452	0.358062523	0.387993381
12.91153846	0.094284984	0.223559829	0.363815031	0.392622844
13.01401099	0.102268324	0.233383288	0.369598772	0.39726652
13.11648352	0.110983673	0.243465632	0.375412539	0.401923819
13.21895604	0.120476039	0.253801911	0.381255103	0.406594144
13.32142857	0.130788181	0.264386426	0.387125215	0.411276891
13.4239011	0.141959634	0.275212722	0.393021608	0.415971449
13.52637363	0.154025698	0.286273599	0.398942994	0.420677201
13.62884615	0.16701639	0.29756112	0.404888067	0.425393524
13.73131868	0.180955405	0.309066622	0.410855507	0.43011979
13.83379121	0.195859114	0.320780732	0.416843974	0.434855365
13.93626374	0.211735616	0.332693392	0.422852117	0.439599611
14.03873626	0.2285839	0.344793878	0.428878567	0.444351883
14.14120879	0.24639312	0.35707083	0.434921943	0.449111534
14.24368132	0.265142045	0.369512285	0.440980853	0.453877911
14.34615385	0.284798682	0.382105711	0.447053893	0.458650359
14.44862637	0.305320114	0.394838045	0.453139647	0.463428218
14.5510989	0.326652559	0.407695735	0.459236691	0.468210825
14.65357143	0.348731667	0.420664783	0.465343594	0.472997514

14.75604396	0.37148305	0.433730796	0.471458916	0.477787618
14.85851648	0.394823048	0.446879032	0.47758121	0.482580466
14.96098901	0.418659718	0.460094452	0.483709025	0.487375384
15.06346154	0.442894016	0.473361774	0.489840908	0.4921717
15.16593407	0.467421155	0.486665527	0.495975398	0.496968738
15.26840659	0.492132108	0.499990109	0.502111036	0.50176582
15.37087912	0.51691521	0.513319841	0.50824636	0.506562271
15.47335165	0.541657817	0.526639027	0.514379909	0.511357412
15.57582418	0.56624799	0.539932007	0.520510223	0.516150565
15.6782967	0.590576153	0.55318322	0.526635844	0.520941054
15.78076923	0.614536679	0.566377255	0.532755316	0.525728201
15.88324176	0.638029376	0.579498908	0.538867191	0.530511331
15.98571429	0.660960825	0.592533238	0.544970021	0.535289768
16.08818681	0.683245547	0.605465617	0.55106237	0.540062839
16.19065934	0.704806983	0.618281782	0.557142804	0.544829874
16.29313187	0.725578247	0.630967882	0.563209903	0.549590201
16.3956044	0.74550267	0.643510525	0.569262251	0.554343155
16.49807692	0.76453411	0.655896822	0.575298445	0.559088071
16.60054945	0.782637045	0.668114424	0.581317095	0.563824288
16.70302198	0.799786457	0.680151561	0.587316821	0.568551148
16.80549451	0.815967515	0.691997074	0.593296258	0.573267996
16.90796703	0.83117509	0.703640448	0.599254052	0.577974183
17.01043956	0.845413123	0.715071836	0.605188869	0.582669061
17.11291209	0.85869386	0.72628208	0.611099388	0.587351989
17.21538462	0.871037003	0.737262734	0.616984306	0.59202233
17.31785714	0.882468789	0.748006076	0.622842338	0.596679452
17.42032967	0.893021036	0.758505119	0.628672216	0.601322728
17.5228022	0.90273017	0.768753621	0.634472694	0.605951537
17.62527473	0.911636272	0.778746085	0.640242546	0.610565264
17.72774725	0.919782159	0.788477762	0.645980565	0.615163299
17.83021978	0.927212506	0.797944646	0.651685568	0.61974504
17.93269231	0.933973048	0.807143466	0.657356394	0.624309889
18.03516484	0.94010985	0.816071678	0.662991906	0.628857258
18.13763736	0.945668664	0.824727447	0.668590989	0.633386564
18.24010989	0.950694376	0.833109636	0.674152555	0.637897232
18.34258242	0.955230537	0.841217783	0.679675539	0.642388694
18.44505495	0.959318989	0.849052081	0.685158903	0.646860391
18.54752747	0.962999571	0.856613351	0.690601637	0.651311771
18.65	0.966309897	0.863903019	0.696002755	0.655742289
18.75247253	0.969285219	0.870923087	0.7013613	0.660151411
18.85494505	0.971958341	0.8776761	0.706676343	0.66453861

18.95741758	0.974359591	0.88416512	0.711946983	0.668903369
19.05989011	0.976516842	0.89039369	0.717172347	0.673245177
19.16236264	0.978455569	0.896365803	0.722351593	0.677563536
19.26483516	0.980198939	0.902085867	0.727483906	0.681857954
19.36730769	0.981767916	0.90755867	0.732568504	0.686127952
19.46978022	0.983181393	0.912789347	0.737604632	0.690373057
19.57225275	0.984456329	0.917783346	0.742591567	0.694592808
19.67472527	0.985607891	0.922546391	0.747528616	0.698786753
19.7771978	0.986649602	0.927084452	0.752415117	0.702954452
19.87967033	0.987593486	0.931403709	0.75725044	0.707095472
19.98214286	0.988450206	0.935510519	0.762033983	0.711209393
20.08461538	0.989229201	0.939411388	0.766765178	0.715295804
20.18708791	0.989938814	0.943112937	0.771443487	0.719354306
20.28956044	0.990586408	0.946621875	0.776068403	0.723384509
20.39203297	0.991178482	0.949944968	0.780639451	0.727386036
20.49450549	0.991720768	0.953089015	0.785156187	0.731358517
20.59697802	0.992218324	0.956060821	0.789618198	0.735301598
20.69945055	0.99267562	0.958867176	0.794025101	0.739214932
20.80192308	0.993096609	0.961514829	0.798376547	0.743098185
20.9043956	0.993484796	0.964010469	0.802672214	0.746951034
21.00686813	0.993843295	0.966360705	0.806911813	0.750773167
21.10934066	0.99417488	0.968572051	0.811095085	0.754564283
21.21181319	0.99448203	0.970650907	0.815221801	0.758324093
21.31428571	0.994766966	0.972603549	0.819291762	0.762052318
21.41675824	0.995031687	0.974436108	0.823304798	0.765748693
21.51923077	0.995277993	0.976154569	0.82726077	0.769412961
21.6217033	0.995507513	0.977764754	0.831159568	0.773044879
21.72417582	0.995721723	0.979272317	0.835001108	0.776644214
21.82664835	0.995921963	0.980682735	0.838785337	0.780210746
21.92912088	0.996109453	0.982001304	0.84251223	0.783744264
22.03159341	0.996285303	0.983233134	0.846181788	0.787244571
22.13406593	0.996450528	0.984383146	0.84979404	0.79071148
22.23653846	0.996606051	0.985456069	0.853349042	0.794144814
22.33901099	0.996752719	0.98645644	0.856846875	0.797544411
22.44148352	0.996891305	0.987388605	0.860287648	0.800910117
22.54395604	0.99702252	0.988256716	0.863671491	0.804241791
22.64642857	0.997147012	0.989064735	0.866998564	0.807539301
22.7489011	0.997265383	0.989816439	0.870269048	0.81080253
22.85137363	0.997378184	0.990515418	0.873483148	0.814031367
22.95384615	0.997485928	0.99116508	0.876641092	0.817225717
23.05631868	0.997589088	0.991768658	0.879743131	0.820385493

23.15879121	0.997688108	0.99232921	0.882789537	0.823510619
23.26126374	0.9977834	0.992849629	0.885780606	0.82660103
23.36373626	0.997875353	0.993332644	0.888716651	0.829656673
23.46620879	0.997964326	0.993780827	0.891598007	0.832677504
23.56868132	0.998050658	0.994196598	0.894425028	0.835663489
23.67115385	0.998134664	0.994582233	0.897198089	0.838614607
23.77362637	0.99816631	0.994939868	0.899917579	0.841530844
23.8760989	0.998296821	0.995271506	0.902583909	0.844412199
23.97857143	0.998375466	0.995579023	0.905197504	0.847258679
24.08104396	0.998452766	0.995864172	0.907758806	0.850070301
24.18351648	0.998528881	0.996128593	0.910268274	0.852847093
24.28598901	0.998603933	0.996373817	0.91272638	0.855589092
24.38846154	0.998677994	0.996601268	0.915133612	0.858296345
24.49093407	0.99875109	0.996812278	0.91749047	0.860968906
24.59340659	0.99882319	0.997008082	0.919797469	0.863606842
24.69587912	0.998894206	0.997189831	0.922055136	0.866210226
24.79835165	0.998963994	0.997358594	0.924264008	0.868779141
24.90082418	0.999032346	0.997515365	0.926424636	0.87131368
25.0032967	0.999099	0.997661064	0.928537578	0.873813941
25.10576923	0.999163637	0.997796548	0.930603406	0.876280034
25.20824176	0.999225886	0.997922608	0.932622698	0.878712077
25.31071429	0.999285337	0.998039979	0.934596041	0.881110193
25.41318681	0.999341544	0.998149343	0.936524033	0.883474517
25.51565934	0.999394039	0.998251329	0.938407275	0.885805189
25.61813187	0.999442348	0.998346523	0.940246378	0.888102357
25.7206044	0.999486	0.998435464	0.942041958	0.890366177
25.82307692	0.999524548	0.998518654	0.943794636	0.892596813
25.92554945	0.999557584	0.998596556	0.94550504	0.894794434
26.02802198	0.999584754	0.998669602	0.947173801	0.896959218
26.13049451	0.999605779	0.998738188	0.948801553	0.899091348
26.23296703	0.999620465	0.998802683	0.950388936	0.901191015
26.33543956	0.999628718	0.998863429	0.951936591	0.903258415
26.43791209	0.999630556	0.998920743	0.953445161	0.905293751
26.54038462	0.999626121	0.998974918	0.954915293	0.907297231
26.64285714	0.999615674	0.999026226	0.956347633	0.909269071
26.74532967	0.999599609	0.999074918	0.957742828	0.91120949
26.8478022	0.999578441	0.99912123	0.959101527	0.913118715
26.95027473	0.999552804	0.999165376	0.960424376	0.914996975
27.05274725	0.99952344	0.999207558	0.961712025	0.916844506
27.15521978	0.999491188	0.999247961	0.962965118	0.91866155
27.25769231	0.999456961	0.999286756	0.9641843	0.920448351

27.36016484	0.999421732	0.999324102	0.965370215	0.92220516
27.46263736	0.999386511	0.999360144	0.966523502	0.92393223
27.56510989	0.99935232	0.999395018	0.9676448	0.92562982
27.66758242	0.999320168	0.999428846	0.968734744	0.927298193
27.77005495	0.999291032	0.999461741	0.969793964	0.928937613
27.87252747	0.999265828	0.999493806	0.970823089	0.93054835
27.975	0.999245393	0.999525136	0.971822743	0.932130678
28.07747253	0.999230465	0.999555813	0.972793544	0.933684873
28.17994505	0.999221666	0.999585914	0.973736108	0.935211213
28.28241758	0.999219491	0.999615507	0.974651043	0.93670998
28.38489011	0.999224295	0.99964465	0.975538954	0.93818146
28.48736264	0.999236292	0.999673396	0.976400441	0.939625939
28.58983516	0.999255549	0.999701789	0.977236095	0.941043706
28.69230769	0.999281995	0.999729865	0.978046504	0.942435054
28.79478022	0.999315419	0.999757656	0.978832249	0.943800276
28.89725275	0.999355488	0.999785184	0.979593904	0.945139667
28.99972527	0.999401755	0.999812468	0.980332036	0.946453525
29.1021978	0.999453675	0.999839517	0.981047206	0.947742147
29.20467033	0.999510621	0.999866339	0.981739969	0.949005834
29.30714286	0.999571904	0.999892932	0.98241087	0.950244887
29.40961538	0.999636794	0.999919291	0.983060449	0.951459607
29.51208791	0.999704532	0.999945406	0.983689237	0.952650298
29.61456044	0.999774357	0.999971262	0.984297759	0.953817263
29.71703297	0.999845517	0.999996839	0.984886531	0.954960806
29.81950549	0.999917289	1.000022114	0.985456062	0.956081232
29.92197802	0.999988994	1.000047059	0.986006852	0.957178845
30.02445055	1.000060006	1.000071643	0.986539395	0.95825395
30.12692308	1.000129766	1.000095833	0.987054174	0.959306853
30.2293956	1.000197792	1.000119592	0.987551666	0.960337857
30.33186813	1.000263677	1.00014288	0.98803234	0.961347267
30.43434066	1.000327102	1.000165657	0.988496655	0.962335387
30.53681319	1.00038783	1.00018788	0.988945064	0.963302521
30.63928571	1.000445705	1.000209504	0.98937801	0.96424897
30.74175824	1.000500654	1.000230484	0.989795928	0.965175037
30.84423077	1.000552673	1.000250775	0.990199245	0.966081022
30.9467033	1.000601823	1.000270329	0.99058838	0.966967226
31.04917582	1.00064822	1.0002891	0.990963742	0.967833947
31.15164835	1.00069202	1.000307043	0.991325734	0.968681482
31.25412088	1.000733409	1.000324112	0.99167475	0.969510127
31.35659341	1.000772587	1.000340263	0.992011175	0.970320177
31.45906593	1.000809754	1.000355453	0.992335386	0.971111924

31.56153846	1.000845095	1.000369641	0.992647753	0.97188566
31.66401099	1.000878766	1.000382787	0.992948636	0.972641674
31.76648352	1.000910881	1.000394854	0.993238388	0.973380252
31.86895604	1.000941501	1.000405807	0.993517354	0.974101681
31.97142857	1.000970626	1.000415614	0.993785871	0.974806244
32.0739011	1.000998189	1.000424246	0.994044268	0.975494222
32.17637363	1.001024053	1.000431676	0.994292867	0.976165893
32.27884615	1.001048012	1.000437881	0.994531981	0.976821534
32.38131868	1.001069797	1.000442842	0.994761915	0.977461419
32.48379121	1.001089083	1.000446543	0.994982969	0.97808582
32.58626374	1.001105501	1.000448971	0.995195433	0.978695005
32.68873626	1.001118652	1.000450117	0.99539959	0.97928924
32.79120879	1.001128123	1.000449976	0.995595717	0.979868789
32.89368132	1.001133506	1.000448548	0.995784083	0.980433914
32.99615385	1.001134416	1.000445834	0.99596495	0.98098487
33.09862637	1.00113051	1.000441842	0.996138572	0.981521914
33.2010989	1.0011215	1.000436582	0.996305198	0.982045298
33.30357143	1.001107173	1.000430068	0.99646507	0.98255527
33.40604396	1.0010874	1.000422318	0.996618421	0.983052075
33.50851648	1.001062145	1.000413354	0.99676548	0.983535958
33.61098901	1.00103147	1.0004032	0.996906468	0.984007156
33.71346154	1.000995536	1.000391886	0.997041601	0.984465907
33.81593407	1.0009546	1.000379444	0.997171089	0.984912442
33.91840659	1.000909011	1.000365907	0.997295133	0.985346992
34.02087912	1.000859195	1.000351316	0.997413931	0.985769783
34.12335165	1.000805648	1.000335709	0.997527674	0.986181038
34.22582418	1.000748917	1.000319132	0.997636547	0.986580975
34.3282967	1.000689587	1.00030163	0.997740731	0.98696981
34.43076923	1.000628264	1.000283251	0.997840399	0.987347756
34.53324176	1.000565557	1.000264046	0.997935719	0.987715022
34.63571429	1.000502061	1.000244066	0.998026856	0.988071812
34.73818681	1.000438347	1.000223366	0.998113968	0.988418327
34.84065934	1.000374941	1.000202	0.998197207	0.988754767
34.94313187	1.000312319	1.000180025	0.998276722	0.989081324
35.0456044	1.000250897	1.000157497	0.998352656	0.989398189
35.14807692	1.000191021	1.000134476	0.998425147	0.98970555
35.25054945	1.000132965	1.000111018	0.99849433	0.990003588
35.35302198	1.000076929	1.000087182	0.998560334	0.990292482
35.45549451	1.000023041	1.000063028	0.998623283	0.99057241
35.55796703	0.999971357	1.000038613	0.998683298	0.990843541
35.66043956	0.99992187	1.000013995	0.998740496	0.991106044

35.76291209	0.999874514	0.999989233	0.998794988	0.991360083
35.86538462	0.999829175	0.999964382	0.998846882	0.991605818
35.96785714	0.9997857	0.999939498	0.998896283	0.991843405
36.07032967	0.999743908	0.999914637	0.998943291	0.992072997
36.1728022	0.999703605	0.999889852	0.998988002	0.992294741
36.27527473	0.999664592	0.999865194	0.99903051	0.992508784
36.37774725	0.999626681	0.999840716	0.999070902	0.992715264
36.48021978	0.999589703	0.999816465	0.999109266	0.992914321
36.58269231	0.999553522	0.99979249	0.999145684	0.993106085
36.68516484	0.999518041	0.999768836	0.999180234	0.993290687
36.78763736	0.999483208	0.999745547	0.999212993	0.993468251
36.89010989	0.999449024	0.999722665	0.999244032	0.993638899
36.99258242	0.999415542	0.999700229	0.999273422	0.993802747
37.09505495	0.999382865	0.999678279	0.999301229	0.99395991
37.19752747	0.999351147	0.999656849	0.999327516	0.994110497
37.3	0.99932058	0.999635975	0.999352344	0.994254613

Table B.10 Fickian model for Sadighian et al.[5], (athabasca bitumen + pentane) considering density variations

Elevation (mm)	66 min	337 min	1853 min	3108 min
0	0	0	0	0
0.102472527	2.31E-05	2.31E-05	0.000770645	0.001573276
0.204945055	4.63E-05	4.63E-05	0.001542244	0.003148545
0.307417582	7.01E-05	7.01E-05	0.00231586	0.004726533
0.40989011	9.46E-05	9.46E-05	0.003092064	0.006307631
0.512362637	0.000120024	0.000120024	0.003871553	0.007892314
0.614835165	0.000146557	0.000146557	0.004655022	0.00948106
0.717307692	0.000174432	0.000174432	0.005443171	0.011074348
0.81978022	0.000203855	0.000203855	0.006236697	0.012672656
0.922252747	0.000235031	0.000235031	0.007036302	0.014276463
1.024725275	0.000268158	0.000268158	0.007842688	0.01588625
1.127197802	0.00030343	0.00030343	0.008656556	0.017502496
1.22967033	0.000341035	0.000341035	0.00947861	0.019125682
1.332142857	0.000381156	0.000381156	0.010309556	0.020756288
1.434615385	0.000423969	0.000423969	0.011150098	0.022394793
1.537087912	0.000469644	0.000469644	0.012000944	0.024041677
1.63956044	0.000518345	0.000518345	0.0128628	0.025697418
1.742032967	0.000570227	0.000570227	0.013736377	0.027362493
1.844505495	0.000625441	0.000625441	0.014622382	0.02903738

1.946978022	0.00068413	0.00068413	0.015521526	0.030722554
2.049450549	0.000746428	0.000746428	0.01643452	0.032418489
2.151923077	0.000812466	0.000812466	0.017362075	0.034125657
2.254395604	0.000882365	0.000882365	0.018304904	0.035844529
2.356868132	0.000956239	0.000956239	0.019263718	0.037575574
2.459340659	0.0010342	0.0010342	0.020239231	0.039319259
2.561813187	0.001116349	0.001116349	0.021232157	0.041076048
2.664285714	0.001202785	0.001202785	0.02224321	0.042846404
2.766758242	0.001293599	0.001293599	0.023273103	0.044630786
2.869230769	0.00138888	0.00138888	0.02432255	0.046429651
2.971703297	0.001488712	0.001488712	0.025392266	0.048243454
3.074175824	0.001593176	0.001593176	0.026482965	0.050072644
3.176648352	0.001702351	0.001702351	0.027595361	0.05191767
3.279120879	0.001816313	0.001816313	0.028730166	0.053778976
3.381593407	0.00193514	0.00193514	0.029888094	0.055657002
3.484065934	0.002058909	0.002058909	0.031069858	0.057552187
3.586538462	0.002187699	0.002187699	0.032276168	0.059464961
3.689010989	0.002321593	0.002321593	0.033507736	0.061395756
3.791483516	0.002460676	0.002460676	0.034765271	0.063344995
3.893956044	0.002605043	0.002605043	0.036049481	0.065313099
3.996428571	0.002754793	0.002754793	0.037361072	0.067300483
4.098901099	0.002910034	0.002910034	0.038700751	0.06930756
4.201373626	0.003070888	0.003070888	0.040069219	0.071334735
4.303846154	0.003237487	0.003237487	0.041467179	0.073382409
4.406318681	0.003409979	0.003409979	0.042895328	0.07545098
4.508791209	0.003588528	0.003588528	0.044354364	0.077540836
4.611263736	0.003773318	0.003773318	0.045844979	0.079652365
4.713736264	0.003964554	0.003964554	0.047367863	0.081785945
4.816208791	0.004162466	0.004162466	0.048923705	0.083941951
4.918681319	0.004367309	0.004367309	0.050513186	0.08612075
5.021153846	0.004579368	0.004579368	0.052136988	0.088322705
5.123626374	0.004798961	0.004798961	0.053795785	0.09054817
5.226098901	0.00502644	0.00502644	0.055490248	0.092797496
5.328571429	0.005262197	0.005262197	0.057221044	0.095071024
5.431043956	0.005506662	0.005506662	0.058988834	0.097369091
5.533516484	0.005760315	0.005760315	0.060794274	0.099692026
5.635989011	0.006023682	0.006023682	0.062638013	0.102040151
5.738461538	0.006297341	0.006297341	0.064520697	0.104413781
5.840934066	0.006581927	0.006581927	0.066442961	0.106813223
5.943406593	0.006878135	0.006878135	0.068405438	0.109238778
6.045879121	0.007186724	0.007186724	0.070408751	0.111690739

6.148351648	0.007508523	0.007508523	0.072453516	0.11416939
6.250824176	0.007844432	0.007844432	0.074540341	0.116675009
6.353296703	0.008195429	0.008195429	0.076669826	0.119207864
6.455769231	0.008562575	0.008562575	0.078842562	0.121768216
6.558241758	0.008947016	0.008947016	0.081059132	0.124356319
6.660714286	0.009349992	0.009349992	0.083320108	0.126972415
6.763186813	0.009772837	0.009772837	0.085626052	0.129616742
6.865659341	0.010216987	0.010216987	0.087977516	0.132289526
6.968131868	0.010683985	0.010683985	0.090375043	0.134990984
7.070604396	0.011175484	0.011175484	0.092819161	0.137721327
7.173076923	0.011693253	0.011693253	0.09531039	0.140480754
7.275549451	0.012239185	0.012239185	0.097849234	0.143269456
7.378021978	0.012815295	0.012815295	0.100436189	0.146087614
7.480494505	0.013423731	0.013423731	0.103071734	0.148935401
7.582967033	0.014066776	0.014066776	0.105756335	0.151812979
7.68543956	0.014746853	0.014746853	0.108490446	0.154720501
7.787912088	0.01546653	0.01546653	0.111274506	0.157658109
7.890384615	0.016228522	0.016228522	0.114108936	0.160625937
7.992857143	0.017035697	0.017035697	0.116994145	0.163624107
8.09532967	0.017891079	0.017891079	0.119930525	0.166652732
8.197802198	0.018797851	0.018797851	0.12291845	0.169711914
8.300274725	0.019759357	0.019759357	0.12595828	0.172801744
8.402747253	0.020779106	0.020779106	0.129050354	0.175922306
8.50521978	0.021860772	0.021860772	0.132194996	0.179073668
8.607692308	0.023008197	0.023008197	0.135392511	0.182255892
8.710164835	0.02422539	0.02422539	0.138643184	0.185469026
8.812637363	0.02551653	0.02551653	0.141947281	0.188713109
8.91510989	0.026885959	0.026885959	0.145305048	0.191988167
9.017582418	0.028338191	0.028338191	0.148716712	0.195294217
9.120054945	0.029877897	0.029877897	0.152182477	0.198631264
9.222527473	0.031509915	0.031509915	0.155702527	0.201999302
9.325	0.033239235	0.033239235	0.159277023	0.205398312
9.427472527	0.035071002	0.035071002	0.162906107	0.208828265
9.529945055	0.037010507	0.037010507	0.166589893	0.21228912
9.632417582	0.039063178	0.039063178	0.170328476	0.215780826
9.73489011	0.041234578	0.041234578	0.174121927	0.219303318
9.837362637	0.043530392	0.043530392	0.177970289	0.222856521
9.939835165	0.045956416	0.045956416	0.181873586	0.226440346
10.04230769	0.04851855	0.04851855	0.185831813	0.230054695
10.14478022	0.051222783	0.051222783	0.189844942	0.233699456
10.24725275	0.054075181	0.054075181	0.193912917	0.237374505

10.34972527	0.057081871	0.057081871	0.198035657	0.241079708
10.4521978	0.060249027	0.060249027	0.202213055	0.244814918
10.55467033	0.063582851	0.063582851	0.206444976	0.248579975
10.65714286	0.067089561	0.067089561	0.210731259	0.252374707
10.75961538	0.070775362	0.070775362	0.215071714	0.256198931
10.86208791	0.074646435	0.074646435	0.219466123	0.260052452
10.96456044	0.078708911	0.078708911	0.223914241	0.263935061
11.06703297	0.082968853	0.082968853	0.228415794	0.267846539
11.16950549	0.087432225	0.087432225	0.232970478	0.271786653
11.27197802	0.092104877	0.092104877	0.237577961	0.27575516
11.37445055	0.096992513	0.096992513	0.242237883	0.279751802
11.47692308	0.10210067	0.10210067	0.24694985	0.283776312
11.5793956	0.107434688	0.107434688	0.251713444	0.287828408
11.68186813	0.112999684	0.112999684	0.256528212	0.291907798
11.78434066	0.118800524	0.118800524	0.261393675	0.296014177
11.88681319	0.124841796	0.124841796	0.26630932	0.300147229
11.98928571	0.131127777	0.131127777	0.271274607	0.304306623
12.09175824	0.13766241	0.13766241	0.276288964	0.308492021
12.19423077	0.144449269	0.144449269	0.281351788	0.312703069
12.2967033	0.151491535	0.151491535	0.286462447	0.316939403
12.39917582	0.158791963	0.158791963	0.291620277	0.321200647
12.50164835	0.166352854	0.166352854	0.296824585	0.325486412
12.60412088	0.174176028	0.174176028	0.302074646	0.329796301
12.70659341	0.182262796	0.182262796	0.307369707	0.334129902
12.80906593	0.190613932	0.190613932	0.312708982	0.338486793
12.91153846	0.199229646	0.199229646	0.318091657	0.342866541
13.01401099	0.208109563	0.208109563	0.323516888	0.347268701
13.11648352	0.217252695	0.217252695	0.328983799	0.351692818
13.21895604	0.226657421	0.226657421	0.334491488	0.356138425
13.32142857	0.236321469	0.236321469	0.340039021	0.360605046
13.4239011	0.246241893	0.246241893	0.345625437	0.365092191
13.52637363	0.256415062	0.256415062	0.351249745	0.369599364
13.62884615	0.266836641	0.266836641	0.356910927	0.374126055
13.73131868	0.277501585	0.277501585	0.362607937	0.378671745
13.83379121	0.288404129	0.288404129	0.368339701	0.383235907
13.93626374	0.299537783	0.299537783	0.374105118	0.387818
14.03873626	0.310895328	0.310895328	0.379903062	0.392417478
14.14120879	0.322468821	0.322468821	0.38573238	0.397033782
14.24368132	0.334249599	0.334249599	0.391591895	0.401666345
14.34615385	0.346228286	0.346228286	0.397480403	0.406314593
14.44862637	0.358394809	0.358394809	0.403396678	0.410977939

14.5510989	0.370738412	0.370738412	0.40933947	0.415655791
14.65357143	0.383247677	0.383247677	0.415307506	0.420347547
14.75604396	0.39591055	0.39591055	0.421299492	0.425052597
14.85851648	0.40871437	0.40871437	0.427314113	0.429770324
14.96098901	0.4216459	0.4216459	0.433350032	0.434500102
15.06346154	0.434691365	0.434691365	0.439405894	0.439241299
15.16593407	0.447836494	0.447836494	0.445480324	0.443993274
15.26840659	0.461066561	0.461066561	0.451571931	0.448755381
15.37087912	0.474366439	0.474366439	0.457679306	0.453526968
15.47335165	0.487720645	0.487720645	0.463801024	0.458307373
15.57582418	0.501113399	0.501113399	0.469935646	0.463095932
15.6782967	0.514528679	0.514528679	0.476081717	0.467891974
15.78076923	0.52795028	0.52795028	0.482237773	0.472694821
15.88324176	0.541361881	0.541361881	0.488402333	0.477503791
15.98571429	0.554747102	0.554747102	0.49457391	0.482318199
16.08818681	0.568089572	0.568089572	0.500751005	0.487137352
16.19065934	0.581372994	0.581372994	0.506932109	0.491960555
16.29313187	0.594581209	0.594581209	0.51311571	0.49678711
16.3956044	0.607698266	0.607698266	0.519300284	0.501616312
16.49807692	0.62070848	0.62070848	0.525484308	0.506447457
16.60054945	0.633596503	0.633596503	0.531666249	0.511279835
16.70302198	0.64634738	0.64634738	0.537844576	0.516112734
16.80549451	0.658946611	0.658946611	0.544017754	0.520945441
16.90796703	0.671380209	0.671380209	0.550184248	0.525777241
17.01043956	0.683634751	0.683634751	0.556342525	0.530607416
17.11291209	0.695697432	0.695697432	0.562491054	0.535435247
17.21538462	0.70755611	0.70755611	0.568628305	0.540260017
17.31785714	0.719199347	0.719199347	0.574752755	0.545081005
17.42032967	0.73061645	0.73061645	0.580862886	0.549897492
17.5228022	0.741797501	0.741797501	0.586957188	0.554708758
17.62527473	0.752733385	0.752733385	0.593034157	0.559514084
17.72774725	0.763415817	0.763415817	0.599092302	0.564312753
17.83021978	0.773837355	0.773837355	0.605130139	0.569104048
17.93269231	0.783991416	0.783991416	0.6111462	0.573887254
18.03516484	0.79387228	0.79387228	0.617139025	0.578661659
18.13763736	0.803475095	0.803475095	0.623107173	0.583426552
18.24010989	0.812795872	0.812795872	0.629049217	0.588181225
18.34258242	0.82183148	0.82183148	0.634963746	0.592924974
18.44505495	0.830579628	0.830579628	0.640849367	0.597657098
18.54752747	0.839038852	0.839038852	0.646704707	0.6023769
18.65	0.847208495	0.847208495	0.652528411	0.607083685

18.75247253	0.855088675	0.855088675	0.658319148	0.611776767
18.85494505	0.862680265	0.862680265	0.664075606	0.616455461
18.95741758	0.869984853	0.869984853	0.669796499	0.621119089
19.05989011	0.877004712	0.877004712	0.675480564	0.625766978
19.16236264	0.883742761	0.883742761	0.681126562	0.63039846
19.26483516	0.890202527	0.890202527	0.686733281	0.635012875
19.36730769	0.8963881	0.8963881	0.692299538	0.639609569
19.46978022	0.902304096	0.902304096	0.697824174	0.644187894
19.57225275	0.90795561	0.90795561	0.703306062	0.648747211
19.67472527	0.913348172	0.913348172	0.708744103	0.653286885
19.7771978	0.918487706	0.918487706	0.714137228	0.657806293
19.87967033	0.923380484	0.923380484	0.7194844	0.662304817
19.98214286	0.92803308	0.92803308	0.724784613	0.66678185
20.08461538	0.932452334	0.932452334	0.730036894	0.671236791
20.18708791	0.936645303	0.936645303	0.7352403	0.67566905
20.28956044	0.940619225	0.940619225	0.740393926	0.680078045
20.39203297	0.944381478	0.944381478	0.745496899	0.684463204
20.49450549	0.947939544	0.947939544	0.750548378	0.688823966
20.59697802	0.951300971	0.951300971	0.75554756	0.693159778
20.69945055	0.954473344	0.954473344	0.760493677	0.697470098
20.80192308	0.957464246	0.957464246	0.765385995	0.701754395
20.9043956	0.960281235	0.960281235	0.770223817	0.706012149
21.00686813	0.962931814	0.962931814	0.775006482	0.710242849
21.10934066	0.965423405	0.965423405	0.779733364	0.714445998
21.21181319	0.967763327	0.967763327	0.784403877	0.718621109
21.31428571	0.969958776	0.969958776	0.789017467	0.722767706
21.41675824	0.972016804	0.972016804	0.793573621	0.726885325
21.51923077	0.973944306	0.973944306	0.798071859	0.730973515
21.6217033	0.975748	0.975748	0.80251174	0.735031837
21.72417582	0.977434421	0.977434421	0.806892859	0.739059863
21.82664835	0.979009907	0.979009907	0.811214848	0.743057179
21.92912088	0.980480589	0.980480589	0.815477374	0.747023382
22.03159341	0.981852388	0.981852388	0.819680142	0.750958082
22.13406593	0.983131006	0.983131006	0.823822892	0.754860904
22.23653846	0.984321926	0.984321926	0.8279054	0.758731482
22.33901099	0.985430405	0.985430405	0.831927477	0.762569467
22.44148352	0.986461478	0.986461478	0.83588897	0.766374521
22.54395604	0.987419953	0.987419953	0.839789759	0.77014632
22.64642857	0.988310417	0.988310417	0.84362976	0.773884551
22.7489011	0.989137238	0.989137238	0.847408922	0.777588919
22.85137363	0.989904563	0.989904563	0.851127229	0.781259137

22.95384615	0.990616328	0.990616328	0.854784695	0.784894935
23.05631868	0.991276261	0.991276261	0.858381368	0.788496056
23.15879121	0.991887885	0.991887885	0.861917327	0.792062255
23.26126374	0.992454527	0.992454527	0.865392685	0.795593301
23.36373626	0.992979321	0.992979321	0.868807581	0.799088978
23.46620879	0.993465219	0.993465219	0.872162187	0.802549083
23.56868132	0.993914993	0.993914993	0.875456704	0.805973423
23.67115385	0.994331244	0.994331244	0.87869136	0.809361824
23.77362637	0.994716412	0.994716412	0.881866413	0.812714121
23.8760989	0.99507278	0.99507278	0.884982145	0.816030165
23.97857143	0.995402479	0.995402479	0.888038867	0.819309818
24.08104396	0.995707503	0.995707503	0.891036916	0.822552958
24.18351648	0.995989709	0.995989709	0.893976651	0.825759473
24.28598901	0.996250827	0.996250827	0.896858457	0.828929266
24.38846154	0.996492468	0.996492468	0.899682743	0.832062254
24.49093407	0.996716128	0.996716128	0.902449937	0.835158364
24.59340659	0.996923198	0.996923198	0.905160492	0.838217538
24.69587912	0.997114968	0.997114968	0.907814881	0.841239729
24.79835165	0.997292634	0.997292634	0.910413596	0.844224905
24.90082418	0.997457305	0.997457305	0.912957147	0.847173044
25.0032967	0.997610007	0.997610007	0.915446066	0.850084137
25.10576923	0.997751691	0.997751691	0.917880899	0.852958187
25.20824176	0.997883233	0.997883233	0.920262209	0.85579521
25.31071429	0.998005447	0.998005447	0.922590576	0.858595232
25.41318681	0.998119083	0.998119083	0.924866594	0.861358293
25.51565934	0.998224835	0.998224835	0.927090872	0.864084442
25.61813187	0.998323343	0.998323343	0.92926403	0.866773741
25.7206044	0.998415199	0.998415199	0.931386702	0.869426263
25.82307692	0.998500949	0.998500949	0.933459535	0.87204209
25.92554945	0.998581098	0.998581098	0.935483182	0.874621317
26.02802198	0.998656112	0.998656112	0.937458312	0.877164049
26.13049451	0.998726422	0.998726422	0.939385597	0.879670401
26.23296703	0.998792424	0.998792424	0.941265723	0.882140498
26.33543956	0.998854487	0.998854487	0.94309938	0.884574475
26.43791209	0.99891295	0.99891295	0.944887265	0.886972477
26.54038462	0.998968126	0.998968126	0.946630083	0.889334658
26.64285714	0.999020306	0.999020306	0.948328542	0.891661182
26.74532967	0.999069758	0.999069758	0.949983357	0.893952221
26.8478022	0.999116728	0.999116728	0.951595245	0.896207956
26.95027473	0.999161447	0.999161447	0.953164927	0.898428579
27.05274725	0.999204125	0.999204125	0.954693127	0.900614286

27.15521978	0.999244957	0.999244957	0.95618057	0.902765285
27.25769231	0.999284123	0.999284123	0.957627981	0.904881789
27.36016484	0.99932179	0.99932179	0.95903609	0.90696402
27.46263736	0.999358109	0.999358109	0.960405623	0.909012209
27.56510989	0.999393222	0.999393222	0.961737306	0.91102659
27.66758242	0.999427255	0.999427255	0.963031866	0.913007408
27.77005495	0.999460327	0.999460327	0.964290027	0.914954912
27.87252747	0.999492544	0.999492544	0.965512509	0.916869359
27.975	0.999524004	0.999524004	0.966700033	0.918751011
28.07747253	0.999554792	0.999554792	0.967853313	0.920600137
28.17994505	0.999584989	0.999584989	0.968973063	0.922417011
28.28241758	0.999614663	0.999614663	0.97005999	0.924201913
28.38489011	0.999643876	0.999643876	0.971114798	0.925955127
28.48736264	0.999672681	0.999672681	0.972138186	0.927676944
28.58983516	0.999701123	0.999701123	0.973130846	0.929367656
28.69230769	0.999729242	0.999729242	0.974093466	0.931027565
28.79478022	0.999757068	0.999757068	0.975026727	0.932656972
28.89725275	0.999784627	0.999784627	0.975931305	0.934256185
28.99972527	0.999811936	0.999811936	0.976807867	0.935825515
29.1021978	0.999839007	0.999839007	0.977657075	0.937365276
29.20467033	0.999865846	0.999865846	0.978479582	0.938875787
29.30714286	0.999892454	0.999892454	0.979276034	0.940357367
29.40961538	0.999918825	0.999918825	0.98004707	0.941810341
29.51208791	0.99994495	0.99994495	0.98079332	0.943235034
29.61456044	0.999970814	0.999970814	0.981515406	0.944631777
29.71703297	0.999996397	0.999996397	0.98221394	0.946000898
29.81950549	1.000021677	1.000021677	0.982889528	0.947342732
29.92197802	1.000046626	1.000046626	0.983542765	0.948657612
30.02445055	1.000071213	1.000071213	0.984174238	0.949945875
30.12692308	1.000095405	1.000095405	0.984784525	0.951207859
30.2293956	1.000119166	1.000119166	0.985374194	0.952443901
30.33186813	1.000142456	1.000142456	0.985943804	0.953654341
30.43434066	1.000165233	1.000165233	0.986493904	0.954839519
30.53681319	1.000187457	1.000187457	0.987025035	0.955999777
30.63928571	1.000209081	1.000209081	0.987537726	0.957135454
30.74175824	1.000230061	1.000230061	0.988032498	0.958246893
30.84423077	1.00025035	1.00025035	0.988509862	0.959334434
30.9467033	1.000269904	1.000269904	0.98897032	0.960398418
31.04917582	1.000288674	1.000288674	0.989414362	0.961439186
31.15164835	1.000306616	1.000306616	0.98984247	0.962457077
31.25412088	1.000323684	1.000323684	0.990255116	0.963452432

31.35659341	1.000339834	1.000339834	0.990652762	0.964425588
31.45906593	1.000355022	1.000355022	0.99103586	0.965376884
31.56153846	1.000369209	1.000369209	0.991404853	0.966306653
31.66401099	1.000382353	1.000382353	0.991760173	0.967215233
31.76648352	1.000394419	1.000394419	0.992102245	0.968102955
31.86895604	1.00040537	1.00040537	0.992431481	0.968970152
31.97142857	1.000415176	1.000415176	0.992748285	0.969817153
32.0739011	1.000423806	1.000423806	0.993053054	0.970644287
32.17637363	1.000431234	1.000431234	0.993346171	0.971451878
32.27884615	1.000437438	1.000437438	0.993628013	0.972240251
32.38131868	1.000442398	1.000442398	0.993898947	0.973009727
32.48379121	1.000446097	1.000446097	0.994159331	0.973760624
32.58626374	1.000448523	1.000448523	0.994409513	0.97449326
32.68873626	1.000449667	1.000449667	0.994649834	0.975207948
32.79120879	1.000449525	1.000449525	0.994880624	0.975904998
32.89368132	1.000448095	1.000448095	0.995102207	0.976584719
32.99615385	1.000445379	1.000445379	0.995314895	0.977247416
33.09862637	1.000441386	1.000441386	0.995518995	0.977893391
33.2010989	1.000436124	1.000436124	0.995714803	0.978522942
33.30357143	1.000429608	1.000429608	0.995902609	0.979136366
33.40604396	1.000421857	1.000421857	0.996082693	0.979733953
33.50851648	1.000412892	1.000412892	0.996255329	0.980315994
33.61098901	1.000402737	1.000402737	0.996420782	0.980882773
33.71346154	1.000391422	1.000391422	0.996579309	0.981434571
33.81593407	1.000378978	1.000378978	0.99673116	0.981971668
33.91840659	1.000365441	1.000365441	0.996876578	0.982494336
34.02087912	1.000350849	1.000350849	0.997015798	0.983002847
34.12335165	1.000335243	1.000335243	0.997149049	0.983497467
34.22582418	1.000318666	1.000318666	0.997276551	0.983978459
34.3282967	1.000301164	1.000301164	0.99739852	0.984446081
34.43076923	1.000282786	1.000282786	0.997515163	0.984900588
34.53324176	1.000263581	1.000263581	0.997626681	0.985342231
34.63571429	1.000243603	1.000243603	0.997733269	0.985771255
34.73818681	1.000222904	1.000222904	0.997835115	0.986187903
34.84065934	1.00020154	1.00020154	0.997932403	0.986592413
34.94313187	1.000179568	1.000179568	0.998025307	0.986985018
35.0456044	1.000157043	1.000157043	0.998113999	0.987365948
35.14807692	1.000134024	1.000134024	0.998198643	0.987735428
35.25054945	1.000110569	1.000110569	0.998279399	0.988093678
35.35302198	1.000086737	1.000086737	0.998356419	0.988440915
35.45549451	1.000062587	1.000062587	0.998429853	0.988777349

35.55796703	1.000038176	1.000038176	0.998499843	0.989103189
35.66043956	1.000013563	1.000013563	0.998566527	0.989418637
35.76291209	0.999988805	0.999988805	0.998630038	0.98972389
35.86538462	0.99996396	0.99996396	0.998690504	0.990019144
35.96785714	0.999939082	0.999939082	0.998748049	0.990304585
36.07032967	0.999914226	0.999914226	0.998802791	0.9905804
36.1728022	0.999889447	0.999889447	0.998854844	0.990846767
36.27527473	0.999864796	0.999864796	0.998904319	0.991103862
36.37774725	0.999840324	0.999840324	0.998951319	0.991351855
36.48021978	0.99981608	0.99981608	0.998995948	0.991590912
36.58269231	0.999792112	0.999792112	0.999038302	0.991821194
36.68516484	0.999768465	0.999768465	0.999078475	0.992042857
36.78763736	0.999745183	0.999745183	0.999116555	0.992256053
36.89010989	0.999722308	0.999722308	0.999152629	0.992460929
36.99258242	0.999699879	0.999699879	0.999186777	0.992657627
37.09505495	0.999677936	0.999677936	0.99921908	0.992846284
37.19752747	0.999656514	0.999656514	0.99924961	0.993027034
37.3	0.999635647	0.999635647	0.999278441	0.993200005

Table B.11 Fickian + sorption model for Sadighian et al.[5] (athabasca bitumen + pentane)

Elevation (mm)	66 min	337 min	1853 min	3108 min
0	0	0	0	0
0.102472527	-9.78E-06	-6.04E-06	-3.87E-06	-3.44E-06
0.204945055	5.53E-05	1.80E-05	5.96E-06	4.10E-06
0.307417582	0.000100383	3.38E-05	1.24E-05	9.03E-06
0.40989011	0.000133359	4.50E-05	1.69E-05	1.25E-05
0.512362637	0.00015631	5.26E-05	2.00E-05	1.49E-05
0.614835165	0.000170092	5.72E-05	2.19E-05	1.64E-05
0.717307692	0.000175087	5.89E-05	2.27E-05	1.70E-05
0.81978022	0.00017143	5.79E-05	2.24E-05	1.68E-05
0.922252747	0.000159079	5.41E-05	2.09E-05	1.57E-05
1.024725275	0.000137773	4.73E-05	1.84E-05	1.38E-05
1.127197802	0.000106851	3.73E-05	1.45E-05	1.09E-05
1.22967033	6.47E-05	2.32E-05	9.12E-06	6.76E-06
1.332142857	6.04E-06	3.24E-06	1.55E-06	1.03E-06
1.434615385	-0.000139579	-2.71E-05	-1.03E-05	-8.09E-06
1.537087912	-0.000268244	-4.89E-05	-1.83E-05	-1.42E-05
1.63956044	-0.000383781	-6.60E-05	-2.44E-05	-1.89E-05
1.742032967	-0.000485821	-7.98E-05	-2.93E-05	-2.27E-05
1.844505495	-0.000573147	-9.07E-05	-3.32E-05	-2.56E-05

1.946978022	-0.000644386	-9.90E-05	-3.61E-05	-2.78E-05
2.049450549	-0.000698287	-0.00010487	-3.81E-05	-2.93E-05
2.151923077	-0.000733853	-0.000108484	-3.93E-05	-3.03E-05
2.254395604	-0.000750422	-0.000109866	-3.98E-05	-3.06E-05
2.356868132	-0.000747712	-0.000109035	-3.95E-05	-3.04E-05
2.459340659	-0.000725833	-0.000105977	-3.84E-05	-2.96E-05
2.561813187	-0.000685284	-0.000100639	-3.66E-05	-2.82E-05
2.664285714	-0.000626916	-9.29E-05	-3.39E-05	-2.61E-05
2.766758242	-0.000551868	-8.27E-05	-3.03E-05	-2.34E-05
2.869230769	-0.000461465	-6.96E-05	-2.56E-05	-1.99E-05
2.971703297	-0.000357024	-5.32E-05	-1.98E-05	-1.55E-05
3.074175824	-0.000239459	-3.25E-05	-1.23E-05	-9.81E-06
3.176648352	-0.000107988	-4.54E-06	-2.06E-06	-2.02E-06
3.279120879	5.04E-05	0.000209925	0.002384254	0.00352485
3.381593407	0.000243729	0.000425128	0.004772088	0.007052327
3.484065934	0.000436981	0.000641017	0.007162701	0.010580917
3.586538462	0.000629149	0.000857721	0.009557357	0.01411113
3.689010989	0.000819853	0.001075413	0.01195732	0.017643472
3.791483516	0.001008911	0.001294289	0.01436385	0.021178449
3.893956044	0.001196314	0.001514564	0.016778204	0.024716564
3.996428571	0.001382223	0.001736463	0.019201634	0.028258321
4.098901099	0.00156697	0.001960227	0.021635389	0.031804218
4.201373626	0.001751038	0.002186115	0.024080707	0.03535475
4.303846154	0.001935044	0.002414397	0.026538825	0.03891041
4.406318681	0.002119708	0.002645365	0.029010967	0.042471688
4.508791209	0.002305814	0.002879329	0.031498353	0.046039068
4.611263736	0.002494175	0.003116623	0.034002189	0.049613031
4.713736264	0.002685588	0.003357602	0.036523676	0.053194051
4.816208791	0.002880791	0.003602652	0.039064001	0.056782599
4.918681319	0.003080426	0.003852184	0.041624341	0.060379141
5.021153846	0.003285004	0.004106645	0.04420586	0.063984135
5.123626374	0.003494877	0.004366514	0.04680971	0.067598034
5.226098901	0.003710219	0.004632312	0.049437029	0.071221284
5.328571429	0.003931014	0.004904598	0.052088939	0.074854326
5.431043956	0.00415706	0.00518398	0.054766551	0.078497592
5.533516484	0.004387976	0.005471112	0.057470956	0.082151507
5.635989011	0.004623221	0.005766705	0.060203231	0.085816488
5.738461538	0.004862124	0.006071523	0.062964434	0.089492944
5.840934066	0.005103913	0.006386396	0.065755608	0.093181277
5.943406593	0.005347762	0.006712219	0.068577774	0.096881878
6.045879121	0.005592823	0.007049957	0.071431935	0.100595132

6.148351648	0.005838276	0.007400654	0.074319075	0.104321411
6.250824176	0.006083362	0.007765434	0.077240156	0.108061082
6.353296703	0.006327425	0.008145507	0.08019612	0.111814497
6.455769231	0.006569937	0.008542179	0.083187886	0.115582004
6.558241758	0.006810519	0.008956851	0.086216349	0.119363935
6.660714286	0.007048964	0.009391029	0.089282384	0.123160615
6.763186813	0.007285231	0.009846331	0.092386839	0.126972357
6.865659341	0.00751945	0.010324489	0.095530539	0.130799464
6.968131868	0.007751909	0.010827359	0.098714284	0.134642226
7.070604396	0.007983037	0.011356925	0.101938846	0.138500922
7.173076923	0.00821338	0.011915305	0.105204974	0.142375822
7.275549451	0.008443578	0.012504759	0.108513386	0.146267179
7.378021978	0.008674341	0.013127695	0.111864775	0.15017524
7.480494505	0.008906418	0.013786674	0.115259806	0.154100234
7.582967033	0.009140582	0.014484414	0.118699114	0.158042381
7.68543956	0.009377607	0.0152238	0.122183306	0.162001888
7.787912088	0.009618261	0.016007886	0.125712957	0.165978948
7.890384615	0.009863299	0.016839902	0.129288613	0.169973742
7.992857143	0.010113466	0.017723257	0.132910791	0.173986438
8.09532967	0.010369504	0.018661545	0.136579973	0.178017189
8.197802198	0.010632171	0.019658547	0.140296613	0.182066138
8.300274725	0.010902257	0.020718235	0.14406113	0.186133411
8.402747253	0.011180608	0.021844774	0.147873911	0.190219123
8.50521978	0.011468154	0.023042525	0.151735311	0.194323374
8.607692308	0.011765929	0.024316045	0.155645652	0.198446249
8.710164835	0.0120751	0.025670086	0.159605219	0.202587822
8.812637363	0.012396985	0.027109594	0.163614267	0.206748152
8.91510989	0.012733071	0.028639709	0.167673014	0.210927282
9.017582418	0.013085029	0.03026576	0.171781643	0.215125243
9.120054945	0.013454721	0.031993262	0.175940304	0.219342051
9.222527473	0.013844205	0.033827907	0.18014911	0.223577709
9.325	0.014255738	0.035775562	0.18440814	0.227832205
9.427472527	0.014691775	0.037842256	0.188717435	0.232105511
9.529945055	0.01515497	0.040034171	0.193077002	0.236397587
9.632417582	0.015648176	0.042357633	0.197486811	0.240708379
9.73489011	0.016174449	0.044819096	0.201946797	0.245037817
9.837362637	0.016737062	0.047425129	0.206456858	0.249385818
9.939835165	0.017339516	0.050182397	0.211016854	0.253752285
10.04230769	0.01798557	0.053097648	0.215626611	0.258137105
10.14478022	0.018679275	0.056177689	0.220285918	0.262540153
10.24725275	0.019425023	0.059429364	0.224994527	0.266961289

10.34972527	0.020227606	0.062859537	0.229752153	0.271400359
10.4521978	0.021092287	0.066475061	0.234558476	0.275857195
10.55467033	0.022024888	0.070282755	0.23941314	0.280331616
10.65714286	0.023031885	0.074289376	0.24431575	0.284823425
10.75961538	0.024120519	0.078501591	0.24926588	0.289332415
10.86208791	0.025298921	0.082925945	0.254263063	0.293858361
10.96456044	0.026576243	0.08756883	0.259306799	0.298401028
11.06703297	0.027962805	0.092436455	0.264396554	0.302960167
11.16950549	0.029470244	0.09753481	0.269531756	0.307535515
11.27197802	0.031111679	0.102869633	0.2747118	0.312126796
11.37445055	0.032901874	0.108446375	0.279936046	0.316733721
11.47692308	0.034857404	0.114270166	0.28520382	0.321355989
11.5793956	0.036996821	0.120345778	0.290514416	0.325993287
11.68186813	0.039340815	0.126677592	0.295867092	0.330645287
11.78434066	0.04191236	0.133269563	0.301261074	0.335311652
11.88681319	0.044736848	0.140125183	0.306695558	0.339992031
11.98928571	0.047842188	0.147247451	0.312169704	0.344686061
12.09175824	0.051258886	0.154638839	0.317682646	0.349393369
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12.39917582	0.063721293	0.178443875	0.334445096	0.363591048
12.50164835	0.068740168	0.186924847	0.340103926	0.368347502
12.60412088	0.07426079	0.195678347	0.345796759	0.373115196
12.70659341	0.080327651	0.204703088	0.351522553	0.377893692
12.80906593	0.086986601	0.213997075	0.357280238	0.382682541
12.91153846	0.094284321	0.223557589	0.363068719	0.387481285
13.01401099	0.102267693	0.233381178	0.368886875	0.392289454
13.11648352	0.110983075	0.243463644	0.374733561	0.397106572
13.21895604	0.120475474	0.253800039	0.380607609	0.401932153
13.32142857	0.130787648	0.264384663	0.386507828	0.4067657
13.4239011	0.141959135	0.275211062	0.392433006	0.411606712
13.52637363	0.154025231	0.286272037	0.39838191	0.416454676
13.62884615	0.167015955	0.29755965	0.404353286	0.421309073
13.73131868	0.180955002	0.309065239	0.410345862	0.426169378
13.83379121	0.195858741	0.320779432	0.416358349	0.431035055
13.93626374	0.211735273	0.332692169	0.42238944	0.435905564
14.03873626	0.228583585	0.344792728	0.428437812	0.440780357
14.14120879	0.246392833	0.35706975	0.434502127	0.445658883
14.24368132	0.265141784	0.36951127	0.440581033	0.450540579
14.34615385	0.284798446	0.382104758	0.446673165	0.455424883
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14.5510989	0.326652368	0.407694895	0.458891592	0.465199024
14.65357143	0.348731496	0.420663995	0.465015103	0.470087706
14.75604396	0.371482898	0.433730058	0.471146273	0.474976684
14.85851648	0.394822914	0.44687834	0.47728369	0.479865371
14.96098901	0.4186596	0.460093803	0.483425934	0.484753175
15.06346154	0.442893912	0.473361166	0.489571579	0.4896395
15.16593407	0.467421064	0.486664958	0.495719195	0.494523747
15.26840659	0.49213203	0.499989577	0.501867351	0.499405317
15.37087912	0.516915142	0.513319344	0.508014612	0.504283606
15.47335165	0.541657758	0.526638562	0.51415954	0.509158008
15.57582418	0.56624794	0.539931573	0.520300702	0.514027918
15.6782967	0.590576111	0.553182815	0.526436662	0.518892726
15.78076923	0.614536644	0.566376877	0.532565987	0.523751823
15.88324176	0.638029347	0.579498556	0.53868725	0.528604601
15.98571429	0.6609608	0.59253291	0.544799025	0.533450448
16.08818681	0.683245527	0.605465311	0.550899894	0.538288755
16.19065934	0.704806966	0.618281497	0.556988445	0.543118912
16.29313187	0.725578233	0.630967617	0.563063271	0.547940309
16.3956044	0.745502659	0.64351028	0.569122979	0.55275234
16.49807692	0.764534101	0.655896594	0.57516618	0.557554396
16.60054945	0.782637038	0.668114212	0.581191501	0.562345874
16.70302198	0.799786452	0.680151364	0.587197576	0.567126169
16.80549451	0.81596751	0.691996892	0.593183054	0.571894681
16.90796703	0.831175087	0.70364028	0.599146598	0.576650813
17.01043956	0.845413121	0.71507168	0.605086886	0.581393967
17.11291209	0.858693858	0.726281936	0.611002609	0.586123553
17.21538462	0.871037002	0.737262601	0.616892477	0.590838981
17.31785714	0.882468789	0.748005953	0.622755216	0.595539667
17.42032967	0.893021035	0.758505006	0.628589572	0.600225031
17.5228022	0.902730169	0.768753517	0.634394307	0.604894495
17.62527473	0.911636272	0.778745989	0.640168205	0.609547487
17.72774725	0.919782159	0.788477674	0.645910071	0.614183442
17.83021978	0.927212506	0.797944565	0.651618731	0.618801798
17.93269231	0.933973048	0.807143392	0.657293032	0.623401999
18.03516484	0.94010985	0.816071609	0.662931845	0.627983494
18.13763736	0.945668665	0.824727384	0.668534064	0.63254574
18.24010989	0.950694376	0.833109579	0.674098609	0.637088198
18.34258242	0.955230537	0.841217731	0.679624424	0.641610337
18.44505495	0.95931899	0.849052033	0.685110476	0.646111632
18.54752747	0.962999571	0.856613307	0.690555762	0.650591566
18.65	0.966309897	0.863902979	0.695959303	0.655049629

18.75247253	0.96928522	0.87092305	0.701320149	0.659485318
18.85494505	0.971958341	0.877676066	0.706637375	0.663898137
18.95741758	0.974359591	0.884165089	0.711910087	0.668287599
19.05989011	0.976516842	0.890393663	0.717137417	0.672653225
19.16236264	0.97845557	0.896365778	0.722318529	0.676994544
19.26483516	0.980198939	0.902085844	0.727452613	0.681311094
19.36730769	0.981767916	0.90755865	0.732538889	0.68560242
19.46978022	0.983181393	0.912789329	0.73757661	0.689868079
19.57225275	0.984456329	0.917783329	0.742565055	0.694107635
19.67472527	0.985607891	0.922546376	0.747503536	0.69832066
19.7771978	0.986649602	0.927084439	0.752391395	0.702506738
19.87967033	0.987593486	0.931403697	0.757228004	0.70666546
19.98214286	0.988450206	0.935510508	0.762012767	0.710796429
20.08461538	0.989229201	0.939411378	0.766745118	0.714899257
20.18708791	0.989938814	0.943112929	0.771424522	0.718973565
20.28956044	0.990586408	0.946621867	0.776050477	0.723018985
20.39203297	0.991178482	0.949944961	0.780622508	0.727035158
20.49450549	0.991720768	0.953089008	0.785140175	0.731021737
20.59697802	0.992218324	0.956060816	0.789603068	0.734978384
20.69945055	0.99267562	0.958867171	0.794010807	0.738904772
20.80192308	0.993096609	0.961514825	0.798363043	0.742800585
20.9043956	0.993484796	0.964010464	0.802659459	0.746665516
21.00686813	0.993843295	0.966360701	0.806899766	0.75049927
21.10934066	0.99417488	0.968572048	0.811083709	0.754301563
21.21181319	0.99448203	0.970650905	0.81521106	0.758072122
21.31428571	0.994766966	0.972603546	0.819281621	0.761810682
21.41675824	0.995031687	0.974436106	0.823295226	0.765516993
21.51923077	0.995277993	0.976154567	0.827251736	0.769190813
21.6217033	0.995507513	0.977764753	0.831151041	0.772831912
21.72417582	0.995721723	0.979272316	0.834993062	0.776440071
21.82664835	0.995921963	0.980682734	0.838777746	0.780015082
21.92912088	0.996109453	0.982001303	0.842505069	0.783556748
22.03159341	0.996285303	0.983233133	0.846175033	0.787064883
22.13406593	0.996450528	0.984383145	0.84978767	0.79053931
22.23653846	0.996606051	0.985456068	0.853343034	0.793979868
22.33901099	0.996752719	0.98645644	0.85684121	0.797386401
22.44148352	0.996891305	0.987388604	0.860282307	0.800758768
22.54395604	0.99702252	0.988256715	0.863666457	0.804096837
22.64642857	0.997147012	0.989064735	0.866993819	0.807400487
22.7489011	0.997265383	0.989816439	0.870264576	0.81066961
22.85137363	0.997378184	0.990515418	0.873478933	0.813904105

22.95384615	0.997485928	0.99116508	0.876637121	0.817103884
23.05631868	0.997589088	0.991768657	0.87973939	0.82026887
23.15879121	0.997688108	0.99232921	0.882786013	0.823398995
23.26126374	0.9977834	0.992849629	0.885777287	0.826494203
23.36373626	0.997875353	0.993332644	0.888713525	0.829554447
23.46620879	0.997964326	0.993780826	0.891595063	0.832579691
23.56868132	0.998050658	0.994196597	0.894422257	0.835569909
23.67115385	0.998134664	0.994582232	0.89719548	0.838525085
23.77362637	0.998216631	0.994939868	0.899915123	0.841445214
23.8760989	0.998296821	0.995271506	0.902581598	0.8443303
23.97857143	0.998375466	0.995579023	0.905195329	0.847180356
24.08104396	0.998452766	0.995864172	0.90775676	0.849995407
24.18351648	0.998528881	0.996128593	0.910266348	0.852775485
24.28598901	0.998603933	0.996373817	0.912724568	0.855520633
24.38846154	0.998677994	0.996601268	0.915131908	0.858230902
24.49093407	0.99875109	0.996812278	0.917488867	0.860906354
24.59340659	0.99882319	0.997008082	0.919795962	0.863547059
24.69587912	0.998894206	0.997189831	0.922053719	0.866153096
24.79835165	0.998963994	0.997358594	0.924262676	0.868724551
24.90082418	0.999032346	0.997515365	0.926423383	0.871261522
25.0032967	0.999099	0.997661064	0.928536401	0.873764113
25.10576923	0.999163637	0.997796548	0.930602299	0.876232437
25.20824176	0.999225886	0.997922608	0.932621658	0.878666615
25.31071429	0.999285337	0.998039979	0.934595064	0.881066775
25.41318681	0.999341544	0.998149343	0.936523115	0.883433055
25.51565934	0.999394039	0.998251329	0.938406412	0.885765599
25.61813187	0.999442348	0.998346523	0.940245568	0.888064559
25.7206044	0.999486	0.998435464	0.942041197	0.890330093
25.82307692	0.999524548	0.998518654	0.943793921	0.892562369
25.92554945	0.999557584	0.998596556	0.945504369	0.894761559
26.02802198	0.999584754	0.998669602	0.94717317	0.896927843
26.13049451	0.999605779	0.998738188	0.948800961	0.899061408
26.23296703	0.999620465	0.998802683	0.950388381	0.901162447
26.33543956	0.999628718	0.998863429	0.95193607	0.903231159
26.43791209	0.999630556	0.998920743	0.953444672	0.90526775
26.54038462	0.999626121	0.998974918	0.954914834	0.90727243
26.64285714	0.999615674	0.999026226	0.956347202	0.909245416
26.74532967	0.999599609	0.999074918	0.957742424	0.911186931
26.8478022	0.999578441	0.99912123	0.959101147	0.913097202
26.95027473	0.999552804	0.999165376	0.960424021	0.914976462
27.05274725	0.99952344	0.999207558	0.961711691	0.91682495

27.15521978	0.999491188	0.999247961	0.962964805	0.918642907
27.25769231	0.999456961	0.999286756	0.964184007	0.92043058
27.36016484	0.999421732	0.999324102	0.96536994	0.922188222
27.46263736	0.999386511	0.999360144	0.966523244	0.923916088
27.56510989	0.99935232	0.999395018	0.967644558	0.925614439
27.66758242	0.999320168	0.999428846	0.968734517	0.927283536
27.77005495	0.999291032	0.999461741	0.969793752	0.928923649
27.87252747	0.999265828	0.999493806	0.97082289	0.930535048
27.975	0.999245393	0.999525136	0.971822556	0.932118008
28.07747253	0.999230465	0.999555813	0.972793369	0.933672805
28.17994505	0.999221666	0.999585914	0.973735944	0.935199719
28.28241758	0.999219491	0.999615507	0.974650889	0.936699036
28.38489011	0.999224295	0.99964465	0.975538811	0.938171039
28.48736264	0.999236292	0.999673396	0.976400306	0.939616017
28.58983516	0.999255549	0.999701789	0.977235969	0.941034261
28.69230769	0.999281995	0.999729865	0.978046386	0.942426064
28.79478022	0.999315419	0.999757656	0.978832138	0.943791719
28.89725275	0.999355488	0.999785184	0.9795938	0.945131523
28.99972527	0.999401755	0.999812468	0.980331939	0.946445775
29.1021978	0.999453675	0.999839517	0.981047115	0.947734773
29.20467033	0.999510621	0.999866339	0.981739884	0.948998818
29.30714286	0.999571904	0.999892932	0.98241079	0.950238212
29.40961538	0.999636794	0.999919291	0.983060374	0.951453258
29.51208791	0.999704532	0.999945406	0.983689167	0.952644259
29.61456044	0.999774357	0.999971262	0.984297694	0.95381152
29.71703297	0.999845517	0.999996839	0.98488647	0.954955345
29.81950549	0.999917289	1.000022114	0.985456005	0.956076039
29.92197802	0.999988994	1.000047059	0.986006799	0.957173908
30.02445055	1.000060006	1.000071643	0.986539345	0.958249257
30.12692308	1.000129766	1.000095833	0.987054127	0.959302391
30.2293956	1.000197792	1.000119592	0.987551622	0.960333616
30.33186813	1.000263677	1.00014288	0.988032299	0.961343237
30.43434066	1.000327102	1.000165657	0.988496617	0.962331557
30.53681319	1.00038783	1.00018788	0.988945028	0.963298881
30.63928571	1.000445705	1.000209504	0.989377977	0.964245512
30.74175824	1.000500654	1.000230484	0.989795897	0.965171751
30.84423077	1.000552673	1.000250775	0.990199216	0.966077901
30.9467033	1.000601823	1.000270329	0.990588352	0.966964262
31.04917582	1.00064822	1.0002891	0.990963716	0.967831131
31.15164835	1.00069202	1.000307043	0.99132571	0.968678808
31.25412088	1.000733409	1.000324112	0.991674728	0.969507588

31.35659341	1.000772587	1.000340263	0.992011154	0.970317766
31.45906593	1.000809754	1.000355453	0.992335367	0.971109635
31.56153846	1.000845095	1.000369641	0.992647734	0.971883487
31.66401099	1.000878766	1.000382787	0.992948619	0.972639611
31.76648352	1.000910881	1.000394854	0.993238372	0.973378295
31.86895604	1.000941501	1.000405807	0.993517339	0.974099824
31.97142857	1.000970626	1.000415614	0.993785857	0.974804481
32.0739011	1.000998189	1.000424246	0.994044255	0.975492549
32.17637363	1.001024053	1.000431676	0.994292855	0.976164306
32.27884615	1.001048012	1.000437881	0.994531969	0.976820028
32.38131868	1.001069797	1.000442842	0.994761905	0.977459991
32.48379121	1.001089083	1.000446543	0.994982959	0.978084465
32.58626374	1.001105501	1.000448971	0.995195423	0.97869372
32.68873626	1.001118652	1.000450117	0.995399581	0.979288021
32.79120879	1.001128123	1.000449976	0.995595709	0.979867634
32.89368132	1.001133506	1.000448548	0.995784076	0.980432818
32.99615385	1.001134416	1.000445834	0.995964943	0.980983831
33.09862637	1.00113051	1.000441842	0.996138566	0.98152093
33.2010989	1.0011215	1.000436582	0.996305192	0.982044364
33.30357143	1.001107173	1.000430068	0.996465064	0.982554385
33.40604396	1.0010874	1.000422318	0.996618415	0.983051237
33.50851648	1.001062145	1.000413354	0.996765475	0.983535163
33.61098901	1.00103147	1.0004032	0.996906464	0.984006403
33.71346154	1.000995536	1.000391886	0.997041597	0.984465193
33.81593407	1.0009546	1.000379444	0.997171085	0.984911766
33.91840659	1.000909011	1.000365907	0.997295129	0.985346352
34.02087912	1.000859195	1.000351316	0.997413927	0.985769177
34.12335165	1.000805648	1.000335709	0.997527671	0.986180463
34.22582418	1.000748917	1.000319132	0.997636544	0.98658043
34.3282967	1.000689587	1.00030163	0.997740728	0.986969295
34.43076923	1.000628264	1.000283251	0.997840396	0.987347268
34.53324176	1.000565557	1.000264046	0.997935717	0.98771456
34.63571429	1.000502061	1.000244066	0.998026854	0.988071374
34.73818681	1.000438347	1.000223366	0.998113965	0.988417913
34.84065934	1.000374941	1.000202	0.998197205	0.988754375
34.94313187	1.000312319	1.000180025	0.99827672	0.989080953
35.0456044	1.000250897	1.000157497	0.998352654	0.989397838
35.14807692	1.000191021	1.000134476	0.998425146	0.989705217
35.25054945	1.000132965	1.000111018	0.998494329	0.990003272
35.35302198	1.000076929	1.000087182	0.998560333	0.990292184
35.45549451	1.000023041	1.000063028	0.998623282	0.990572128

35.55796703	0.999971357	1.000038613	0.998683297	0.990843274
35.66043956	0.99992187	1.000013995	0.998740495	0.991105792
35.76291209	0.999874514	0.999989233	0.998794987	0.991359844
35.86538462	0.999829175	0.999964382	0.998846881	0.991605592
35.96785714	0.9997857	0.999939498	0.998896282	0.991843191
36.07032967	0.999743908	0.999914637	0.99894329	0.992072794
36.1728022	0.999703605	0.999889852	0.998988001	0.992294549
36.27527473	0.999664592	0.999865194	0.999030509	0.992508602
36.37774725	0.999626681	0.999840716	0.999070902	0.992715092
36.48021978	0.999589703	0.999816465	0.999109266	0.992914157
36.58269231	0.999553522	0.99979249	0.999145683	0.99310593
36.68516484	0.999518041	0.999768836	0.999180234	0.99329054
36.78763736	0.999483208	0.999745547	0.999212992	0.993468112
36.89010989	0.999449024	0.999722665	0.999244032	0.993638767
36.99258242	0.999415542	0.999700229	0.999273422	0.993802623
37.09505495	0.999382865	0.999678279	0.999301228	0.993959792
37.19752747	0.999351147	0.999656849	0.999327515	0.994110385
37.3	0.99932058	0.999635975	0.999352344	0.994254506

Table B.12 Sadighian et al.[5], experimental data (Pentane mass fraction in Athabasca atmospheric residue at different elevations and times

Elevation (mm)	0 s	3420 s	6780 s	14820 s	25980 s
0.276	-0.00526	-0.00255	-0.000967	-0.01033	-0.00108
0.368	-0.00704	-0.0033	-0.000238	-0.01077	-0.00123
0.46	-0.0081	-0.00375	0.000752	-0.01042	-0.00131
0.552	-0.00862	-0.00346	0.00169	-0.00977	-0.000992
0.644	-0.00881	-0.0034	0.00201	-0.00891	-0.00082
0.736	-0.00861	-0.00438	0.00189	-0.0075	-0.000748
0.828	-0.00804	-0.00548	0.00173	-0.00571	-0.000864
0.92	-0.00743	-0.00578	0.00121	-0.00441	-0.00178
1.012	-0.0074	-0.00556	0.000125	-0.00438	-0.00336
1.104	-0.0078	-0.00593	-0.00039	-0.005	-0.00469
1.196	-0.0075	-0.00656	-0.000264	-0.00512	-0.00522
1.288	-0.00661	-0.00611	0.00000607	-0.00467	-0.00468
1.38	-0.00551	-0.00479	0.000185	-0.00486	-0.00419
1.472	-0.00486	-0.00385	0.000466	-0.00614	-0.0042
1.564	-0.00402	-0.00386	0.00111	-0.00682	-0.00351

1.656	-0.00309	-0.0045	0.00173	-0.00611	-0.0011
1.748	-0.00294	-0.00429	0.000915	-0.00611	-0.0011
1.84	-0.00425	-0.00422	-0.00115	-0.00626	-0.000691
1.932	-0.0066	-0.00523	-0.00292	-0.00689	-0.00134
2.024	-0.0088	-0.0065	-0.00393	-0.00666	-0.00206
2.116	-0.01005	-0.00718	-0.00436	-0.00519	-0.00204
2.208	-0.01126	-0.00684	-0.00481	-0.00408	-0.00252
2.3	-0.01191	-0.00598	-0.00473	-0.00309	-0.00327
2.392	-0.01158	-0.00534	-0.00405	-0.00199	-0.00339
2.484	-0.01068	-0.00479	-0.00341	-0.00114	-0.00269
2.576	-0.00912	-0.00394	-0.00311	-0.000561	-0.00153
2.668	-0.00714	-0.00311	-0.00301	-0.00068	-0.000588
2.76	-0.00581	-0.00259	-0.00319	-0.00117	-0.000231
2.852	-0.004	-0.0026	-0.00295	-0.00153	0.000367
2.944	-0.00238	-0.00315	-0.00293	-0.0024	0.000549
3.036	-0.00132	-0.0037	-0.00276	-0.00361	-0.000116
3.128	0.000347	-0.00383	-0.00199	-0.00419	-0.00121
3.22	0.00157	-0.00376	-0.00146	-0.00457	-0.00222
3.312	0.00042	-0.00355	-0.00142	-0.0053	-0.00322
3.404	-0.000595	-0.00326	-0.000739	-0.00589	-0.0037
3.496	-0.00116	-0.00321	-0.0000576	-0.00619	-0.00408
3.588	-0.00192	-0.00267	-0.0000972	-0.00652	-0.00415
3.68	-0.00254	-0.002	-0.000664	-0.00647	-0.0041
3.772	-0.00329	-0.00193	-0.00169	-0.00687	-0.00443
3.864	-0.00405	-0.00212	-0.00202	-0.00695	-0.00436
3.956	-0.00295	-0.00271	-0.00139	-0.00628	-0.00332
4.048	-0.00165	-0.00349	-0.00134	-0.00602	-0.00258
4.14	0.000867	-0.00386	-0.00126	-0.00614	-0.00222
4.232	-0.000253	-0.00384	-0.000269	-0.00571	-0.0019
4.324	0.000653	-0.00376	0.000783	-0.00477	-0.0015
4.416	0.000866	-0.00286	0.00154	-0.00341	-0.000834
4.508	0.000397	-0.00171	0.0016	-0.00191	-0.000358
4.6	-0.000929	-0.000702	0.000837	-0.000754	-0.0000884
4.692	-0.00269	0.000415	0.0003	-0.000105	0.000755
4.784	-0.00494	0.00138	0.000175	0.000253	0.00173
4.876	-0.00636	0.00204	0.000801	0.000683	0.00279
4.968	-0.00735	0.00253	0.00241	0.000338	0.00433
5.06	-0.00779	0.00287	0.00387	-0.00105	0.00565
5.152	-0.00747	0.00327	0.0044	-0.00262	0.0063

5.244	-0.00533	0.00357	0.0049	-0.00306	0.00674
5.336	-0.0021	0.00386	0.00575	-0.00197	0.00701
5.428	0.00109	0.00419	0.00604	-0.000806	0.00675
5.52	0.00334	0.00417	0.00525	-0.00055	0.00645
5.612	0.0052	0.00394	0.00347	-0.000473	0.00576
5.704	0.00655	0.0035	0.00195	0.000335	0.00508
5.796	0.00753	0.00285	0.00192	0.00165	0.00476
5.888	0.00707	0.00231	0.00235	0.00203	0.00425
5.98	0.00538	0.00192	0.00171	0.000828	0.00321
6.072	0.0039	0.00127	0.00064	-0.000332	0.00263
6.164	0.00286	0.00058	0.000203	-0.00061	0.0021
6.256	0.00188	0.000436	0.000622	-0.000413	0.00172
6.348	0.000428	0.000651	0.00148	-0.000325	0.00129
6.44	-0.00178	0.00121	0.00154	-0.00117	0.000793
6.532	-0.00365	0.00181	0.000759	-0.00201	0.000485
6.624	-0.0046	0.00194	0.000473	-0.00204	0.000598
6.716	-0.00445	-0.00209	0.000981	-0.00189	0.000827
6.808	-0.00351	0.00224	0.00138	-0.00195	0.00121
6.9	0.00222	0.0017	0.00133	-0.00225	0.0012
6.992	-0.00104	0.000704	0.00173	-0.00242	0.00148
7.084	-0.0000515	0.000597	0.00321	-0.00221	0.00183
7.176	0.0000149	-0.00099	0.00524	-0.00111	0.00215
7.268	0.000106	-0.000547	0.00743	0.000847	0.0029
7.36	-0.000574	-0.0000962	0.00832	0.00204	0.00323
7.452	-0.000942	0.000582	0.00849	0.00251	0.0032
7.544	-0.0000953	0.00121	0.00883	0.00317	0.00421
7.636	0.00179	0.00171	0.00889	0.00426	0.00546
7.728	0.00405	0.00255	0.00826	0.00516	0.00667
7.82	0.00692	0.00282	0.00747	0.00508	0.00794
7.912	0.00818	0.00229	0.00595	0.0041	0.00833
8.004	0.00884	0.00185	0.00514	0.00391	0.00898
8.096	0.00813	0.00131	0.00461	0.00378	0.00904
8.188	0.00495	0.00167	0.00342	0.00282	0.00737
8.28	0.000594	0.00171	0.0016	0.00131	0.00473
8.372	-0.00229	0.000544	0.0000441	0.000282	0.00202
8.464	-0.00492	-0.00172	-0.0012	-0.000326	-0.000583
8.556	-0.00659	-0.00363	-0.00177	-0.000745	-0.00219
8.648	-0.00754	-0.00465	-0.00186	-0.00163	-0.00304
8.74	-0.0073	-0.00516	-0.0014	-0.00219	-0.00261

8.832	-0.00618	-0.00573	-0.000202	-0.00157	-0.00111
8.924	-0.00353	-0.0055	-0.00161	-0.000358	0.000989
9.016	0.0000303	-0.00421	0.00358	0.000477	0.00366
9.108	0.00437	-0.00201	0.00539	0.0013	0.00626
9.2	0.00806	0.00028	0.00683	0.00199	0.00807
9.29	0.01037	0.00192	0.0077	0.00302	0.0091
9.38	0.01094	0.0029	0.00808	0.00419	0.00967
9.48	0.01112	0.00348	0.00843	0.00496	0.0106
9.57	0.01042	0.00377	0.00877	0.0056	0.0123
9.66	0.00823	0.00447	0.00854	0.00635	0.01359
9.75	0.00552	0.00547	0.00826	0.00681	0.01458
9.84	0.00429	0.00615	0.00861	0.00737	0.01572
9.94	0.00353	0.00648	0.00941	0.00752	0.01679
10.03	0.00365	0.00696	0.01037	0.00779	0.01806
10.12	0.00473	0.00688	0.01125	0.00869	0.01975
10.21	0.00644	0.00644	0.01213	0.00998	0.02127
10.3	0.00873	0.00595	0.01343	0.01131	0.0228
10.4	0.01106	0.00632	0.0149	0.01191	0.02467
10.49	0.01226	0.00728	0.01584	0.01156	0.02639
10.58	0.01463	0.0082	0.01647	0.0118	0.02835
10.67	0.01829	0.00897	0.01776	0.01287	0.03031
10.76	0.02144	0.00996	0.01983	0.01416	0.03144
10.86	0.02339	0.01107	0.02126	0.01427	0.03126
10.95	0.02358	0.01159	0.022	0.01353	0.03085
11.04	0.02315	0.01074	0.0227	0.01399	0.03179
11.13	0.0235	0.00972	0.02333	0.01545	0.03412
11.22	0.02266	0.01009	0.02377	0.01679	0.0367
11.32	0.02063	0.01085	0.02365	0.01761	0.03924
11.41	0.01911	0.01151	0.02248	0.01798	0.04201
11.5	0.01829	0.01239	0.02154	0.01943	0.04587
11.59	0.01875	0.01313	0.0215	0.02191	0.05091
11.68	0.01962	0.01394	0.02237	0.02403	0.05542
11.78	0.0198	0.01511	0.02462	0.02692	0.05995
11.87	0.0202	0.01608	0.02766	0.03081	0.06538
11.96	0.02018	0.01773	0.03035	0.03498	0.07133
12.05	0.01978	0.02003	0.03308	0.03896	0.07821
12.14	0.01987	0.02202	0.03648	0.04258	0.08622
12.24	0.01989	0.02432	0.0399	0.04667	0.09521
12.33	0.01939	0.02687	0.04277	0.0521	0.10572

12.42	0.02029	0.02911	0.04517	0.05779	0.11715
12.51	0.02222	0.03115	0.04782	0.06339	0.12927
12.6	0.02455	0.03283	0.05114	0.06932	0.14221
12.7	0.0269	0.03439	0.05483	0.07635	0.15566
12.79	0.02966	0.03622	0.05875	0.08467	0.16974
12.88	0.03234	0.03803	0.06338	0.09381	0.18397
12.97	0.03624	0.04025	0.06818	0.10312	0.19734
13.06	0.04019	0.04324	0.0727	0.11208	0.21021
13.16	0.04373	0.04639	0.07726	0.12143	0.22315
13.25	0.04628	0.04896	0.08236	0.13204	0.23673
13.34	0.04841	0.05098	0.08862	0.14362	0.25087
13.43	0.0492	0.05324	0.09546	0.1554	0.26458
13.52	0.05031	0.05555	0.1026	0.16724	0.27745
13.62	0.05255	0.05793	0.1113	0.18001	0.29087
13.71	0.05526	0.06011	0.12205	0.19445	0.30513
13.8	0.05829	0.0627	0.13435	0.21042	0.31945
13.89	0.06297	0.06699	0.14824	0.22656	0.33278
13.98	0.0685	0.07342	0.16334	0.24297	0.34532
14.08	0.07397	0.08077	0.17979	0.25996	0.35795
14.17	0.079	0.08868	0.19751	0.27774	0.37108
14.26	0.08331	0.0968	0.21572	0.29579	0.38453
14.35	0.08629	0.10601	0.23404	0.31343	0.39757
14.44	0.08854	0.11649	0.25272	0.33037	0.40967
14.54	0.0909	0.12743	0.27206	0.34743	0.42139
14.63	0.09457	0.13882	0.2918	0.36438	0.43295
14.72	0.1007	0.15213	0.31157	0.38121	0.44448
14.81	0.10918	0.16833	0.33147	0.3973	0.45568
14.9	0.11799	0.18778	0.35157	0.4125	0.46592
15	0.12877	0.20923	0.37176	0.4276	0.47592
15.09	0.14134	0.23127	0.39176	0.44293	0.48682
15.18	0.15534	0.25485	0.41091	0.45791	0.49863
15.27	0.17066	0.28004	0.42929	0.47223	0.51061
15.36	0.18798	0.3061	0.44749	0.4861	0.52235
15.46	0.2077	0.33219	0.46574	0.50016	0.53409
15.55	0.23219	0.3583	0.48406	0.51426	0.54611
15.64	0.26125	0.3852	0.50238	0.52844	0.55813
15.73	0.2948	0.41372	0.52025	0.54258	0.56965
15.82	0.33274	0.44296	0.5378	0.55665	0.58105
15.92	0.37471	0.47242	0.55579	0.57098	0.59319

16.01	0.41875	0.50212	0.57382	0.5855	0.60542
16.1	0.46386	0.5325	0.59143	0.60022	0.61752
16.19	0.50854	0.56262	0.60875	0.6153	0.6299
16.28	0.55184	0.59209	0.62604	0.63083	0.64267
16.38	0.59377	0.62071	0.6436	0.64646	0.6557
16.47	0.63346	0.64857	0.66168	0.66236	0.66885
16.56	0.66954	0.67555	0.68011	0.67854	0.6816
16.65	0.70287	0.70115	0.69873	0.69467	0.6944
16.74	0.73398	0.72518	0.71713	0.71057	0.70748
16.84	0.76254	0.748	0.73518	0.72638	0.72054
16.93	0.78842	0.76946	0.75269	0.74169	0.73339
17.02	0.81189	0.78968	0.76999	0.75649	0.74603
17.11	0.83297	0.80845	0.78675	0.77039	0.75787
17.2	0.85234	0.826	0.80224	0.78322	0.76905
17.3	0.86965	0.84219	0.8167	0.79575	0.78019
17.39	0.88409	0.85701	0.83055	0.808	0.79129
17.48	0.89618	0.87075	0.84366	0.81952	0.80178
17.57	0.9072	0.88329	0.8561	0.83044	0.81166
17.66	0.91681	0.89465	0.86779	0.8406	0.82083
17.76	0.92486	0.90535	0.87869	0.85034	0.82957
17.85	0.93202	0.91494	0.88901	0.86002	0.83798
17.94	0.93915	0.9233	0.89869	0.86916	0.84602
18.03	0.94627	0.9307	0.90776	0.87766	0.85384
18.12	0.95359	0.93713	0.91654	0.88555	0.86129
18.22	0.96002	0.94276	0.92473	0.89263	0.86823
18.31	0.96569	0.94785	0.93179	0.89913	0.87486
18.4	0.97076	0.95213	0.93772	0.90518	0.8814
18.49	0.97486	0.95591	0.9427	0.91082	0.88773
18.58	0.9777	0.95966	0.94698	0.91625	0.89344
18.68	0.98039	0.9633	0.95075	0.92132	0.89831
18.77	0.98245	0.96667	0.95381	0.92585	0.90257
18.86	0.98407	0.96959	0.95638	0.92994	0.90655
18.95	0.98579	0.97208	0.95877	0.93378	0.91045
19.04	0.98766	0.97432	0.96132	0.93742	0.91446
19.14	0.98934	0.97633	0.96399	0.94071	0.91832
19.23	0.99153	0.978	0.9666	0.94346	0.92164
19.32	0.99388	0.9794	0.96895	0.94583	0.92461
19.41	0.99583	0.98072	0.97086	0.94827	0.92763
19.5	0.99716	0.98201	0.9722	0.95098	0.9305

19.6	0.99794	0.98308	0.97359	0.95384	0.93345
19.69	0.99801	0.98392	0.97481	0.95636	0.9361
19.78	0.99822	0.98492	0.97588	0.9584	0.9384
19.87	0.99842	0.986	0.97707	0.96035	0.94093
19.96	0.99842	0.98687	0.97831	0.96254	0.94377
20.06	0.99866	0.98767	0.97962	0.96476	0.94644
20.15	0.99951	0.98862	0.98116	0.96658	0.94883
20.24	1.00021	0.98962	0.98241	0.96768	0.95077
20.33	1.00132	0.99066	0.98355	0.96873	0.95256
20.42	1.00284	0.99136	0.9847	0.97014	0.95444
20.52	1.00413	0.99189	0.98564	0.97173	0.95621
20.61	1.00468	0.99262	0.98659	0.97332	0.95784
20.7	1.00451	0.99342	0.98758	0.97463	0.95961
20.79	1.00367	0.99417	0.98866	0.97598	0.96162
20.88	1.00306	0.99492	0.9899	0.97769	0.96371
20.98	1.00244	0.99556	0.9912	0.97943	0.96584
21.07	1.00152	0.99626	0.99228	0.98093	0.9679
21.16	1.00048	0.99712	0.99318	0.98227	0.96967
21.25	1.00004	0.99779	0.99396	0.98336	0.97137
21.34	1.00016	0.99823	0.99474	0.98443	0.97299
21.44	1.00101	0.99853	0.99543	0.98553	0.97449
21.53	1.00232	0.99854	0.99616	0.98634	0.97569
21.62	1.00407	0.99843	0.99672	0.98699	0.97652
21.71	1.00569	0.99839	0.99725	0.98769	0.97742
21.8	1.00703	0.99834	0.9979	0.98847	0.97849
21.9	1.00791	0.9984	0.99845	0.98907	0.97922
21.99	1.00821	0.99845	0.99883	0.98945	0.9797
22.08	1.00748	0.99845	0.99922	0.98989	0.98041
22.17	1.00622	0.99852	0.99961	0.99052	0.98141
22.26	1.00447	0.99871	1.00013	0.99121	0.98252
22.36	1.00288	0.99896	1.00066	0.99194	0.98328
22.45	1.00139	0.99906	1.00092	0.99253	0.98384
22.54	1.00031	0.99891	1.0009	0.9929	0.98439
22.63	0.9999	0.99854	1.00077	0.99313	0.9849
22.72	1.00075	0.99821	1.00062	0.99303	0.9852
22.82	1.00187	0.99812	1.00051	0.99295	0.98535
22.91	1.0029	0.99787	1.0004	0.99297	0.9855
23	1.00404	0.9973	1.0003	0.99283	0.98575
23.09	1.00526	0.99676	1.00025	0.99245	0.98625

23.18	1.00576	0.99659	1.00023	0.99239	0.9869
23.28	1.00577	0.99664	1.00007	0.99248	0.98728
23.37	1.00539	0.99643	0.99978	0.99253	0.98721
23.46	1.00484	0.99579	0.99949	0.9925	0.98727
23.55	1.004	0.99509	0.99901	0.9923	0.98746
23.64	1.00259	0.99477	0.99846	0.99212	0.98767
23.74	1.00112	0.99447	0.99791	0.99209	0.9876
23.83	1.00018	0.99402	0.99756	0.99201	0.98754
23.92	0.99985	0.99343	0.9976	0.9921	0.98796
24.01	0.99969	0.99279	0.99778	0.99228	0.98874
24.1	0.99957	0.99274	0.99785	0.9924	0.98929
24.2	0.99964	0.99298	0.99787	0.99279	0.98955
24.29	0.99975	0.99299	0.99796	0.99322	0.98964
24.38	0.99988	0.99298	0.99829	0.99365	0.98995
24.47	1.00004	0.99293	0.99867	0.99393	0.99017
24.56	0.99989	0.99305	0.99874	0.99395	0.99008
24.66	0.99912	0.99336	0.99858	0.99417	0.99003
24.75	0.9981	0.99326	0.99838	0.99464	0.99018
24.84	0.99695	0.99301	0.99821	0.99484	0.99041
24.93	0.99611	0.99297	0.99797	0.99474	0.99071
25.02	0.99555	0.99291	0.9977	0.99457	0.99106
25.12	0.99501	0.99252	0.99744	0.9945	0.99143
25.21	0.99439	0.99196	0.99747	0.99472	0.992
25.3	0.99393	0.99149	0.99758	0.99492	0.99242
25.39	0.99332	0.99135	0.99771	0.9949	0.99273
25.48	0.99318	0.99124	0.998	0.99505	0.99318
25.58	0.99362	0.99095	0.99835	0.99538	0.99369
25.67	0.99436	0.99086	0.99856	0.99581	0.99412
25.76	0.99526	0.99111	0.99872	0.99628	0.99456
25.85	0.99641	0.99145	0.99869	0.99659	0.99481
25.94	0.99733	0.99171	0.99854	0.99684	0.99494
26.04	0.99803	0.99177	0.99816	0.99694	0.99501
26.13	0.99843	0.99174	0.99746	0.9968	0.99514
26.22	0.9984	0.99167	0.99685	0.99686	0.99538
26.31	0.99795	0.99127	0.99659	0.99703	0.9957
26.4	0.99777	0.99067	0.99672	0.99732	0.99614
26.5	0.99767	0.99023	0.99694	0.99764	0.99662
26.59	0.99764	0.99004	0.9971	0.99775	0.99705

Table B.13 Fickian model for Sadighian et al.[5], (athabasca atmospheric residue + pentane) considering constant density

Elevation (mm)	3420 s	6780 s	14820 s	25980 s
0	0	0	0	0
0.092361111	-0.00041876	-0.000254487	-0.000119385	-5.54E-05
0.184722222	-0.000835093	-0.000507963	-0.000238481	-0.000110588
0.277083333	-0.001243621	-0.000758174	-0.000356638	-0.000165407
0.369444444	-0.00164209	-0.001004158	-0.000473575	-0.00021969
0.461805556	-0.002027638	-0.001244676	-0.000588923	-0.000273271
0.554166667	-0.002397583	-0.001478544	-0.000702326	-0.000325987
0.646527778	-0.002749455	-0.001704637	-0.000813432	-0.000377677
0.738888889	-0.00308102	-0.001921903	-0.000921904	-0.00042818
0.83125	-0.003390305	-0.002129368	-0.001027415	-0.000477338
0.923611111	-0.003675613	-0.002326145	-0.001129655	-0.000524994
1.015972222	-0.003935532	-0.00251144	-0.001228325	-0.000570995
1.108333333	-0.004168949	-0.002684555	-0.001323146	-0.000615189
1.200694444	-0.004375043	-0.002844897	-0.001413853	-0.000657425
1.293055556	-0.004553295	-0.002991971	-0.001500203	-0.000697558
1.385416667	-0.004703477	-0.003125393	-0.001581969	-0.000735443
1.477777778	-0.004825644	-0.003244878	-0.001658945	-0.000770939
1.570138889	-0.004920131	-0.00335025	-0.001730943	-0.000803907
1.6625	-0.004987532	-0.00344143	-0.001797799	-0.000834212
1.754861111	-0.005028689	-0.00351844	-0.001859367	-0.000861719
1.847222222	-0.005044674	-0.003581394	-0.001915521	-0.000886298
1.939583333	-0.005036764	-0.003630494	-0.001966158	-0.000907821
2.031944444	-0.005006427	-0.003666025	-0.002011194	-0.000926162
2.124305556	-0.004955286	-0.003688346	-0.002050564	-0.000941199
2.216666667	-0.004885098	-0.003697887	-0.002084223	-0.000952808
2.309027778	-0.004797722	-0.003695136	-0.002112147	-0.00096087
2.401388889	-0.004695086	-0.003680635	-0.002134326	-0.000965267
2.49375	-0.004579157	-0.00365497	-0.002150771	-0.000965882
2.586111111	-0.004451901	-0.003618765	-0.002161506	-0.000962598
2.678472222	-0.004315256	-0.00357267	-0.002166572	-0.0009553
2.770833333	-0.004171092	-0.003517359	-0.002166025	-0.00094387
2.863194444	-0.004021186	-0.003453518	-0.00215993	-0.000928193
2.955555556	-0.003867188	-0.003381839	-0.002148367	-0.00090815
3.047916667	-0.003710602	-0.003303015	-0.002131424	-0.000883623
3.140277778	-0.00355276	-0.003217732	-0.0021092	-0.00085449
3.232638889	-0.003394812	-0.003126664	-0.002081798	-0.000820627
3.325	-0.003237716	-0.00303047	-0.00204933	-0.000781906
3.417361111	-0.003082234	-0.002929786	-0.002011911	-0.000738196

3.509722222	-0.002928941	-0.002825225	-0.001969657	-0.000689358
3.602083333	-0.00277823	-0.002717372	-0.001922688	-0.000635252
3.694444444	-0.00263033	-0.002606783	-0.001871122	-0.000575727
3.786805556	-0.002485331	-0.002493979	-0.001815076	-0.000510628
3.879166667	-0.002343202	-0.00237945	-0.001754665	-0.000439789
3.971527778	-0.002203825	-0.002263651	-0.001689996	-0.000363036
4.063888889	-0.002067021	-0.002147001	-0.001621174	-0.000280186
4.15625	-0.001932579	-0.002029885	-0.001548293	-0.000191041
4.248611111	-0.001800287	-0.001912652	-0.001471441	-9.54E-05
4.340972222	-0.001669951	-0.001795613	-0.001390694	6.97E-06
4.433333333	-0.001541424	-0.001679047	-0.001306118	0.000116301
4.525694444	-0.001414615	-0.001563196	-0.001217767	0.000232839
4.618055556	-0.001289504	-0.001448267	-0.00112568	0.000356856
4.710416667	-0.001166147	-0.001334434	-0.001029882	0.000488638
4.802777778	-0.001044673	-0.001221837	-0.000930383	0.000628493
4.895138889	-0.000925282	-0.001110579	-0.000827176	0.000776746
4.9875	-0.00080823	-0.001000732	-0.000720237	0.000933748
5.079861111	-0.000693816	-0.000892333	-0.000609524	0.001099871
5.172222222	-0.000582365	-0.000785383	-0.000494974	0.001275514
5.264583333	-0.000474209	-0.000679852	-0.000376507	0.001461099
5.356944444	-0.000369664	-0.000575671	-0.00025402	0.00165708
5.449305556	-0.000269014	-0.000472738	-0.00012739	0.001863939
5.541666667	-0.000172494	-0.000370915	3.53E-06	0.002082189
5.634027778	-8.03E-05	-0.000270027	0.000138902	0.002312375
5.726388889	7.57E-06	-0.000169863	0.000278923	0.002555077
5.81875	9.10E-05	-7.02E-05	0.000423805	0.002810913
5.911111111	0.000170147	2.93E-05	0.000573789	0.003080535
6.003472222	0.000245158	0.000128963	0.00072914	0.003364637
6.095833333	0.00031631	0.000229095	0.000890149	0.003663954
6.188194444	0.000383961	0.00033012	0.001057134	0.003979262
6.280555556	0.000448551	0.000432473	0.001230441	0.004311384
6.372916667	0.000510594	0.000536624	0.001410445	0.004661189
6.465277778	0.000570679	0.000643077	0.001597551	0.005029593
6.557638889	0.000629458	0.000752368	0.001792196	0.005417562
6.65	0.000687645	0.000865065	0.001994848	0.005826115
6.742361111	0.000746016	0.000981762	0.002206009	0.006256323
6.834722222	0.000805403	0.001103082	0.002426218	0.006709314
6.927083333	0.000866698	0.001229666	0.00265605	0.007186272
7.019444444	0.000930856	0.001362179	0.00289612	0.007688438
7.111805556	0.000998893	0.001501298	0.003147086	0.008217115
7.204166667	0.001071892	0.001647713	0.003409647	0.008773668

7.296527778	0.001151001	0.001802122	0.003684551	0.009359523
7.388888889	0.001237436	0.001965225	0.003972595	0.009976174
7.48125	0.001332475	0.002137724	0.004274629	0.010625177
7.573611111	0.001437454	0.002320313	0.004591559	0.011308158
7.665972222	0.001553757	0.002513678	0.004924349	0.012026811
7.758333333	0.001682805	0.002718493	0.00527403	0.012782899
7.850694444	0.001826036	0.002935414	0.005641699	0.013578255
7.943055556	0.001984891	0.003165081	0.006028525	0.014414784
8.035416667	0.002160785	0.003408109	0.006435754	0.015294461
8.127777778	0.002355089	0.00366509	0.006864717	0.016219336
8.220138889	0.002569097	0.003936594	0.007316829	0.017191527
8.3125	0.002804005	0.004223163	0.0077936	0.01821323
8.404861111	0.00306088	0.00452532	0.008296638	0.019286708
8.497222222	0.003340636	0.004843562	0.008827656	0.020414299
8.589583333	0.003644012	0.005178373	0.009388477	0.021598411
8.681944444	0.003971552	0.00553022	0.009981041	0.022841523
8.774305556	0.004323588	0.005899565	0.010607412	0.024146184
8.866666667	0.00470023	0.006286871	0.011269785	0.025515008
8.959027778	0.00510136	0.006692609	0.011970488	0.026950679
9.051388889	0.005526633	0.00711727	0.012711996	0.028455941
9.14375	0.005975484	0.00756138	0.013496929	0.030033604
9.236111111	0.006447141	0.008025508	0.014328066	0.031686535
9.328472222	0.006940644	0.008510285	0.015208345	0.033417656
9.420833333	0.007454872	0.009016421	0.016140873	0.035229945
9.513194444	0.00798858	0.00954472	0.017128931	0.037126427
9.605555556	0.008540434	0.010096102	0.018175974	0.039110172
9.697916667	0.009109058	0.010671623	0.019285645	0.041184292
9.790277778	0.009693085	0.011272499	0.02046177	0.043351935
9.882638889	0.010291213	0.011900126	0.021708367	0.045616278
9.975	0.010902259	0.012556106	0.023029645	0.047980525
10.06736111	0.011525223	0.013242274	0.024430012	0.0504479
10.15972222	0.012159348	0.013960723	0.025914067	0.053021638
10.25208333	0.012804178	0.014713828	0.027486607	0.055704983
10.34444444	0.01345962	0.015504281	0.029152625	0.058501176
10.43680556	0.014125995	0.016335114	0.030917305	0.061413453
10.52916667	0.014804086	0.01720973	0.032786019	0.064445032
10.62152778	0.015495185	0.018131931	0.034764324	0.067599111
10.71388889	0.016201128	0.01910595	0.036857955	0.070878851
10.80625	0.016924319	0.02013648	0.039072817	0.074287378
10.89861111	0.017667752	0.021228701	0.041414972	0.077827766
10.99097222	0.018435023	0.022388315	0.043890637	0.081503031

11.08333333	0.019230333	0.023621566	0.04650616	0.085316122
11.17569444	0.020058484	0.024935278	0.049268015	0.089269909
11.26805556	0.020924872	0.026336874	0.052182781	0.093367177
11.36041667	0.021835481	0.027834404	0.055257123	0.097610613
11.45277778	0.022796865	0.029436566	0.058497779	0.102002796
11.54513889	0.02381615	0.03115273	0.061911528	0.106546191
11.6375	0.024901024	0.032992952	0.065505178	0.111243132
11.72986111	0.026059746	0.034967987	0.069285532	0.116095818
11.82222222	0.027301166	0.037089299	0.073259367	0.121106299
11.91458333	0.028634753	0.039369065	0.077433404	0.126276469
12.00694444	0.030070643	0.041820171	0.081814277	0.131608053
12.09930556	0.031619705	0.044456202	0.086408505	0.137102599
12.19166667	0.033293625	0.047291427	0.091222457	0.142761468
12.28402778	0.035105004	0.050340769	0.09626232	0.148585825
12.37638889	0.037067473	0.053619773	0.101534064	0.154576628
12.46875	0.039195834	0.057144559	0.107043408	0.160734623
12.56111111	0.041506191	0.060931763	0.112795781	0.167060331
12.65347222	0.044016104	0.064998472	0.118796291	0.173554043
12.74583333	0.046744736	0.069362138	0.125049684	0.180215814
12.83819444	0.049712993	0.07404049	0.131560309	0.187045449
12.93055556	0.052943651	0.079051424	0.138332084	0.194042505
13.02291667	0.056461455	0.084412884	0.145368457	0.20120628
13.11527778	0.06029319	0.090142731	0.152672374	0.208535809
13.20763889	0.064467709	0.096258599	0.160246245	0.216029859
13.3	0.069015904	0.10277774	0.168091909	0.223686926
13.39236111	0.073970624	0.109716857	0.176210608	0.23150523
13.48472222	0.079366521	0.117091929	0.184602953	0.239482714
13.57708333	0.085239819	0.124918031	0.193268899	0.247617042
13.66944444	0.09162801	0.133209145	0.202207722	0.255905597
13.76180556	0.098569459	0.141977965	0.211417997	0.264345484
13.85416667	0.106102934	0.151235711	0.220897576	0.272933525
13.94652778	0.114267052	0.160991934	0.230643575	0.281666268
14.03888889	0.123099652	0.171254326	0.240652358	0.290539981
14.13125	0.1326371	0.182028547	0.250919533	0.299550664
14.22361111	0.142913545	0.193318048	0.261439941	0.308694047
14.31597222	0.153960128	0.205123919	0.272207656	0.317965598
14.40833333	0.165804175	0.217444742	0.283215988	0.327360526
14.50069444	0.178468386	0.230276475	0.294457488	0.336873791
14.59305556	0.191970041	0.243612343	0.305923955	0.346500113
14.68541667	0.206320248	0.257442768	0.317606455	0.356233973
14.77777778	0.221523258	0.27175531	0.329495336	0.366069631

14.87013889	0.237575864	0.286534648	0.34158025	0.37600113
14.9625	0.254466911	0.301762582	0.353850176	0.38602231
15.05486111	0.272176927	0.317418071	0.366293458	0.396126818
15.14722222	0.290677909	0.3334773	0.378897828	0.406308122
15.23958333	0.309933255	0.349913773	0.39165045	0.416559521
15.33194444	0.329897868	0.366698445	0.404537958	0.42687416
15.42430556	0.350518428	0.38379988	0.417546498	0.437245045
15.51666667	0.371733826	0.401184431	0.430661778	0.447665056
15.60902778	0.393475776	0.418816461	0.443869112	0.458126963
15.70138889	0.415669558	0.436658572	0.457153476	0.46862344
15.79375	0.438234917	0.454671862	0.470499558	0.479147082
15.88611111	0.461087065	0.472816207	0.483891815	0.489690421
15.97847222	0.484137782	0.491050545	0.497314529	0.500245941
16.07083333	0.507296582	0.509333178	0.510751863	0.510806096
16.16319444	0.530471924	0.527622082	0.524187923	0.521363325
16.25555556	0.55357243	0.545875215	0.537606812	0.53191007
16.34791667	0.576508083	0.564050829	0.550992691	0.542438792
16.44027778	0.599191389	0.582107778	0.564329836	0.552941987
16.53263889	0.62153846	0.600005808	0.577602697	0.563412204
16.625	0.643470012	0.617705847	0.590795952	0.573842058
16.71736111	0.664912243	0.635170271	0.603894563	0.584224249
16.80972222	0.68579759	0.652363155	0.616883826	0.594551577
16.90208333	0.706065339	0.669250498	0.629749426	0.604816955
16.99444444	0.725662098	0.68580043	0.642477484	0.615013427
17.08680556	0.744542112	0.701983388	0.6550546	0.62513418
17.17916667	0.762667433	0.717772268	0.667467897	0.635172561
17.27152778	0.780007951	0.733142546	0.679705064	0.645122084
17.36388889	0.796541289	0.748072371	0.691754384	0.654976451
17.45625	0.812252571	0.762542628	0.703604778	0.664729555
17.54861111	0.827134092	0.776536976	0.715245822	0.6743755
17.64097222	0.841184886	0.790041852	0.726667781	0.683908606
17.73333333	0.854410226	0.803046452	0.737861628	0.69332342
17.82569444	0.866821059	0.81554269	0.748819058	0.702614725
17.91805556	0.878433405	0.827525119	0.759532506	0.71177755
18.01041667	0.889267727	0.838990853	0.769995156	0.720807175
18.10277778	0.899348294	0.849939446	0.780200944	0.729699139
18.19513889	0.908702549	0.860372775	0.790144563	0.738449246
18.2875	0.917360489	0.870294889	0.79982146	0.747053568
18.37986111	0.925354077	0.879711864	0.80922783	0.755508451
18.47222222	0.93271669	0.888631636	0.818360611	0.763810519
18.56458333	0.939482604	0.897063834	0.827217466	0.771956671

18.65694444	0.945686534	0.905019601	0.835796774	0.77994409
18.74930556	0.951363215	0.912511427	0.844097608	0.787770238
18.84166667	0.956547045	0.919552963	0.852119716	0.795432858
18.93402778	0.961271766	0.926158856	0.859863499	0.802929973
19.02638889	0.965570213	0.932344575	0.867329982	0.810259885
19.11875	0.96947409	0.938126246	0.874520791	0.817421168
19.21111111	0.973013812	0.943520499	0.881438122	0.824412672
19.30347222	0.976218369	0.948544314	0.88808471	0.831233514
19.39583333	0.979115243	0.953214886	0.894463797	0.837883072
19.48819444	0.981730345	0.957549492	0.900579101	0.844360987
19.58055556	0.984087994	0.961565376	0.906434783	0.850667148
19.67291667	0.986210906	0.965279635	0.912035407	0.856801694
19.76527778	0.988120217	0.968709125	0.917385914	0.862764999
19.85763889	0.989835512	0.971870378	0.922491583	0.868557672
19.95	0.991374875	0.974779522	0.927357995	0.874180544
20.04236111	0.992754945	0.977452217	0.931991003	0.879634662
20.13472222	0.99399098	0.979903604	0.936396698	0.88492128
20.22708333	0.995096929	0.982148262	0.940581372	0.89004185
20.31944444	0.996085504	0.984200168	0.944551491	0.894998012
20.41180556	0.996968255	0.986072674	0.948313663	0.899791585
20.50416667	0.997755643	0.987778492	0.951874604	0.904424559
20.59652778	0.998457119	0.989329677	0.955241117	0.908899082
20.68888889	0.999081192	0.99073763	0.958420056	0.913217453
20.78125	0.999635504	0.992013096	0.961418308	0.917382109
20.87361111	1.000126896	0.993166174	0.964242763	0.92139562
20.96597222	1.000561473	0.994206328	0.966900293	0.925260672
21.05833333	1.000944665	0.995142404	0.969397731	0.928980063
21.15069444	1.001281293	0.995982649	0.97174185	0.93255669
21.24305556	1.001575615	0.996734737	0.973939347	0.935993539
21.33541667	1.001831387	0.997405787	0.975996822	0.939293679
21.42777778	1.002051905	0.998002398	0.977920766	0.942460246
21.52013889	1.002240059	0.998530671	0.97971755	0.94549644
21.6125	1.002398369	0.99899624	0.981393404	0.948405513
21.70486111	1.00252903	0.999404304	0.982954417	0.951190759
21.79722222	1.002633949	0.99975965	0.984406519	0.953855508
21.88958333	1.002714776	1.000066689	0.985755479	0.956403116
21.98194444	1.002772941	1.000329482	0.987006895	0.958836957
22.07430556	1.002809685	1.00055177	0.988166188	0.961160416
22.16666667	1.002826085	1.000736998	0.989238601	0.963376882
22.25902778	1.002823084	1.000888346	0.990229193	0.965489739
22.35138889	1.002801517	1.00100875	0.991142839	0.967502361

22.44375	1.002762136	1.001100931	0.991984225	0.969418104
22.53611111	1.002705632	1.001167412	0.992757853	0.971240304
22.62847222	1.002632661	1.001210542	0.993468035	0.972972264
22.72083333	1.002543863	1.001232516	0.9941189	0.974617258
22.81319444	1.002439886	1.001235391	0.994714392	0.976178519
22.90555556	1.002321405	1.001221104	0.995258272	0.977659237
22.99791667	1.002189142	1.001191483	0.995754126	0.979062554
23.09027778	1.002043882	1.001148263	0.99620536	0.980391562
23.18263889	1.001886491	1.001093096	0.99661521	0.9816493
23.275	1.001717927	1.001027562	0.996986745	0.982838746
23.36736111	1.001539255	1.000953173	0.997322867	0.983962822
23.45972222	1.001351652	1.000871381	0.997626321	0.985024384
23.55208333	1.001156414	1.000783585	0.997899697	0.986026226
23.64444444	1.000954958	1.000691131	0.998145433	0.986971075
23.73680556	1.00074882	1.000595315	0.998365825	0.98786159
23.82916667	1.000539647	1.000497386	0.998563026	0.988700363
23.92152778	1.000329194	1.00039854	0.998739054	0.989489916
24.01388889	1.0001193	1.000299924	0.998895798	0.990232702
24.10625	0.999911882	1.000202632	0.999035021	0.990931104
24.19861111	0.999708906	1.000107701	0.999158367	0.991587436
24.29097222	0.999512367	1.000016106	0.999267364	0.992203942
24.38333333	0.999324261	0.99992876	0.999363428	0.9927828
24.47569444	0.999146559	0.999846506	0.999447873	0.993326116
24.56805556	0.998981172	0.999770113	0.99952191	0.993835935
24.66041667	0.998829925	0.999700271	0.999586655	0.994314233
24.75277778	0.998694526	0.999637591	0.999643134	0.994762925
24.84513889	0.998576532	0.999582592	0.999692286	0.995183862
24.9375	0.998477326	0.999535704	0.999734967	0.995578838
25.02986111	0.998398084	0.999497265	0.999771957	0.995949586
25.12222222	0.998339758	0.999467512	0.999803963	0.996297787
25.21458333	0.998303052	0.999446587	0.999831624	0.996625067
25.30694444	0.998288406	0.99943453	0.999855516	0.996933001
25.39930556	0.998295984	0.999431282	0.999876152	0.997223117
25.49166667	0.998325669	0.999436685	0.999893993	0.997496899
25.58402778	0.998377054	0.999450484	0.999909447	0.997755788
25.67638889	0.998449451	0.999472329	0.999922876	0.998001186
25.76875	0.998541894	0.999501781	0.999934598	0.998234457
25.86111111	0.998653147	0.999538314	0.999944894	0.998456936
25.95347222	0.998781728	0.999581327	0.999954009	0.998669926
26.04583333	0.998925918	0.999630141	0.999962159	0.998874704
26.13819444	0.999083793	0.999684017	0.999969531	0.999072524

26.23055556	0.999253246	0.999742157	0.999976292	0.999264622
26.32291667	0.999432016	0.999803719	0.99998259	0.999452216
26.41527778	0.99961772	0.999867821	0.99998856	0.999636513
26.50763889	0.99980789	0.999933556	0.999994324	0.99981871
26.6	1	1	1	1

Table B.14 Fickian model for Sadighian et al.[5], (athabasca atmospheric residue + pentane) considering variations in density

Elevation (mm)	6780 s	14820 s	25980 s
0	0	0	0
0.092361111	-0.000255142	-0.000119727	-5.56E-05
0.184722222	-0.000509227	-0.000239154	-0.000111113
0.277083333	-0.000759999	-0.000357631	-0.000166192
0.369444444	-0.001006494	-0.000474877	-0.000220734
0.461805556	-0.001247474	-0.000590523	-0.000274574
0.554166667	-0.001481756	-0.00070421	-0.000327549
0.646527778	-0.001708216	-0.00081559	-0.000379498
0.738888889	-0.001925804	-0.000924322	-0.000430262
0.83125	-0.002133548	-0.001030083	-0.000479682
0.923611111	-0.002330565	-0.001132559	-0.000527604
1.015972222	-0.002516065	-0.001231455	-0.000573874
1.108333333	-0.002689354	-0.00132649	-0.000618341
1.200694444	-0.002849839	-0.001417402	-0.000660856
1.293055556	-0.002997034	-0.001503946	-0.000701276
1.385416667	-0.003130555	-0.001585896	-0.000739455
1.477777778	-0.003250123	-0.001663047	-0.000775255
1.570138889	-0.003355564	-0.001735213	-0.000808539
1.6625	-0.003446802	-0.001802229	-0.000839172
1.754861111	-0.003523863	-0.001863949	-0.000867023
1.847222222	-0.003586861	-0.001920251	-0.000891965
1.939583333	-0.003636003	-0.001971029	-0.00091387
2.031944444	-0.003671573	-0.002016201	-0.000932616
2.124305556	-0.003693934	-0.002055704	-0.000948083
2.216666667	-0.003703515	-0.002089494	-0.000960151
2.309027778	-0.003700805	-0.002117544	-0.000968706
2.401388889	-0.003686347	-0.002139848	-0.000973632
2.49375	-0.003660727	-0.002156416	-0.000974817
2.586111111	-0.003624569	-0.002167274	-0.000972149
2.678472222	-0.003578523	-0.002172463	-0.000965518
2.770833333	-0.003523263	-0.002172038	-0.000954812

2.863194444	-0.003459473	-0.002166067	-0.000939922
2.955555556	-0.003387846	-0.002154629	-0.000920737
3.047916667	-0.003309075	-0.002137813	-0.000897145
3.140277778	-0.003223844	-0.002115718	-0.000869034
3.232638889	-0.003132828	-0.002088449	-0.000836288
3.325	-0.003036684	-0.002056116	-0.00079879
3.417361111	-0.00293605	-0.002018837	-0.000756419
3.509722222	-0.002831538	-0.001976728	-0.000709049
3.602083333	-0.002723731	-0.001929909	-0.000656553
3.694444444	-0.002613186	-0.001878499	-0.000598794
3.786805556	-0.002500425	-0.001822617	-0.000535633
3.879166667	-0.002385937	-0.001762377	-0.000466921
3.971527778	-0.002270177	-0.001697889	-0.000392503
4.063888889	-0.002153565	-0.001629257	-0.000312215
4.15625	-0.002036485	-0.001556579	-0.000225884
4.248611111	-0.001919286	-0.001479941	-0.000133327
4.340972222	-0.001802281	-0.001399424	-3.43E-05
4.433333333	-0.001685747	-0.001315094	7.13E-05
4.525694444	-0.001569929	-0.001227007	0.000183718
4.618055556	-0.001455033	-0.001135204	0.00030326
4.710416667	-0.001341234	-0.001039714	0.000430137
4.802777778	-0.001228672	-0.00094055	0.000564615
4.895138889	-0.001117451	-0.000837707	0.000706978
4.9875	-0.001007643	-0.000731165	0.00085753
5.079861111	-0.000899286	-0.000620885	0.001016593
5.172222222	-0.000792384	-0.000506811	0.001184511
5.264583333	-0.000686904	-0.000388866	0.00136165
5.356944444	-0.000582782	-0.000266955	0.0015484
5.449305556	-0.000479914	-0.000140961	0.001745175
5.541666667	-0.000378165	-1.07E-05	0.001952415
5.634027778	-0.000277361	0.000123851	0.002170589
5.726388889	-0.00017729	0.00026301	0.002400194
5.81875	-7.77E-05	0.000406935	0.002641754
5.911111111	2.17E-05	0.000555855	0.00289583
6.003472222	0.000121172	0.000710021	0.003163011
6.095833333	0.00022115	0.000869709	0.003443923
6.188194444	0.000322003	0.001035222	0.003739225
6.280555556	0.000424163	0.001206886	0.004049616
6.372916667	0.000528098	0.001385056	0.004375832
6.465277778	0.00063431	0.001570112	0.004718648
6.557638889	0.000743334	0.001762464	0.00507888

6.65	0.000855734	0.001962551	0.00545739
6.742361111	0.000972103	0.002170842	0.005855079
6.834722222	0.001093062	0.002387839	0.006272898
6.927083333	0.00121925	0.002614076	0.006711841
7.019444444	0.001351328	0.00285012	0.007172952
7.111805556	0.001489973	0.003096578	0.007657326
7.204166667	0.001635871	0.003354093	0.008166105
7.296527778	0.001789719	0.003623348	0.008700486
7.388888889	0.001952215	0.003905068	0.009261717
7.48125	0.002124057	0.004200027	0.009851101
7.573611111	0.002305937	0.004509041	0.010469998
7.665972222	0.00249854	0.00483298	0.011119822
7.758333333	0.002702536	0.005172767	0.011802046
7.850694444	0.00291858	0.005529383	0.012518199
7.943055556	0.003147305	0.005903867	0.013269871
8.035416667	0.003389326	0.006297326	0.014058711
8.127777778	0.003645229	0.006710931	0.014886428
8.220138889	0.00391558	0.00714593	0.015754791
8.3125	0.004200916	0.007603645	0.016665632
8.404861111	0.00450175	0.008085481	0.01762084
8.497222222	0.004818573	0.008592929	0.018622371
8.589583333	0.005151857	0.009127571	0.019672236
8.681944444	0.005502057	0.009691086	0.020772511
8.774305556	0.005869619	0.010285255	0.02192533
8.866666667	0.006254986	0.010911964	0.023132889
8.959027778	0.006658607	0.011573214	0.024397441
9.051388889	0.007080944	0.01227112	0.025721298
9.14375	0.00752249	0.013007922	0.027106827
9.236111111	0.007983771	0.013785988	0.028556454
9.328472222	0.008465372	0.014607819	0.030072655
9.420833333	0.008967942	0.015476052	0.031657961
9.513194444	0.009492218	0.01639347	0.033314951
9.605555556	0.010039038	0.017363002	0.035046253
9.697916667	0.010609364	0.018387727	0.03685454
9.790277778	0.011204297	0.019470882	0.038742525
9.882638889	0.011825103	0.020615861	0.040712965
9.975	0.012473232	0.02182622	0.042768648
10.06736111	0.013150342	0.023105679	0.044912399
10.15972222	0.01385832	0.024458125	0.04714707
10.25208333	0.014599308	0.02588761	0.049475536
10.34444444	0.015375725	0.027398355	0.051900697

10.43680556	0.016190294	0.028994747	0.054425464
10.52916667	0.017046064	0.030681341	0.057052762
10.62152778	0.017946435	0.032462852	0.059785522
10.71388889	0.018895186	0.034344158	0.062626675
10.80625	0.019896492	0.036330294	0.065579147
10.89861111	0.020954957	0.038426445	0.068645855
10.99097222	0.02207563	0.040637943	0.071829697
11.08333333	0.023264033	0.042970257	0.075133549
11.17569444	0.024526181	0.045428985	0.078560259
11.26805556	0.025868602	0.048019847	0.082112635
11.36041667	0.027298361	0.05074867	0.085793445
11.45277778	0.028823072	0.05362138	0.089605404
11.54513889	0.030450922	0.056643986	0.093551173
11.6375	0.032190678	0.059822565	0.097633343
11.72986111	0.034051702	0.063163248	0.101854434
11.82222222	0.036043961	0.066672203	0.106216886
11.91458333	0.038178028	0.070355615	0.110723047
12.00694444	0.040465088	0.074219667	0.115375172
12.09930556	0.042916928	0.078270521	0.120175406
12.19166667	0.045545936	0.082514291	0.125125784
12.28402778	0.048365079	0.086957028	0.130228215
12.37638889	0.051387889	0.091604688	0.135484482
12.46875	0.05462843	0.096463112	0.140896225
12.56111111	0.058101267	0.101537997	0.146464939
12.65347222	0.061821424	0.10683487	0.15219196
12.74583333	0.065804329	0.112359062	0.158078462
12.83819444	0.070065759	0.118115675	0.164125446
12.93055556	0.074621768	0.124109559	0.170333731
13.02291667	0.079488609	0.130345275	0.176703948
13.11527778	0.08468265	0.136827074	0.18323653
13.20763889	0.090220274	0.143558857	0.189931706
13.3	0.096117774	0.150544152	0.196789491
13.39236111	0.102391234	0.15778608	0.203809685
13.48472222	0.10905641	0.165287326	0.210991856
13.57708333	0.116128594	0.173050108	0.218335344
13.66944444	0.123622473	0.18107615	0.225839247
13.76180556	0.131551982	0.189366649	0.233502419
13.85416667	0.139930153	0.197922253	0.241323465
13.94652778	0.148768953	0.206743027	0.249300732
14.03888889	0.158079124	0.215828434	0.257432311
14.13125	0.16787002	0.225177308	0.265716029

14.22361111	0.178149441	0.234787831	0.274149444
14.31597222	0.188923473	0.244657514	0.282729851
14.40833333	0.200196327	0.254783177	0.291454269
14.50069444	0.211970182	0.265160938	0.300319448
14.59305556	0.224245048	0.275786191	0.309321866
14.68541667	0.237018618	0.286653604	0.31845773
14.77777778	0.250286152	0.297757106	0.327722976
14.87013889	0.264040368	0.309089886	0.337113271
14.9625	0.278271345	0.320644391	0.346624018
15.05486111	0.292966455	0.332412327	0.356250358
15.14722222	0.308110313	0.344384669	0.365987176
15.23958333	0.323684751	0.356551669	0.375829105
15.33194444	0.339668815	0.368902871	0.385770533
15.42430556	0.3560388	0.381427131	0.395805614
15.51666667	0.372768306	0.394112638	0.405928268
15.60902778	0.389828325	0.40694694	0.416132201
15.70138889	0.407187362	0.419916979	0.426410906
15.79375	0.424811591	0.433009125	0.436757681
15.88611111	0.442665031	0.446209211	0.447165635
15.97847222	0.460709766	0.459502585	0.457627707
16.07083333	0.47890618	0.472874148	0.468136674
16.16319444	0.497213232	0.486308411	0.47868517
16.25555556	0.515588738	0.499789548	0.489265698
16.34791667	0.53398969	0.513301449	0.499870649
16.44027778	0.552372581	0.526827786	0.510492315
16.53263889	0.570693742	0.54035207	0.52112291
16.625	0.58890969	0.553857717	0.531754583
16.71736111	0.606977478	0.567328114	0.542379442
16.80972222	0.624855034	0.580746684	0.552989567
16.90208333	0.642501504	0.594096955	0.563577032
16.99444444	0.659877571	0.607362624	0.574133925
17.08680556	0.676945761	0.620527626	0.584652362
17.17916667	0.69367072	0.633576199	0.595124513
17.27152778	0.710019475	0.646492947	0.605542616
17.36388889	0.72596165	0.659262905	0.615898998
17.45625	0.741469658	0.671871593	0.626186095
17.54861111	0.756518853	0.68430508	0.636396469
17.64097222	0.771087647	0.696550029	0.646522826
17.73333333	0.785157585	0.708593755	0.656558036
17.82569444	0.798713384	0.720424263	0.666495148
17.91805556	0.811742935	0.732030292	0.676327406

18.01041667	0.824237269	0.743401352	0.686048269
18.10277778	0.836190486	0.754527753	0.69565142
18.19513889	0.847599659	0.765400632	0.705130785
18.2875	0.8584647	0.776011972	0.714480546
18.37986111	0.868788215	0.786354621	0.723695149
18.47222222	0.878575324	0.796422298	0.732769321
18.56458333	0.887833472	0.806209598	0.741698075
18.65694444	0.896572227	0.815711995	0.750476726
18.74930556	0.904803064	0.824925833	0.759100889
18.84166667	0.912539148	0.833848314	0.767566496
18.93402778	0.919795111	0.842477488	0.775869795
19.02638889	0.926586834	0.850812229	0.784007358
19.11875	0.932931231	0.858852212	0.79197608
19.21111111	0.938846038	0.866597888	0.799773187
19.30347222	0.944349615	0.874050449	0.807396231
19.39583333	0.949460759	0.881211798	0.814843094
19.48819444	0.954198522	0.888084512	0.822111985
19.58055556	0.958582055	0.894671799	0.829201436
19.67291667	0.962630454	0.900977464	0.836110299
19.76527778	0.966362632	0.907005862	0.842837745
19.85763889	0.969797194	0.912761855	0.849383251
19.95	0.972952341	0.918250772	0.855746602
20.04236111	0.975845776	0.923478361	0.861927876
20.13472222	0.978494633	0.928450747	0.86792744
20.22708333	0.980915414	0.933174386	0.87374594
20.31944444	0.983123941	0.937656024	0.879384291
20.41180556	0.985135324	0.941902654	0.884843665
20.50416667	0.986963929	0.945921475	0.890125485
20.59652778	0.988623368	0.949719851	0.895231407
20.68888889	0.990126491	0.953305276	0.900163313
20.78125	0.991485386	0.956685333	0.904923297
20.87361111	0.99271139	0.959867662	0.909513654
20.96597222	0.993815102	0.96285993	0.913936863
21.05833333	0.994806403	0.965669795	0.91819558
21.15069444	0.995694479	0.968304882	0.92229262
21.24305556	0.996487849	0.970772755	0.926230949
21.33541667	0.997194394	0.973080895	0.930013664
21.42777778	0.997821391	0.975236674	0.933643989
21.52013889	0.998375542	0.977247341	0.937125253
21.6125	0.998863012	0.97912	0.940460886
21.70486111	0.999289463	0.980861598	0.943654399

21.79722222	0.999660087	0.982478908	0.946709377
21.88958333	0.99997964	0.983978522	0.949629467
21.98194444	1.000252478	0.985366838	0.952418364
22.07430556	1.000482588	0.986650054	0.955079799
22.16666667	1.000673617	0.98783416	0.957617534
22.25902778	1.000828907	0.988924936	0.960035347
22.35138889	1.000951519	0.989927948	0.962337021
22.44375	1.001044262	0.990848544	0.96452634
22.53611111	1.001109716	0.991691856	0.966607075
22.62847222	1.001150259	0.9924628	0.968582978
22.72083333	1.001168087	0.993166076	0.970457775
22.81319444	1.00116523	0.993806171	0.972235153
22.90555556	1.001143578	0.994387365	0.973918761
22.99791667	1.001104888	0.994913731	0.975512198
23.09027778	1.001050807	0.995389139	0.977019009
23.18263889	1.000982878	0.995817267	0.978442676
23.275	1.000902557	0.996201599	0.979786618
23.36736111	1.000811216	0.996545434	0.981054184
23.45972222	1.000710158	0.996851895	0.982248648
23.55208333	1.000600621	0.997123929	0.983373206
23.64444444	1.000483782	0.997364319	0.984430971
23.73680556	1.000360763	0.997575685	0.985424972
23.82916667	1.000232636	0.997760496	0.98635815
23.92152778	1.000100423	0.997921073	0.987233358
24.01388889	0.9999651	0.998059596	0.988053354
24.10625	0.999827598	0.998178112	0.988820804
24.19861111	0.9996888	0.998278537	0.989538279
24.29097222	0.999549547	0.998362668	0.990208253
24.38333333	0.999410634	0.998432183	0.990833101
24.47569444	0.999272814	0.99848865	0.991415104
24.56805556	0.999136791	0.998533533	0.99195644
24.66041667	0.999003226	0.998568193	0.992459191
24.75277778	0.998872736	0.9985939	0.992925339
24.84513889	0.998745891	0.998611829	0.993356765
24.9375	0.998623217	0.998623073	0.993755255
25.02986111	0.998505197	0.998628641	0.994122492
25.12222222	0.998392269	0.998629465	0.994460064
25.21458333	0.99828483	0.998626405	0.994769457
25.30694444	0.998183237	0.998620246	0.995052063
25.39930556	0.998087806	0.998611711	0.995309174
25.49166667	0.99799882	0.998601456	0.995541986

25.58402778	0.997916524	0.998590075	0.995751601
25.67638889	0.997841132	0.998578105	0.995939021
25.76875	0.997772828	0.998566026	0.996105157
25.86111111	0.99771177	0.998554262	0.996250823
25.95347222	0.997658088	0.998543185	0.996376738
26.04583333	0.997611893	0.998533117	0.996483531
26.13819444	0.997573273	0.998524328	0.996571733
26.23055556	0.9975423	0.998517041	0.996641784
26.32291667	0.997519026	0.998511431	0.996694033
26.41527778	0.997503491	0.998507625	0.996728734
26.50763889	0.997495718	0.998505704	0.996746049
26.6	0.997495718	0.998505704	0.996746049

Table B.15 Fickian + sorption model for Sadighian et al.[5], (athabasca atmospheric residue + pentane)

Elevation (mm)	3420 s	6780 s	14820 s	25980 s
0	0	0	0	0
0.092361111	-0.000466086	-0.000255632	-7.77E-05	-3.55E-05
0.184722222	-0.000925941	-0.000505818	-0.000147992	-6.47E-05
0.277083333	-0.001375834	-0.000749712	-0.00021363	-9.04E-05
0.369444444	-0.001811881	-0.000985627	-0.000275244	-0.000113279
0.461805556	-0.002230123	-0.001211623	-0.000332948	-0.000133906
0.554166667	-0.002626759	-0.001425735	-0.000386651	-0.000152461
0.646527778	-0.002998209	-0.001626051	-0.000436176	-0.00016908
0.738888889	-0.00334116	-0.001810745	-0.000481301	-0.000183847
0.83125	-0.003652585	-0.001978117	-0.000521792	-0.000196815
0.923611111	-0.003929765	-0.002126611	-0.000557419	-0.000208018
1.015972222	-0.004170289	-0.002254837	-0.000587963	-0.000217478
1.108333333	-0.004372059	-0.002361584	-0.000613232	-0.000225209
1.200694444	-0.004533287	-0.002445839	-0.00063306	-0.000231218
1.293055556	-0.004652492	-0.002506795	-0.000647314	-0.000235511
1.385416667	-0.0047285	-0.002543861	-0.000655897	-0.000238089
1.477777778	-0.004760449	-0.00255667	-0.000658751	-0.000238953
1.570138889	-0.004747793	-0.002545082	-0.000655857	-0.000238105
1.6625	-0.004690321	-0.002509188	-0.000647236	-0.000235544
1.754861111	-0.004588168	-0.002449309	-0.000632951	-0.00023127
1.847222222	-0.004441843	-0.002365993	-0.000613098	-0.00022528
1.939583333	-0.004252247	-0.002260011	-0.000587814	-0.000217571
2.031944444	-0.004020701	-0.002132349	-0.000557267	-0.000208135
2.124305556	-0.003748965	-0.001984195	-0.000521652	-0.000196959

2.216666667	-0.003439252	-0.001816932	-0.000481188	-0.000184023
2.309027778	-0.003094234	-0.001632117	-0.000436108	-0.000169293
2.401388889	-0.002717036	-0.001431461	-0.000386648	-0.000152717
2.49375	-0.002311216	-0.001216809	-0.00033303	-0.000134212
2.586111111	-0.001880731	-0.000990107	-0.000275434	-0.000113647
2.678472222	-0.001429873	-0.000753357	-0.000213953	-9.08E-05
2.770833333	-0.000963185	-0.000508542	-0.00014848	-6.53E-05
2.863194444	-0.000485291	-0.000257442	-7.84E-05	-3.63E-05
2.955555556	-3.15E-07	-8.12E-07	-1.07E-06	-1.15E-06
3.047916667	1.96E-05	1.34E-05	8.50E-06	6.04E-06
3.140277778	7.58E-06	5.68E-06	3.85E-06	2.73E-06
3.232638889	-4.94E-05	-3.14E-05	-2.02E-05	-1.52E-05
3.325	-8.42E-05	-5.35E-05	-3.43E-05	-2.56E-05
3.417361111	-0.000105727	-6.69E-05	-4.28E-05	-3.19E-05
3.509722222	-0.000116228	-7.34E-05	-4.69E-05	-3.50E-05
3.602083333	-0.000116431	-7.35E-05	-4.70E-05	-3.51E-05
3.694444444	-0.000106359	-6.74E-05	-4.32E-05	-3.22E-05
3.786805556	-8.53E-05	-5.43E-05	-3.50E-05	-2.62E-05
3.879166667	-5.13E-05	-3.29E-05	-2.14E-05	-1.61E-05
3.971527778	3.67E-06	2.57E-06	1.49E-06	8.25E-07
4.063888889	-1.41E-05	-1.07E-05	-7.93E-06	-6.48E-06
4.15625	2.10E-05	1.41E-05	8.80E-06	6.15E-06
4.248611111	2.48E-05	1.70E-05	1.10E-05	7.94E-06
4.340972222	2.53E-06	2.12E-06	1.65E-06	1.28E-06
4.433333333	-6.14E-05	-3.61E-05	-2.24E-05	-1.66E-05
4.525694444	-0.000102887	-5.99E-05	-3.70E-05	-2.73E-05
4.618055556	-0.000130015	-7.50E-05	-4.63E-05	-3.41E-05
4.710416667	-0.000144894	-8.33E-05	-5.13E-05	-3.78E-05
4.802777778	-0.000148263	-8.51E-05	-5.25E-05	-3.87E-05
4.895138889	-0.000140258	-8.08E-05	-4.99E-05	-3.69E-05
4.9875	-0.000120532	-6.99E-05	-4.35E-05	-3.22E-05
5.079861111	-8.79E-05	-5.17E-05	-3.25E-05	-2.43E-05
5.172222222	-3.91E-05	-2.39E-05	-1.56E-05	-1.20E-05
5.264583333	4.40E-05	2.48E-05	1.42E-05	9.71E-06
5.356944444	0.000100462	5.56E-05	3.25E-05	2.29E-05
5.449305556	0.000142304	7.74E-05	4.53E-05	3.21E-05
5.541666667	0.000172014	9.24E-05	5.40E-05	3.83E-05
5.634027778	0.000190429	0.00010148	5.92E-05	4.20E-05
5.726388889	0.000197834	0.000104977	6.11E-05	4.34E-05
5.81875	0.000194286	0.000103015	5.99E-05	4.25E-05
5.911111111	0.000179703	9.55E-05	5.55E-05	3.93E-05

6.003472222	0.000153807	8.21E-05	4.76E-05	3.36E-05
6.095833333	0.00011586	6.21E-05	3.57E-05	2.50E-05
6.188194444	6.38E-05	3.38E-05	1.87E-05	1.26E-05
6.280555556	-1.09E-05	-9.46E-06	-8.13E-06	-7.23E-06
6.372916667	-4.38E-05	-3.07E-05	-2.14E-05	-1.68E-05
6.465277778	-5.74E-05	-3.94E-05	-2.67E-05	-2.06E-05
6.557638889	-5.57E-05	-3.80E-05	-2.56E-05	-1.96E-05
6.65	-3.79E-05	-2.59E-05	-1.75E-05	-1.35E-05
6.742361111	3.78E-06	2.65E-06	1.51E-06	8.24E-07
6.834722222	-2.49E-05	-1.81E-05	-1.28E-05	-1.01E-05
6.927083333	-2.36E-05	-1.72E-05	-1.20E-05	-9.47E-06
7.019444444	9.42E-06	7.37E-06	5.11E-06	3.68E-06
7.111805556	1.22E-05	8.63E-06	5.55E-06	3.86E-06
7.204166667	-2.45E-05	-1.76E-05	-1.24E-05	-9.78E-06
7.296527778	-2.85E-05	-2.08E-05	-1.48E-05	-1.18E-05
7.388888889	-6.15E-06	-5.84E-06	-5.45E-06	-5.14E-06
7.48125	5.23E-05	3.04E-05	1.77E-05	1.22E-05
7.573611111	8.87E-05	5.22E-05	3.14E-05	2.23E-05
7.665972222	0.000111046	6.54E-05	3.95E-05	2.83E-05
7.758333333	0.000121469	7.14E-05	4.32E-05	3.10E-05
7.850694444	0.000120616	7.09E-05	4.29E-05	3.07E-05
7.943055556	0.000108422	6.36E-05	3.84E-05	2.74E-05
8.035416667	8.40E-05	4.91E-05	2.93E-05	2.08E-05
8.127777778	4.48E-05	2.53E-05	1.44E-05	9.75E-06
8.220138889	-2.07E-05	-1.61E-05	-1.22E-05	-1.00E-05
8.3125	-5.57E-05	-3.79E-05	-2.58E-05	-2.00E-05
8.404861111	-7.39E-05	-4.91E-05	-3.27E-05	-2.50E-05
8.497222222	-7.87E-05	-5.18E-05	-3.43E-05	-2.60E-05
8.589583333	-7.04E-05	-4.63E-05	-3.06E-05	-2.32E-05
8.681944444	-4.77E-05	-3.15E-05	-2.10E-05	-1.60E-05
8.774305556	-4.04E-06	-2.97E-06	-2.40E-06	-2.17E-06
8.866666667	0.000788425	0.000771526	0.001054684	0.002084873
8.959027778	0.001580377	0.001546252	0.002115528	0.004177484
9.051388889	0.002371362	0.0023214	0.003183421	0.006280969
9.14375	0.003160898	0.003097212	0.004261789	0.008400669
9.236111111	0.003948486	0.003873992	0.005354131	0.010541935
9.328472222	0.004733609	0.004652117	0.006464033	0.012710123
9.420833333	0.005515733	0.005432062	0.007595173	0.014910594
9.513194444	0.006294314	0.006214415	0.008751343	0.017148716
9.605555556	0.007068798	0.006999897	0.009936459	0.019429854
9.697916667	0.007838637	0.007789385	0.011154581	0.021759381

9.790277778	0.008603305	0.008583932	0.012409924	0.024142667
9.882638889	0.009362325	0.009384787	0.013706877	0.026585082
9.975	0.010115299	0.010193419	0.015050013	0.029091995
10.06736111	0.010861951	0.011011538	0.016444101	0.031668769
10.15972222	0.011602174	0.011841118	0.017894123	0.034320756
10.25208333	0.01233609	0.012684422	0.01940528	0.0370533
10.34444444	0.013064108	0.013544027	0.020982999	0.039871727
10.43680556	0.013786991	0.014422844	0.022632947	0.04278134
10.52916667	0.014505925	0.015324148	0.024361033	0.045787419
10.62152778	0.015222579	0.016251603	0.026173413	0.048895209
10.71388889	0.015939167	0.017209286	0.028076493	0.052109916
10.80625	0.016658498	0.018201715	0.030076929	0.0554367
10.89861111	0.017384018	0.019233877	0.032181627	0.058880664
10.99097222	0.018119835	0.020311258	0.034397738	0.062446851
11.08333333	0.018870731	0.021439867	0.036732652	0.066140226
11.17569444	0.019642163	0.022626269	0.039193991	0.069965676
11.26805556	0.020440243	0.023877615	0.041789598	0.073927991
11.36041667	0.021271707	0.025201671	0.044527522	0.078031858
11.45277778	0.022143877	0.026606848	0.047416003	0.082281848
11.54513889	0.023064614	0.028102234	0.050463454	0.086682403
11.6375	0.024042268	0.029697624	0.053678436	0.091237822
11.72986111	0.025085637	0.031403547	0.057069638	0.095952255
11.82222222	0.026203924	0.033231298	0.060645845	0.100829681
11.91458333	0.027406721	0.035192957	0.064415911	0.105873897
12.00694444	0.028704005	0.037301418	0.068388725	0.11108851
12.09930556	0.03010616	0.039570404	0.072573174	0.116476915
12.19166667	0.03162403	0.042014477	0.076978106	0.122042283
12.28402778	0.033269003	0.04464905	0.081612289	0.127787552
12.37638889	0.035053122	0.04749038	0.086484364	0.133715406
12.46875	0.036989241	0.050555561	0.091602804	0.139828266
12.56111111	0.039091199	0.053862497	0.096975865	0.146128272
12.65347222	0.041374028	0.057429871	0.102611532	0.152617274
12.74583333	0.043854184	0.061277091	0.108517476	0.159296816
12.83819444	0.046549787	0.065424229	0.114700992	0.166168127
12.93055556	0.049480868	0.069891936	0.121168955	0.173232102
13.02291667	0.052669614	0.074701344	0.12792776	0.180489298
13.11527778	0.056140586	0.07987394	0.13498327	0.187939919
13.20763889	0.059920914	0.085431434	0.142340762	0.195583809
13.3	0.064040439	0.091395593	0.150004874	0.20342044
13.39236111	0.068531803	0.09778806	0.157979553	0.211448905
13.48472222	0.073430454	0.104630158	0.166268004	0.219667913

13.57708333	0.078774572	0.111942668	0.174872644	0.228075778
13.66944444	0.084604887	0.119745595	0.18379505	0.236670421
13.76180556	0.090964394	0.128057917	0.193035924	0.245449361
13.85416667	0.097897937	0.13689732	0.202595046	0.254409714
13.94652778	0.105451684	0.146279931	0.212471242	0.263548193
14.03888889	0.113672471	0.156220036	0.222662351	0.272861109
14.13125	0.122607022	0.166729808	0.233165201	0.282344369
14.22361111	0.132301069	0.177819027	0.243975581	0.291993482
14.31597222	0.142798363	0.189494814	0.25508823	0.301803565
14.40833333	0.154139613	0.201761385	0.266496827	0.311769344
14.50069444	0.166361373	0.214619806	0.278193978	0.321885166
14.59305556	0.179494889	0.228067792	0.29017123	0.332145008
14.68541667	0.193564965	0.242099519	0.302419066	0.342542481
14.77777778	0.208588864	0.256705479	0.314926931	0.353070852
14.87013889	0.22457528	0.271872364	0.327683244	0.363723046
14.9625	0.241523432	0.287583004	0.34067543	0.374491672
15.05486111	0.259422298	0.303816337	0.353889957	0.385369027
15.14722222	0.278250038	0.320547435	0.367312369	0.396347123
15.23958333	0.297973626	0.337747572	0.38092734	0.4074177
15.33194444	0.318548711	0.355384353	0.394718724	0.418572246
15.42430556	0.339919733	0.373421878	0.408669614	0.429802019
15.51666667	0.362020301	0.391820964	0.422762407	0.441098066
15.60902778	0.384773821	0.410539412	0.436978871	0.45245125
15.70138889	0.408094382	0.429532317	0.451300222	0.463852267
15.79375	0.431887868	0.448752413	0.4657072	0.475291675
15.88611111	0.45605328	0.468150459	0.480180149	0.486759915
15.97847222	0.480484225	0.48767565	0.494699104	0.498247339
16.07083333	0.505070547	0.507276051	0.509243876	0.509744231
16.16319444	0.529700031	0.526899052	0.523794138	0.521240839
16.25555556	0.554260165	0.546491824	0.538329519	0.532727394
16.34791667	0.578639877	0.566001783	0.552829688	0.544194142
16.44027778	0.602731228	0.585377054	0.567274447	0.555631364
16.53263889	0.626431005	0.60456691	0.581643818	0.567029407
16.625	0.649642161	0.623522204	0.595918129	0.578378706
16.71736111	0.6722751	0.642195775	0.610078098	0.58966981
16.80972222	0.694248741	0.660542815	0.624104916	0.600893405
16.90208333	0.715491373	0.678521215	0.637980322	0.612040341
16.99444444	0.735941268	0.696091857	0.651686679	0.623101653
17.08680556	0.755547063	0.713218873	0.665207042	0.634068582
17.17916667	0.774267908	0.729869854	0.678525225	0.6449326
17.27152778	0.792073391	0.746016014	0.691625856	0.655685427

17.36388889	0.808943262	0.761632304	0.70449443	0.666319053
17.45625	0.824866977	0.776697479	0.717117362	0.676825753
17.54861111	0.839843087	0.79119412	0.729482021	0.687198108
17.64097222	0.853878503	0.805108612	0.741576768	0.697429018
17.73333333	0.866987664	0.818431073	0.753390983	0.707511717
17.82569444	0.879191649	0.831155253	0.764915086	0.717439786
17.91805556	0.890517242	0.843278392	0.776140553	0.727207164
18.01041667	0.900995994	0.854801049	0.787059921	0.736808161
18.10277778	0.910663303	0.865726901	0.797666794	0.746237464
18.19513889	0.919557528	0.876062523	0.807955835	0.755490142
18.2875	0.927719148	0.885817151	0.817922757	0.764561659
18.37986111	0.935190001	0.895002423	0.827564307	0.773447872
18.47222222	0.94201259	0.903632128	0.836878245	0.782145035
18.56458333	0.948229465	0.911721933	0.845863313	0.790649803
18.65694444	0.953882705	0.919289121	0.854519211	0.79895923
18.74930556	0.959013463	0.926352329	0.862846555	0.807070766
18.84166667	0.963661611	0.932931293	0.870846839	0.81498226
18.93402778	0.967865445	0.939046599	0.878522396	0.822691948
19.02638889	0.971661474	0.944719458	0.885876347	0.830198454
19.11875	0.975084264	0.949971479	0.892912557	0.837500783
19.21111111	0.978166343	0.954824471	0.899635579	0.844598308
19.30347222	0.980938149	0.959300254	0.906050611	0.851490768
19.39583333	0.983428024	0.963420494	0.912163435	0.858178255
19.48819444	0.985662241	0.967206551	0.917980367	0.864661203
19.58055556	0.987665054	0.97067935	0.923508203	0.870940378
19.67291667	0.989458771	0.973859265	0.928754167	0.877016867
19.76527778	0.991063845	0.976766025	0.933725853	0.88289206
19.85763889	0.992498967	0.979418635	0.93843118	0.888567643
19.95	0.993781171	0.981835315	0.942878332	0.894045578
20.04236111	0.994925942	0.984033447	0.947075719	0.899328093
20.13472222	0.995947319	0.986029547	0.951031919	0.904417665
20.22708333	0.996858001	0.987839239	0.954755643	0.909317005
20.31944444	0.997669446	0.989477248	0.95825568	0.914029042
20.41180556	0.998391966	0.990957396	0.961540865	0.91855691
20.50416667	0.999034815	0.992292615	0.964620037	0.922903929
20.59652778	0.999606281	0.993494956	0.967502004	0.92707359
20.68888889	1.000113756	0.994575621	0.970195506	0.931069542
20.78125	1.000563817	0.995544982	0.972709191	0.934895575
20.87361111	1.000962291	0.996412616	0.975051582	0.938555602
20.96597222	1.001314325	0.997187343	0.977231054	0.942053649
21.05833333	1.001624444	0.99787726	0.97925581	0.945393836

21.15069444	1.001896608	0.998489784	0.981133866	0.948580366
21.24305556	1.002134271	0.999031688	0.982873028	0.951617507
21.33541667	1.002340427	0.999509149	0.984480882	0.954509582
21.42777778	1.002517664	0.999927783	0.985964778	0.957260956
21.52013889	1.002668204	1.000292691	0.987331824	0.959876019
21.6125	1.002793949	1.000608496	0.988588878	0.962359178
21.70486111	1.002896519	1.000879385	0.989742539	0.964714847
21.79722222	1.002977287	1.001109144	0.990799146	0.966947429
21.88958333	1.003037415	1.001301197	0.991764777	0.969061313
21.98194444	1.003077879	1.001458641	0.992645246	0.97106086
22.07430556	1.003099499	1.001584278	0.993446106	0.972950395
22.16666667	1.003102965	1.001680646	0.994172652	0.974734199
22.25902778	1.003088854	1.001750052	0.994829922	0.976416501
22.35138889	1.003057655	1.001794596	0.995422705	0.978001468
22.44375	1.003009786	1.001816197	0.995955546	0.979493202
22.53611111	1.002945616	1.001816619	0.996432749	0.980895733
22.62847222	1.00286548	1.001797491	0.996858388	0.98221301
22.72083333	1.002769699	1.001760329	0.997236313	0.983448901
22.81319444	1.002658599	1.001706549	0.997570159	0.984607184
22.90555556	1.002532532	1.001637489	0.997863352	0.985691547
22.99791667	1.002391895	1.001554419	0.99811912	0.986705581
23.09027778	1.002237149	1.001458554	0.9983405	0.987652781
23.18263889	1.002068837	1.001351065	0.998530347	0.988536539
23.275	1.001887606	1.001233085	0.998691343	0.989360145
23.36736111	1.001694218	1.001105722	0.998826005	0.990126786
23.45972222	1.001489568	1.000970056	0.998936696	0.990839541
23.55208333	1.001274688	1.000827149	0.999025628	0.991501385
23.64444444	1.001050759	1.000678043	0.999094876	0.992115184
23.73680556	1.000819104	1.000523765	0.99914638	0.992683699
23.82916667	1.000581189	1.000365322	0.999181957	0.993209584
23.92152778	1.000338609	1.000203703	0.999203306	0.993695384
24.01388889	1.000093073	1.000039876	0.999212017	0.994143541
24.10625	0.999846381	0.999874784	0.999209572	0.994556391
24.19861111	0.999600394	0.999709343	0.999197358	0.994936166
24.29097222	0.999357006	0.999544436	0.99917667	0.995284995
24.38333333	0.999118107	0.999380912	0.999148713	0.995604907
24.47569444	0.99888554	0.999219577	0.999114613	0.995897829
24.56805556	0.998661069	0.999061195	0.999075419	0.996165591
24.66041667	0.998446331	0.998906482	0.999032107	0.996409927
24.75277778	0.998242801	0.998756103	0.998985583	0.996632475
24.84513889	0.998051757	0.99861067	0.998936691	0.996834781

24.9375	0.99787425	0.998470737	0.998886213	0.997018299
25.02986111	0.997711076	0.998336805	0.998834873	0.997184393
25.12222222	0.997562759	0.998209317	0.998783341	0.997334342
25.21458333	0.997429544	0.998088658	0.998732235	0.997469336
25.30694444	0.997311396	0.99797516	0.998682122	0.997590483
25.39930556	0.997208008	0.997869103	0.998633524	0.997698808
25.49166667	0.997118817	0.997770718	0.998586916	0.997795254
25.58402778	0.997043038	0.997680189	0.998542732	0.997880688
25.67638889	0.996979695	0.997597662	0.998501361	0.997955895
25.76875	0.996927664	0.997523244	0.998463156	0.998021587
25.86111111	0.996885723	0.997457012	0.998428428	0.9980784
25.95347222	0.996852606	0.997399019	0.998397451	0.998126896
26.04583333	0.99682705	0.997349297	0.998370465	0.998167564
26.13819444	0.996807856	0.99730786	0.998347672	0.998200822
26.23055556	0.996793938	0.997274716	0.998329238	0.998227015
26.32291667	0.996784365	0.997249864	0.998315297	0.99824642
26.41527778	0.996778404	0.997233299	0.998305948	0.998259243
26.50763889	0.996775551	0.997225018	0.998301258	0.998265621
26.6	0.996775551	0.997225018	0.998301258	0.998265621

Table B.16 Wen et al.[6], experimental data (Heptane mass fraction in Cold Lake bitumen at different elevations and time)

Elevation (cm)	138 min	319 min	606 min	1398 min	1753 min
1.225507837	0.950631123	0.92523025	0.88415223	0.814140818	0.780360052
1.232216301	0.943117276	0.915929941	0.874589565	0.802473546	0.767303521
1.239238245	0.937483532	0.906254483	0.863368653	0.792893251	0.754828776
1.247984326	0.929507934	0.894287539	0.849696413	0.781469837	0.739758685
1.256448276	0.919877934	0.88279459	0.836886834	0.766675304	0.723431612
1.26654232	0.905135352	0.869199952	0.822268605	0.749503615	0.705289794
1.279896552	0.888998612	0.851398726	0.804123231	0.731802253	0.683734844
1.296448276	0.871681864	0.829621404	0.779726263	0.709737907	0.65695747
1.316166144	0.846587365	0.804082973	0.75109525	0.685515698	0.62689482
1.3402727	0.815073277	0.773442718	0.718257567	0.658013128	0.59481381
1.366009404	0.781231955	0.741416924	0.680956685	0.625862162	0.56342323
1.405476489	0.720614036	0.69363167	0.633858321	0.588977517	0.531503779
1.477702194	0.621064941	0.61011089	0.57982116	0.551597759	0.50158542
1.557702194	0.526592599	0.523086042	0.527951347	0.517678656	0.476142194
1.601495298	0.463916678	0.477706277	0.485329507	0.489479714	0.454342443
1.630429467	0.40480035	0.448549852	0.445990458	0.463031934	0.431262125

1.679332288	0.333839502	0.400698026	0.408552078	0.436421445	0.407461746
1.737169279	0.262451531	0.346303541	0.371105371	0.410198036	0.384507226
1.790492163	0.192938093	0.298145554	0.333925237	0.385072409	0.363856748
1.845915361	0.121264666	0.249997131	0.296729972	0.360495906	0.342729805
1.905727273	0.053316223	0.200090156	0.260483663	0.336471375	0.320818776
1.968478707	0.014613491	0.149885549	0.224253749	0.313401889	0.298717282
2.03363701	0.003691043	0.099946617	0.186700285	0.288659011	0.277503624
2.095481829	0.003320791	0.054486134	0.149022488	0.263401307	0.256328789
2.138770704	0.002715918	0.023728322	0.107669072	0.238675437	0.234529356
2.158716064	0.002371386	0.009839523	0.063988094	0.213761266	0.212347161
2.164038925	0.002477941	0.006162503	0.030242975	0.188049982	0.18913292
2.16684711	0.003308079	0.004227582	0.013702684	0.162819609	0.165998429
2.169802037	0.002792771	0.002195242	0.007799214	0.135524955	0.142438754
2.171511212	0.002576687	0.00102143	0.004903051	0.107527394	0.119059766
2.170337214	0.003168302	0.001827562	0.003871251	0.080650649	0.094617791
2.169316702	0.003316243	0.002528787	0.003167222	0.054386751	0.069177555
2.170553801	0.002678801	0.001678797	0.003274983	0.032323158	0.045455738
2.171853602	0.001913945	0.000786438	0.002510079	0.01682926	0.027191371
2.170122614	0.003272345	0.001974983	0.002463972	0.009632495	0.016137425
2.168793511	0.003611772	0.002888462	0.003420261	0.005336884	0.00935136
2.16971755	0.002146903	0.002253298	0.003552113	0.003189992	0.0049378
2.169285635	0.002379946	0.002550141	0.003252475	0.003380221	0.004466661
2.168763629	0.003589602	0.002909008	0.004206756	0.004249332	0.004739066
2.170524599	0.003208803	0.001698853	0.004145594	0.00316624	0.003230084
2.170432407	0.002740029	0.001762175	0.003931641	0.002888909	0.002357286
2.169723237	0.003482152	0.00224939	0.003928841	0.003588491	0.002993132

Table B.17 Fickian model for Wen et al.[6], considering constant density

Elevation (mm)	138 min	319 min	606 min	1398 min	1753 min
0	0	0	0	0	0
0.217	2.15E-17	3.91E-09	6.88E-06	0.000693378	0.001356006
0.434	6.63E-17	8.76E-09	1.42E-05	0.001394919	0.00272179
0.651	1.82E-16	1.57E-08	2.25E-05	0.002112935	0.004107275
0.868	4.89E-16	2.63E-08	3.23E-05	0.002855695	0.005522273
1.085	1.29E-15	4.28E-08	4.42E-05	0.003631601	0.006976659
1.302	3.39E-15	6.88E-08	5.89E-05	0.004449191	0.00848035
1.519	8.75E-15	1.09E-07	7.72E-05	0.005317174	0.01004331
1.736	2.23E-14	1.73E-07	0.000100175	0.006244456	0.01167556

1.953	5.63E-14	2.71E-07	0.000129042	0.007240169	0.013387181
2.17	1.40E-13	4.22E-07	0.000165259	0.008313694	0.015188318
2.387	3.45E-13	6.53E-07	0.000210598	0.009474685	0.017089182
2.604	8.39E-13	1.00E-06	0.000267194	0.010733087	0.019100046
2.821	2.01E-12	1.53E-06	0.000337607	0.012099147	0.021231248
3.038	4.77E-12	2.32E-06	0.000424895	0.013583429	0.023493175
3.255	1.12E-11	3.49E-06	0.000532696	0.01519682	0.025896266
3.472	2.58E-11	5.22E-06	0.000665323	0.016950525	0.028450991
3.689	5.88E-11	7.75E-06	0.000827854	0.018856073	0.03116784
3.906	1.32E-10	1.14E-05	0.001026251	0.0209253	0.034057305
4.123	2.94E-10	1.67E-05	0.001267473	0.023170342	0.037129861
4.34	6.44E-10	2.43E-05	0.001559601	0.025603607	0.040395937
4.557	1.39E-09	3.51E-05	0.001911972	0.028237758	0.043865896
4.774	2.97E-09	5.03E-05	0.00233532	0.031085673	0.047549997
4.991	6.25E-09	7.16E-05	0.002841915	0.034160414	0.051458368
5.208	1.30E-08	0.000101322	0.003445711	0.037475179	0.055600967
5.425	2.66E-08	0.000142293	0.004162484	0.041043256	0.059987542
5.642	5.37E-08	0.000198449	0.005009978	0.044877962	0.064627594
5.859	1.07E-07	0.000274853	0.006008028	0.048992585	0.069530328
6.076	2.10E-07	0.00037804	0.00717868	0.053400319	0.074704608
6.293	4.06E-07	0.000516371	0.008546291	0.058114187	0.080158912
6.51	7.75E-07	0.000700445	0.010137601	0.063146965	0.085901277
6.727	1.46E-06	0.000943572	0.011981784	0.068511104	0.091939254
6.944	2.70E-06	0.001262316	0.014110458	0.074218639	0.09827985
7.161	4.94E-06	0.001677086	0.016557656	0.080281103	0.104929478
7.378	8.89E-06	0.002212791	0.019359754	0.086709436	0.111893907
7.595	1.58E-05	0.002899529	0.02255534	0.093513886	0.119178201
7.812	2.76E-05	0.003773299	0.026185035	0.100703921	0.126786676
8.029	4.75E-05	0.004876712	0.030291246	0.108288126	0.134722841
8.246	8.06E-05	0.00625967	0.034917856	0.116274111	0.142989354
8.463	0.000134615	0.007979971	0.040109855	0.124668418	0.15158797
8.68	0.000221582	0.010103799	0.045912893	0.133476425	0.160519496
8.897	0.000359241	0.012706049	0.052372778	0.142702257	0.16978375
9.114	0.000573621	0.015870424	0.059534901	0.152348706	0.179379518
9.331	0.000902053	0.019689271	0.067443618	0.162417143	0.18930452
9.548	0.001396978	0.024263072	0.076141563	0.172907448	0.199555376
9.765	0.002130517	0.029699561	0.085668937	0.183817941	0.210127578
9.982	0.003199695	0.036112426	0.096062753	0.195145323	0.221015467
10.199	0.004732116	0.04361956	0.107356073	0.206884621	0.232212216
10.416	0.006891669	0.052340852	0.119577232	0.219029149	0.24370981
10.633	0.009883708	0.06239554	0.132749087	0.231570471	0.255499048

10.85	0.013958909	0.07389915	0.146888283	0.244498383	0.267569532
11.067	0.019414871	0.086960084	0.162004575	0.257800895	0.279909673
11.284	0.026594436	0.101675954	0.178100215	0.271464238	0.292506702
11.501	0.035879724	0.11812976	0.195169416	0.28547287	0.305346684
11.718	0.047681039	0.13638607	0.213197923	0.299809497	0.318414539
11.935	0.062420207	0.156487332	0.232162694	0.314455113	0.331694069
12.152	0.080508368	0.178450511	0.252031709	0.329389042	0.34516799
12.369	0.10231901	0.202264193	0.272763924	0.344588995	0.358817975
12.586	0.12815772	0.227886341	0.294309364	0.360031142	0.372624692
12.803	0.158230911	0.25524284	0.316609371	0.375690185	0.386567856
13.02	0.192616371	0.284226957	0.339597008	0.391539451	0.400626288
13.237	0.231238781	0.314699798	0.363197607	0.407550989	0.414777964
13.454	0.273853359	0.346491816	0.387329464	0.423695676	0.429000091
13.671	0.320040253	0.379405362	0.411904667	0.439943331	0.443269165
13.888	0.369211476	0.413218233	0.436830042	0.456262833	0.457561046
14.105	0.420630929	0.447688112	0.4620082	0.472622254	0.471851032
14.322	0.473446634	0.482557762	0.487338671	0.488988982	0.486113939
14.539	0.526732922	0.517560779	0.512719089	0.505329857	0.500324175
14.756	0.579539103	0.552427699	0.538046422	0.521611309	0.514455826
14.973	0.630940349	0.586892222	0.563218205	0.537799492	0.528482737
15.19	0.680086264	0.620697314	0.588133759	0.553860422	0.542378594
15.407	0.726242873	0.653600947	0.612695371	0.569760112	0.556117012
15.624	0.768824611	0.685381278	0.636809409	0.585464704	0.569671615
15.841	0.807414075	0.715841074	0.660387344	0.600940601	0.583016122
16.058	0.841768706	0.744811228	0.68334667	0.616154588	0.596124426
16.275	0.871814987	0.772153299	0.705611693	0.631073955	0.608970681
16.492	0.89763195	0.797760987	0.727114189	0.64566661	0.621529376
16.709	0.919426651	0.821560573	0.747793896	0.659901185	0.633775415
16.926	0.937504749	0.843510357	0.767598864	0.673747136	0.645684192
17.143	0.952239317	0.863599182	0.786485637	0.687174837	0.657231663
17.36	0.964040727	0.881844175	0.804419272	0.700155663	0.668394417
17.577	0.973329816	0.898287837	0.821373209	0.712662064	0.679149741
17.794	0.980515831	0.912994661	0.83732899	0.724667638	0.689475683
18.011	0.985979868	0.926047429	0.85227584	0.736147184	0.699351114
18.228	0.990063873	0.937543369	0.866210125	0.74707676	0.708755785
18.445	0.993064724	0.947590309	0.879134702	0.757433722	0.717670375
18.662	0.995232566	0.95630297	0.891058179	0.767196764	0.726076548
18.879	0.996772414	0.963799505	0.901994102	0.776345946	0.733956992
19.096	0.99784798	0.970198367	0.911960088	0.78486272	0.741295464
19.313	0.998586818	0.975615567	0.920976927	0.792729945	0.748076832
19.53	0.999086	0.980162349	0.929067669	0.7999319	0.754287104

19.747	0.999417745	0.98394328	0.936256713	0.806454297	0.759913464
19.964	0.999634625	0.987054758	0.942568921	0.81228428	0.764944299
20.181	0.9997741	0.989583886	0.948028776	0.817410431	0.769369228
20.398	0.999862312	0.99160767	0.952659582	0.821822769	0.773179116
20.615	0.999917123	0.993192503	0.956482747	0.825512747	0.776366104
20.832	0.999950469	0.994393848	0.95951714	0.828473252	0.778923615
21.049	0.999970117	0.995256088	0.961778534	0.830698597	0.780846375
21.266	0.999980921	0.99581248	0.96327916	0.832184523	0.782130419
21.483	0.999985687	0.996085156	0.964027362	0.832928193	0.782773102
21.7	0.999985687	0.996085156	0.964027362	0.832928193	0.782773102

Table B.18 Fickian model for Wen et al.[6] considering variations in density

Elevation (mm)	138 min	319 min	606 min	1398 min	1753 min
0	0	0	0	0	0
0.217	1.84E-17	3.34E-09	5.87E-06	0.000591704	0.001157265
0.434	5.68E-17	7.48E-09	1.21E-05	0.001190503	0.002323367
0.651	1.56E-16	1.34E-08	1.92E-05	0.001803499	0.003506792
0.868	4.19E-16	2.24E-08	2.76E-05	0.002437762	0.00471595
1.085	1.11E-15	3.65E-08	3.77E-05	0.003100484	0.005959316
1.302	2.90E-15	5.87E-08	5.02E-05	0.003798981	0.007245421
1.519	7.48E-15	9.35E-08	6.59E-05	0.004540723	0.008582853
1.736	1.91E-14	1.48E-07	8.55E-05	0.005333358	0.009980266
1.953	4.82E-14	2.32E-07	0.00011013	0.006184739	0.011446388
2.17	1.20E-13	3.61E-07	0.000141039	0.007102946	0.012990023
2.387	2.95E-13	5.58E-07	0.000179733	0.008096306	0.01462006
2.604	7.18E-13	8.57E-07	0.000228035	0.009173413	0.016345467
2.821	1.72E-12	1.31E-06	0.00028813	0.010343141	0.018175299
3.038	4.08E-12	1.98E-06	0.000362628	0.01161466	0.020118691
3.255	9.55E-12	2.98E-06	0.000454637	0.01299744	0.022184855
3.472	2.21E-11	4.46E-06	0.000567836	0.01450126	0.024383077
3.689	5.03E-11	6.61E-06	0.000706566	0.01613621	0.026722704
3.906	1.13E-10	9.75E-06	0.000875917	0.017912687	0.029213139
4.123	2.51E-10	1.43E-05	0.001081836	0.019841388	0.031863821
4.34	5.51E-10	2.07E-05	0.001331231	0.021933302	0.034684216
4.557	1.19E-09	3.00E-05	0.001632084	0.024199694	0.037683794
4.774	2.54E-09	4.30E-05	0.001993578	0.026652083	0.040872011
4.991	5.35E-09	6.12E-05	0.002426216	0.029302221	0.044258283
5.208	1.11E-08	8.65E-05	0.002941949	0.03216206	0.047851966

5.425	2.27E-08	0.000121463	0.003554305	0.035243722	0.051662321
5.642	4.59E-08	0.000169397	0.00427851	0.038559458	0.055698486
5.859	9.14E-08	0.000234614	0.005131607	0.042121605	0.059969444
6.076	1.79E-07	0.000322694	0.00613257	0.045942537	0.064483988
6.293	3.47E-07	0.000440775	0.007302394	0.050034615	0.069250682
6.51	6.62E-07	0.000597908	0.008664183	0.054410128	0.074277821
6.727	1.25E-06	0.000805463	0.010243203	0.059081231	0.079573393
6.944	2.31E-06	0.001077589	0.012066921	0.064059881	0.085145033
7.161	4.22E-06	0.001431731	0.014165007	0.06935777	0.090999982
7.378	7.60E-06	0.001889192	0.016569305	0.074986248	0.097145037
7.595	1.35E-05	0.002475728	0.019313763	0.080956252	0.103586509
7.812	2.36E-05	0.003222176	0.022434327	0.087278224	0.110330169
8.029	4.06E-05	0.004165079	0.02596878	0.093962035	0.11738121
8.246	6.88E-05	0.005347301	0.029956541	0.101016899	0.124744186
8.463	0.000114964	0.006818589	0.034438408	0.108451289	0.132422974
8.68	0.00018923	0.008636049	0.039456251	0.116272856	0.14042072
8.897	0.000306781	0.010864519	0.045052653	0.124488343	0.148739793
9.114	0.000489847	0.013576758	0.051270497	0.133103498	0.157381734
9.331	0.000770314	0.016853457	0.058152507	0.142122992	0.166347219
9.548	0.001192994	0.020782985	0.065740738	0.151550338	0.175636002
9.765	0.001819545	0.025460872	0.074076023	0.161387812	0.185246884
9.982	0.002732994	0.030988962	0.083197384	0.171636371	0.195177665
10.199	0.00404268	0.037474232	0.093141411	0.182295585	0.205425106
10.416	0.005889319	0.04502726	0.103941616	0.193363565	0.215984898
10.633	0.008449749	0.053760323	0.115627773	0.204836899	0.226851624
10.85	0.011940765	0.06378515	0.128225251	0.216710595	0.238018734
11.067	0.01662132	0.075210354	0.141754354	0.228978026	0.249478518
11.284	0.022792338	0.08813857	0.156229679	0.241630887	0.261222083
11.501	0.030793345	0.10266337	0.171659499	0.254659157	0.273239341
11.718	0.040995261	0.118866016	0.188045197	0.268051069	0.285518993
11.935	0.053788878	0.13681214	0.205380753	0.281793089	0.298048523
12.152	0.069568882	0.156548461	0.223652296	0.295869907	0.310814196
12.369	0.088713611	0.178099629	0.242837752	0.310264435	0.323801063
12.586	0.111561238	0.201465347	0.26290658	0.324957816	0.336992967
12.803	0.138383487	0.226617881	0.28381963	0.339929446	0.350372564
13.02	0.169358459	0.253500096	0.305529107	0.355157001	0.36392134
13.237	0.204544566	0.282024158	0.327978687	0.370616481	0.377619638
13.454	0.243857895	0.312071009	0.351103759	0.386282267	0.391446696
13.671	0.287055511	0.34349073	0.374831819	0.402127178	0.405380684
13.888	0.333727215	0.376103874	0.399083004	0.418122553	0.419398753
14.105	0.383297938	0.409703801	0.423770785	0.434238332	0.433477083

14.322	0.435042314	0.444060036	0.448802783	0.450443155	0.447590948
14.539	0.488111898	0.478922585	0.474081725	0.466704466	0.461714777
14.756	0.541574121	0.514027121	0.499506515	0.482988632	0.475822226
14.973	0.594460498	0.549100872	0.524973397	0.49926106	0.489886254
15.19	0.645820135	0.58386901	0.550377198	0.515486332	0.503879206
15.407	0.694773498	0.618061297	0.575612617	0.531628344	0.517772896
15.624	0.740561003	0.651418687	0.600575533	0.547650444	0.531538703
15.841	0.782581427	0.683699625	0.625164309	0.563515583	0.545147661
16.058	0.820416409	0.714685736	0.649281046	0.579186465	0.558570563
16.275	0.853839187	0.744186659	0.672832773	0.594625699	0.571778059
16.492	0.882807802	0.77204382	0.695732528	0.609795953	0.584740762
16.709	0.907444958	0.798133	0.717900313	0.624660108	0.597429356
16.926	0.928008129	0.822365614	0.739263892	0.639181411	0.609814702
17.143	0.944854204	0.844688711	0.759759423	0.65332362	0.621867949
17.36	0.958402914	0.86508376	0.779331892	0.667051157	0.633560643
17.577	0.96910269	0.883564357	0.797935359	0.680329241	0.644864835
17.794	0.977401535	0.900173037	0.815533005	0.693124033	0.655753192
18.011	0.98372441	0.91497741	0.832096979	0.705402758	0.6661991
18.228	0.988457568	0.928065837	0.847608061	0.717133833	0.676176773
18.445	0.991939399	0.939542892	0.862055151	0.728286978	0.685661353
18.662	0.994456853	0.949524818	0.875434608	0.73883333	0.694629008
18.879	0.996246158	0.958135144	0.887749452	0.748745536	0.70305703
19.096	0.997496543	0.965500641	0.899008458	0.75799785	0.710923925
19.313	0.99835576	0.971747688	0.909225177	0.766566212	0.718209499
19.53	0.998936417	0.976999149	0.918416895	0.774428327	0.72489494
19.747	0.999322381	0.981371762	0.926603574	0.781563729	0.730962894
19.964	0.999574744	0.984974052	0.933806794	0.787953843	0.736397538
20.181	0.999737056	0.98790473	0.940048723	0.793582036	0.741184638
20.398	0.999839722	0.990251516	0.945351137	0.798433662	0.745311613
20.615	0.999903519	0.992090343	0.949734518	0.802496101	0.748767584
20.832	0.999942335	0.993484838	0.953217246	0.805758789	0.751543417
21.049	0.999965206	0.994486037	0.955814896	0.808213247	0.75363176
21.266	0.999977785	0.995132243	0.957539662	0.8098531	0.755027074
21.483	0.999983332	0.995448978	0.958399919	0.81067409	0.755725658
21.7	0.999983332	0.995448978	0.958399919	0.81067409	0.755725658

Table B.19 Fickian + sorption model for Wen et al.[6]

Elevation (mm)	138 min	319 min	606 min	1398 min	1753 min

0	0	0	0	0	0
0.217	8.85E-264	1.05E-222	2.64E-184	2.37E-121	4.37E-101
0.434	7.04E-259	4.47E-218	7.13E-180	3.65E-117	5.80E-97
0.651	5.62E-254	1.90E-213	1.92E-175	5.59E-113	7.65E-93
0.868	4.45E-249	8.04E-209	5.17E-171	8.52E-109	1.00E-88
1.085	3.50E-244	3.38E-204	1.38E-166	1.29E-104	1.31E-84
1.302	2.72E-239	1.41E-199	3.68E-162	1.96E-100	1.69E-80
1.519	2.10E-234	5.87E-195	9.78E-158	2.97E-96	2.20E-76
1.736	1.61E-229	2.43E-190	2.58E-153	4.50E-92	2.87E-72
1.953	1.23E-224	9.97E-186	6.80E-149	6.83E-88	3.78E-68
2.17	9.25E-220	4.08E-181	1.78E-144	1.04E-83	5.01E-64
2.387	6.94E-215	1.66E-176	4.64E-140	1.56E-79	6.67E-60
2.604	5.17E-210	6.71E-172	1.20E-135	2.34E-75	8.78E-56
2.821	3.82E-205	2.69E-167	3.09E-131	3.45E-71	1.13E-51
3.038	2.81E-200	1.07E-162	7.89E-127	5.00E-67	1.40E-47
3.255	2.05E-195	4.26E-158	2.01E-122	7.13E-63	1.66E-43
3.472	1.48E-190	1.67E-153	5.08E-118	1.01E-58	1.90E-39
3.689	1.06E-185	6.52E-149	1.28E-113	1.45E-54	2.15E-35
3.906	7.55E-181	2.53E-144	3.23E-109	2.14E-50	2.61E-31
4.123	5.31E-176	9.73E-140	8.14E-105	3.28E-46	3.69E-27
4.34	3.69E-171	3.73E-135	2.05E-100	5.19E-42	5.98E-23
4.557	2.54E-166	1.42E-130	5.16E-96	8.20E-38	9.79E-19
4.774	1.73E-161	5.43E-126	1.29E-91	1.25E-33	1.43E-14
4.991	1.16E-156	2.07E-121	3.18E-87	1.78E-29	1.71E-10
5.208	7.76E-152	7.83E-117	7.72E-83	2.31E-25	1.54E-06
5.425	5.14E-147	2.95E-112	1.84E-78	2.67E-21	0.00455943
5.642	3.39E-142	1.10E-107	4.33E-74	2.70E-17	0.009251551
5.859	2.22E-137	4.06E-103	1.01E-69	2.40E-13	0.014187039
6.076	1.46E-132	1.48E-98	2.35E-65	1.95E-09	0.019441039
6.293	9.51E-128	5.27E-94	5.60E-61	1.67E-05	0.025052599
6.51	6.19E-123	1.86E-89	1.38E-56	0.006036658	0.031032392
6.727	4.00E-118	6.48E-85	3.49E-52	0.012150281	0.037374731
6.944	2.56E-113	2.26E-80	8.95E-48	0.01843841	0.04406863
7.161	1.61E-108	7.96E-76	2.26E-43	0.024973686	0.051104927
7.378	9.93E-104	2.86E-71	5.46E-39	0.031816882	0.058479132
7.595	5.99E-99	1.05E-66	1.23E-34	0.039015582	0.066191235
7.812	3.53E-94	3.87E-62	2.54E-30	0.046604685	0.074244137
8.029	2.04E-89	1.43E-57	4.74E-26	0.054608175	0.082641897
8.246	1.16E-84	5.14E-53	7.88E-22	0.063041506	0.091388401
8.463	6.57E-80	1.77E-48	1.17E-17	0.071914049	0.100486585
8.68	3.77E-75	5.73E-44	1.58E-13	0.081231168	0.109938082

8.897	2.22E-70	1.73E-39	2.22E-09	0.090995725	0.119743135
9.114	1.35E-65	4.80E-35	4.62E-05	0.101208993	0.129900628
9.331	8.43E-61	1.22E-30	0.009803399	0.111871066	0.140408141
9.548	5.25E-56	2.96E-26	0.019830174	0.122980934	0.15126201
9.765	3.18E-51	8.15E-22	0.030338602	0.134536365	0.162457345
9.982	1.84E-46	3.76E-17	0.041516957	0.146533711	0.173988048
10.199	9.92E-42	2.63E-12	0.053513266	0.15896773	0.185846796
10.416	4.93E-37	1.69E-07	0.066432965	0.171831437	0.19802504
10.633	2.23E-32	0.006547698	0.080343727	0.185116004	0.210512984
10.85	9.05E-28	0.017012395	0.095283545	0.198810715	0.223299583
11.067	3.28E-23	0.030859875	0.111268988	0.212902934	0.236372539
11.284	1.06E-18	0.046857517	0.128301752	0.227378117	0.249718308
11.501	3.18E-14	0.064560144	0.146372795	0.242219824	0.263322114
11.718	1.02E-09	0.083995597	0.165464293	0.257409751	0.277167967
11.935	5.12E-05	0.105287438	0.18555013	0.272927771	0.291238695
12.152	0.022864251	0.128518452	0.206595661	0.288751986	0.305515976
12.369	0.04743736	0.153709167	0.228557314	0.304858789	0.319980378
12.586	0.075153962	0.180825938	0.251382349	0.321222932	0.334611407
12.803	0.10693482	0.209791049	0.275008891	0.337817614	0.349387559
13.02	0.143212929	0.240489314	0.299366249	0.354614574	0.364286376
13.237	0.184026001	0.272771693	0.32437546	0.371584192	0.379284512
13.454	0.229124437	0.306457645	0.349950042	0.3886956	0.394357797
13.671	0.278045276	0.341337582	0.375996876	0.405916809	0.40948131
13.888	0.330151641	0.377176201	0.402417233	0.423214829	0.424629455
14.105	0.384658487	0.413716882	0.429107887	0.440555808	0.439776037
14.322	0.440662465	0.450687046	0.455962321	0.457905166	0.454894347
14.539	0.497182686	0.487804223	0.482871985	0.47522774	0.469957246
14.756	0.553210648	0.524782546	0.509727597	0.492487927	0.484937248
14.973	0.60776403	0.561339367	0.536420452	0.509649827	0.499806612
15.19	0.659938527	0.597201753	0.562843716	0.526677393	0.514537427
15.407	0.70895277	0.632112598	0.588893676	0.543534568	0.529101703
15.624	0.754182548	0.665836123	0.614470926	0.56018543	0.543471459
15.841	0.795181995	0.69816259	0.639481452	0.57659433	0.557618813
16.058	0.831690878	0.728912055	0.663837612	0.592726021	0.571516067
16.275	0.86362861	0.757937071	0.687458973	0.608545788	0.585135797
16.492	0.891076871	0.785124278	0.710273011	0.624019571	0.598450933
16.709	0.914253669	0.810394888	0.732215641	0.639114072	0.611434845
16.926	0.933482136	0.8337041	0.753231585	0.653796869	0.624061421
17.143	0.949157421	0.855039556	0.773274571	0.668036508	0.636305143
17.36	0.961714682	0.874418948	0.792307354	0.681802594	0.648141166
17.577	0.971600534	0.891886945	0.810301584	0.695065877	0.659545381

17.794	0.979249561	0.907511607	0.827237506	0.707798315	0.670494489
18.011	0.985066652	0.921380464	0.843103521	0.719973147	0.680966063
18.228	0.989415258	0.933596433	0.857895612	0.731564941	0.690938606
18.445	0.992611039	0.944273742	0.871616655	0.742549645	0.700391609
18.662	0.994920054	0.953533985	0.884275635	0.752904626	0.709305605
18.879	0.99656042	0.961502453	0.895886789	0.762608699	0.717662216
19.096	0.997706359	0.968304799	0.906468679	0.771642157	0.725444196
19.313	0.998493646	0.974064122	0.916043248	0.779986786	0.732635479
19.53	0.999025631	0.978898495	0.924634845	0.787625883	0.739221208
19.747	0.999379221	0.982918927	0.932269262	0.794544262	0.745187776
19.964	0.99961041	0.986227777	0.938972797	0.800728261	0.750522853
20.181	0.999759104	0.988917548	0.944771351	0.806165744	0.755215413
20.398	0.999853158	0.991070035	0.949689588	0.810846103	0.759255758
20.615	0.999911605	0.992755766	0.953750171	0.814760253	0.762635541
20.832	0.999947166	0.994033667	0.956973075	0.817900631	0.765347779
21.049	0.999968121	0.994950897	0.959375003	0.820261195	0.767386871
21.266	0.999979645	0.995542794	0.960968907	0.821837416	0.768748607
21.483	0.999984728	0.995832877	0.961763623	0.822626279	0.769430177
21.7	0.999984728	0.995832877	0.961763623	0.822626279	0.769430177

Table B.20 Toluene + polybutene smoothed experimental data

Elevation (mm)	3 hr	6 hr	12 hr
2.1	0.163500853	0.201088166	0.213649608
2.4	0.095914676	0.174466805	0.164168137
2.7	0.071026795	0.186153905	0.125021564
3	0.103273494	0.235461469	0.088457382
3.3	0.132515856	0.35334841	0.14722004
3.6	0.206036739	0.352797017	0.161924186
3.9	0.19056653	0.22035221	0.044456718
4.2	0.175129687	0.23317156	-0.014801164
4.5	0.247192918	0.304567671	1.43E-05
4.8	0.289732104	0.188267536	1.01E-05
5.1	0.248583812	0.088479855	3.07E-06
5.4	0.190683568	0.088061753	-1.02E-06
5.7	0.131094182	0.044666254	0
6	0.087251025	0.043570893	0
6.3	0.145355581	0.101132398	0
6.6	0.160267233	0.058380642	-0.014703558
6.9	0.04423033	-0.01459516	-0.484661144

7.2	-0.014692298	0	0.882546393
7.5	3.09E-06	0	7.931501131
7.8	-1.03E-06	0	15.9912693
8.1	0	-0.01448694	20.07536381
8.4	0	-0.057950306	21.06044963
8.7	-0.029155697	-0.103856418	25.73364334
9	0.043961294	2.031922451	30.7881716
9.3	-0.06829919	9.394684951	34.72965528
9.6	2.196168034	17.66580987	36.29294239
9.9	5.38980469	22.86597899	38.56904846
10.2	10.98400147	24.94752174	39.89161201
10.5	16.40519557	31.29115644	42.67993608
10.8	20.75249242	38.2684486	45.4829201
11.1	22.56359861	43.35419577	48.81288688
11.4	23.86065746	44.38768444	50.92255115
11.7	32.73397127	47.42974952	53.7414614
12	44.92152511	50.13062766	55.54382362
12.3	55.12688936	53.82522276	59.00515075
12.6	58.51578483	56.64076207	61.64952194
12.9	67.25499253	61.60384145	65.50024992
13.2	74.58786708	65.86886725	67.7934646
13.5	82.92051477	70.89976171	70.90082006
13.8	87.76649095	74.04155028	72.2013286
14.1	92.99716085	78.71844317	74.90219503
14.4	94.78355349	81.91512995	76.29544464
14.7	96.90420272	85.98697416	78.99679358
15	97.46215352	88.46037565	80.19231423
15.3	98.35894687	92.00485321	83.10488675
15.6	98.66184711	93.76510312	85.03932339
15.9	99.38045388	96.00976427	88.3137409
16.2	99.51061429	96.69596669	89.7905536
16.5	99.38045388	98.33113472	92.47301698
16.8	98.66184711	98.38480466	93.06418477
17.1	98.20605295	98.34331649	95.0638864
17.4	97.92083528	96.75758899	94.08607307
17.7	98.03786769	96.14582035	94.26122274
18	98.02971278	95.28692239	93.36273763
18.3	98.02971278	95.59851229	93.92463226
18.6	97.95752805	95.68209289	92.93662865
18.9	98.16606171	96.24188706	93.85966208
19.2	98.9870683	96.93247725	94.24056946
19.5	99.83156896	97.74715877	95.17329146
19.8	100.0802053	98.00477085	95.599519
20.1	100	97.8439625	95.84186425

20.4	100	98.16531354	96.08354203
20.7	100	98.72199344	96.64206509
21	100	99.04334448	96.96448011
21.3	100	98.96300672	96.88387636
21.6	100	98.96300672	96.88387636
21.9	100	98.96300672	96.88387636
22.2	100.0802053	98.96300672	96.88387636
22.5	99.67917898	98.96300672	96.88387636
22.8	99.52444351	98.96300672	96.88387636
23.1	99.43856321	98.96300672	96.88387636
23.4	99.28382775	98.96300672	96.88387636
23.7	98.88280147	98.96300672	96.88387636
24	98.95893263	98.95893263	96.87163385
24.3	98.97930312	98.97930312	96.93284638
24.6	98.98716305	98.98716305	96.95646516
24.9	98.99152542	98.99152542	96.9695739
25.2	98.99938535	98.99938535	96.99319267
25.5	99.01975584	99.01975584	97.0544052
25.8	98.93955059	98.93955059	96.97393272
26.1	99.32020637	99.32020637	97.31508261
26.4	99.4670819	99.4670819	97.44671485
26.7	99.54859984	99.62880409	97.51977255
27	99.69547537	99.45486261	97.65140479
27.3	100.0761312	99.27976357	97.99255468
27.6	100	98.88281539	97.9243247
27.9	100	98.96301964	97.9243247
28.2	100	98.96301964	98.00479451
28.5	100	98.96301964	97.60244546
28.8	100	98.96301964	97.4471996
29.1	100	98.96301964	97.28056621
29.4	100.0802043	98.96301964	97.4471996
29.7	99.67918297	98.96301964	97.60244546
30	99.44424518	98.96301964	98.00479451
30.3	99.67918297	98.96301964	97.84398783
30.6	100.0802043	98.88281539	98.16533531
30.9	100	99.20363241	98.72200903
31.2	100	99.75938723	98.96315226
31.5	100	100.0802043	99.20363241
31.8	100	100.0816948	99.66908785
32.1	100	100.0530632	99.94443594
32.4	100	99.96365209	100.067915

Table B.21 Toluene + (0.01 mass fraction of carbon nanotubes + polybutene) smoothed experimental data

Elevation (mm)	3 hr	6 hr	9 hr	12 hr
2.1	1.35E-05	0	4.70E-07	0.237535045
2.4	1.34E-05	0	-6.87E-07	-0.362302816
2.7	1.34E-05	0	-1.06E-06	-0.493218556
3	1.34E-05	0	-1.04E-06	-0.337201285
3.3	1.45E-05	0	-0.014701062	1.733031882
3.6	1.03E-05	0	-0.01438934	4.869010953
3.9	3.11E-06	-0.014596821	-0.219929961	10.48399362
4.2	-1.04E-06	-0.014282146	2.343845234	16.10384818
4.5	-0.014703558	-0.186932116	5.750270678	20.79226084
4.8	-0.029604828	2.225961929	11.25793805	22.20163324
5.1	-0.078469372	5.413270783	17.96065717	28.16500491
5.4	2.228857188	10.87086883	24.11787656	35.23567471
5.7	5.699805866	17.40171645	30.81364733	40.85021381
6	7.211862645	22.48152973	38.31909486	42.7376784
6.3	10.62851878	29.46701705	43.40183656	45.65136191
6.6	16.52245921	38.58604271	44.81773384	47.49153818
6.9	21.30488921	44.76453924	47.34760118	49.53977094
7.2	21.91659664	45.77434396	48.66639139	51.03399637
7.5	31.26812725	47.64111355	49.85334292	53.5330144
7.8	43.17442398	48.43146933	50.51462872	55.68542337
8.1	52.21121262	50.51562741	52.57338101	59.58169606
8.4	52.16634181	52.99061147	55.83186342	63.52418329
8.7	65.50003184	55.40728251	61.58793146	67.45602391
9	83.78594976	58.36226093	66.9597066	69.84537872
9.3	97.36720105	66.42549964	73.00610985	75.42836596
9.6	98.7124804	74.15568041	76.69066004	79.90345968
9.9	100.4832213	82.47545193	82.57625567	87.38895935
10.2	100	89.30858012	89.20194793	94.50781442
10.5	100	96.04583251	95.98885758	99.14359856
10.8	100	98.63132815	98.23957468	97.68288848
11.1	100	100.4832257	99.28515609	97.12528814
11.4	100	100	99.04334448	96.88400952
11.7	100.0802053	100	98.72199344	96.64206509
12	99.75938423	100.0802053	98.16531354	96.08354203
12.3	99.20362249	99.83972199	97.92443309	95.84186425
12.6	98.88280147	98.96260921	97.68288848	95.599519
12.9	98.96300672	98.08510829	97.12528814	95.04007093
13.2	98.96300672	97.8439625	96.80340576	94.71712192
13.5	99.03519145	97.99253104	96.94814665	94.77742518
13.8	98.74645253	97.71960791	96.69106547	94.85916116

14.1	98.24626697	97.24682022	96.24572094	95.00075329
14.4	97.88127022	96.97389709	95.98863976	95.08248927
14.7	98.26256036	96.97389898	96.06924686	95.08249317
15	98.77059894	97.23865964	95.98756284	94.98030367
15.3	99.06777033	97.75220885	95.95604517	94.94087399
15.6	98.98715014	98.04901216	95.93855243	94.91898997
15.9	98.97929021	97.95689553	95.90703476	94.87956029
16.2	98.95484564	97.90796602	95.80901395	94.75693289
16.5	98.97929021	97.95689553	95.90703476	94.87956029
16.8	98.98715014	97.97262835	95.93855243	94.91898997
17.1	98.9915125	97.98136028	95.95604517	94.94087399
17.4	98.99937243	97.99709311	95.98756284	94.98030367
17.7	99.01974291	98.03786769	96.06924686	95.08249317
18	99.09192664	98.10609659	96.05291005	95.06205527
18.3	98.78689532	97.80056134	96.05291005	95.06205527
18.6	98.18630153	97.20304853	95.98863976	95.00175201
18.9	98.17000914	97.1704364	96.24572094	95.24296504
19.2	98.74645253	97.71960791	96.69106547	95.66082098
19.5	99.03519145	97.99253104	96.94814665	95.90203401
19.8	98.96300672	97.92430026	96.88387636	95.84173075
20.1	98.96300672	97.92430026	96.88387636	95.84173075
20.4	98.96300672	97.92430026	96.88387636	95.84173075
20.7	98.96300672	97.92430026	96.88387636	95.84173075
21	98.96300672	97.92430026	96.88387636	95.84173075
21.3	98.96300672	97.92430026	96.88387636	95.84173075
21.6	98.96300672	97.92430026	96.88387636	95.84173075
21.9	98.96300672	97.92430026	96.88387636	95.84173075
22.2	98.96300672	97.92430026	96.88387636	95.84173075
22.5	98.96300672	97.92430026	96.88387636	95.84173075
22.8	98.96300672	97.92430026	96.88387636	95.92246801
23.1	98.96300672	97.92430026	96.88387636	95.51878175
23.4	98.96300672	97.92430026	96.88387636	95.36301993
23.7	98.96300672	97.92430026	96.88387636	95.27656999
24	98.95893263	97.91614533	96.87163385	95.10037021
24.3	98.97930312	97.95691998	96.93284638	94.7988738
24.6	98.98716305	97.97265282	96.95646516	94.91904087
24.9	98.99152542	97.98138476	96.9695739	94.94092496
25.2	98.99938535	97.9971176	97.06970209	94.98035478
25.5	99.01975584	98.03789225	96.82487696	95.08254463
25.8	99.01975484	97.95755349	96.2182125	95.00180403
26.1	99.07564627	98.39485566	96.23352275	95.30331717
26.4	98.68650362	98.23253763	96.43402384	95.41965563
26.7	98.4587672	97.76473701	96.50284091	95.48422506
27	98.67428432	97.57106792	96.62683259	95.60056351

27.3	99.03520347	97.99255468	96.9481805	95.90207666
27.6	98.96301964	97.9243247	96.88391092	95.84177403
27.9	98.96301964	97.9243247	96.88391092	95.84177403
28.2	98.96301964	97.9243247	96.88391092	95.84177403
28.5	98.96301964	97.9243247	96.88391092	95.84177403
28.8	98.96301964	97.9243247	96.88391092	95.84177403
29.1	98.96301964	97.9243247	96.88391092	95.84177403
29.4	98.96301964	97.9243247	96.88391092	95.92251071
29.7	98.96301964	97.9243247	96.88391092	95.51882728
30	98.96301964	97.9243247	96.88391092	95.28232987
30.3	98.96301964	97.9243247	96.88391092	95.51882728
30.6	98.96301964	97.9243247	96.88391092	95.92251071
30.9	98.96301964	97.9243247	96.88391092	95.84177403
31.2	98.96301964	97.9243247	96.88391092	95.92251071
31.5	98.96301964	97.9243247	96.88391092	95.58216625
31.8	98.96301964	97.9243247	96.88391092	95.17920057
32.1	98.96301964	97.9243247	96.88391092	94.65493691

Table B.22 Toluene + (0.05 mass fraction of carbon nanotube + polybutene) smoothed experimental data

Elevation (mm)	3hr	6hr	9hr	12hr
2.1	0	0	0	0
2.4	0	0	0	0
2.7	0	0	0	0
3	0	0	0	0
3.3	0	0	0	0
3.6	0	0	0	0
3.9	0	0	0	0
4.2	0	0	0	0
4.5	0	0	0	0
4.8	0	0	0	0
5.1	0	0	0	0
5.4	0	0	0	0
5.7	0	0	0	0
6	0	0	0	0
6.3	0	0	0	0.00E+00
6.6	0	0	0	0
6.9	0	0	0	0
7.2	0	0	0	0
7.5	0	0	0	0.003821143

7.8	0	0	0.000168744	0.011554359
8.1	0	0	0.004547149	0.022497361
8.4	0	0	0.012954318	0.034130261
8.7	0	0.001246455	0.027835291	0.045107597
9	0	0.006705252	0.043993679	0.058070873
9.3	0	0.013316819	0.063769891	0.074049405
9.6	0.001011704	0.022872874	0.090243194	0.093698739
9.9	0.004368654	0.037249107	0.113543855	0.117680689
10.2	0.015658246	0.062875615	0.141221506	0.142094569
10.5	0.040731048	0.099530401	0.185932378	0.160525635
10.8	0.062186541	0.133123248	0.239351496	0.184814659
11.1	0.089568549	0.165692578	0.29130227	0.225544929
11.4	0.149256057	0.192615858	0.336635188	0.275056621
11.7	0.228875495	0.218320141	0.381413532	0.324675534
12	0.327860492	0.266564193	0.437807784	0.372733376
12.3	0.472449477	0.338767386	0.492178041	0.422221143
12.6	0.626741238	0.413689381	0.530322722	0.478075755
12.9	0.737856594	0.48835317	0.552860644	0.543855673
13.2	0.807819284	0.543585016	0.558776926	0.604657828
13.5	0.837562114	0.561572918	0.580028124	0.64717016
13.8	0.840891089	0.59507835	0.646858488	0.657294645
14.1	0.864452899	0.662762802	0.724743432	0.649049789
14.4	0.918787113	0.744091361	0.785726243	0.656006276
14.7	0.965304495	0.831710024	0.834842779	0.690955828
15	0.983693412	0.901316924	0.86256421	0.748122805
15.3	0.983186706	0.928068948	0.87751631	0.813992287
15.6	0.974513671	0.938042587	0.898040778	0.868057982
15.9	0.969538588	0.957216339	0.915812935	0.895251486
16.2	0.973296924	0.973892999	0.926493988	0.913157821
16.5	0.980981507	0.985279919	0.93436478	0.930037135
16.8	0.989454729	0.990343685	0.942577306	0.943742322
17.1	0.99878248	0.988380627	0.953387248	0.953697074
17.4	1.004277857	0.986789694	0.965722748	0.959798137
17.7	1.0058227	0.991859147	0.979414242	0.966915044
18	1.008056774	1.002618634	0.989897511	0.979025771
18.3	1.004893094	1.014738823	0.991805965	0.991213419
18.6	0.999049948	1.020267169	0.991015961	0.99533483
18.9	0.999641815	1.01573336	0.991031712	0.997276399
19.2	1.000329014	1.010235641	0.988929113	0.996789557
19.5	0.999554729	1.009442911	0.99301112	0.99189424
19.8	1.000205777	1.013137079	1.00107305	0.993250909

20.1	0.999646105	1.018045667	1.005490483	1.001356181
20.4	0.999695297	1.017816982	1.008585091	1.005277721
20.7	1.001035339	1.009380569	1.009416854	1.005719853
21	0.99681733	0.998563125	1.005441254	1.009219422
21.3	0.988077237	0.995317747	1.003636797	1.013334676
21.6	0.984931289	0.99936353	1.004648698	1.016524281
21.9	0.989162814	1.006230297	1.004325934	1.018343826
22.2	1.000049588	1.00930585	1.00676821	1.013630122
22.5	1.013685028	1.006185798	1.007374768	1.003921097
22.8	1.020454402	1.000314424	1.006858746	0.995963084
23.1	1.018959385	0.997726716	1.010417085	0.989822576
23.4	1.014609486	1.000838249	1.015597065	0.984980247
23.7	1.012481052	1.001449111	1.015078662	0.98515806
24	1.009342826	1.000337666	1.006057045	0.988417466
24.3	1.004374279	1.001638838	0.993677561	0.991048413
24.6	1.00430502	1.001674082	0.985285661	0.994673517
24.9	1.005261615	1.001300488	0.985740946	0.99784613
25.2	1.004283774	1.001031649	0.991504548	1.000864009
25.5	1.003901222	0.996612255	0.99885279	1.007027423
25.8	1.001014732	0.993801678	1.003616258	1.010665712
26.1	0.993175935	1.000332777	1.004926485	1.003194827
26.4	0.989625139	1.00599039	1.006501891	0.990048767
26.7	0.994822672	1.004363356	1.004681466	0.98342773
27	1.002329618	1.001894444	0.996920482	0.986455594
27.3	1.007896312	0.997401724	0.987927923	0.993970152
27.6	1.006887904	0.993225881	0.983291948	1.000198776
27.9	0.997838527	0.991472035	0.983382646	1.000479888
28.2	0.989482408	0.987143525	0.98468164	0.993186122
28.5	0.991710202	0.98229232	0.985131821	0.983846444
28.8	1.000748498	0.984430864	0.989169969	0.97957561
29.1	1.006584399	0.99300968	0.994968133	0.980759187
29.4	1.007518119	1.001676843	0.998428412	0.985074395
29.7	1.006461403	1.004881514	1.004175968	0.988235491
30	1.006736577	0.998965814	1.008454392	0.987583966
30.3	1.013482561	0.99034545	1.009144721	0.986806626
30.6	1.019864577	0.984480979	1.012961357	0.988366848
30.9	1.013401696	0.986497756	1.015107165	0.994611124
31.2	1.000986385	0.995274149	1.009220752	1.004557807
31.5	0.993432089	1.000652385	1.006126276	1.012328472
31.8	0.991597966	1.001002453	1.007969923	1.012331673
32.1	0.998194038	0.997715979	1.005963192	1.005263574

32.4	1.007537109	0.991774746	1.004607528	0.995999046
32.7	1.009073978	0.99069107	1.00612685	0.990979038
33	1.005320948	0.997435382	1.002055331	0.992213957
33.3	0.997944198	0.999507158	0.998085031	0.992656119
33.6	0.993496489	0.997039376	0.99726383	0.992956597
33.9	0.992343939	0.991892638	0.997419074	0.993888348
34.2	0.99387007	0.98351193	0.998296445	0.994646715
34.5	0.998383248	0.971618146	1.000138964	0.995177643

Table B.23 Toluene + (0.01 volume fraction of nanodiamond (65 nm)+polybutene) smoothed experimental data

Elevation (mm)	3 hr	6 hr	9 hr
2.1	0.045695266	0	0
2.4	0.062192172	0	0
2.7	0.049199732	0	0
3	-0.013500359	0	0
3.3	0	0	0
3.6	0	0	0
3.9	0	0	0
4.2	-0.01349869	-0.01349869	0
4.5	0.05399476	0.05399476	0
4.8	0.093535709	0.093535709	0
5.1	0.05399476	0.05399476	0
5.4	-0.02699738	-0.01349869	0
5.7	0.05399476	0	0
6	0.079946539	0	0
6.3	0.108351438	0	0
6.6	0.067074805	0	0
6.9	0.108713357	0	0
7.2	0.080573495	0	0
7.5	0.054356678	0	0
7.8	-0.01358917	0	0
8.1	0	0	0
8.4	0	0	0
8.7	0	0	0
9	0	0	-0.013407952
9.3	0	0	0.013491612
9.6	0	-0.013407952	-0.335670667
9.9	0	-0.555810719	1.276966577

10.2	-0.026787988	-1.117929997	6.971427683
10.5	-0.01095255	15.1381797	20.18818381
10.8	-3.325817669	38.7791907	35.4868653
11.1	12.89593328	51.44932863	45.95447592
11.4	39.90302069	49.48633144	48.50418157
11.7	55.33921656	49.94253753	49.09094598
12	51.48944514	49.87911382	49.23857653
12.3	51.97671556	50.20663432	49.57074223
12.6	52.49060086	50.43451904	49.42601326
12.9	52.77021575	50.55871249	49.49324796
13.2	52.53963674	50.36250918	49.83686842
13.5	52.46694229	50.56361679	50.3382011
13.8	53.1195298	50.8566547	50.49252977
14.1	54.82330526	51.23150025	50.63818373
14.4	56.3210021	51.50328027	50.91918668
14.7	56.60753739	50.87559076	50.63260408
15	53.8747783	53.29664537	51.46416319
15.3	65.14126223	62.61496585	59.59830786
15.6	84.85173561	72.5179703	69.42285134
15.9	97.10566223	78.96379085	76.49030535
16.2	95.53371005	82.33194917	79.15094976
16.5	95.75340877	86.2328385	83.71064833
16.8	96.08223221	88.39710975	86.63013608
17.1	96.84215026	91.60339044	90.17753411
17.4	97.28082328	92.79105662	91.58721598
17.7	97.17115503	94.45059224	94.44968785
18	97.15639851	94.18431717	95.18757649
18.3	97.31769629	94.4140271	96.84239647
18.6	96.92334394	93.39453437	95.52144366
18.9	96.62377243	93.01278985	95.44821115
19.2	96.79159914	92.36799119	94.34469125
19.5	97.20086283	93.39495664	94.71314707
19.8	97.62400622	94.29642899	93.86444114
20.1	98.39052327	94.75236033	95.16212131
20.4	98.77772482	95.00314444	95.71297784
20.7	98.60594214	95.6947147	96.20027469
21	99.03257281	96.62198795	96.23215068
21.3	99.72000128	97.26089823	96.21388754
21.6	100.0954831	97.61331738	96.56630669
21.9	100	97.47315032	97.275693
22.2	100	97.91185345	97.73783332
22.5	100	98.58063928	97.68760597
22.8	100	98.92900522	97.67621306
23.1	100	98.8390655	97.67621306

23.4	100	98.8390655	97.67621306
23.7	100	98.8390655	97.67621306
24	100	98.83400617	97.66608602
24.3	100	98.85424352	97.70659417
24.6	100	98.88930091	97.77676686
24.9	100	98.90953826	97.81727501
25.2	100	98.90447893	97.80714797
25.5	100.084732	98.90447893	97.80714797
25.8	99.66107187	98.81974689	97.7273343
26.1	99.49760315	99.24340705	98.12640265
26.4	99.32214374	99.40687577	98.28038265
26.7	99.49760315	99.49760315	98.36584366
27	99.66107187	99.66107187	98.51982366
27.3	100.084732	100.084732	98.91889201
27.6	100	100.0897904	98.83907834
27.9	100	99.73062886	98.83907834
28.2	100	99.10844947	98.92901718
28.5	100	98.74928796	98.56926181
28.8	100	98.83907834	97.94605369
29.1	100	98.83907834	97.58629832
29.4	100	98.83907834	97.67623716
29.7	100	98.83907834	97.67623716
30	100	98.83907834	97.67623716
30.3	100	98.83907834	97.67623716
30.6	100	98.83907834	97.67623716
30.9	100	98.83907834	97.67623716
31.2	100	98.83907834	97.67623716
31.5	100	98.83907834	97.67623716
31.8	100	98.83907834	97.67623716
32.1	100	98.83907834	97.67623716

Table B.24 Toluene + (0.00135 volume fraction of nanodiamond (12nm)+polybutene) smoothed experimental data

Elevation (mm)	3 hr	6 hr	9 hr	12 hr
2.1	0.108139868	0.046667661	0.473118169	0.409451136
2.4	0.128769021	0.017499669	0.359040084	0.23546752
2.7	0.130296478	0.028192139	0.313398356	0.17080186
3	0.064710676	0.062776779	0.289392869	0.199448258
3.3	0.284526967	0.239408851	0.664220004	0.428518263
3.6	0.520180642	0.35735125	1.03631262	0.657014637
3.9	0.616715725	0.272073395	1.049786438	0.698937244
4.2	0.404364945	0.121958905	0.663151396	0.561004654

4.5	0.22350518	0.001807252	0.165361768	0.455085433
4.8	0.115971939	-0.008647408	-0.117503333	0.311399564
5.1	0.138891415	-0.031766815	0.149674743	0.219940342
5.4	0.356311137	0.171990993	0.692192619	0.524939411
5.7	0.476696759	0.282260941	0.748498566	0.676193125
6	0.189495988	0.156455757	0.189211666	0.263861153
6.3	-0.010767286	-0.057471714	0.078452489	-0.129726625
6.6	0.252179779	0.053831533	0.592041301	0.145425027
6.9	0.475089171	0.176309414	1.013595007	0.590405296
7.2	0.334164616	0.248122508	1.044018096	0.940604011
7.5	0.250301378	0.249207673	1.136138646	0.938356851
7.8	0.213809353	0.178211194	0.819209829	0.515201982
8.1	0.143972645	0.053285163	0.200724929	0.360017551
8.4	-0.071596628	-0.053440609	0.17827235	0.656885729
8.7	0.142413868	0.106693929	0.90518158	1.014928421
9	0.211357613	0.33644338	1.262882958	0.871829527
9.3	0.251178029	0.587900111	0.641815668	0.730031644
9.6	0.270908732	0.483000661	0.599372602	0.717034965
9.9	0.643150083	0.430684838	1.036419174	0.909784416
10.2	0.522786149	0.528596455	1.438359912	0.698770413
10.5	0.357910537	0.601911858	0.826577191	0.20710491
10.8	0.616941619	0.61314406	0.260049983	-0.068922096
11.1	0.702877565	0.673983113	-0.086746136	0
11.4	0.581791437	0.460028984	0	0
11.7	0.707450401	0.060792546	0	0
12	0.688419774	-0.032072123	0	0
12.3	0.114499788	0	0	0
12.6	-0.049998114	0	0	0
12.9	0	0	0	0
13.2	0	0	0	-0.154643739
13.5	0	0	0	0.310375219
13.8	0	0	0	0.883645066
14.1	0	0	-0.238471167	6.906863054
14.4	0	0	-0.528838198	14.60269635
14.7	0	-0.187539429	5.879059674	23.13453715
15	0	-0.61403078	15.14807152	28.76157021
15.3	0	5.207573624	26.08496657	36.0255753
15.6	0	13.44470571	33.90005736	40.38401843
15.9	-0.238788568	24.8094125	41.25658769	44.81485672
16.2	0.579716733	33.94461755	44.01407831	46.92287131
16.5	2.664118238	41.10320327	46.97531752	48.69161703
16.8	3.752125832	42.40029686	48.08436621	48.91683575
17.1	9.729765182	44.73701774	48.84200393	49.67114246
17.4	19.77156281	45.86056839	48.71752483	50.03139129

17.7	27.30631949	46.77012263	48.30783114	51.4459221
18	27.95593515	47.21524248	48.78905836	53.32589753
18.3	36.1508359	48.17802983	52.24208403	57.72178779
18.6	45.77850573	50.08479782	57.05982428	61.7204304
18.9	62.56280406	53.96600391	62.20069883	66.03726381
19.2	77.04372921	58.25718588	66.23403661	68.26251256
19.5	87.78563493	64.89483182	70.70956845	71.38428748
19.8	88.83435567	71.75876258	73.81338265	73.33606241
20.1	92.56283298	78.61505615	78.28725455	76.64743373
20.4	93.59461791	82.02432197	81.0303439	78.18870852
20.7	95.15125375	85.79217239	84.98458512	81.1162897
21	95.85721999	87.43579072	86.84019686	82.97295056
21.3	96.73114643	90.09511519	89.65439335	85.73848144
21.6	97.0632356	91.75337294	91.0752587	87.37929849
21.9	97.78724074	94.36319079	93.88074509	89.9815024
22.2	98.27222695	95.26112382	94.85471725	91.14254052
22.5	98.64668549	96.60140325	96.91003173	93.47794037
22.8	98.56987747	96.40810396	97.12218582	94.12385125
23.1	98.63361113	96.45034297	97.97015883	94.84602543
23.4	98.17410706	95.44648471	96.63923798	93.35577627
23.7	98.0345753	94.89223341	96.06298165	93.22003616
24	97.91080179	94.01627772	95.01643942	92.2690159
24.3	97.82608387	94.61864506	94.93685854	92.42450542
24.6	97.34278177	95.13582412	94.37538919	91.66846624
24.9	97.79731132	95.63690511	95.62859093	92.8071769
25.2	98.3517452	95.60625453	96.12105361	93.26513772
25.5	98.71106641	95.60558164	96.21230058	94.02421574
25.8	98.63240103	95.9036993	96.36473208	94.4727024
26.1	98.61175402	96.39111602	96.62268436	94.70513416
26.4	98.57184873	96.60326857	96.75950817	94.39647971
26.7	98.58513181	96.55830739	97.31564339	94.74561838
27	98.56865106	96.51821766	97.62693781	95.26223774
27.3	98.53933006	96.36244493	97.49398335	95.47583779
27.6	98.52643796	96.753329	97.39258802	95.2778981
27.9	98.54586133	96.96773081	97.74221243	95.65644925
28.2	98.53095835	97.00586384	98.27008561	96.16478576
28.5	98.57183826	97.23212046	98.65614657	96.61056036
28.8	98.54707288	97.58667641	98.54707288	96.46572836
29.1	98.53427433	97.48530942	98.53427433	96.35658965
29.4	98.56311807	97.53479554	98.56311807	96.73038369
29.7	98.55283164	97.5171475	98.55283164	97.28020757
30	98.46978519	97.37466781	98.46978519	97.45454403
30.3	98.48313196	97.39756637	98.4038308	97.39756637
30.6	98.57662193	97.55796361	98.81012565	97.55796361

30.9	98.56962175	97.54595366	99.37208318	97.54595366
31.2	98.51162484	97.44645053	99.6512443	97.44645053
31.5	98.48979765	97.40900245	99.56879543	97.325572
31.8	98.48575428	97.40206538	99.56764093	97.65224042
32.1	98.4799432	97.39209553	99.56598171	98.22164948
32.4	98.49954744	97.4257298	99.57157926	98.58461475
32.7	98.49030432	97.40987172	99.5689401	98.49030432
33	98.49133203	97.41163492	99.56923354	98.49133203
33.3	98.47500415	97.38362179	99.56457147	98.47500415
33.6	98.52111891	97.46273915	99.5436726	98.52111891
33.9	98.52257991	97.388489	99.68379572	98.44595083
34.2	98.464462	97.7310286	99.91076308	98.77097831
34.5	98.81142541	98.20290963	100.0130788	99.23962016
34.8	99.20503627	98.45560064	100.0376165	99.51384107
35.1	99.70277316	98.52817909	99.98162029	99.63196191

Table B.25 Toluene + (0.0027 volume fraction of nanodiamond (12 nm) + polybutene) smoothed experimental data

Elevation (mm)	3 hr	6 hr	9hr
2.1	0	-0.011325036	-0.02275817
2.4	0	0.00863723	0.017928243
2.7	0	0.056998097	0.112916889
3	0	0.140686409	0.275596756
3.3	0	0.199495069	0.375275082
3.6	0	0.196871808	0.429296519
3.9	0	0.135763923	-0.448356608
4.2	0	0.041788947	2.174151074
4.5	0	-0.041571714	9.921139274
4.8	0	0	20.76605899
5.1	0	8.699815053	29.1282813
5.4	0	33.07250912	35.35258711
5.7	24.15968488	50.90042423	40.69168751
6	65.06711105	51.61875237	44.06671275
6.3	87.28010316	52.15468809	43.36073922
6.6	83.92265595	53.68929943	40.96203715
6.9	84.76796786	56.52123909	46.06546153
7.2	85.5104707	59.87353934	52.98568746
7.5	86.60554537	68.2009519	63.23234646
7.8	87.46960964	76.36867913	72.53411942
8.1	87.81601607	81.18061776	79.86416697
8.4	88.42265595	82.3053793	81.03361916

8.7	88.8922656	84.97594841	83.26723206
9	89.0077344	85.77584348	84.80945567
9.3	89.0077344	86.95447277	86.06766257
9.6	88.85876355	87.86280905	85.3692694
9.9	89.54269633	88.13984616	83.68967524
10.2	89.68907633	87.67807152	82.90125991
10.5	90.97343716	87.86595272	83.22687433
10.8	92.35110053	87.38832469	82.74670932
11.1	93.19260638	86.56092446	81.91491427
11.4	91.88688482	86.08329643	81.43474926
11.7	91.24154282	86.23658086	81.56328234
12	90.52991569	86.10107118	81.4177506
12.3	90.29883604	85.95206951	81.9082401
12.6	89.82287268	85.47358693	82.23503502
12.9	89.46720445	84.91332869	81.97556167
13.2	89.22775711	84.57035579	81.45170236
13.5	89.28761894	84.65609902	81.55477608
13.8	89.28761894	84.65609902	81.55477608
14.1	89.28761894	84.5364817	81.55477608
14.4	89.28761894	85.01495096	81.55477608
14.7	89.16863197	85.84380844	81.43473576
15	89.64457987	86.32227769	81.91489706
15.3	90.46906959	86.20266038	82.74668569
15.6	90.94501748	86.20266038	83.22684699
15.9	90.82603051	86.20266038	83.10680667
16.2	90.82603051	86.20266038	83.10680667
16.5	90.82603051	86.20266038	83.10680667
16.8	90.82603051	86.20266038	83.10680667
17.1	90.82603051	86.20266038	83.10680667
17.4	90.82603051	86.20266038	83.10680667
17.7	90.82603051	86.20266038	83.10680667
18	90.82603051	86.20266038	83.10680667
18.3	90.82603051	86.20266038	83.10680667
18.6	90.82603051	86.20266038	83.10680667
18.9	90.88515984	86.12556335	83.12377534
19.2	90.64864253	86.43395146	83.05590064
19.5	90.17979556	87.04527588	82.92135393
19.8	90.12851533	86.96816223	82.82694576
20.1	90.85366344	86.74231985	83.43348048
20.4	91.2403324	86.65976415	83.77786766
20.7	91.03103984	86.5110188	83.48438038
21	90.77471582	86.12551704	83.01238029
21.3	90.82598062	86.20261739	83.10678031
21.6	90.82598062	86.20261739	83.10678031

21.9	90.82598062	86.20261739	83.10678031
22.2	90.82598062	86.20261739	83.10678031
22.5	90.82598062	86.20261739	83.10678031
22.8	90.82598062	86.20261739	83.10678031
23.1	90.82598062	86.20261739	83.10678031
23.4	90.82598062	86.20261739	83.10678031
23.7	90.82598062	86.20261739	83.10678031
24	90.82598062	86.20261739	83.10678031
24.3	90.82598062	86.08321111	83.10678031
24.6	90.70720246	86.56083623	83.10678031
24.9	91.1823151	87.38823143	82.9869525
25.2	92.00535788	87.86585656	83.46626371
25.5	92.48047052	87.74645028	84.29657973
25.8	92.36169236	87.74645028	84.77589094
26.1	92.36169236	87.74645028	84.65606313
26.4	92.36169236	87.74645028	84.65606313
26.7	92.36169236	87.74645028	84.65606313
27	92.36169236	87.74645028	84.65606313
27.3	92.36169236	87.74645028	84.65606313
27.6	92.24312248	87.62725392	84.65606313
27.9	92.71740202	88.10403934	84.53644637
28.2	93.53900163	88.92997991	85.01491342
28.5	94.01328117	89.40676533	85.8437671
28.8	93.89471129	89.28756897	86.32223415
29.1	93.77634913	89.16858199	86.08321111
29.4	94.24979777	89.64452992	86.56083623
29.7	95.06995799	90.46901968	87.38823143
30	95.42525165	90.82618945	87.7466602
30.3	95.77950941	91.1823151	88.10403934
30.6	96.48028569	91.886788	88.81099292
30.9	97.43462356	92.87598289	89.82353521
31.2	97.96639624	93.29125451	90.16080281
31.5	98.83864165	93.99500328	90.7517344
31.8	99.54005509	94.5977153	91.2883622
32.1	100.1527394	95.16770582	91.82977003

Table B.26 Toluene + (0.0005 mass fraction of nanosilica + polybutene) smoothed experimental data

Elevation (mm)	3 hr	6 hr	9 hr	12 hr
2.1	0.088503253	0.294712322	0.296527149	0.537529297
2.4	0.268421922	0.318676262	0.309498364	0.558778055
2.7	0.394234026	0.367342853	0.380353711	0.606072811

3	0.433554803	0.41450559	0.489071947	0.652780563
3.3	0.511039561	0.587236412	0.697895834	0.829519117
3.6	0.465620364	0.579112439	0.727729548	0.822509461
3.9	0.567961127	0.7181762	0.827813533	0.959781535
4.2	0.9040387	0.99515999	1.069210742	1.231923221
4.5	1.097710411	1.243936913	1.225424225	1.477453815
4.8	0.94734614	1.05392877	1.035499403	1.286596311
5.1	0.639268153	0.693169467	0.766886937	0.929115205
5.4	0.696604284	0.751780074	0.879481648	0.988706177
5.7	0.830734648	0.939543235	1.013260705	1.178786878
6	0.828594348	0.974001532	0.955572164	1.212526298
6.3	0.783005783	0.889735845	0.871272739	1.126513157
6.6	0.798139319	0.870318643	0.944171065	1.106638503
6.9	0.96572472	0.947679889	1.057880226	1.186155627
7.2	1.212616249	1.212616249	1.357408732	1.446600356
7.5	1.353797826	1.336021366	1.4404485	1.569115224
7.8	1.323048656	1.394154496	1.446711729	1.627116007
8.1	1.143313792	1.266491211	1.322287509	1.501084664
8.4	1.135936346	1.207042186	1.316496445	1.422372035
8.7	1.346898785	1.310706588	1.455937236	1.614748654
9	1.323425	1.39708795	1.484876685	1.753566304
9.3	1.104099585	1.231706714	1.357339163	1.538438285
9.6	1.229131538	1.284507454	1.464355527	1.519981073
9.9	1.382256174	1.436988577	1.635255956	1.598464666
10.2	1.401190886	1.509685283	1.564462425	1.638113357
10.5	1.298578919	1.444610743	1.426407964	1.536387704
10.8	1.382059792	1.490029955	1.490029955	1.634107166
11.1	1.440691346	1.51357503	1.51357503	1.617162507
11.4	1.508266945	1.490046024	1.490046024	1.560472304
11.7	1.319465754	1.337473779	1.337473779	1.319867209
12	1.26789386	1.195861761	1.213589513	1.195861761
12.3	1.337255498	1.212473509	1.141562501	1.212473509
12.6	1.423028927	1.350996827	1.228156917	1.350996827
12.9	1.103423304	1.13940488	1.068493872	1.121431329
13.2	0.991611718	0.919717514	0.937445266	0.97364927
13.5	1.031968424	0.925669346	0.907425313	1.067440764
13.8	1.053844519	0.908974183	0.963638011	1.160332742
14.1	0.969139659	0.860695865	1.02462079	1.647746344
14.4	1.014290859	0.90490797	1.193406015	1.120233604
14.7	0.97883477	1.088308326	1.464855698	10.70209872
15	0.851924904	1.213776043	0.118744833	25.00089161
15.3	0.816247937	1.558101127	9.290902623	34.41399694
15.6	0.975287346	0.307949389	24.12763212	34.341937
15.9	1.277805916	10.51101237	34.42326997	36.8692171

16.2	1.543736648	26.20570571	34.87360092	38.34424677
16.5	2.139255886	36.53218724	37.735476	40.78443658
16.8	3.110759135	36.63576816	39.78868124	43.02839468
17.1	3.503647685	39.83933094	42.65742247	45.90091637
17.4	9.892605652	42.05461683	44.55927233	47.64574166
17.7	25.93646754	44.89195833	46.52784198	49.63812951
18	40.49728824	46.99272778	48.22464334	51.70063159
18.3	46.91423139	49.99216683	50.8299154	54.96202597
18.6	49.23817887	52.17548091	53.3560813	57.67056271
18.9	54.10181056	53.99037527	56.13152333	60.31011426
19.2	57.25817241	55.23192448	58.69025393	61.99612528
19.5	66.36432146	58.6996626	62.68641234	65.34546016
19.8	74.76959296	63.73178343	66.2513317	68.09207332
20.1	82.99630342	69.89849287	70.16492093	71.59207269
20.4	85.99647034	73.54055401	72.63025958	73.33101767
20.7	90.81952137	77.36181295	76.30909814	76.28896936
21	92.58609862	79.60239815	78.01354984	77.30039979
21.3	95.44884261	83.25978421	81.34573911	79.90090452
21.6	96.45856962	85.66262683	83.78274713	81.78468419
21.9	98.34147521	90.17742353	87.71048183	85.6186801
22.2	99.41288828	92.34060398	89.69624252	87.26182874
22.5	100.1949154	95.02844691	92.62186857	90.03882479
22.8	100	96.13342922	93.99188949	91.12737091
23.1	100	98.31817321	96.23018524	93.49072268
23.4	100	99.21536712	97.52459082	94.8149288
23.7	100	99.97270641	99.12290934	97.57637197
24	100	99.86265702	99.49721411	98.06709917
24.3	100	100.0666907	99.9134593	98.84406784
24.6	100	99.87058007	99.73252787	98.74840919
24.9	100.0291449	99.80494936	99.91239135	99.59730709
25.2	99.91247931	99.78305938	99.49134363	98.9480099
25.5	99.71224602	99.82075554	99.31541317	98.67561651
25.8	99.59486848	99.29025033	98.99853458	97.98378568
26.1	99.59401809	99.141782	99.21471093	98.19819565
26.4	99.57943257	99.05323428	99.05323428	97.91959467
26.7	99.58922616	98.90707288	98.90707288	98.19959211
27	99.58529904	98.4611678	98.4611678	97.90250122
27.3	99.57565558	98.51382389	98.51382389	98.07608333
27.6	99.5882796	98.55803682	98.55803682	97.89346272
27.9	99.59598504	98.58502347	98.58502347	98.11324156
28.2	99.58377217	98.5422505	98.5422505	98.22044152
28.5	99.58907409	98.56081936	98.56081936	98.64127161
28.8	99.59196799	98.57095463	98.57095463	98.57095463
29.1	99.59240849	98.49326978	98.57249739	98.57249739

29.4	99.59296603	98.80095384	98.57445004	98.57445004
29.7	99.57475706	99.33690643	98.42629249	98.51067702
30	99.55120083	99.63061142	98.68725139	98.42817632
30.3	99.56165068	99.56165068	99.27925174	98.38067872
30.6	99.58189111	99.58189111	99.67229775	98.79107024
30.9	99.57980715	99.57980715	99.57980715	99.35033956
31.2	99.57157651	99.57157651	99.57157651	99.65003954
31.5	99.56542683	99.56542683	99.56542683	99.56542683
31.8	99.5301036	99.56406508	99.56406508	99.56406508
32.1	99.67192127	99.53607535	99.5681011	99.5681011
32.4	99.90426356	99.66893619	99.57511703	99.57511703
32.7	100.0324849	99.89663895	99.5375893	99.56976377
33	100	100.0339615	99.70133556	99.57263764
33.3	100	100	99.76273735	99.57080471
33.6	100	100	99.80535378	99.5890243
33.9	100	100	99.867847	99.53946225
34.2	100	100	100.0330382	99.65664665
34.5	100	100	100	99.88534377
34.8	100	100	100	100.0061713
35.1	100	100	100	100.0384471
35.4	100	100	100	99.9824002

Table B.27 Toluene + (0.00135 mass fraction of nanosilica + polybutene) smoothed experimental data

Elevation (mm)	3 hr	6 hr	9 hr	12 hr
2.1	0	0	0.228408804	0.000876201
2.4	0	0	-0.338635598	-0.584375105
2.7	0	0	-0.499784665	1.991064105
3	0	0	-0.44155565	7.902614032
3.3	0	0	1.486638709	15.96495387
3.6	0	-0.014705215	4.613461615	19.37301093
3.9	0	-0.448156924	10.32899176	24.95696641
4.2	0	1.541918533	16.07361859	33.57518379
4.5	-0.029375569	4.590203357	20.25916124	34.47848832
4.8	-0.35560977	9.967535924	21.69214637	31.62208172
5.1	1.534985592	15.36603622	23.41396501	30.55770926
5.4	5.086880689	19.17850437	25.3144203	30.70832323
5.7	7.398692863	19.99712259	26.65065336	29.35050611
6	5.622979349	22.03300358	28.55065324	30.69362692
6.3	10.18462314	25.13831105	30.12596115	30.93020067
6.6	27.91009314	27.212505	31.30084182	31.25301723

6.9	57.79455041	35.09227923	32.83455233	39.1437019
7.2	79.22838068	43.06987235	33.96948205	50.88535497
7.5	87.94159544	59.09986743	42.5407905	60.6065835
7.8	88.80930509	75.3553971	53.17554069	64.46488179
8.1	92.06846014	88.26638852	66.68164061	70.2091487
8.4	93.58323181	89.69906503	76.03655189	73.96453398
8.7	95.84762794	93.19893832	86.890754	79.43114833
9	97.11855909	94.78991584	92.43333526	84.62996855
9.3	98.48748365	96.48794141	96.81899693	91.06010335
9.6	98.56146335	96.40028238	96.56175632	94.38528887
9.9	98.00424163	96.24489038	95.92194137	95.52651682
10.2	97.04494938	95.51891257	94.9594645	94.71711857
10.5	96.88400952	95.120942	94.797993	94.87873025
10.8	96.64206509	94.39363761	94.55524594	94.55524594
11.1	96.08354203	94.31835486	93.99487055	94.07587579
11.4	95.761127	94.15089055	93.67138624	93.42837053
11.7	95.84173075	94.39922594	93.75225732	93.02907634
12	95.84173075	94.15089055	93.75225732	92.29935674
12.3	95.84173075	94.31835486	93.75225732	92.14268395
12.6	95.84173075	94.47437486	93.75225732	92.38036198
12.9	95.84173075	94.87873025	93.75225732	92.78606063
13.2	95.84173075	94.79785917	93.75225732	92.7049209
13.5	95.82539729	94.85418882	93.80460677	92.75328355
13.8	95.89073114	94.62887023	93.59520897	92.55983294
14.1	96.00390967	94.2385484	93.155576	92.14769792
14.4	96.06924351	94.01322981	93.25374173	92.26232106
14.7	96.06924686	94.09410525	93.8634326	92.87302371
15	95.98756284	93.9713763	94.04826718	93.03779502
15.3	95.95604517	93.84314997	93.9240215	92.90548352
15.6	95.93855243	94.22122506	93.89773893	92.87479512
15.9	95.90703476	94.32989113	93.85038413	92.81950206
16.2	95.80901395	94.273318	93.70310939	92.64753914
16.5	95.90703476	94.55607416	93.85038413	92.81950206
16.8	95.93855243	94.9998615	93.89773893	92.87479512
17.1	95.95604517	94.94087399	93.9240215	92.90548352
17.4	95.98756284	94.98030367	93.9713763	92.96077658
17.7	96.06924686	95.08249317	94.09410525	93.10407902
18	96.05291005	95.06205527	94.06955946	93.07541853
18.3	96.05291005	95.06205527	94.06955946	93.07541853
18.6	95.98863976	95.00175201	94.01322981	93.02306908
18.9	96.24572094	95.24296504	94.2385484	93.23246688
19.2	96.69106547	95.66082098	94.62887023	93.59520897
19.5	96.94814665	95.90203401	94.85418882	93.80460677
19.8	96.88387636	95.84173075	94.79785917	93.75225732

20.1	96.88387636	95.84173075	94.79785917	93.75225732
20.4	96.88387636	95.84173075	94.79785917	93.75225732
20.7	96.88387636	95.84173075	94.79785917	93.75225732
21	96.88387636	95.84173075	94.79785917	93.75225732
21.3	96.88387636	95.84173075	94.79785917	93.75225732
21.6	96.88387636	95.92246801	94.79785917	93.75225732
21.9	96.88387636	95.599519	94.79785917	93.75225732
22.2	96.88387636	95.04007093	94.79785917	93.75225732
22.5	96.88387636	94.71712192	94.79785917	93.75225732
22.8	96.88387636	94.79785917	94.79785917	93.75225732
23.1	96.88387636	94.79785917	94.79785917	93.75225732
23.4	96.88387636	94.79785917	94.79785917	93.75225732
23.7	96.88387636	94.79785917	94.79785917	93.75225732
24	96.87163385	94.7774212	94.7774212	93.72771143
24.3	96.93284638	94.87961105	94.87961105	93.85044088
24.6	96.95646516	94.91904087	94.99580403	93.97468638
24.9	96.9695739	94.94092496	94.63387233	93.69340704
25.2	96.99319267	94.98035478	94.52520733	93.20796903
25.5	97.0544052	95.08254463	94.54520253	93.02313648
25.8	96.97393272	95.00180403	94.32034064	93.02313211
26.1	97.31508261	95.30331717	94.21817034	93.284877
26.4	97.44671485	95.41965563	94.40360605	93.38587092
26.7	97.51977255	95.48422506	94.4639208	93.44192393
27	97.65140479	95.60056351	94.57259335	93.54291785
27.3	97.99255468	95.90207666	94.85423884	93.80466274
27.6	97.9243247	95.84177403	94.79790974	93.75231376
27.9	97.9243247	95.84177403	94.79790974	93.75231376
28.2	97.9243247	95.84177403	94.79790974	93.75231376
28.5	97.9243247	95.84177403	94.79790974	93.75231376
28.8	98.00479451	95.84177403	94.79790974	93.75231376
29.1	97.68291527	95.84177403	94.79790974	93.75231376
29.4	97.12532035	95.84177403	94.79790974	93.75231376
29.7	96.80344111	95.84177403	94.79790974	93.75231376
30	96.88391092	95.84177403	94.79790974	93.75231376
30.3	96.80344111	95.84177403	94.79790974	93.75231376
30.6	97.12532035	95.84177403	94.79790974	93.75231376
30.9	97.68291527	95.84177403	94.79790974	93.75231376
31.2	98.00479451	95.84177403	94.79790974	93.75231376
31.5	97.9243247	95.84177403	94.79790974	93.67144314
31.8	97.9243247	95.84177403	94.71717305	93.99492563
32.1	97.9243247	95.84177403	95.0401198	94.55529787
32.4	97.9243247	95.80720815	95.50866514	94.78921666
32.7	97.9243247	96.13193641	95.78584111	95.18187257
33	97.9243247	96.75382631	95.91013986	95.66695084

Table B.28 Toluene + (0.0027 volume fraction of nanosilica + polybutene) smoothed experimental data

Elevation (mm)	3 hr	6 hr	9 hr
2.1	0.003342245	0.340777003	0.307099599
2.4	-0.011377705	0.233966789	0.144037007
2.7	0.009499271	0.170944479	0.064681904
3	0.070834664	0.142625787	0.07592198
3.3	0.14213316	0.185025228	0.137972623
3.6	0.096381676	0.084618525	0.097705073
3.9	-0.012351255	0.000292824	-0.005000766
4.2	0.043322201	0.005781369	-0.003388773
4.5	0.145049436	0.00529359	0
4.8	0.12620052	-0.014701851	0
5.1	0.093011677	0.053513814	0
5.4	0.079667076	0.092702562	0
5.7	0.045186942	0.053513814	0
6	0.01534045	-0.013378454	-0.516788189
6.3	0.0343552	-0.027092726	0.763656364
6.6	0.14714945	-0.426326399	7.27554258
6.9	0.103138055	0.989761689	14.35878871
7.2	2.284412786	7.638307409	23.5581375
7.5	5.473522099	15.68827569	33.07035917
7.8	8.627838617	19.5802125	39.11445522
8.1	12.57105803	25.70164126	38.62551439
8.4	15.28466507	34.00266769	38.32509396
8.7	25.28890411	38.45513653	38.93989947
9	38.70399914	37.79621952	40.20115672
9.3	47.50214789	39.27099859	43.21707108
9.6	47.31488626	41.95419612	47.15727153
9.9	48.21947471	44.80535006	49.43789894
10.2	47.66759627	46.50060579	49.53784567
10.5	46.42358573	47.09471322	47.65033447
10.8	44.78835174	47.57958462	48.08243028
11.1	46.93542972	47.59276936	50.80227784
11.4	49.08378964	46.70902297	55.41279485
11.7	63.48446632	46.99823496	62.26061559
12	83.06976684	55.13911742	70.19365481
12.3	96.71278771	70.19843998	76.98464928
12.6	96.69279142	80.93155164	80.07539764
12.9	98.79153628	86.66305345	84.51589388
13.2	99.48490129	90.3607005	87.27666882
13.5	100.1666961	94.3079641	90.98961795
13.8	99.99993679	95.25313124	92.03813191

14.1	99.99995626	97.55883009	94.4503422
14.4	99.99997742	98.74171511	95.87845779
14.7	99.99998541	99.77109708	98.16990217
15	99.99992507	99.69388432	98.68962016
15.3	99.99989334	100.1550572	99.46960013
15.6	99.99989948	99.76670052	98.36238125
15.9	100.0767471	99.28495627	97.30534143
16.2	99.69249904	98.65495267	96.11214569
16.5	99.46739278	98.26809879	96.36341572
16.8	99.69250338	97.86302771	95.95098911
17.1	100.0767481	98.19464383	95.85615182
17.4	99.99989967	98.73743526	96.20047466
17.7	99.99990307	99.11271714	96.79298884
18	99.99990364	99.03546513	97.39105806
18.3	99.99990326	98.95390363	97.83360465
18.6	99.99989308	99.24116651	98.01818462
18.9	99.99992206	99.75930572	98.10126753
19.2	99.99997672	100.078346	98.9492876
19.5	100.0000078	100.0000078	99.81851763
19.8	100	100	100.084202
20.1	100	100	99.99989691
20.4	100	100	99.99989716
20.7	100	100	99.99989783
21	100	100	99.99989741
21.3	100	100	99.9998981
21.6	100	100	99.99989756
21.9	100	100	99.99989958
22.2	100	100	99.99989878
22.5	100	100	99.99989492
22.8	100	100	99.99989057
23.1	100	100	99.99989028
23.4	100	100	99.99989151
23.7	100	100	99.99989416
24	100	100	99.99989489
24.3	100	100.0000079	99.99989775
24.6	100	99.99997582	99.9999002
24.9	100	99.99992313	99.9999018
25.2	100	99.99989572	99.99990309
25.5	100	99.99990747	99.99990747
25.8	100	99.99989699	99.99989699
26.1	100	99.99993113	99.99993113
26.4	100	99.99994587	99.99994587
26.7	100	99.99995642	99.99995642
27	100	99.99997028	99.99997028

27.3	100	100.0000074	100.0000074
27.6	100	100	100
27.9	100	100	100
28.2	100	100	100.0000078
28.5	100	100	99.99997641
28.8	100	100	99.99991456
29.1	100	100	99.99991476
29.4	100	100	99.99997674
29.7	100	100	100.0000078
30	100	100	100
30.3	100	100	100
30.6	100	100	100
30.9	100	100	100
31.2	100	100	100
31.5	100	100	100
31.8	100	100	100
32.1	100	100	100

Table B.29 Toluene + (0.01 volume fraction of nanosilica+polybutene) smoothed experimental data

Elevation (mm)	3 hr	6 hr	9 hr	12 hr
2.1	0	0	0	0
2.4	0	0	0	0
2.7	0	0	0	0
3	0	0	0	0
3.3	0	0	0	0
3.6	0	0	0	-0.018168588
3.9	0	0	0	-0.070255373
4.2	0	0	-0.017991817	0.431475731
4.5	0	0	-0.070962455	0.747829013
4.8	0	-0.089598574	0.465278623	6.33420862
5.1	0	0.215464572	0.66861832	14.87640214
5.4	-0.035947564	0.97902531	5.741323961	21.23089561
5.7	0.072038976	0.900254816	14.15812214	26.54375114
6	0.357787504	4.338856393	23.81094563	33.12958415
6.3	1.107950815	18.21201374	31.541871	37.33864864
6.6	-0.525115858	32.79780287	37.16044959	38.64570953
6.9	11.37338189	39.66027072	39.68481743	40.6264497
7.2	29.64832119	40.72394523	41.48456196	41.7429184
7.5	43.40859995	44.94985443	45.47953012	45.38265624

7.8	46.19207561	48.22118951	48.65087759	48.94821847
8.1	52.69232405	52.95312712	53.95899954	55.41553389
8.4	56.20101304	56.59851524	58.59261551	62.02055061
8.7	58.33575533	59.51326654	62.59177046	66.02988071
9	58.28186181	60.10155205	63.36518732	65.21550095
9.3	58.67853349	60.18314111	63.715076	65.56242971
9.6	56.839475	59.66459208	63.195982	66.47934466
9.9	66.62682231	58.1370077	63.83144061	67.57276309
10.2	82.84518184	58.04530312	65.39858416	69.0038409
10.5	95.04427756	65.49659616	70.7748413	72.18174896
10.8	97.11420054	77.09648342	77.68618187	76.89592929
11.1	99.75562973	86.6655817	85.74114262	82.61884883
11.4	99.74576656	91.60326398	90.93288567	86.53605039
11.7	100.0847445	96.36883495	95.89516504	92.01391464
12	100	98.90099577	98.57750236	97.70740316
12.3	100	100.4023822	100.4832555	100.8079771
12.6	100	100	100	100.084632
12.9	100	100	100.0000085	99.74568088
13.2	100	100.0000085	99.9999746	99.24339218
13.5	100.0000085	99.9999746	100.0846529	98.56493895
13.8	99.9999746	99.99991593	99.74567106	98.06154659
14.1	100.0801267	100.1604359	99.31480835	97.87406443
14.4	99.67903896	99.44241207	98.27927605	97.28383946
14.7	99.52430131	98.70897956	97.63810537	96.56546819
15	99.43841509	98.28885015	97.22213085	96.15365494
15.3	99.28366898	98.22731796	97.16922895	96.10939765
15.6	98.88261509	97.84823363	96.81215032	95.77436097
15.9	98.96282587	97.9240505	96.80309077	95.8413683
16.2	98.96282587	97.9240505	97.20546716	95.8413683
16.5	98.88261464	97.84370741	97.36072356	95.76076051
16.8	99.28367079	98.16507977	97.44689299	96.08319167
17.1	99.43841778	98.7217966	97.60214939	96.64174268
17.4	99.6045157	99.12351205	98.00452577	96.96417384
17.7	99.35820655	98.64145351	97.9240505	96.88356605
18	99.52430447	98.40610904	97.9240505	96.88356605
18.3	99.67905146	98.64145351	97.9240505	96.88356605
18.6	100.1603188	99.12351205	97.9240505	96.88356605
18.9	99.67905146	98.64145351	97.9240505	96.88356605
19.2	99.52430447	98.40610904	97.9240505	96.88356605
19.5	99.35820655	98.64145351	97.9240505	96.88356605
19.8	99.6045157	99.04316896	97.9240505	96.88356605
20.1	99.35820655	98.96282587	97.9240505	96.88356605
20.4	99.6045157	98.96282587	97.9240505	96.88356605
20.7	99.35820655	98.96282587	97.9240505	96.88356605

21	99.52430447	98.96282587	97.9240505	96.88356605
21.3	99.67905146	98.96282587	97.9240505	96.88356605
21.6	100.1603188	98.96282587	97.9240505	96.88356605
21.9	99.75926269	98.96282587	97.9240505	96.88356605
22.2	99.20345956	99.04316896	97.9240505	96.88356605
22.5	98.80240341	98.64145351	97.9240505	96.88356605
22.8	99.28367079	98.48645213	97.9240505	96.88356605
23.1	99.43841778	98.32008115	97.9240505	96.88356605
23.4	99.6045157	98.56679522	97.9240505	96.88356605
23.7	99.43841778	98.32008115	97.9240505	96.88356605
24	99.28367079	98.56679522	97.9240505	96.88356605
24.3	98.88261464	98.32008115	97.9240505	96.88356605
24.6	98.96282587	98.56679522	97.9240505	96.88356605
24.9	98.96282587	98.32008115	97.9240505	96.88356605
25.2	98.96282587	98.56679522	97.9240505	96.88356605
25.5	98.96282587	98.32008115	97.9240505	96.88356605
25.8	98.96282587	98.56679522	97.9240505	96.88356605
26.1	98.96282587	98.40042424	97.9240505	96.88356605
26.4	98.96282587	98.24542286	97.9240505	96.88356605
26.7	98.96282587	97.84370741	97.9240505	96.88356605
27	98.96282587	97.9240505	97.9240505	96.88356605
27.3	98.96282587	97.9240505	97.9240505	96.88356605
27.6	98.96282587	97.9240505	97.9240505	96.88356605
27.9	98.96282587	97.9240505	97.9240505	96.88356605
28.2	98.96282587	97.9240505	98.00452577	96.88356605
28.5	98.96282587	97.9240505	97.60214939	96.88356605
28.8	98.96282587	97.9240505	97.36641771	96.88356605
29.1	98.96282587	97.9240505	97.60214939	96.88356605
29.4	98.96282587	97.9240505	98.00452577	96.88356605
29.7	98.96282587	97.9240505	97.9240505	96.88356605
30	98.96282587	97.84370741	97.9240505	96.88356605
30.3	98.88261464	98.16507977	97.9240505	96.88356605
30.6	99.28367079	98.7217966	97.9240505	96.88356605
30.9	99.43841823	99.04769617	97.93311191	96.89716912
31.2	99.52430266	98.94471703	97.88780485	96.82915376
31.5	99.67904878	98.93598293	97.87032318	96.80291012
31.8	100.0801044	98.93113539	97.86062061	96.78834454
32.1	100.0801041	98.99821905	97.91455545	96.82910892
32.4	99.67904302	98.59649425	97.51216585	96.42605343
32.7	99.52429545	98.45475057	97.38344743	96.22977325
33	99.43840818	98.37356822	97.30697774	96.56106625
33.3	99.28366016	98.22729733	97.08872186	96.58730479
33.6	98.88260134	97.84820859	97.05354353	96.33857669
33.9	98.88111063	97.84679955	97.51924904	96.53895922

34.2	98.90974492	97.87386524	97.82102475	96.7436689
34.5	98.99916442	97.95838632	98.02453684	96.99000415

Appendix C. Acoustic view cell

The acoustic view cell can be used to measure speed of sound in either liquids or solids with an accuracy of about 3m/s. Figure C.1 shows different parts of the apparatus for measurements in liquids.

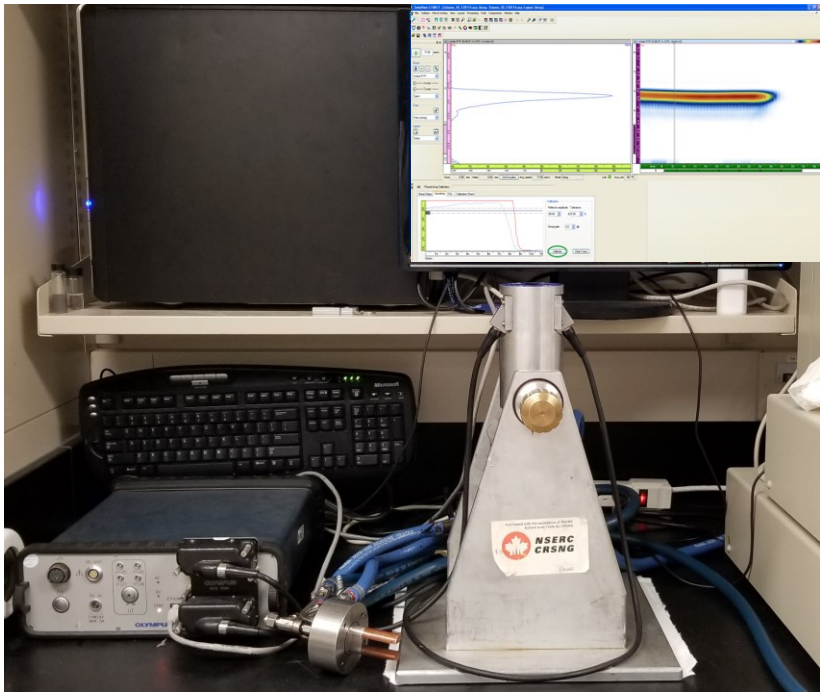

Figure C.1 Acoustic view cell setup

The main important parts are cell, frame, copper rods, probes, acoustic gel, lid, acquisition unit and computer. **Cell** is used to hold the liquid sample during measurements. The cell is 4cm high and has a width of 1.6cm. **Frame** is to hold the cell

vertically and constant during the time of measurements. **Copper rods** are to control the temperature inside the cell. Mixture of water and glycerol would flow in them and would be placed in the cell. The safe range of temperatures to work with is from -40 to 40 degrees Celsius. **Probes** have the duty of sending and receiving acoustic waves. Each probe possesses 64 elements each being 7mm wide and 0.6mm high with a nominal frequency of 10 MHz. Probes can function echo or sender/receiver modes. Acoustic gel would be put on the surface of probes to insure that acoustic waves move through perfectly without any attenuation. Acquisition unit and computer is used to run the Tomo-view software and analyze the data.

Acoustic waves go a distance of 6.7 mm through the cell and 16 mm through the sample to get to second probe. The apparatus is calibrated to eliminate interference of cell wall on determination of speed of sound in the fluid.

Appendix D. Values of n_w and calculation method

Table D. 1 Toluene + polybutene

Toluene mass fraction	$n_{w\text{-integral fit}}$
0.1	0.45
0.25	0.525
0.3	0.5125
0.35	0.5
0.4	0.5
0.42	0.5
0.45	0.5
0.49	0.5125
0.76	0.525
0.78	0.5125
0.8	0.5125

Toluene mass fraction	$n_{w\text{-derivative fit}}$
0.04	0.4125
0.2	0.525
0.29	0.45
0.31	0.5375
0.35	0.5375
0.55	0.5375
0.57	0.45
0.6	0.525
0.63	0.4875
0.65	0.525
0.69	0.5375
0.75	0.55

Table D. 2 Toluene + (0.01 mass fraction carbon nanotubes + polybutene)

Toluene mass fraction	$n_{w\text{-integral fit}}$
0.1	0.425
0.15	0.425
0.2	0.45
0.25	0.45
0.3	0.475
0.35	0.4
0.4	0.45
0.45	0.475
0.5	0.475
0.56	0.5
0.83	0.475
Toluene mass fraction	$n_{w\text{-derivative fit}}$
0.05	0.4
0.12	0.45
0.25	0.475
0.29	0.475
0.35	0.45
0.65	0.525
0.7	0.525
0.78	0.55

Table D. 3 Toluene + (0.05 mass fraction carbon nanotubes + polybutene)

Toluene mass fraction	$n_{w\text{-integral fit}}$
0.05	0.35
0.1	0.375
0.2	0.35
0.3	0.325
0.4	0.375
0.7	0.525
Toluene mass fraction	$n_{w\text{-derivative fit}}$
0.03	0.375
0.45	0.4
0.5	0.4
0.55	0.4

Table D. 4 Toluene + (0.01 volume fraction 65nm nanodiamond+ polybutene)

Toluene mass fraction	$n_{w\text{-integral fit}}$
0.1	0.4875
0.2	0.475
0.3	0.5
0.75	0.5
0.78	0.475
Toluene mass fraction	$n_{w\text{-derivative fit}}$
0.4	0.5
0.5	0.475
0.6	0.525
0.7	0.55
0.8	0.525

Table D. 5 Toluene + (0.00135 volume fraction 12nm nanodiamond+ polybutene)

Toluene mass fraction	$n_{w\text{-integral fit}}$
0.05	0.45
0.10	0.425
0.15	0.425
0.20	0.4375
0.25	0.45
0.30	0.475
0.35	0.45
0.40	0.425
0.45	0.525
0.52	0.5125

0.82	0.5
0.86	0.5125
Toluene mass fraction	$n_{w\text{-derivative fit}}$
0.59	0.5
0.62	0.55
0.91	0.5

Table D. 6 Toluene + (0.0027 volume fraction 12nm nanodiamond+ polybutene)

Toluene mass fraction	$n_{w\text{-integral fit}}$
0.05	0.35
0.1	0.35
0.15	0.3575
Toluene mass fraction	$n_{w\text{-derivative fit}}$
0.2	0.36

Table D. 7 Toluene + (0.0005 volume fraction nanosilica+ polybutene)

Toluene mass fraction	$n_{w\text{-integral fit}}$
0.10	0.45
0.15	0.45
0.20	0.45
0.25	0.45
0.30	0.475
0.37	0.425
0.40	0.375
0.45	0.45
0.52	0.5125
0.68	0.5
0.69	0.5
0.79	0.5
0.83	0.525
0.88	0.5125
0.92	0.5375
Toluene mass fraction	$n_{w\text{-derivative fit}}$
0.5	0.45
0.40	0.4
0.49	0.525
0.51	0.5
0.66	0.5375
0.74	0.5375
0.76	0.5375

0.79	0.55
0.92	0.525

Table D. 8 Toluene + (0.00135 volume fraction nanosilica+ polybutene)

Toluene mass fraction	$n_{w\text{-integral fit}}$
0.05	0.4
0.10	0.375
0.20	0.45
0.70	0.525
Toluene mass fraction	$n_{w\text{-derivative fit}}$
0.30	0.475
0.35	0.475
0.40	0.425
0.50	0.45
0.60	0.475

Table D. 9 Toluene + (0.0027 volume fraction nanosilica+ polybutene)

Toluene mass fraction	$n_{w\text{-integral fit}}$
0.10	0.375
0.20	0.375
0.30	0.3875
0.40	0.4
Toluene mass fraction	$n_{w\text{-derivative fit}}$
0.05	0.35
0.15	0.35

Table D. 10 Toluene + (0.01 volume fraction nanosilica+ polybutene)

Toluene mass fraction	$n_{w\text{-integral fit}}$
0.10	0.3375
0.15	0.325
0.20	0.325
0.25	0.3
0.30	0.275
Toluene mass fraction	$n_{w\text{-derivative fit}}$
0.05	0.325

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