Liquid to Liquid-Liquid Transitions: Impact on the Apparent Viscosity of Model Hydrocarbon + "Solvent" Mixtures

by

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Abstract

Injection of carbon dioxide or low molar mass hydrocarbons to improve the productivity of oil wells has become a common practice. Such injectants are not fully miscible in reservoir fluids and oils leading to liquid-liquid phase behaviour in reservoirs, in production systems and surface facilities at high pressures. Well-known and relevant binary mixture examples include: CO_2 + n-tridecane, propane + phenanthrene, methane + hexane. In this work, a setup was put together and validated to study such mixtures. Single-phase liquid mixtures mimicking this behaviour were fed to a rheometer. The temperature was then lowered (2.5°C/minute) to a final temperature at fixed pressure. The mixtures transitioned to liquid-liquid phase behaviour in the rheometer. Rheological responses were measured at constant shear rate. For these proof of concept measurements, the rheological responses of glycerol + 1-pentanol binary mixtures, which exhibit liquid-liquid phase behaviour below 63.6°C, was evaluated at atmospheric pressure. The mixtures were fed from a heated reservoir at 75°C to a rheometer (Anton-Paar 301). The matrix of experiments included shear rate, mixture composition, and final temperature realized in separate experiments (20°C, 40°C and 60°C). The miscible glycerol + water binary mixture provided a negative (single phase) control. Supporting data including phase densities and volumes of mixing are reported. Measurement reproducibility, the impacts of the proximity of the liquid-liquid critical point, and the relative volumes of the glycerol-rich and pentanol-rich phases on rheological responses are discussed. The key findings include the uncertainty in apparent viscosity at 0.5 phase volume fraction and saturated phase viscosities acting as limits for apparent viscosities. The implication of these findings include applicability of present equations used in

industry to calculate blend viscosity of oil + low molar mass hydrocarbon/non-hydrocarbon mixtures. More detailed study of the near critical region for two-phase mixtures is warranted.

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Chapter 1: General Introduction

As the population with access to higher standards of living grows, global energy demand increases. According to the International Energy Agency (IEA) world energy outlook 2015[1], world energy demand is expected to rise by nearly one-third between 2013 and 2040. There has been a similar trend in global energy demand since the industrial revolution. So far, energy supply has kept pace by exploiting available coal, oil and gas reserves and by tapping nuclear and renewable sources. Oil and hydrocarbons more broadly are expected to stay at the center stage of the world energy scene for the foreseeable future. With the dependence of energy supply on oil, it is imperative that maximum recoveries be achieved during production with increasingly difficult to produce "heavy" or "unconventional" oil reserves[2,3]. Advanced technologies must be applied to partially produced conventional oil reserves and unconventional reserves to obtain significant production. These Enhanced Oil Recovery (EOR) processes include Steam Assisted Gravity Drainage (SAGD), solvent addition, chemical flooding and CO_2-EOR (miscible and immiscible) to name a few typically involve fluid injection into reservoirs from light hydrocarbons to water and water + surfactants and salts, and gases such as CO_2. Some of these processes are more developed and commercially pursued such as SAGD and CO_2-EOR[4], while others remain at the laboratory or pilot scale e.g., VAPEX (Vapor Extraction), ES-SAGD (Expanding Solvent- SAGD)[5–8]. While many of these processes are proven from a technical perspective, they still remain subject to ongoing study and improvement, and can only be used when economically justified or driven by legislation. For example, there are dual incentives to inject CO_2 into reservoirs. CO_2 injection increases oil recovery and facilitates geological storage of CO_2.

All of these processes have basic and engineering knowledge gaps associated them. In this work the focus is on a fluid mechanics knowledge gap. Fluid injection frequently leads to the formation of additional liquid phases. This impacts the apparent viscosity of fluids moving through the reservoirs. Liquid-liquid emulsions can have apparent viscosities orders of magnitude greater than their constituents.[9] In production models for oils, single-phase equivalent or average properties are typically used because of the limits on computational intensity. The potential impact of this effect is ignored. Compromises related to the treatment of phase density and relative phase density of and among phases present are also ignored, even when these are the basis for the production method employed. For example, the density of liquid hydrocarbon mixtures arising in ES-SAGD or VAPEX operations can be greater than or less than that of water under the same temperature and pressure conditions[7].

1.1 Research Objectives

This work focuses on the principles related to the impacts of transitions from single to two liquid phase behaviour on the apparent viscosity of liquid mixtures. Rather than working with resource or resource fraction based fluids that exhibit liquid-liquid behaviour [10–15], in the absence of water, or with SAGD oil-water emulsions[16] directly, the focus is on the underlying rheological phenomena of such systems, a second liquid phase is introduced by pressure or temperature fluctuations. The specific objectives of this work include:

1. Development of an apparatus and a protocol that mimic possible rheological phenomena occurring in reservoirs.

a. Calibration of a heating system, motor and pressure gage and validation of the protocol using standard oils.

b. Establishment of a baseline for the behavior of a single-phase liquid in the apparatus.

2. Analysis of the impact of transitions from liquid to liquid-liquid phase behavior on the apparent viscosity of a well-defined model fluid where the volume fractions of the two phases is controlled, and the impacts of liquid-liquid critical phenomena (zero density difference and interfacial tension difference between the phases) can be explored systematically.

1.2 Thesis Structure

The balance of thesis is divided into four chapters. Chapter 2 covers the literature review starting with a brief discussion about bitumen and heavy oil resources and their recovery. Which in turn is followed by the reasons for present shift towards solvent addition and CO_2 flooding. A brief review about the working of some of the important processes, their status of development and some limitations is provided. Lastly, the research to date related to rheological measurements of oil + solvent mixtures is considered and some setups built by different research groups and their strengths and shortcomings are discussed in detail. Chapter 3 covers the experimental section. The experimental apparatus developed in this work and the benefits of this system over other systems is discussed. It is followed by a detailed protocol for achieving required phase states in the rheometer and the conditions required for the experiments. The apparatus calibration data are presented and described. The selection of glycerol and pentanol for proof of concept measurements is discussed and justified. In Chapter 4, the results of rheological and density measurements of systems of glycerol and pentanol and glycerol and water are placed in context. The conclusions and future work are presented in Chapter 5.

Chapter 2: Literature Review

2.1 Bitumen/Heavy Oil and SAGD

The characteristics of heavy oil and bitumen include very high viscosity, high specific gravity and high concentration of asphaltenes, dissolved gases, and hetero atoms sulfur and nitrogen and metals[2]. Their viscosity can exceed 10^5 mPa.s at ambient conditions. Apart from a very high viscosity the biggest challenge with dealing with such oils is their ill-defined nature – speciation presents numerous challenges[17]. Production processes for these resources are based primarily on viscosity reduction. This is achieved by combinations of heating and solvent addition. SAGD[18] (Steam Assisted Gravity Drainage) is the most commonly used production process for heavy oil/bitumen systems. It is a thermal process where steam is injected into an upper horizontal well to produce oil from a second lower horizontal well. The process is illustrated in Figure 2-1. Steam heats the reservoir, reduces the hydrocarbon viscosity and allowing the heavy oil/bitumen to drain. As the reservoir is produced steam creates a chamber. Hydrocarbons and liquid water gather at the producer and are pumped to the surface for further treatment and separation. This process is proven industrially but it is energy intensive and includes, significant net consumption of water, and the release of significant amounts of CO_2/barrel of hydrocarbons produced[19,20]. There are social license and legislative drivers to reduce CO_2 emissions[4,21]. New or modified production processes that include the use of solvents in addition to or instead of steam are becoming attractive[3].

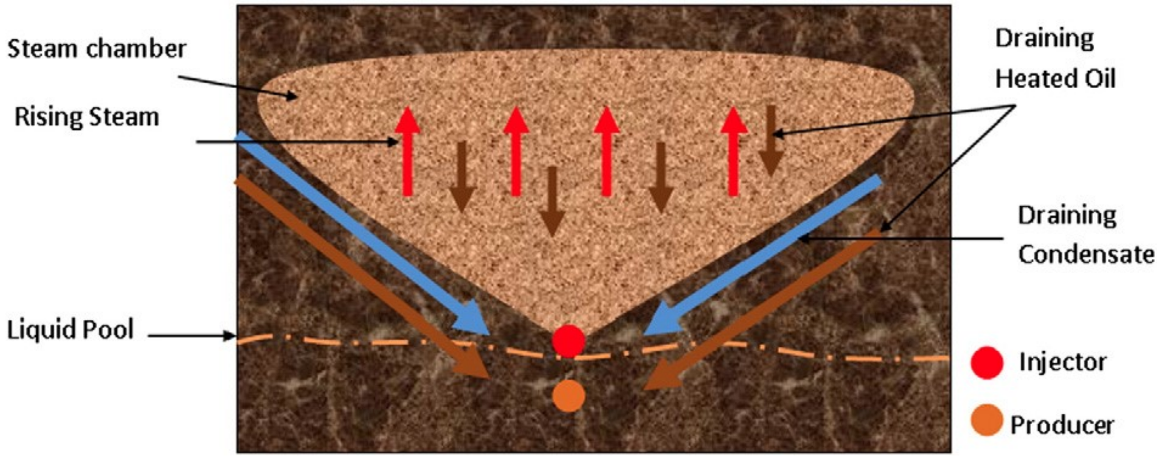


Figure 2-1. SAGD mechanism overview[20]

2.2 Alternate Processes

Adaptation of more conventional gas flooding techniques, development of heavy oil/bitumen specific solvent or gas addition technologies or addition of organic solvents to SAGD processes are technologies targeting water use and CO_2 emission reduction associated with SAGD processes. Introduction of hydrocarbon soluble diluents into reservoirs complicates the fluid mechanics within reservoirs, leading to phase order inversion[7] – that is to say the relative density of hydrocarbon-rich and water-rich phases can vary within a reservoir, or within production and surface separation equipment – and can introduce additional hydrocarbon rich phases into the reservoir – the subject of this thesis. These processes are briefly surveyed below.

CO_2 Flooding (Miscible and Immiscible) --- Enhanced oil recovery using carbon dioxide is considered promising as it is thought to be more cost effective and environment friendly than other enhanced oil recovery methods. It is expected to recover 6-18% original oil in place after secondary oil recovery by viscosity reduction, oil swelling and light hydrocarbon extraction[22,23]. CO_2-EOR or CO_2 flooding can be divided into two types: immiscible and miscible. These differences are based on the reservoir pressure. If the reservoir pressure is lower than the minimum miscibility pressure (MMP) then the major factors in improving oil recovery are viscosity reduction, oil swelling and solution gas drive while viscosity reduction due to gas miscibility plays major role in case of high pressure systems[22]. These processes can further be divided into different types based on the use of CO_2 in conjunction with other additives. For example immiscible CO_2 flooding can be done in many ways including continuous or slug CO_2 injection, CO_2 with water alternate or CO_2 with water simultaneous injection[24]. Many additive hydrocarbons have been considered to enhance swelling effect for the case of miscible flooding[25].

CO_2EOR processes have been under consideration for long time due to their applicability as tertiary recovery processes for conventional system. These processes are also considered promising for heavy oils sytems[4,8]. The rising interest in CO_2 flooding led to considerable research in phase behavior of CO_2 + oil systems and CO_2 + light hydrocarbon systems showing some interesting multiphase behaviour[10,12,26–28]. CO_2+ heavy oil and bitumen mixtures are expected to exhibit liquid-liquid phase behavior below the critical temperature of CO_2 (304.18K).

ES-SAGD --- Expanding Solvent SAGD is similar to SAGD in the way that it uses steam as the heating medium. The oil-soluble solvent reduces the oil viscosity. The hydrocarbon solvent is added with the steam as a vapor and condenses along with the steam[5]. This process is expected to achieve higher recovery rates and to lower the environmental footprint of a SAGD process. Solvents used in this process are costly and require high solvent recovery for the process to be economically viable[29]. As with CO_2EOR, liquid-liquid phase behavior is expected at temperatures below the critical temperature of the "expending solvent" where ever they occur as well as oil-water phase order inversion in the single hydrocarbon rich liquid region. There are also suggestions that there is a significant decrease in temperature near the chamber edge (adjacent to the undisturbed resource front) for ES-SAGD leading to multiple phase systems in this part of reservoirs as well[30,31].

VAPEX --- Vapor extraction method or VAPEX is an alternative to SAGD to achieve the same reduction in oil viscosity without using steam and instead stimulating the oil with diluents only[6,32]. The process is similar to SAGD but steam injection is replaced with vaporized solvent injection. This process uses less heat and relies more on vapor dissolution and diffusion in the oil and is also expected to be more efficient than SAGD. Light alkane solvents like propane and butane or their mixtures with CO_2 are most commonly considered solvents for this process[32–34]. Mixtures with carbon dioxide are considered for economic as well as environmental benefits as propane and butane are costly and also there are benefits to storing CO_2 in depleted reservoirs. Again as with CO_2EOR, liquid-liquid phase behavior is expected at temperatures below the critical temperature of the "solvent" [32,33,35–37] where ever this occurs as well as oil-water phase order inversion in the single hydrocarbon rich liquid region. Thus it is important for such a process to define the diffusivity of solvent in the oil, the phase behavior of system and the rheological behavior of resulting mixtures[32].

2.3 Knowledge Gap

While in principle it is possible to realize individual operating conditions in a laboratory where only a single hydrocarbon rich phase obtains, in reservoirs compositions, pressures and temperatures all vary spatially. The number of hydrocarbon rich liquid phases can vary spatially and comprises an uncontrolled variable both in the field and in field scale models where pseudo single-phase behavior is assumed. Processes and process models based on the concept that solvent addition reduces hydrocarbon viscosity with a minimum asymptotic to the viscosity of the solvent[38,39] may prove to be incorrect. This perspective must be tested and confirmed or refuted because of the importance of rheology to the technical and economic success of all of these alternate production processes for SAGD.

2.4 High Pressure Rheology Apparatus

Available apparatus for measuring viscosity and their capability to imitate expected reservoir conditions are reviewed critically in this section. Kariznovi et al. reviewed options for measuring phase behavior, viscosity and density simultaneously[14,40] and showed the limitations of all such apparatus developed prior to their design. The setup developed by Kariznovi et al. reference in their work covers all those limitations while allowing for separate sampling of vapor and liquid phases for phase composition measurement. Their setup, like others reviewed in the paper, can measure only the viscosity of saturated phases and focuses on phase behaviour measurements. The relevance of their study is that it covers all such equipment up to 2010 and shows their limitations. In the present review, the focus is on two recent apparatus not covered in Kariznovi et al.'s review, and that focus specifically on the viscosity of mixtures.

Bazyleva et al.[41] proposed a design shown schematically in Figure 2-2.

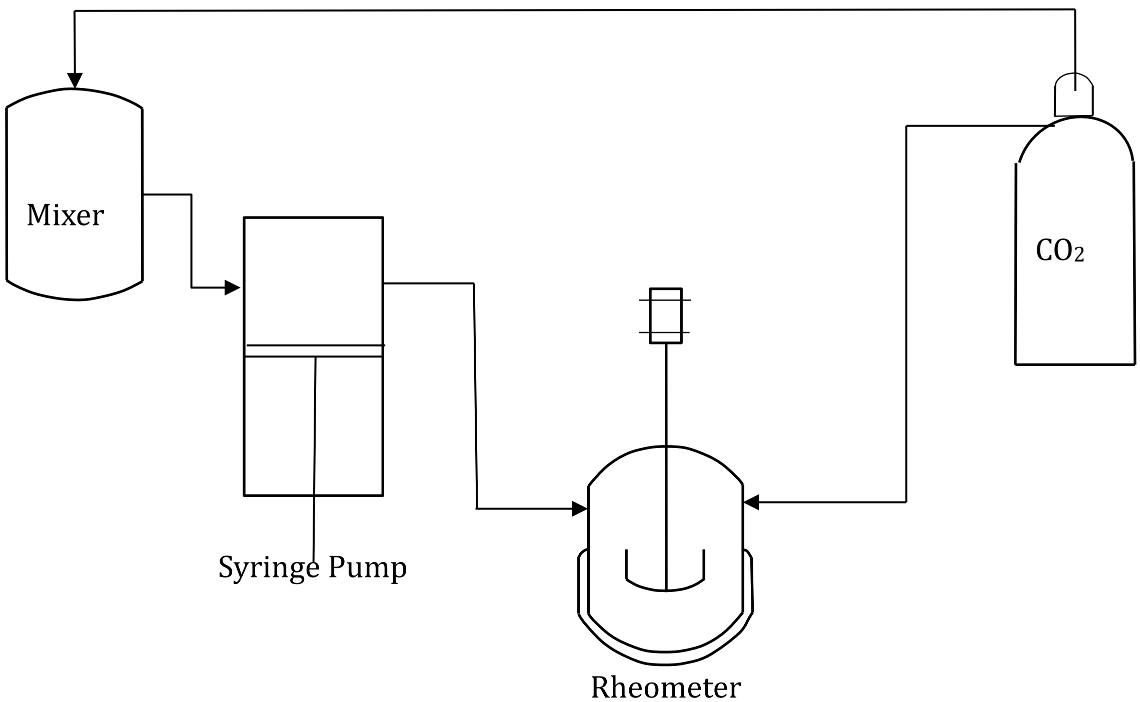


Figure 2-2. Bazyleva et al. schematic of circulation system to measure viscosity of methane saturated heavy oils[41]

The experimental setup presented in Figure 2-2 shows that this is a very simple measuring system comprising of four main components: a mixer system, a syringe pump, a gas cylinder for pressurizing and a Rheometer. The procedure, which includes saturating the heavy oil at a certain pressure in a gas environment while under constant agitation until pressure plateaus, is very straightforward.

<u>Strengths of this design</u>:

i. It includes precise control over pumped liquid volume to the rheometer. In a separate study, Behzadfar et al.[42] saturated oil with CO_2 inside their rheometer. This may pose problems if the volume of mixing is positive as is expected, for example, during enhanced recovery using carbon dioxide[25]. The researchers[42] did note peculiarities in their results, but the possible impact of such phenomena on outcomes remains a concern.

ii. The mixer can handle high pressures and complements the rheometer range of working pressures.

iii. The apparatus can handle suspensions, emulsions or oil mixtures equally and has a broad operating range for viscosity measurements.

<u>Limitations</u>:

i. There is no way to measure the composition of the gas inside the mixture. Compositions are obtained from other studies.

ii. Temperature of saturation is limited to near ambient conditions.

iii. Even if temperature of saturation is increased using a heating jacket, there is no control over the heat loss in tubing or the pump, which could lead to gas bubble formation.

iv. The maximum pressure achievable is limited to the pressure of the gas cylinder. Therefore, supercritical conditions for carbon dioxide containing mixtures cannot be achieved in the mixer or in the rheometer.

v. Pressure set point variation in the rheometer is controlled manually and is not precise. Measurements are best made at fixed pressure.

A recent report by Hu et al.[43] underscores the importance of viscosity measurement and the heightened interest in correlating phase behaviour data with rheological measurements. Their apparatus is sketched in Figure 2-3.

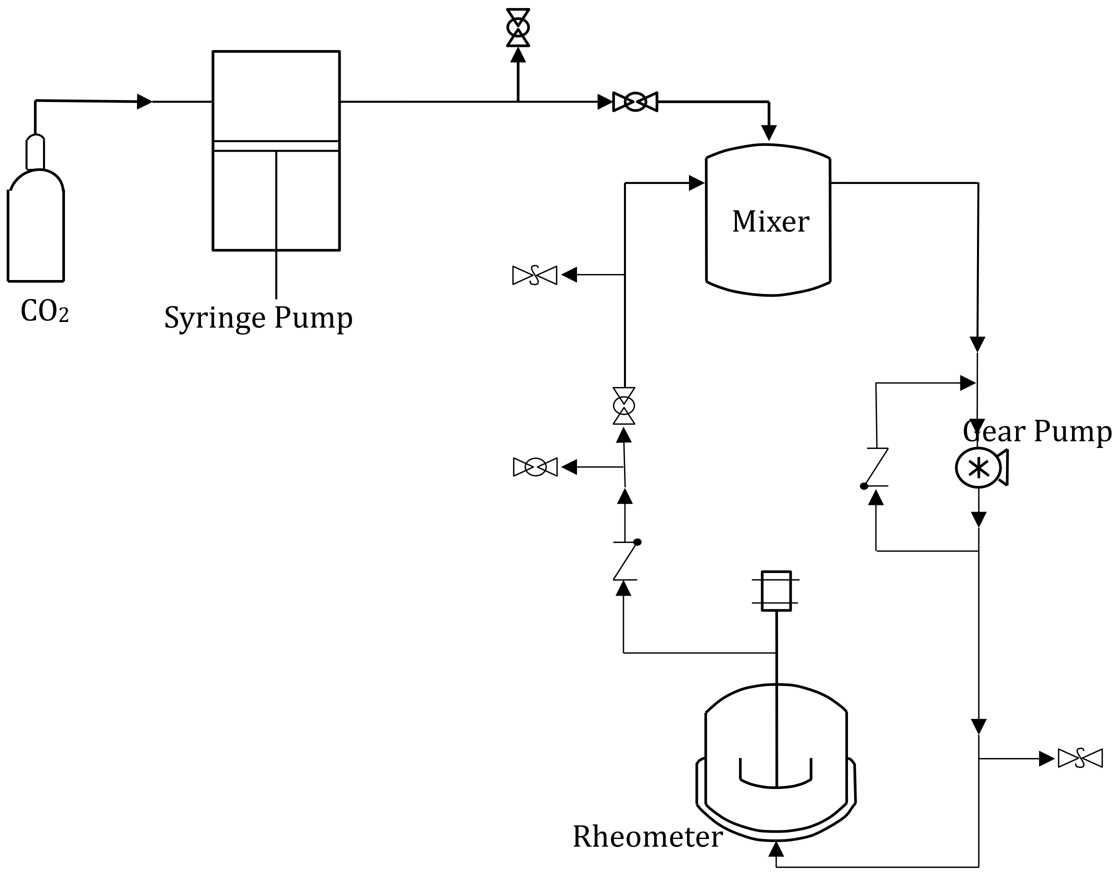


Figure 2-3. Hu et al. schematic of circulation system to measure viscosity of CO_2 saturated crude oils[43]

Their design includes the strengths of the Bazyleva et al. apparatus and it incorporates a gear pump and recycle loop from previous studies[44–46].

Strengths:

In addition to those noted for the_Bazyleva et al. experimental setup include:

i. The samples flow through the rheometer taking simultaneous measurements. Rheometer filling accuracy and separate pressure controls are eliminated.

ii. The use of syringe pump downstream of the gas cylinder and before the mixer permits supercritical states to be explored, and permits measurement of dissolved gas content.

iii. Sample recirculation permits excellent sample composition and temperature control.

Limitations:

i. The benefit of not having a separate pressurizing system for the rheometer is also a limitation in the sense that pressure cannot be varied – a backward step relative to the Bazyleva et al. apparatus.

ii. Also, the measurements have to be taken at the mixing temperatures because of the system floating with the mixer. Increasing the temperature will lead to increasing pressure of the whole system as the measurements are taken with constant rotation and results will vary.

iii. The gear pump is an unnecessarily complicated method for achieving steady state without heat loss. This can be ensured in other simpler ways. Heating tape and insulation are a cheaper option and achieve the same result.

iv. The gear pump presents a second limitation. The gear pump is primed using oil. The oil may coat the walls of the rheometer thus skewing the rheology data.

These apparatus do not reach beyond a gas-saturated liquid phase for a gas in oil mixture and have temperature and pressure limitations. These are significant limitations that need to be overcome in order to investigate the rheological response of multiphase mixtures relevant to hydrocarbon resource production. Two types of studies are of particular interest: transitions from one to two liquid phases by varying temperature at fixed composition and pressure; transitions from one to two liquid phases by varying pressure at fixed temperature and composition[36,47].

2.5 Phase Transition Viscosity

The viscosity of a mixture undergoing phase change from a single liquid phase (L) to two liquid phases liquid-liquid (LL), or from liquid-vapor (LV) to liquid-liquid-vapor (LLV) phase behaviour are of interest. The rheological behavior of a mixture undergoing such changes has not been studied for hydrocarbons but a few cases are available for metal alloys showing miscibility gaps[48,49]. High viscosities are anticipated if emulsions form. Further, at liquid-liquid critical points, the interfacial tension approaches zero facilitating emulsion formation and promoting emulsion stability[50]. The impacts of transition are the focus of the present work.

2.6 Summary

In this chapter, the motivation for the oil production sector to introduce solvent aided processes as a means to increase recovery and at the same time improve the efficiency of thermal processes is discussed and an overview of such processes and their development status was provided. Kinematic viscosity (intrinsic viscosity divided by fluid density) is a critical property in such processes. A critical review of apparatus for viscosity measurement outlines their strengths and limitations. The motivation to measure apparent viscosities under phase transition conditions actuated by temperature or pressure variations was presented.

Chapter 3: Experimental Section

3.1 Apparatus Design

A system was designed and built to create and study the rheology of mixtures undergoing phase transitions – from one liquid phase to two liquid phases. Bazyleva et al.[41] discussed the underlying principles in detail and due to the similarity between the rheometer used in their work and the Anton Paar Physica MCR 301 rheometer in the Petroleum Thermodynamics Laboratory, aspects of their experimental set up, and their liquid saturation approach in particular, were adopted for this study. Several modifications were introduced to increase the operating range of the apparatus over all, and to address challenges faced by researchers elsewhere[43] working on related topics.

A schematic of the setup is shown in Figure 3-1. The setup comprises four major pieces of equipment: a rheometer, a syringe pump (syringe pump 2 is a suggested upgrade), a mixer and a gas cylinder. The samples including glycerol + pentanol or glycerol + water mixtures are loaded into a temperature controlled mixer and heated. Mixtures are then transferred to the pump by pressurizing the mixer with inert gas through tubing, which is heated with a temperature-controlled jacket. Afterward, the mixture is pumped to the rheometer for rheological measurements. Details related to individual components are presented below.

- **Rheometer**: An Anton Paar Physica MCR 301 rheometer, with a reported uncertainty of 10%[51], is used to measure the viscosity of samples as they transition from one to two liquid phases inside the rheometer. Inlet conditions are controlled to ensure feeds are in single phase. The temperature inside the rheometer is regulated using a Peltier or electric heating system. The temperature can be varied from 30°C to 300°C. Pressure can be varied from 1 bar to 150 bar. The main limitations of the rheometer include the large fixed volume of sample (16 mL) and the fixed concentric cylinder geometry. Other geometries, such as the double gap geometry that require much less volume of sample cannot be used because the feed line to the rheometer is at the bottom of the cell. The feed line is blocked if the other configurations are used.

- **Syringe pump**: A Teledyne Isco 500D syringe pump was used to achieve required pressures and to meter required volumes for rheometer feeds. The maximum operating pressure for the pump is 258 bar and flow range from 0.001 to 204 mL/min. This syringe pump includes a temperature-control jacket that can be used to heat or cool the pump cylinder for liquefying gases or thermal stabilization using water circulator as shown in Fig 3.1. The pump is suitable for very low flow rates and can be operated at constant flow or constant pressure modes. Constant flow mode is used when liquid is pumped from the mixer to the rheometer. This mode provides precise control over the flow rate and ensures exact volumes of liquid are transferred to the rheometer. Constant pressure mode ensures that liquids remain saturated during transfer. In constant pressure mode, the decrease or increase in volume of gas inside the pump is recorded. This helps determine the volume of gas dissolved, and is important for conditions where the "gas" phase is supercritical, i.e., where the phase density and liquid solubility are both very pressure sensitive.

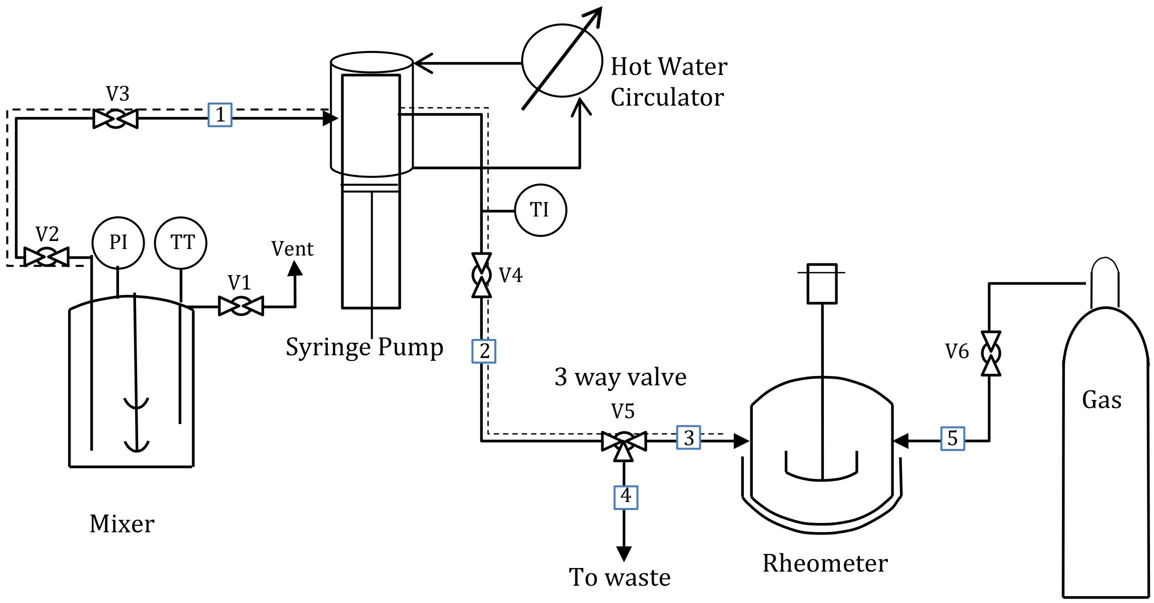


Figure 3-1. Experimental setup. (- - -) Dashed lines indicate insulated and heated tubes.

- **Mixer**: The 500 mL Parr 4563 mixer can be operated at up to ~200 bar and 350°C. Two four-blade impellers and a 1/8 horsepower variable speed motor provided efficient mixing. Other components of the mixer include a 0-200 bar gauge, a 206 bar rupture disk, a networked thermocouple Type J (Iron - Constantan), a gas release valve, and cooling loops for the sample in the mixer.

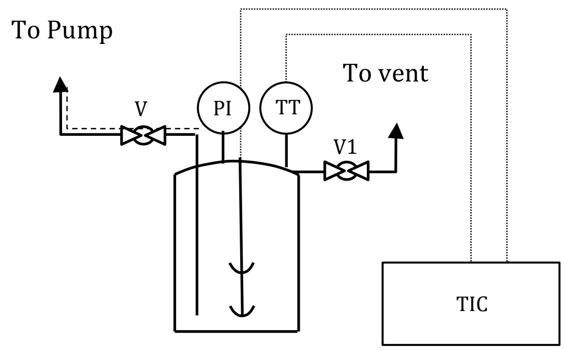


Figure 3-2. Control system for Mixer Reactor.

- **Gas cylinder**: Nitrogen gas, in a 172 bar (when full) is used to pressurize the mixer and to transfer mixtures to the syringe pump.

- **Other components**: The lines connecting apparatus components are insulated with heating tape. Thermocouples are installed on both sides of the pump for temperature measurement. A three-way valve (V5- ball valve) is installed at the rheometer inlet to facilitate the control and measurement of flow rates. Other key valves are a mixer outlet valve near the mixer head (V2- needle valve), a pump inlet valve (V3- needle valve) and a pump outlet valve (V4- needle valve). These valves help control the flow at different stages. The mixer outlet valve (V2) and the pump inlet valve (V3) are both between the pump and mixer. After reaching the pressure inside the mixer, the mixer outlet valve (V2) is kept closed and pressure inside the pump is varied using pump inlet (V3) and outlet valves (V4), removing the excess pressure through the three-way valve (V5) open to ambient. While loading the sample in the mixer, the pump outlet valve (V4) is kept closed and both pump inlet (V3) and mixer outlet valves (V2) are opened allowing pressure to fill the tubes up to the pump outlet valve before using pump suction.

3.1.1 Advantages of this setup

1. The temperature-controlled jacket on the pump permits gases like propane to be liquefied easily and mixtures with high gas mass fractions can be prepared. Such mixtures are of interest in numerous applications including bitumen, shale oil, and natural gas production.
2. The syringe pump provides precise flow control from 0.001 mL/min to 204 mL/min. This is the same configuration used by Bazyleva et al.[41] with the added feature of heated tubing. Rheometer operation requires a fixed volume of sample to be injected. This can only be achieved with precise flow control (flow rate uncertainty of 0.5% of set point).
3. Independent temperature control for all system components permits flexible operation and ensures that fluids reach the rheometer as a single phase. Once in the rheometer, the temperature and pressure of fluids can be varied to obtain a range of phase states and phase distributions, overcoming a challenge encountered in prior designs.

3.2 Operating Protocols

The experimental setup and hence the operating protocol build on the work of Bazyleva et al.[41]_This protocol can also be applied to emulsions or suspensions made in the mixer or for example as in this work with glycerol + pentanol and glycerol + water mixtures, which exhibit a liquid to liquid-liquid transition at ambient pressure.

1. The whole setup is cleaned internally using water followed by acetone and finally a nitrogen purge. The waste line (4) is used to suction water and acetone at ambient pressure. First, the rheometer (2) and mixer side (1) tubes are disconnected (Figure 3-3) and water is suctioned from waste tubing (4) and then pumped out from both sides (line 1 & 3). The rest of the setup (mixer and rheometer) is cleaned separately. After three or four washes with water, acetone is passed through three or four times. Afterward, the lines are heated to 90°C under vacuum to evaporate remaining water/acetone.

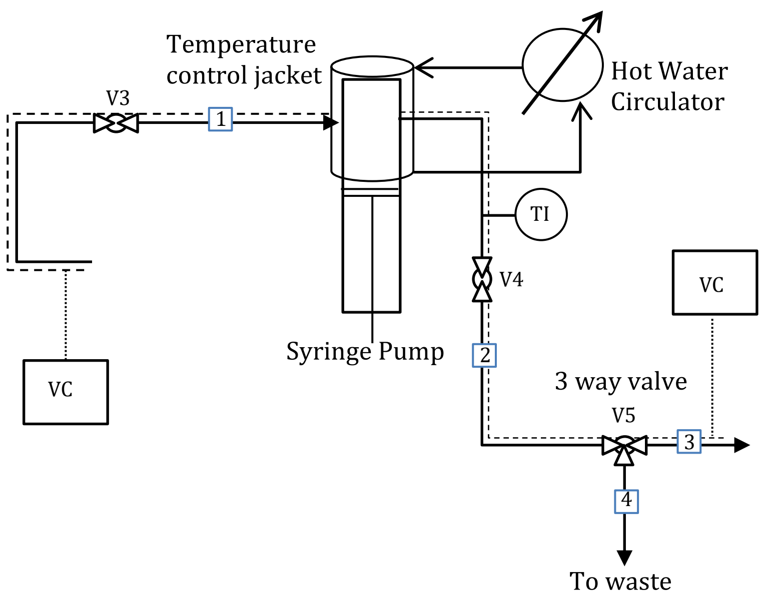


Figure 3-3. Isolated pump for cooling and Control loop for pump and heat tracing

2. Once the cleaning is done, line 3 is connected back to the cleaned rheometer pressure cell and, which is sealed and purged using nitrogen to remove any

remaining liquid inside the pump and lines. The pump has a dead volume of ~2.4 mL. Once there is no vapor coming out of the mixer side, the cleaning procedure is completed. This normally takes three or four nitrogen purges alternated with creating a vacuum inside the pump. Once the mixer is clean, the inlet and outlet valves are closed.

3. The required amount of sample to be loaded in the mixer is prepared gravimetrically, using a Mettler Toledo (MS603S) balance with repeatability of 0.001g and capacity 600g.
4. Once the sample has been uploaded in the mixer and it is closed, the unit is pressurized to 25 bar using an inert low solubility gas, nitrogen, which will enhance the flow of high-viscosity mixtures through the lines to the rheometer.
5. The temperature controllers for the pump jacket and voltage controller for heat tracing on lines 1 & 2 (Figure 3-3.), as well as the inlet temperature for the rheometer, are set to desired temperature settings (e.g., 75°C for glycerol mixtures).
6. Line 1 is connected to the top of the mixer. It must be ensured that cooling water is circulating through the mixer's motor to avoid overheating while agitation is in process.
7. Once it is ensured that all connections are in place, the mixer heater is started with simultaneous slow rotation (45°C set point for the heater and 200 rpm for the motor). When the temperature of the mixer reaches the set temperature, the set point is increased slowly to 75°C using 5°C increments (higher set point leads to offshoot in the mixer's temperature, while slower increments allow better temperature control and precise temperatures (±1°C) can be achieved).

8. Leak tests are performed while the mixer reaches temperature equilibrium. This is done by closing the three-way valve (V5) and pressurizing the rheometer and checking for leaks. Rheometer has pressure indicator (±0.001 bar) calibrated by professional from Anton Paar, which is used for leak testing. Opening the three-way valve (V5) but keeping the valve between the pump and the rheometer closed allows for leak tests in connections for lines 2 & 3 and three way valve (V5). Finally, by opening V3 between the mixer and the pump leak tests to the connecting point of the mixer can be done as V2 is inbuilt in the mixer body and does not require a leak test. Pump pressure display has accuracy of ±0.1 bar but as the complete system up to V2 is floating with rheometer, the rheometer pressure indicator with better accuracy is used.
9. Once temperature equilibrium in the mixer is achieved, the speed of rotation is increased to 500 rpm for 10 minutes to ensure complete mixing. The mixture is then allowed to stand for 5 minutes to ensure that entrained bubbles disengage. These times were validated visually using a transparent vial for the mixture, where a vial with a mixture was heated until a single phase was attained. After stable single phase, the vial was again agitated using a vortex mixer to create bubbles and then the maximum time taken by the bubbles to disengage was noted.
10. The mixer is then pressurized using nitrogen at 20 bar with the motor switched off to minimize transfer to the liquid. The solubility of nitrogen is low in relevant fluids including water and pentanol, and in glycerol[52,53] in particular. The mixer inlet valve is closed after pressurization and the downstream components of the apparatus are depressurized.

Although nitrogen solubility is low in components considered in this work, care was taken to ensure no entrained/dissolved nitrogen (if any) resulted in erroneous measurements. Steps 1 to 5 of measurement matrix were followed for all experiments to allow for disengaging of any entrained nitrogen bubbles. Pure glycerol tests (Figure 3-4) were conducted as a part of measurement approach validation. Viscosity measurements of glycerol using the complete setup and the rheometer only are discussed in section (section 3.3).

11. The mixer, now under nitrogen pressure, is subjected to slow rotation (≤ 50 rpm) for 5 minutes to remove any bubbles created by pressurizing with nitrogen. The system is then allowed to rest for 2 minutes before starting pumping.
12. At the same time the rheometer is checked for temperature stability (for glycol mixtures used in this work, the set point is 75°C, 5°C higher than the maximum liquid-liquid to liquid phase boundary). The rheometer is calibrated by performing inertia check for the motor and setting the normal force to -0.09N after lowering the motor. The normal force must be within the range of -0.1 to 0.1N. Setting the normal force at -0.09N at 75°C ensures that the normal force does not go outside the recommended range on cooling.
13. Valves between the mixer and the pump outlet (V2 and V3) are opened slowly to allow fluid to fill the lines up to the pump outlet. 40 mL of liquid is then suctioned from the mixer at 10 mL/min. Bubble formation in the suction tube must be avoided.
14. Once the pump is filled, the pump inlet and mixer outlet valves are closed and the heating in the mixer is switched off. The pump outlet valve is then opened with the

three-way valve turned to the waste side. This releases nitrogen (if present). The pump is then started at 20 mL/min until single-phase liquid starts to come out of the unheated waste line.

15. The pump is stopped and the three-way valve is turned to the rheometer side. The pump is set to dispense mode and a given amount of liquid (18 mL in this case) is fed to the rheometer. The volume is set to 18 mL to account for the internal volume of the tubing (0.65 mL connecter tubing + 1.3 mL rheometer inside tubing) and the required fluid volume (16 mL) for rheometric measurement.
16. Once the sample is ready, the matrix of rheological measurements shown in Table 3-1 is executed. The average cooling rate used is 2.5°C/min, and the measurements are taken concurrently with the cooling. For the constant temperatures readings the wait time at each temperature prior to measurement is 20 minutes. Step number 6 in Table 3-1 (highlighted in grey) is where the phase transition is achieved inside the rheometer for the glycerol and pentanol mixture.

Table 3-1. Settings for Rheometer to record phase transition viscosity

Step	Temperature (°C)	Shear rate	Number of points	Point duration(s)	Step Type
1	75	250	30	10	Isothermal
2	70	0	30	10	Non-Isothermal
3	70	200	30	10	Isothermal
4	70	0	180	10	Isothermal
5	70	250	30	10	Isothermal
6	20	250	300	10	Non-Isothermal
7	20	0	180	10	Isothermal
8	20	250	60	10	Isothermal
9	20	0	180	10	Isothermal
10	20	250	60	10	Isothermal
11	20	50-250	90	10	Isothermal

3.3 Calibration

Calibration protocols for the rheometer are described elsewhere[41]. They include air bearing check, motor adjustment and inertia check, as well as measuring viscosities of known standards. These protocols were followed in this work. Other system components were calibrated as outlined below.

- Heating Tape Calibration. Silicone rubber heating tapes were wrapped around tubing with small gaps between each turn. These heating tapes can reach temperatures up to 232°C. Each tape has a separate temperature controller. Table 3-2 shows the controller set points (Voltage Controller) and temperatures obtained by the mixer (Line 1) and rheometer side (Line 2) heating tapes. It took ~15 minutes to reach steady state temperatures in the tubing. The calibrations differ because of the position of controllers and parallax error in setting the higher percentage set points that are on the back of the controller leading to minor fluctuation in the set points ±2 °C.

Table 3-2. Controller set points and temperatures for the heating tape on the lines connecting mixer – pump – rheometer.

Controller Set Point, %	Mixer-Pump Side Tape (Line 1)	Pump-Rheometer Side Tape (Line 2)
	Temp (°C)	Temp (°C)
10	25.7	28.6
15	30.7	33.5
20	37.8	40.0
25	46.0	47.6
30	57.7	57.7
35	66.8	67.5
40	78.6	78.0
45	93.5	93.2
50	106.2	107.3

Table 3-3. Motor speed calibration using speed gun (all speeds in rpm)

Speed on Controller Panel	Gun Speed	Speed on Panel	Gun Speed
12	16.4	343	351.5
33	38.1	366	375.2
54	59.2	391	399.3
80	84.8	418	427.1
97	102.2	454	464.5
130	135	492	502.5
159	164.9	531	543.6
196	202.3	563	575.5
235	242.2	605	618.8
272	279.1	624	637.3
310	317.1	656	671.2

- Motor Rotation calibration. The mixer's motor was calibrated using a speed gun as shown in Table 3-3. The controller values are systematically smaller than, but linearly related to those obtained using the speed gun. The speed gun model number 05-028-23 4059 Touchless Tachometer has a resolution of 0.1 rpm and accuracy of ±0.05% of the reading + 0.1 rpm.
- Pressure gage calibration. Pressure gage calibration was done by floating the rheometer and pump with the mixer. The mixer pressure gage is usually not required as the system is floating with the pump but this is useful in cases when the system is kept for equilibration, or in the case of liquefied gases, when the system is not floating with any other systems. The calibration for the mixer also helped in the calibration for the pump. The rheometer calibration was already done by Anton Paar and used as a reference. The pump pressure transducer gave same values as the

rheometer with a variation of ±0.1 bar, which was expected as the rheometer gives pressure values in three decimal places (±0.001 bar) while the pump can give in one decimal place (±0.1 bar). One challenge found was the lack of accuracy in the pressure in the mixer, as this unit does not have a digital pressure display but only a gage (readability 2 bar and range 200 bar). On repeated tests the mixer gage was found to display 2 bar lower pressure than the rheometer pressure with readings taken parallel to the screen of display. This variation remained constant for all the pressures showing an offset value.

3.4 Apparatus and Operating Protocol Validation

Viscosity measurement reproducibility was validated using glycerol and a viscosity standard, Cannon S600 (obtained from CANNON Instrument Company) . For glycerol, two viscosity tests were carried out in the rheometer at 20 °C. In one, 16 mL of glycerol was loaded into the rheometer using a syringe. In the second test, 16 mL of glycerol were loaded into the rheometer using the pump. The sample loaded with the syringe had an average viscosity of 1425 mPa.s while the one loaded using the pump had an average viscosity of 1418 mPa.s. The viscosity values obtained in both tests agree with one another to 3 significant figures and with the published value (1372 +/- 20 mPa.s[54]) to two significant figures at 50 Hz.

Figure 3-3 shows the reproducibility of the protocol outlined in Table 3-1 using glycerol. The viscosity trajectories for both tests show the reproducibility of the protocol. Based on equilibrium viscosity data, samples are warmer than indicated initially by the temperature controller and then become sub-cooled, slightly, as the final temperature is approached.

Table 3-4 shows equilibrium viscosity data from the literature[54] and the time at which the system attains these values showing actual temperature of the system at specific times.

Figure 3-4 (a) and (b) show the repeatability data for the standard Cannon S600 at 20°C and shear rate of 250 Hz and 50 Hz respectively. The certified analysis supplied by Cannon for this standard reports a viscosity value of 1464 mPa.s at 20 ºC. The average viscosity values for Runs 1 and 2 and their deviation from the reported values for this Cannon standard are reported in Table 3-5.

The validation data show that the rheometer provides repeatable and reproducible data. The data are systematically high by ~ 2 %. This offset is within the reported measurement uncertainty (10%) of the rheometer and does not impact interpretation of difference measurements.

Table 3-4. Equilibrium viscosity data for glycerol and the time at which these values are reached following cooling protocol Table 3-1, step 6

Time (min)	Temperature (°C)	Literature Viscosity (mPa.s)
0	70	49.5
2.8	60	79.4
5.3	50	139
9.2	40	276
14	30	595
28.8	20	1372

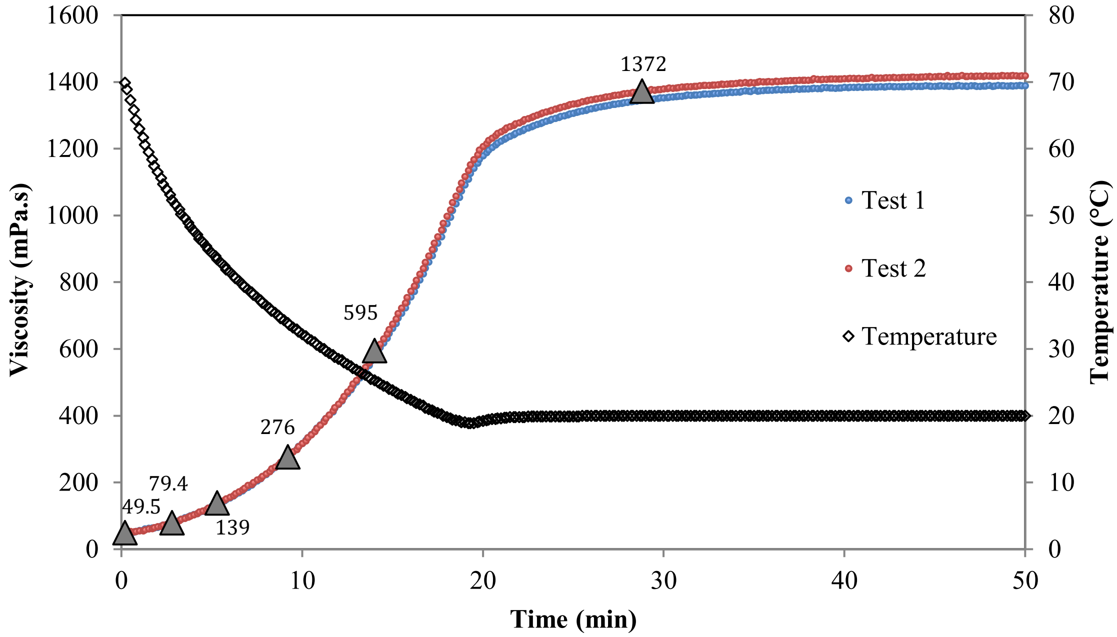
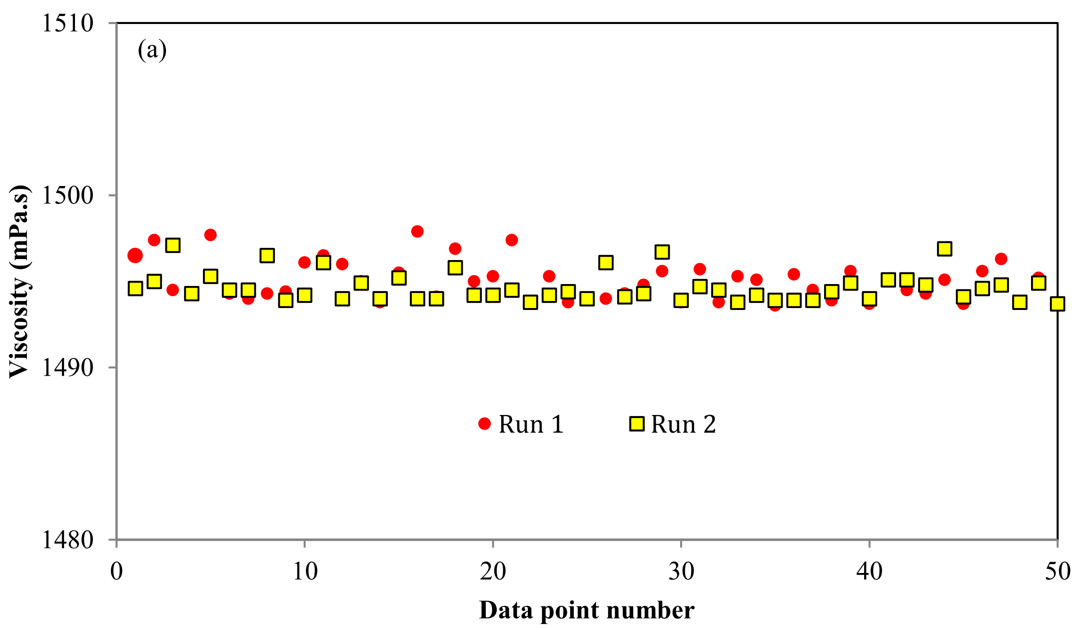


Figure 3-4. Reproducibility of cooling protocol, Table 3-1, with glycerol. Equilibrium viscosity data for glycerol[54] are provided for reference. Viscosity values are parameters.



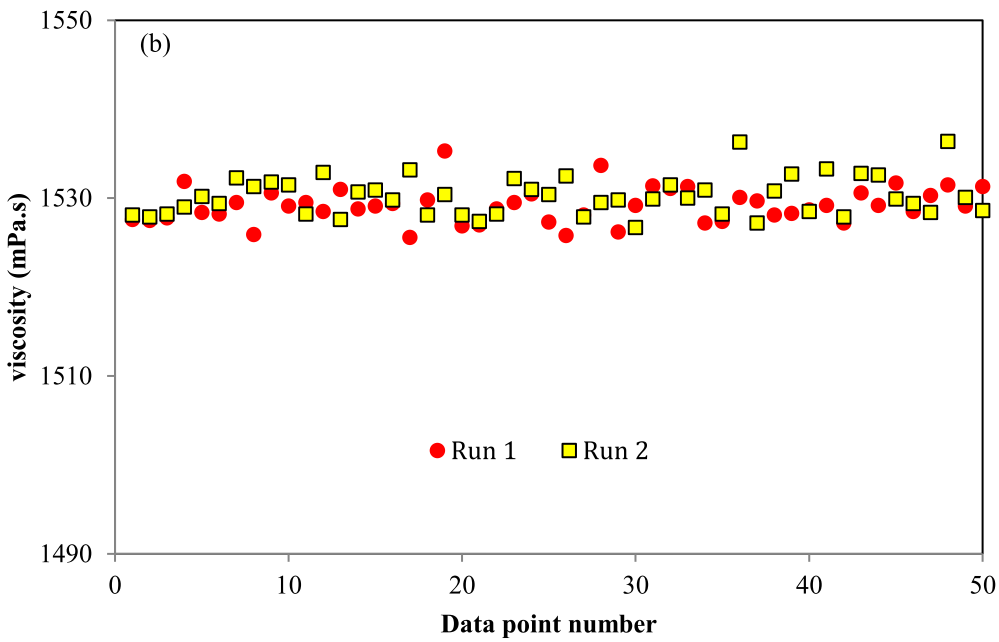
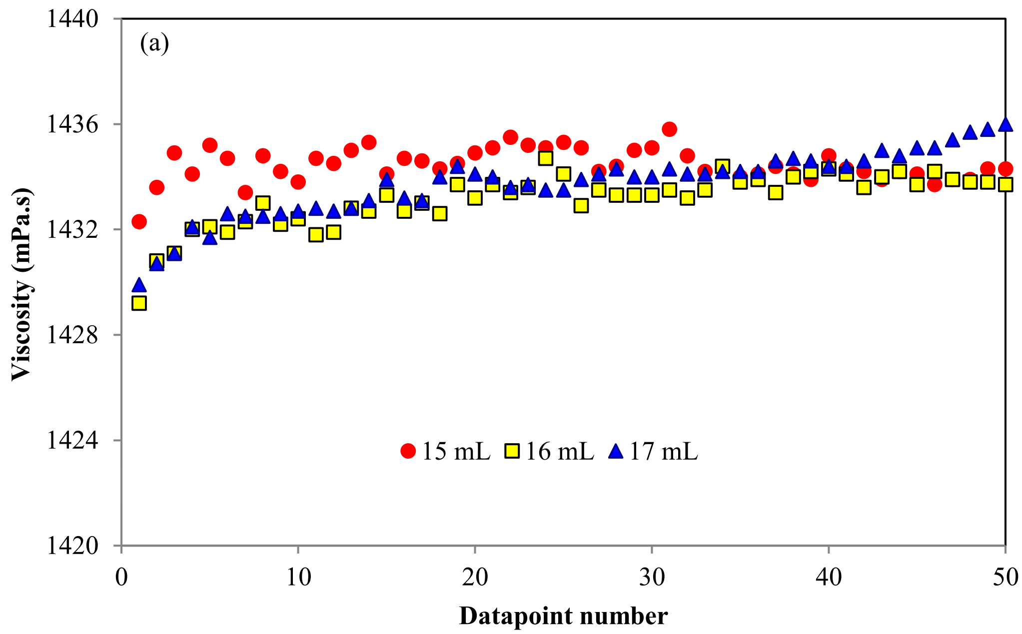


Figure 3-5. Viscosity values for the standard Cannon S600 (50 data points obtained at 1 point /10 s) at 20 ºC: (a) shear rate 250 Hz. (b) shear rate 50 Hz.

Table 3-5. Average values for S600 repeatability runs and deviation from standard data

Shear rate (/s)		Average (mPa.s)	Deviation (%)
250	Run1	1494	2.1
	Run 2	1494	2.1
50	Run1	1529	4.4
	Run 2	1530	4.5

The setup is designed to add controlled volume of sample in the rheometer. The volume of the line after three-way valve and the tube inside the rheometer is calculated and the total volume gives a value of 1.84 mL but an additional 0.2 mL is added to ensure an adequate amount of sample is transferred to the rheometer. The impact of variable volume fed to the rheometer, ± 1 mL, on viscosity measurements was assessed and the outcomes are reported here for glycerol (Figure 3-5, Table 3-6) and Canon standard 6000 (Figure 3-6, Table 3-7). In all cases the viscosity value variations are less than the repeatability uncertainty of the measurements and the impact of feed volume variation expected to be less than ± 0.1 mL can be neglected.



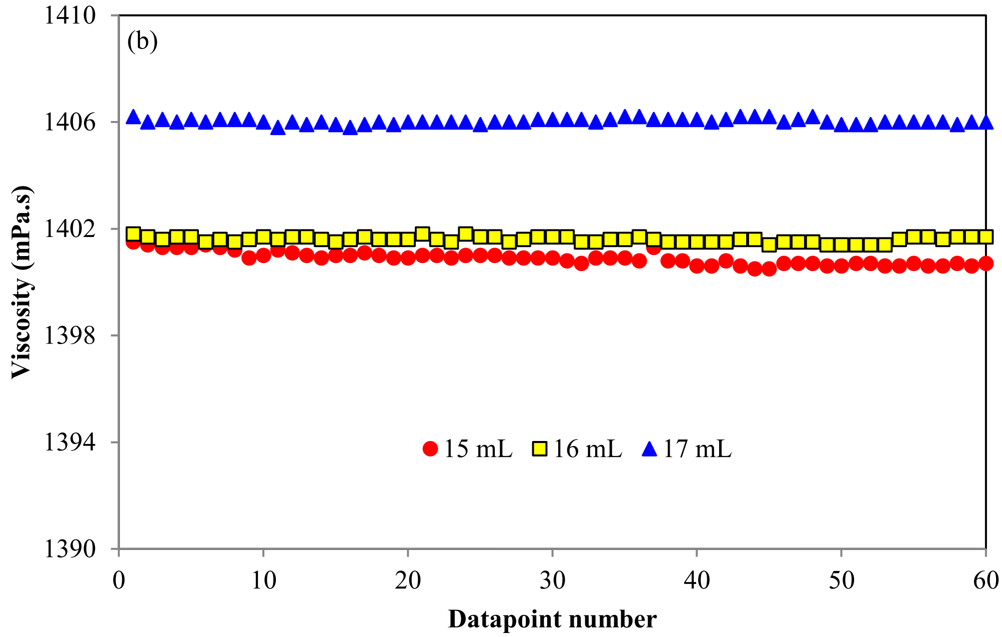


Figure 3-6. Viscosity data for 15 mL, 16 mL and 17 mL glycerol (50 data points obtained at 1 point/ 10 s) at 20 °C: (a) shear rate 50 Hz. (b) shear rate 250 Hz

Table 3-6. Glycerol viscosities for different loading volumes and their respective deviation from literature

Shear rate (s^{-1})	Volume (mL)	Average (mPa.s)	Deviation (%)
250	15	1403	2.3
	16	1403	2.3
	17	1407	2.6
50	15	1434	4.5
	16	1433	4.5
	17	1434	4.5

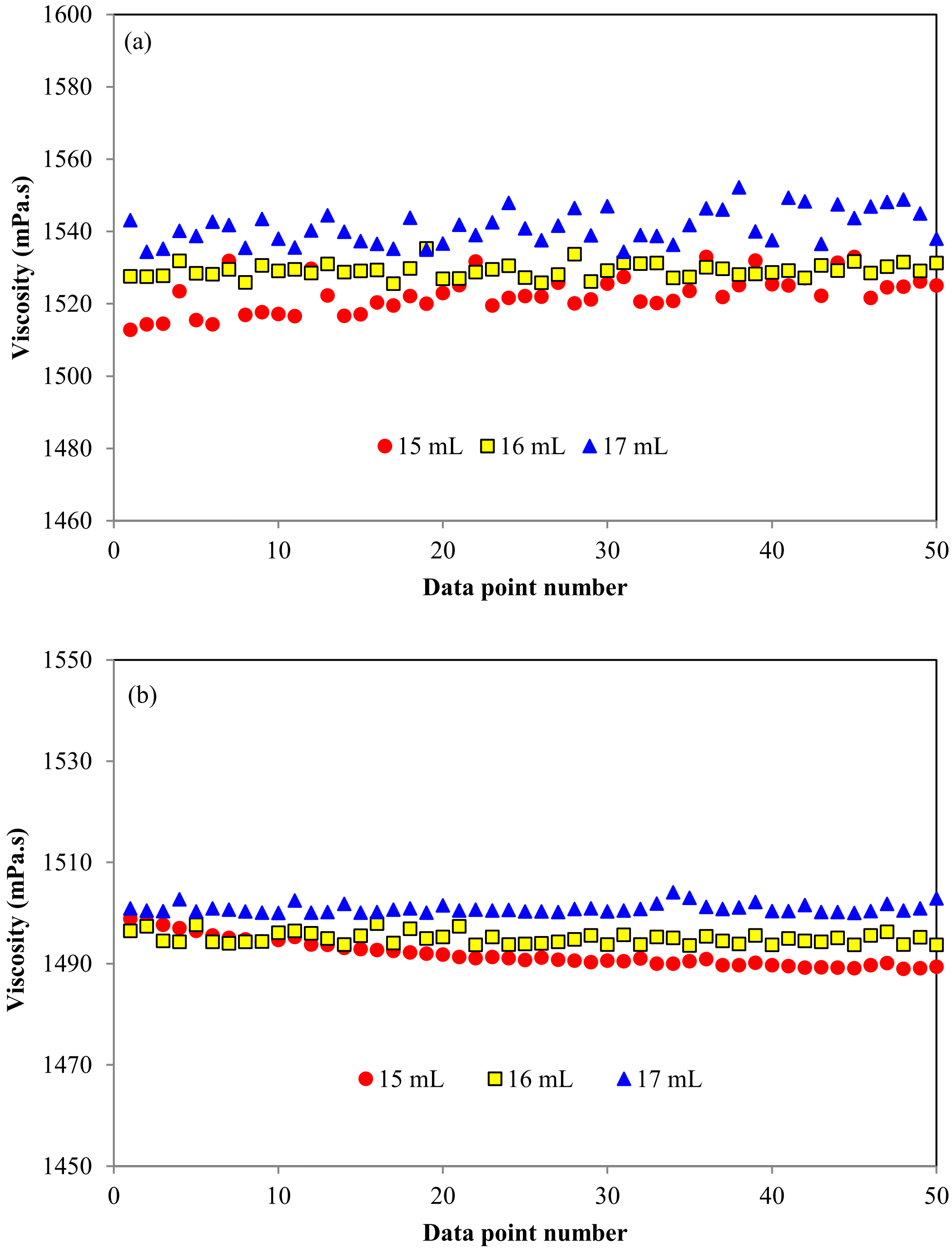


Figure 3-7. Viscosity data for 15 mL, 16 mL and 17 mL for Cannon S600 (50 data points obtained at 1 point/10 s) at 20 °C: a) shear rate 50 Hz. b) shear rate 250 Hz.

Table 3-7. Cannon S600 viscosity measurements for different loading volumes and their deviation from the certification analysis

Shear rate (s^{-1})	Volume (mL)	Average (mPa.s)	Deviation (%)
250	15	1491	1.9
	16	1494	2.1
	17	1500	2.5
50	15	1523	4.0
	16	1529	4.4
	17	1541	5.2

3.5 Materials

Glycerol with purity > 99.8% was ordered from Fischer Scientific and 1-Pentanol with purity > 99% was received from Sigma Aldrich. Glycerol and Pentanol are chosen as reagents for positive proof of concept measurements as the binary mixture displays phase transition[55]. Figure 3-7 shows the two-phase envelope for the binary system glycerol + pentanol. The liquid-liquid critical point is 337.6 K, 0.70 glycerol mole fraction. Canon standard S600 was used to validate rheometer for repeatability and reproducibility. DIUF (Deionized Ultra filtered) water was used to take density measurements for reproducibility validation of density meter and also as component for negative control mixture of glycerol and water.

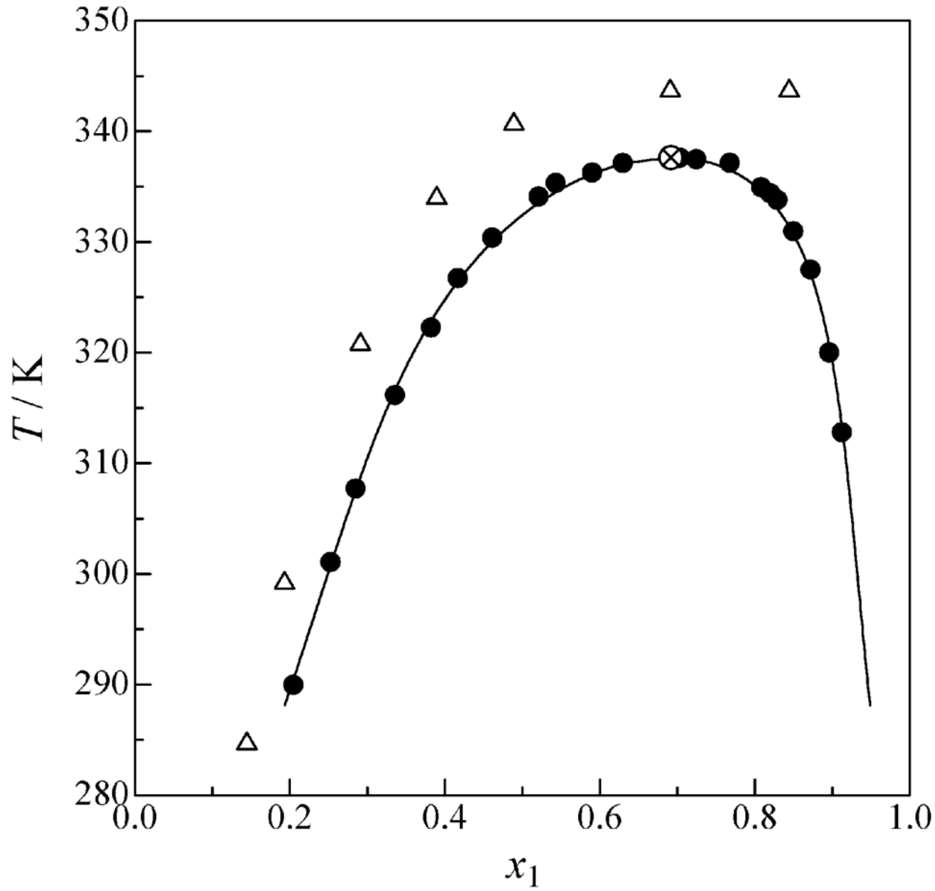


Figure 3-8. Two phase envelope for Glycerol + Pentanol mixtures, ●(Matsuda et al.)[55], Δ (Mel'nikova et al.)[56], x_1 is mole fraction glycerol

3.6 Additional Equipment

Density meter: Anton Paar DMA 5000 was used for density measurements. The density meter operates in a temperature range from 0 to 90°C and atmospheric pressure conditions; it was used to measure density change through phase transition and at the same time explore the possibility of phase inversion, which is proven possible in some systems of oil and solvents[7]. The system has automatic sample changer and a temperature scan feature that allows for automated operation over the range of temperatures. The system was validated using water density checks at the required temperatures and the final values compared with NIST (National Institute of Standards and Technology) data. Reproducibility measurements were performed for water. The measured uncertainties are 10^{-5} g/mL or less and approach the reported uncertainty of the DMA 5000 (+/- 0.00001 g/mL).

Table 3-8. Water density values, this work, compared to NIST[57] values

Temperature (°C)	NIST Density (g/mL) (+/- 0.00001)	Measured Density (g/mL)	Deviation (g/mL)
20	0.998207	0.998219	-0.000012
30	0.995649	0.995655	-0.000006
40	0.992216	0.99222	-0.000004
50	0.988035	0.988039	-0.000004
60	0.983196	0.983198	-0.000002
70	0.977765	0.977776	-0.000011

3.7 Summary

This chapter describes the experimental setup design and operation in detail. The features and roles of components are discussed, as are improvements relative to previous apparatus. Operating protocols for all measurements are described and validated, using benchmark measurements.

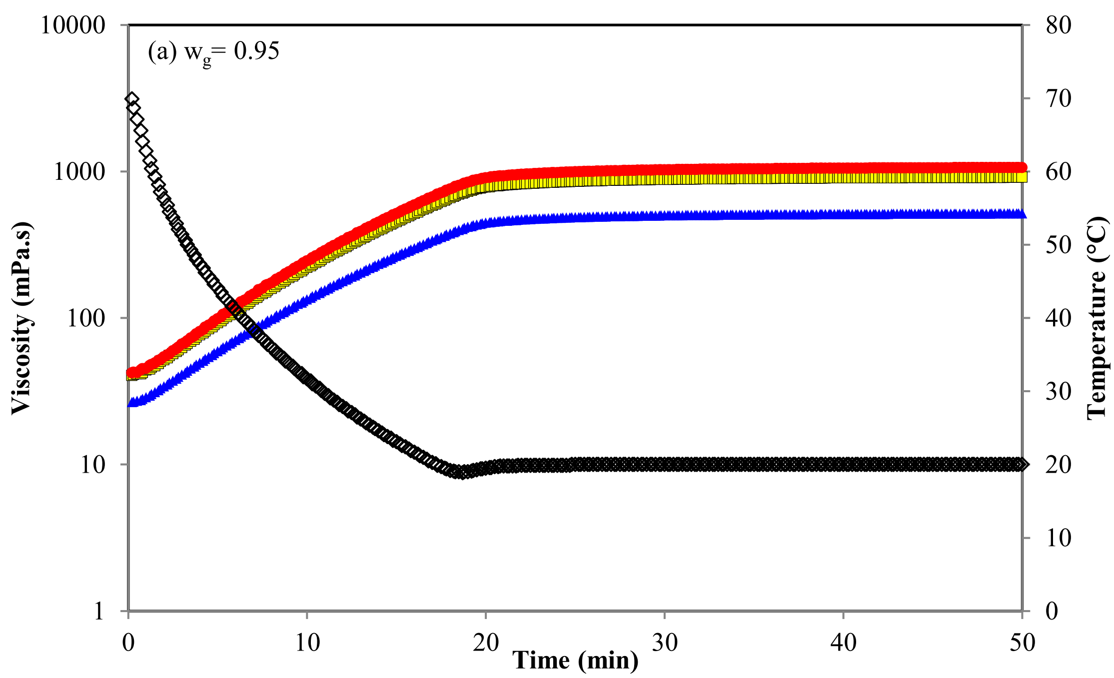
Chapter 4: Results and Discussion

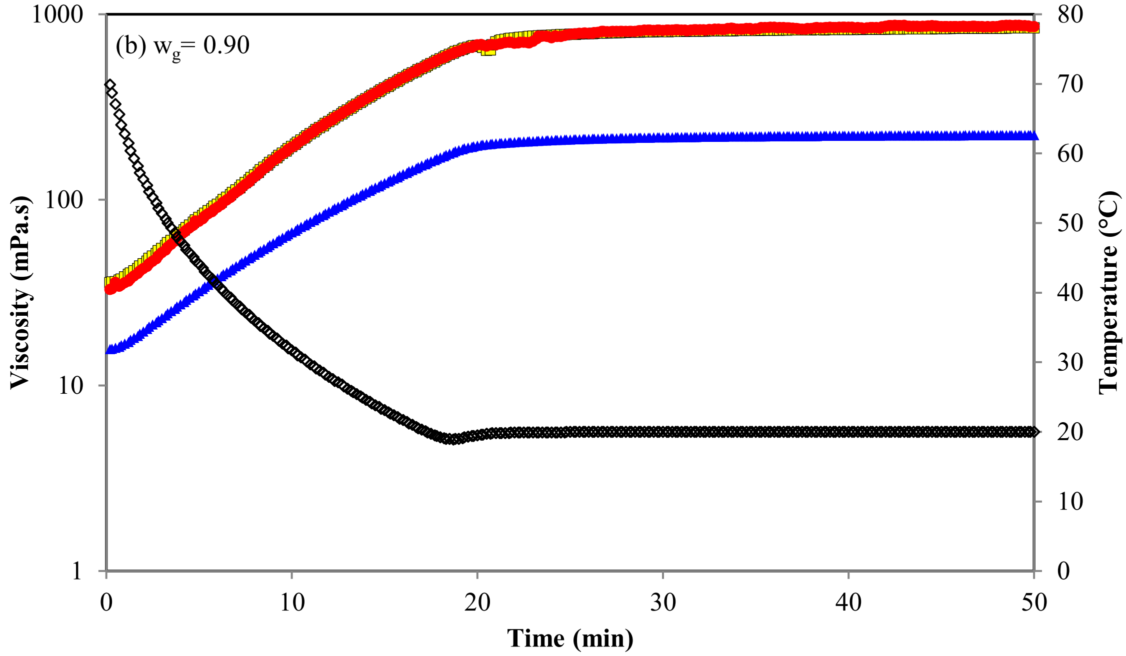
Multiphase fluids arise in a multitude of applications from refrigeration, to food processing, to oil processing. In this work, steady shear experiments were conducted to assess the impact of transitions from one to two-liquid phases using glycerol + pentanol mixtures and a reference single-phase mixture glycerol + water. Transitions were induced by reducing temperature at constant pressure while simultaneously shearing mixtures. As the volume fractions of phases are expected to impact rheological responses, density measurements were also carried out for mixtures. The results of these experiments are presented and underlying physics leading to them are discussed.

4.1 Rheological Measurements and Discussion

4.1.1 Impact of Final Temperature Variation on Steady shear viscosity Measurements

The temperature was varied from 70°C to 20°C, 40°C and 60°C in separate experiments at two shear rates (50 Hz and 250 Hz). Single and two-phase viscosities were measured. Single-phase mixtures were introduced in the rheometer at 75°C, as described in chapter 3, section 3.2. The flow curves for glycerol + pentanol mixtures undergoing phase transitions from 70°C to 20°C at shear rates of 50 Hz and 250 Hz are shown in Figures 4-1 a-j. Transitions from 70°C to 40°C are shown in Figures 4-2 a-i. Rheological measurements for glycerol + water mixtures were used as a single-phase reference. All of the data were obtained using the same protocol. In these Figures, single-phase reference viscosities, and the relationship between time and temperature are provided. For mixtures with low viscosity, the flow curves exhibit significant scatter and values below ~ 5 mPa.s are not reported, as this is the effective measurement threshold for the rheometer. Anton Paar, the rheometer's manufacturer, does not recommend using concentric cylinder for viscosities less than 1 mPa.s irrespective of the shear rate. Partial flow values for glycerol mass fractions of 0.4 and 0.3, where the maximum viscosity values are higher than 5 mPa.s, are presented in Appendix, Table S-5 – Table S-7.





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Viscosity (mPa.s)
Temperature (°C)
Time (min)
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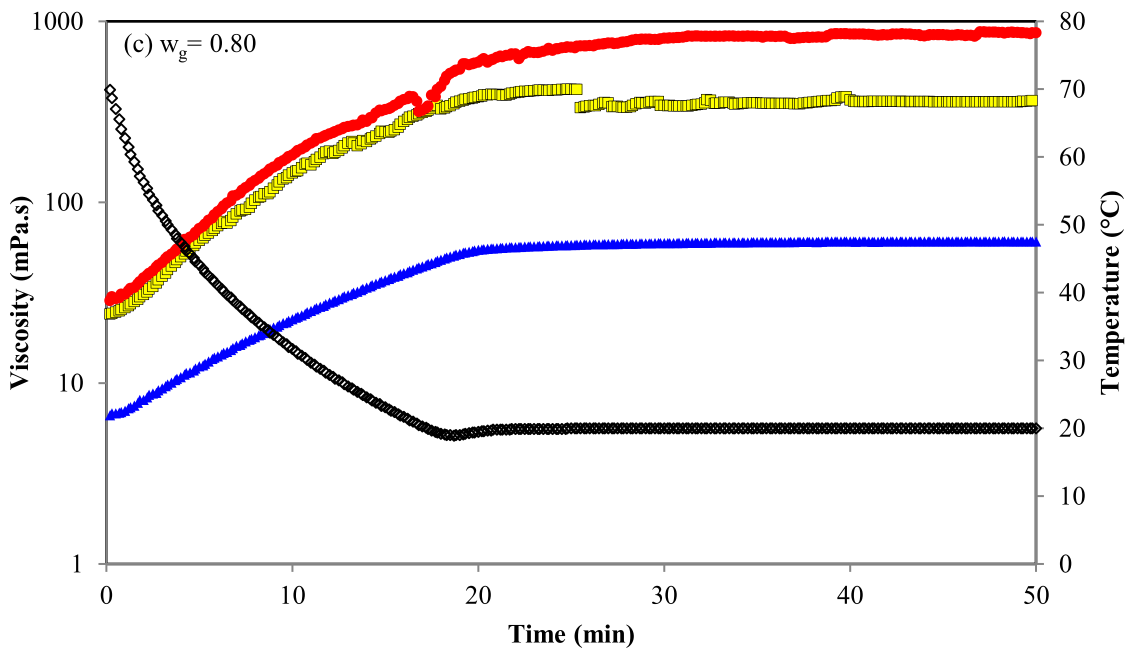

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Temperature (°C)
Time (min)
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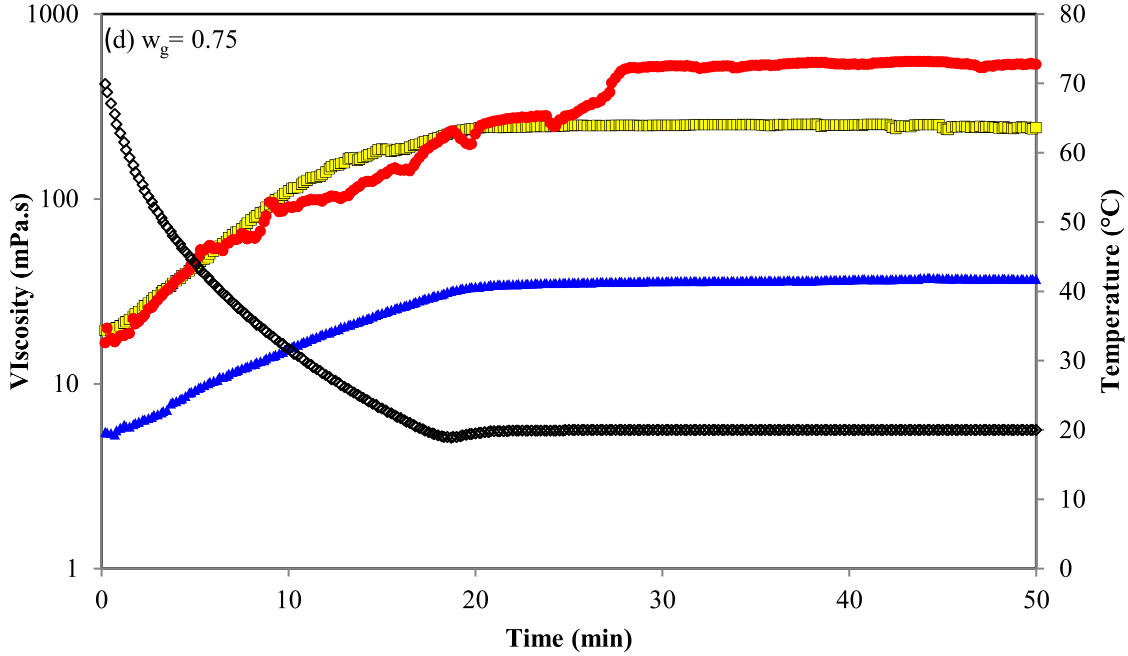
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VIscosity (mPa.s)
Temperature (°C)
Time (min)
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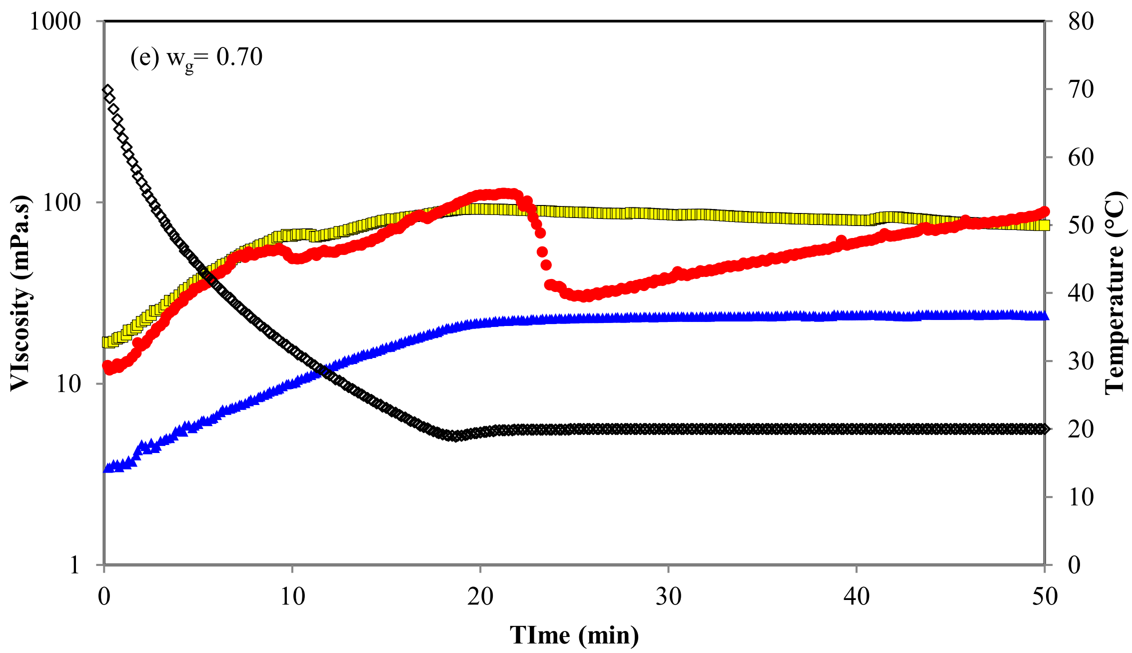
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VIscosity (mPa.s)
Temperature (°C)
TIme (min)
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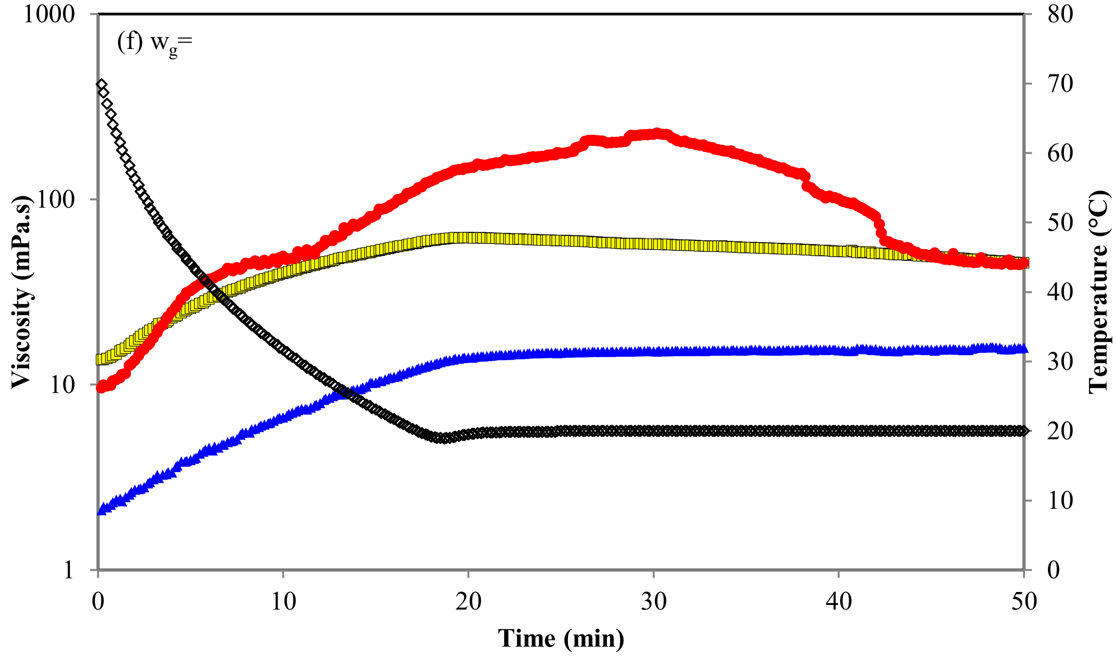
50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Temperature (°C)
Time (min)
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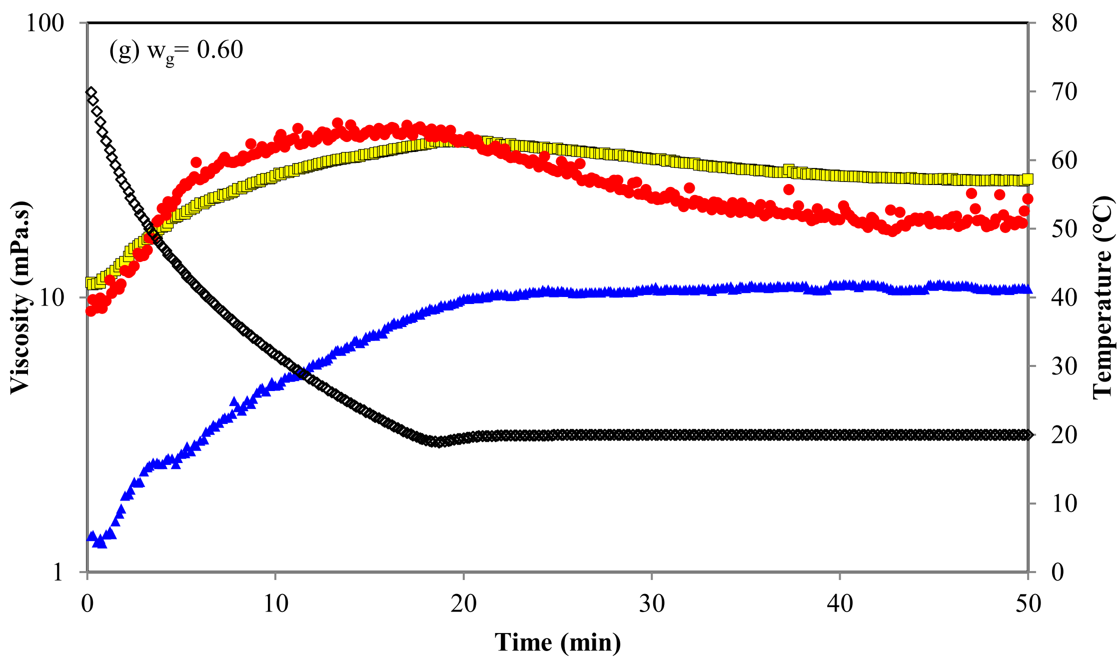
10
0
0
10
20
30
40
50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Temperature (°C)
Time (min)
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10
20
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40
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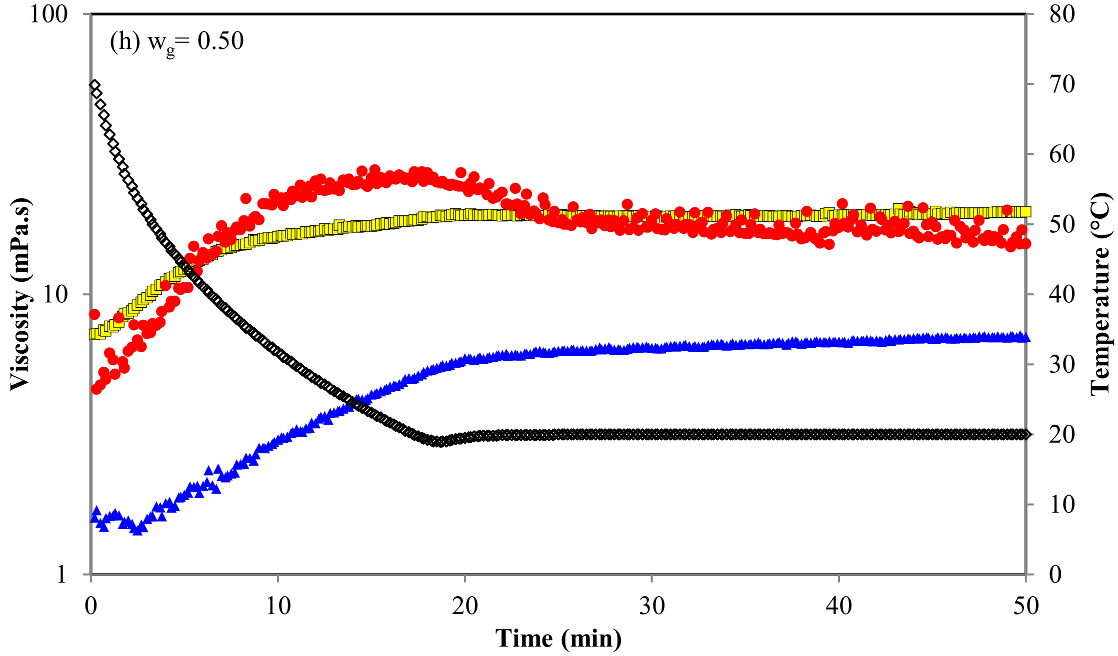
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Viscosity (mPa.s)
Temperature (°C)
Time (min)
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10
20
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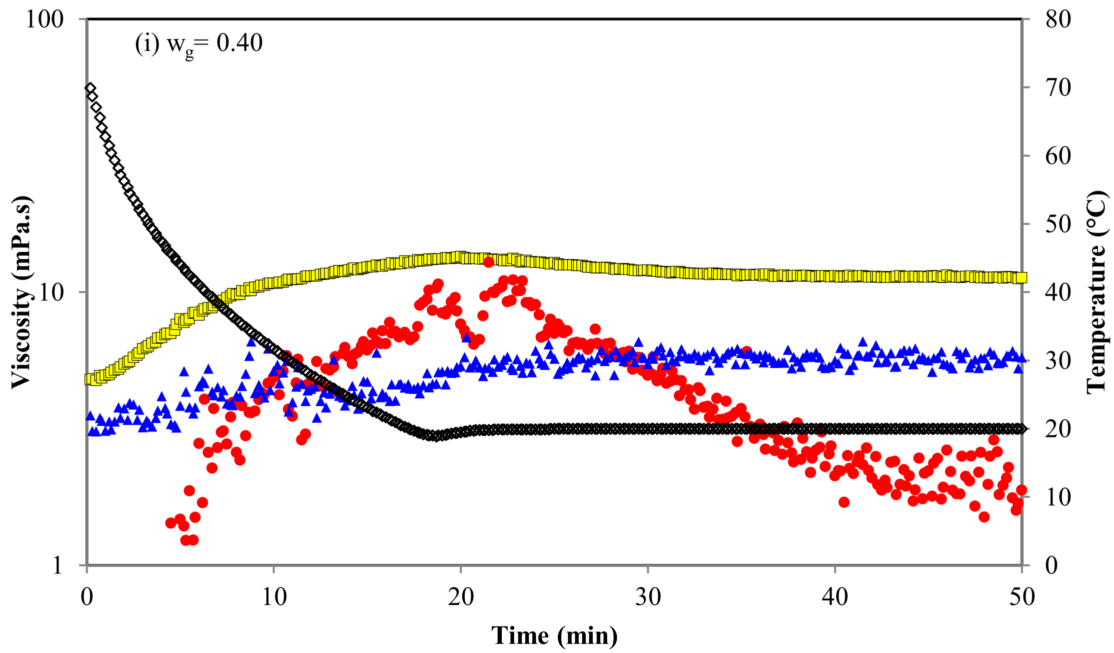
40
50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Temperature (°C)
Time (min)
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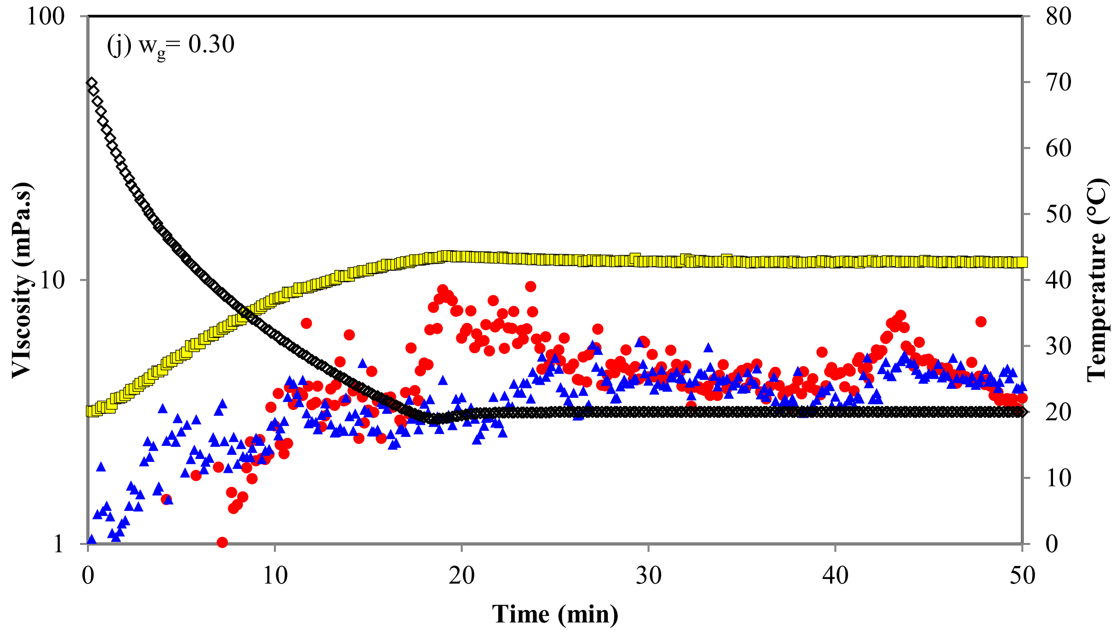
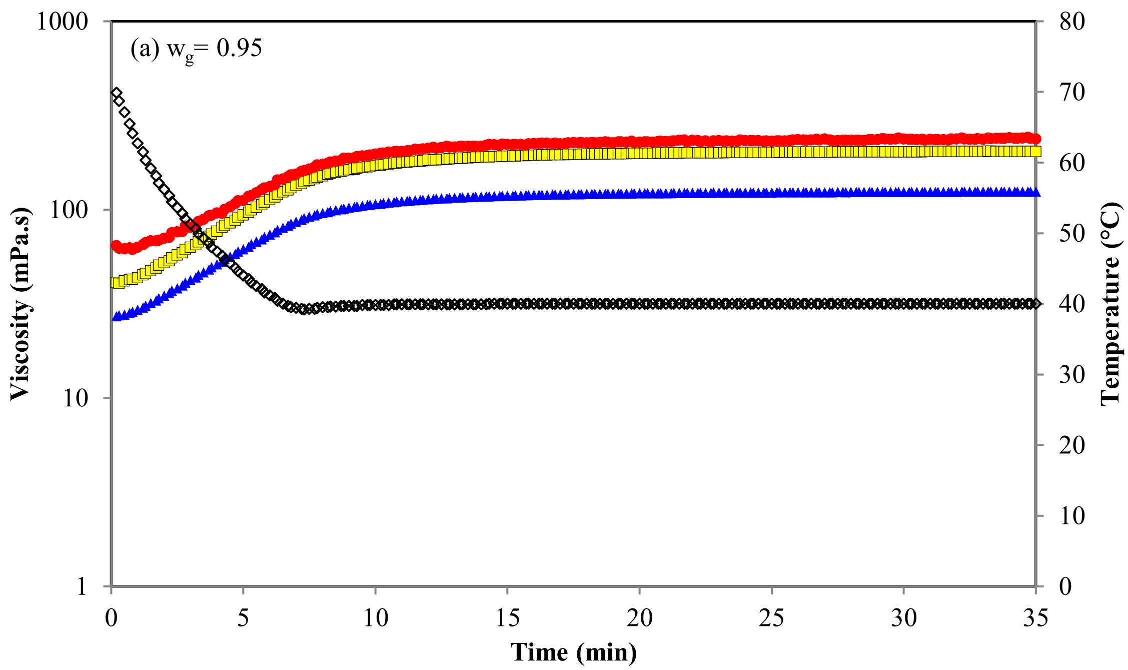
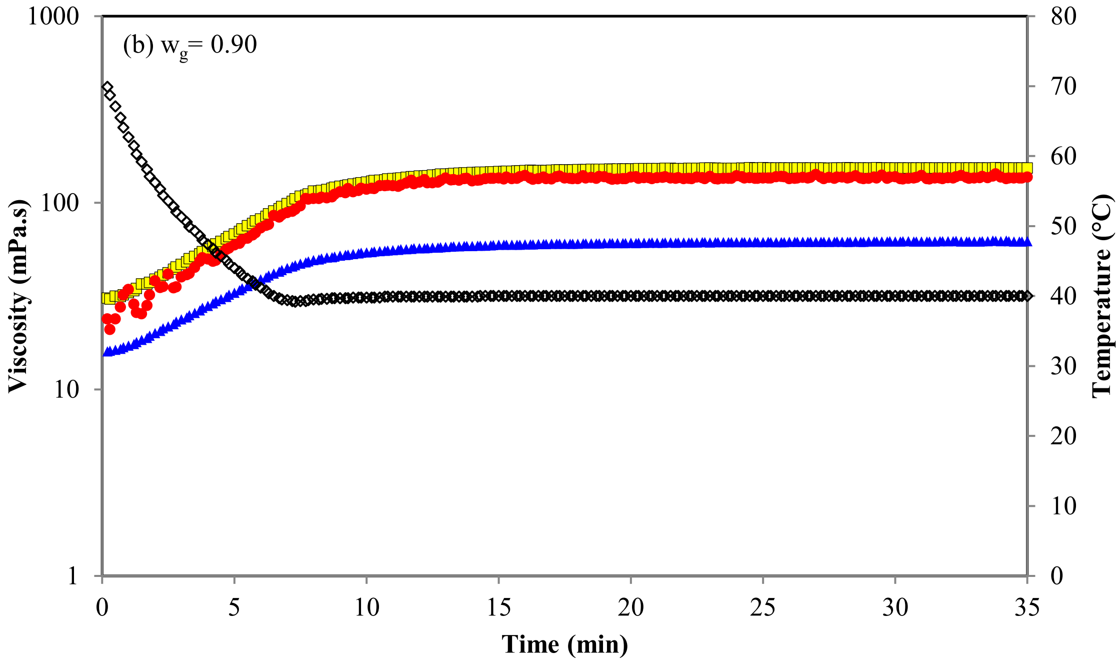


Figure 4-1. Flow curve for glycerol + pentanol at 250 Hz [□] and 50 Hz [●], and glycerol + water at 250 Hz [▲] with temperature [◊] change from 70°C to 20°C at 2.5°C/min at constant glycerol mass fraction: a) 0.95, b) 0.90, c) 0.80, d) 0.75, e) 0.70, f) 0.65, g) 0.60, h) 0.50, i) 0.40, j) 0.30

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Time (min)
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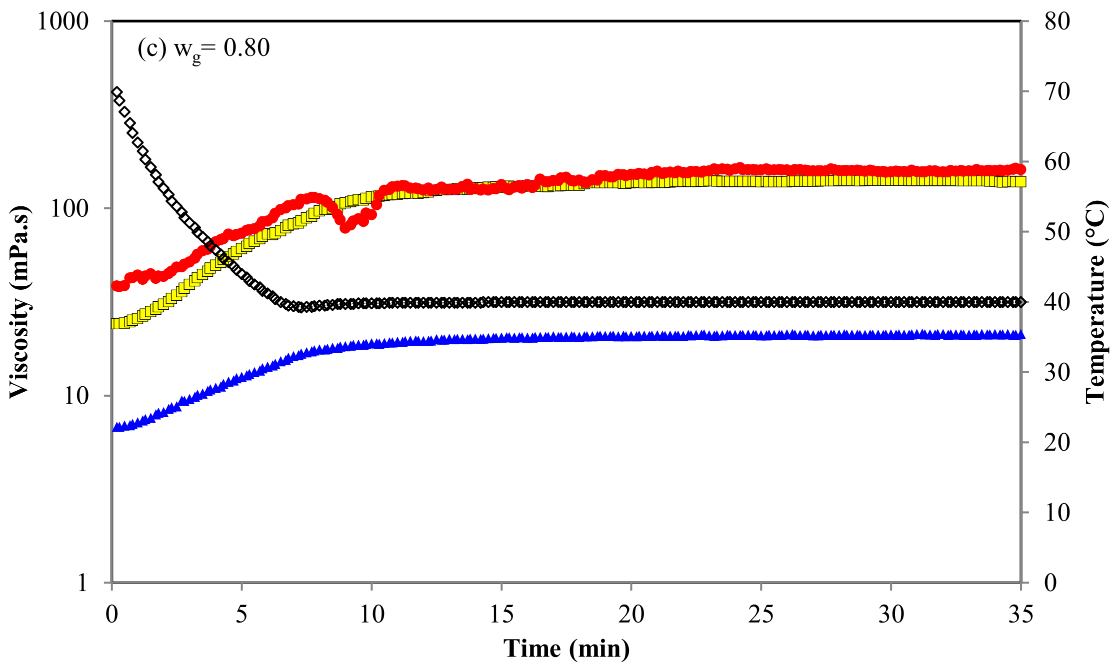
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Time (min)
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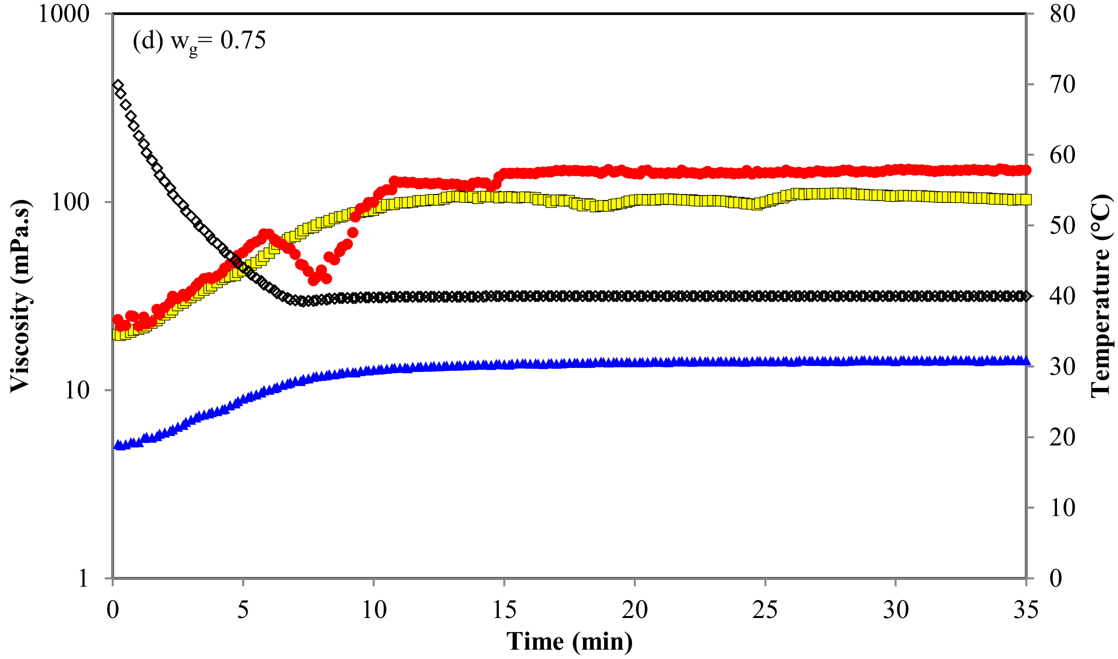
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Time (min)
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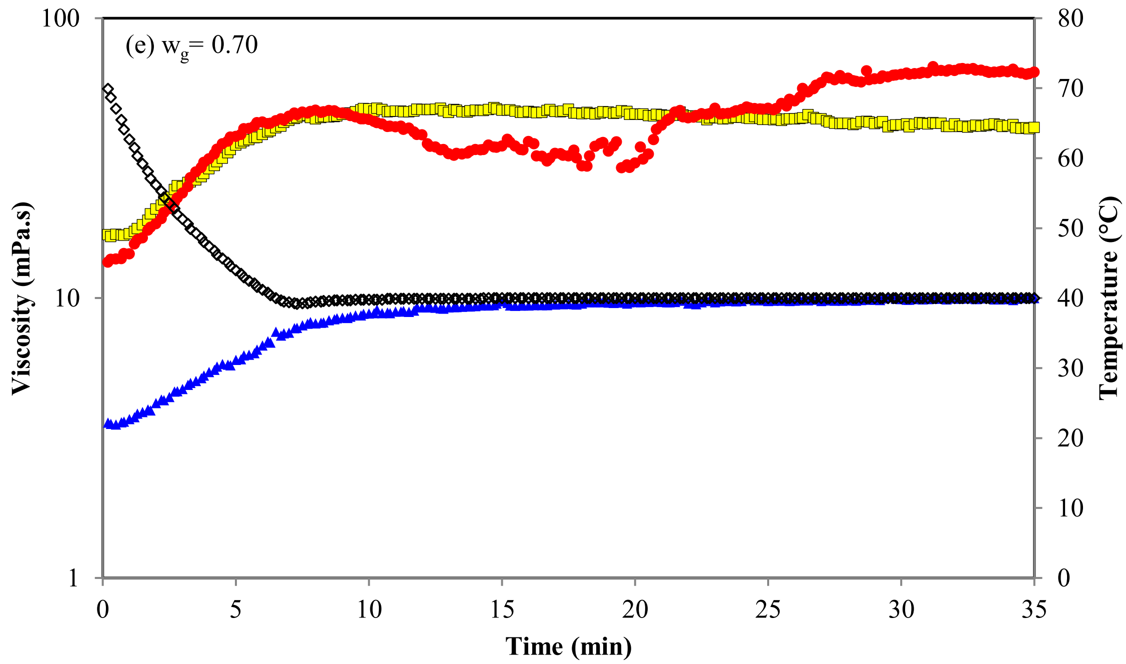
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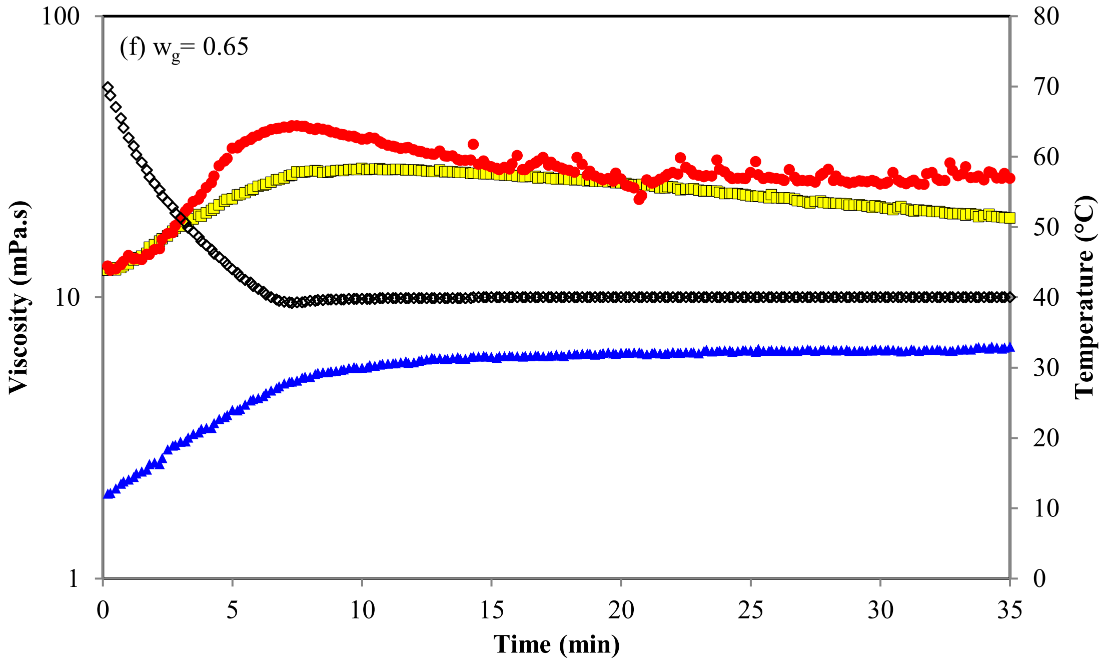
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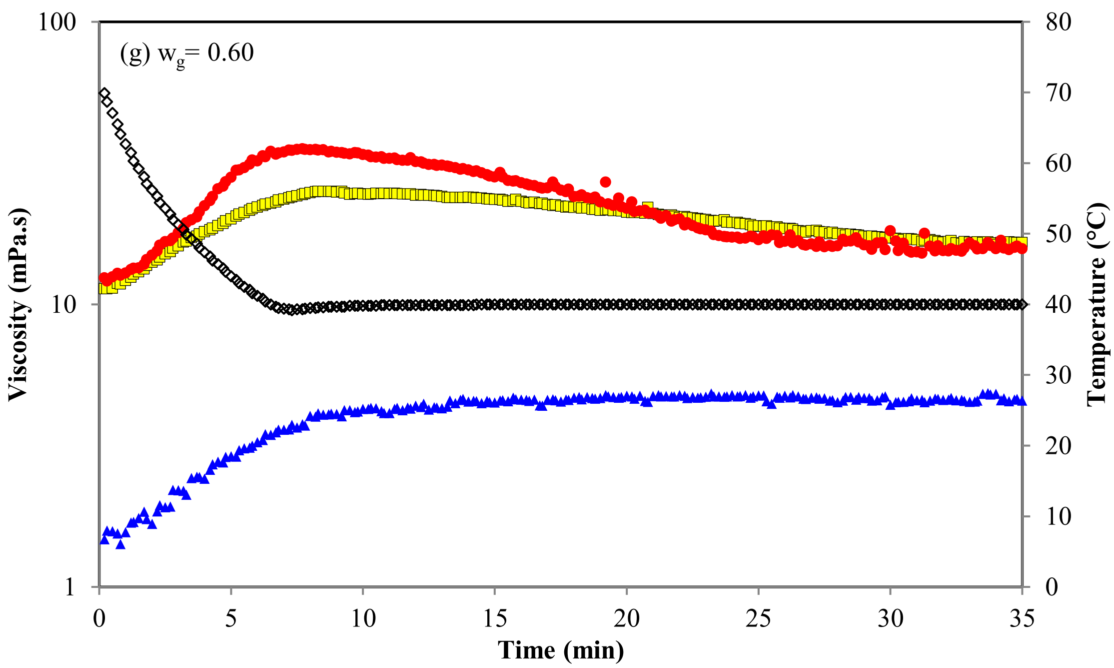
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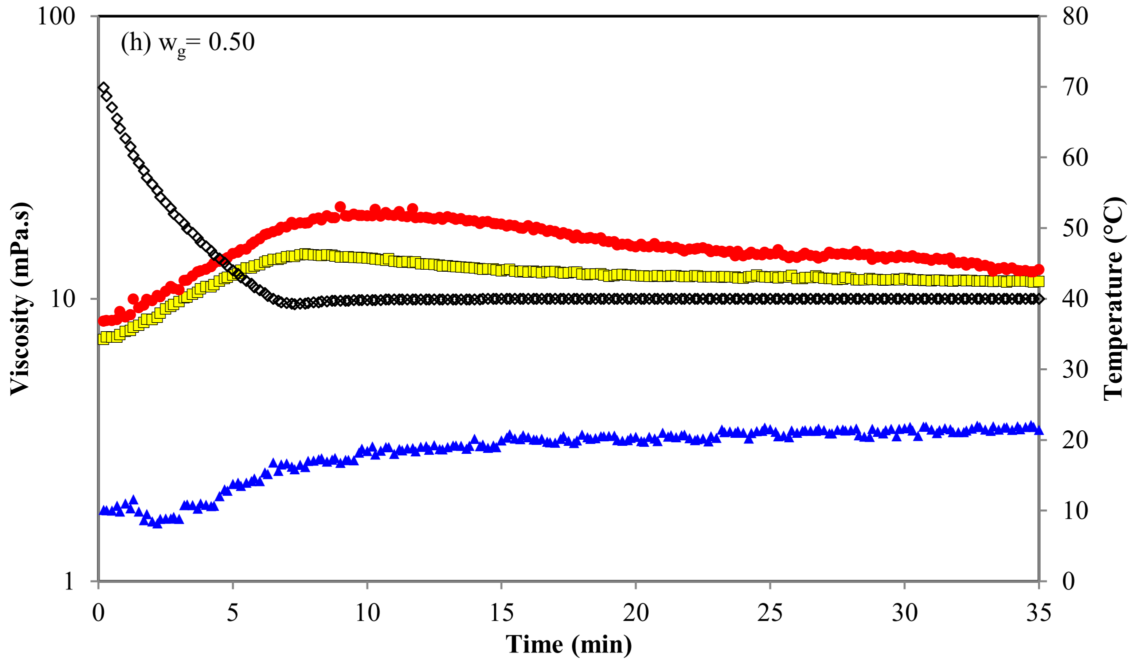


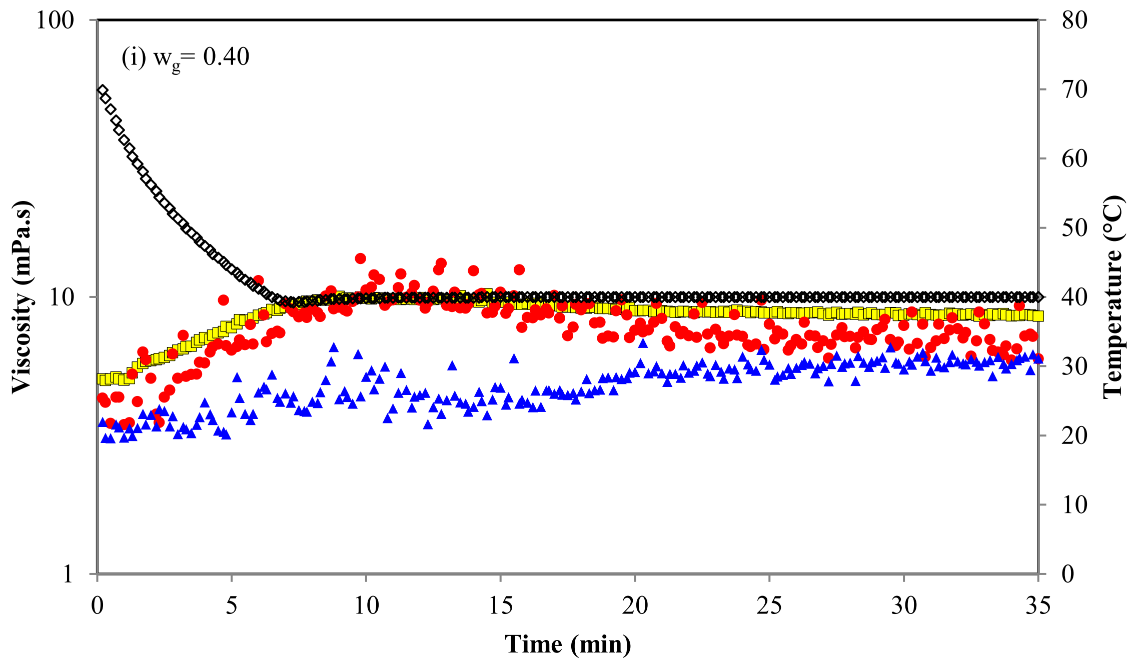


Figure 4-2. Flow curve for glycerol + pentanol at 250 Hz [□] and 50 Hz [●], and glycerol + water at 250 Hz [▲] with temperature [◊] change from 70°C to 40°C at 3°C/min at constant glycerol mass fraction: a) 0.95, b) 0.90, c) 0.80, d) 0.75, e) 0.70, f) 0.65, g) 0.60, h) 0.50 i) 0.40

While the addition of water or pentanol to glycerol reduces the viscosity of the mixture, at 250 Hz, steady state viscosity values remain closer to the peak values in the two phase zone as is evident in Figures 4-1 a-j for glycerol + pentanol at 250 Hz. The impact of the two-phase emulsions is more visible at lower shear rate where higher relative maxima are achieved. This shows the significance of shear history in the data set. These outcomes, related to the formation of emulsions are discussed in sections 4.1.4 and 4.1.5.

Figures 4-2 a-h illustrate similar results for temperature drops from 70°C to 40°C. The expected difference for these Figures compared to Figures 4-1 a-h was an increase in viscosity as stability of emulsions formed should increase as the UCST temperature of 63.6° C is approached. A peak is observed again at glycerol mass fraction of 0.65 but is not as high as in the case of 70 to 20°C.

Glycerol and water measurements for both temperature drops 70 to 20°C and 70°C to 40°C were done for 250Hz only. This was done because viscosity values for this mixture at all compositions are low and go below the rheometer limiting viscosity value at 50Hz.

4.1.2 Steady shear viscosity measurements at constant temperature after an interval of rest

At 20°C and 40°C, mixtures in the rheometer were allowed to rest for 30 minutes. During this time the two-phase mixtures separate in whole or in part (see section 4.1.4) and apparent viscosity values were re-measured. The purpose of this test was to allow the sample to separate into its constituent phases. This test gives insight into the results obtained if the sample is a two phase separated system. These results demonstrate the conditions at the end of phase transition period and the behaviour of phase separated systems as recorded by rheometer. The viscosity values, shown in Figure 4-3 and 4-4 are tabulated in Appendix 1 and comprise Tables S-8 and S-9.

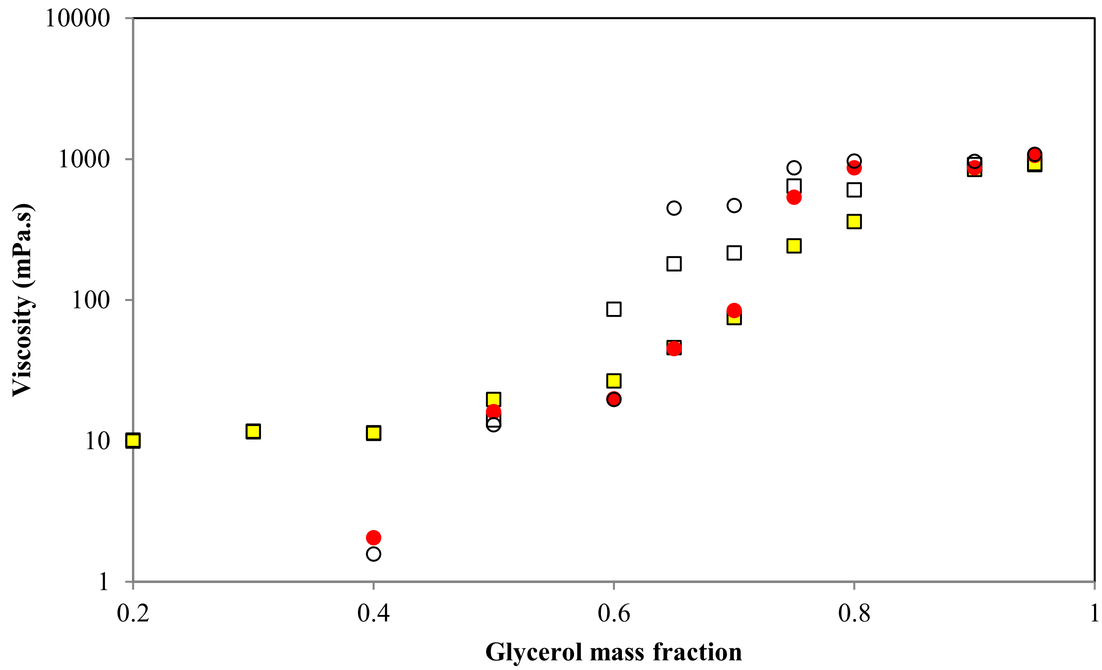


Figure 4-3. Viscosity for dispersed steady state after phase transition at 250 Hz [■] and 50 Hz [●] and for separated phases after interval of rest for 250 Hz [□] and 50 Hz [○] for glycerol + pentanol system at 20°C for different mass fractions of glycerol

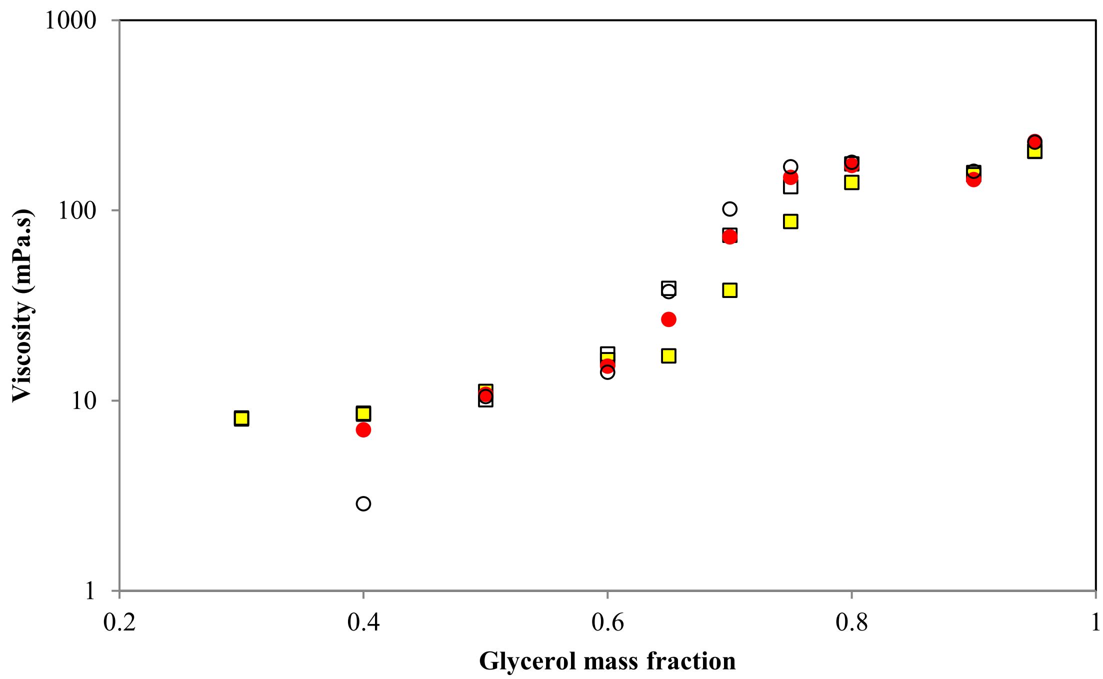


Figure 4-4. Viscosity for dispersed steady state after phase transition at 250 Hz [■] and 50 Hz [●] and for separated phases after interval of rest for 250 Hz [□] and 50 Hz [○] for glycerol + pentanol system at 40°C for different mass fractions of glycerol

Figures 4-3 and 4-4 present the viscosity comparison between a dispersed steady state system achieved at the end of phase transition and a phase separated system reached after interval of rest as indicated in Table 3-1 (see Step 6 for Phase transition and Step 10 for measurements after interval of rest).

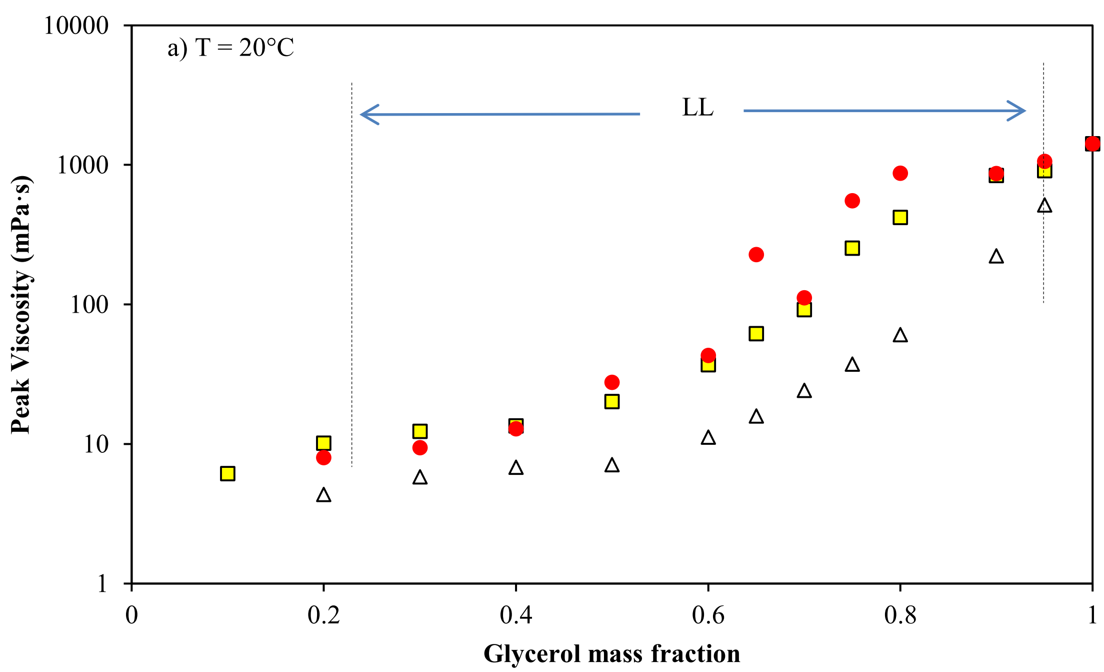
Some observations and inferences from Figures 4-3 and 4-4

- Mixtures with mass fraction of 0.6 and higher (up to 0.8) show increased viscosity after separation.
- Viscosity values at higher shear rates have lower values while viscosity values at lower shear rates are closer to the viscosity after separation indicating stability of emulsions at higher shear rates at steady state.
- For mass fractions below 0.6 the viscosity values for all cases studied are similar.

- The lower measurement threshold impacts measurements at low mass fractions. More discrepancies between low and high shear viscosity values are observed at mass fraction below 0.4.

4.1.3 Viscosity comparisons

Steady shear viscosities obtained in the two-phase region are presented in Figures 4-5 a-c as a function of composition and temperature, along with the reference single-phase viscosity. Observed viscosities remain bounded by the saturated liquid viscosities of glycerol + pentanol mixtures and only a shallow maximum in viscosity is observed in the two-phase region. Large peaks anticipated for emulsions with approximately 50% phase volume fraction were not observed. This outcome was surprising. However, depending on which phase is continuous (e.g., Figure 4-5a) large differences in viscosity can arise at fixed composition. If the pentanol-rich phase is continuous, the viscosity is lower than when the glycerol-rich phase is continuous.



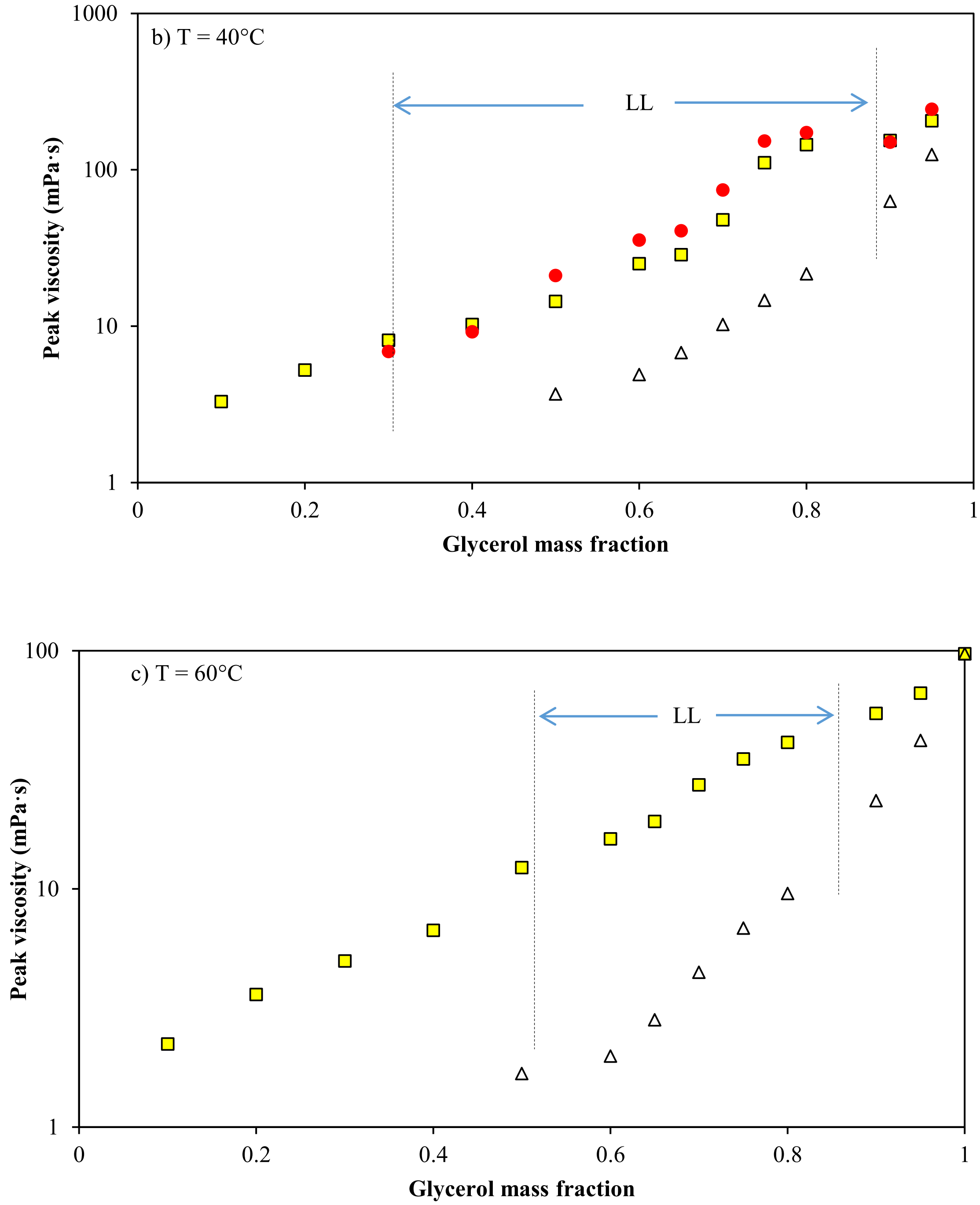
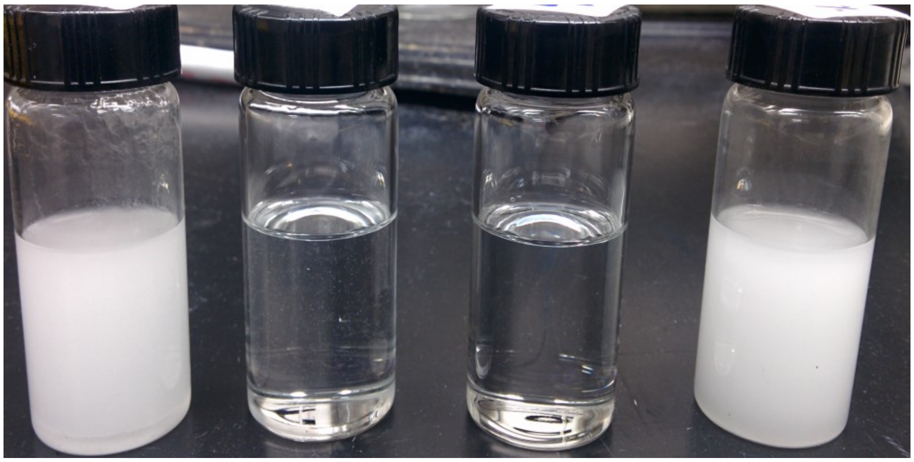


Figure 4-5. Peak viscosity vs. Glycerol mass fraction for Glycerol + Pentanol 250 Hz [□] and 50 Hz [●] and Glycerol + Water mixtures at 250 Hz [Δ] at a) 20°C, b) 40°C, and c) 60°C

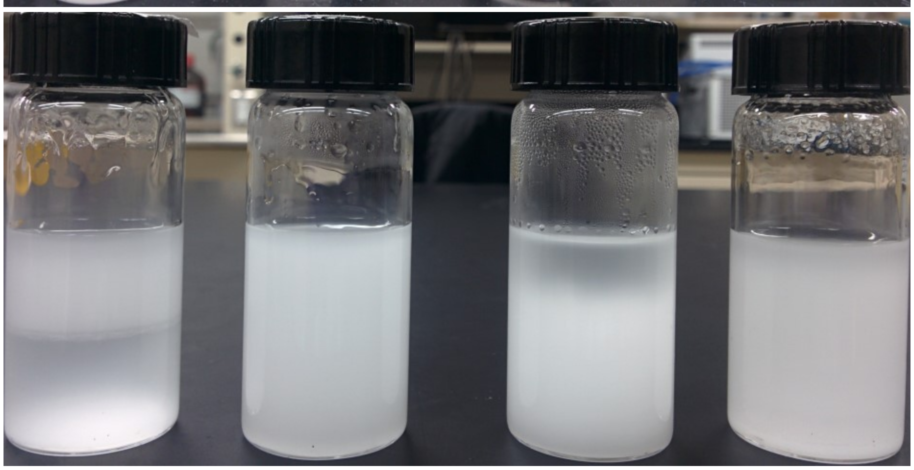
4.1.4 Emulsion Stability

Tests were carried out to check the stability of the emulsion formed for the system glycerol + pentanol.

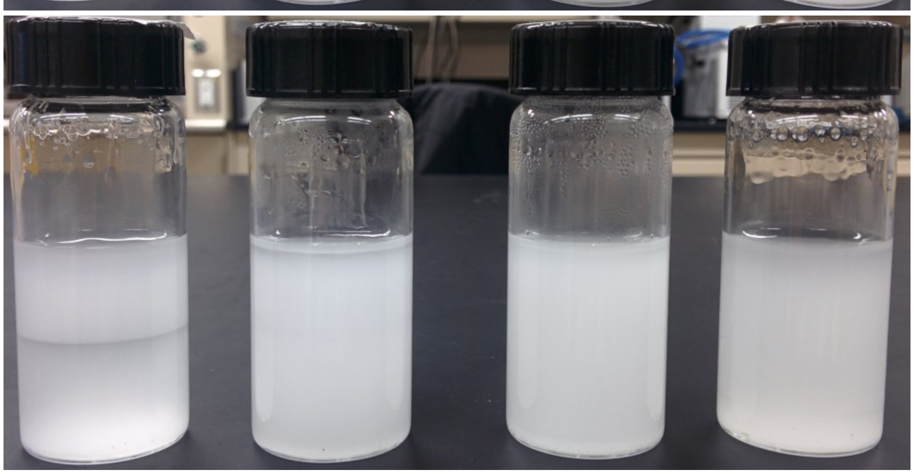
(a)



(b)



(c)



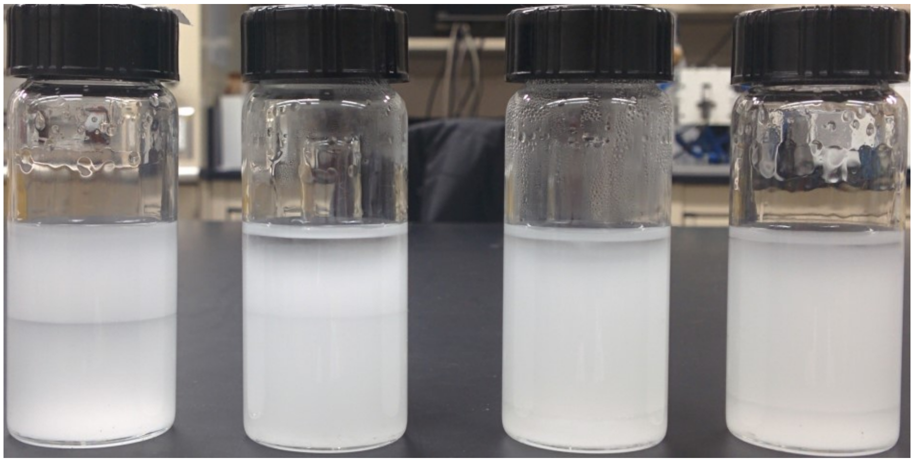
(d) 

Figure 4-6. Picture showing stability testing of emulsion formation for glycerol + pentanol mixtures with and without (w/o) heating, From left to right 0.70 w/o heating, 0.70 heated, 0.40 heated and 0.40 w/o heating a) 0 min, b) 10 min, c) 20 min and d) 30 min

Figure 4-6 (a-d) show the images taken at 10 minutes interval for two compositions of mixtures of glycerol + pentanol to check the stability of emulsion formed in absence of shear. Two types of mixtures were tested. In one case, the glycerol + pentanol mixtures were agitated (without heating) at high speed using a vortex mixer and in the other case the glycerol + pentanol mixtures were heated to form a single liquid phase (temperature > 70°C). These mixtures were prepared at the same time. The agitated mixtures were kept at constant agitation using two vortex mixers while the heated mixtures were placed in an oven and heated to 74°C. Both types of mixtures were then allowed to rest at room temperature and images of the resulting emulsions are shown in Figures 4-6 a-d. Compositions shown here are those that displayed minimum/similar stability times in regions of volume fractions greater than and less than 0.5 of the denser glycerol-rich liquid phase. As it can be seen in Figure 4-6, the mixtures prepared at room temperature separate faster than the mixtures formed by cooling into the two-phase region. None of the above emulsions is stable for more than ~30 minutes. In the absence of a stabilizer, separation is expected[58]. However, the mixtures form emulsions. The formation of emulsions is more important in the present context than their stability. Apparent viscosity data are obtained as emulsions form and then separate over time. This qualitative outcome justifies the use of the integrated experimental setup. Phase separation of mixtures during the loading process in the rheometer would negatively impact the quality and reproducibility of viscosity measurements.

4.1.5 Interpretation of Viscosity Outcomes

The viscosity value variations including local maxima for emulsions shown in Figures 4-5 a-c, align with the phase distribution observations identified in Figures 4-6 a-d and correspond to five spatial distribution regions illustrated in Figure 4-7. Many types of complex emulsions are possible depending upon the surfactants or drop interactions. These interpretations are used as a conceptual guideline to understand the system. Also, these interpretations act as the base for viscosity correlations developed in literature and therefore need to be understood before making any comparison. Which phase is continuous and the properties of the emulsion formed depend on the shear and thermal history of the samples. The 0.50 phase volume fraction occurs at 0.65 glycerol mass fraction at 20°C and closer to 0.7 glycerol mass fraction at 60°C. Mixtures where the lower viscosity phase is continuous have lower measured viscosities.

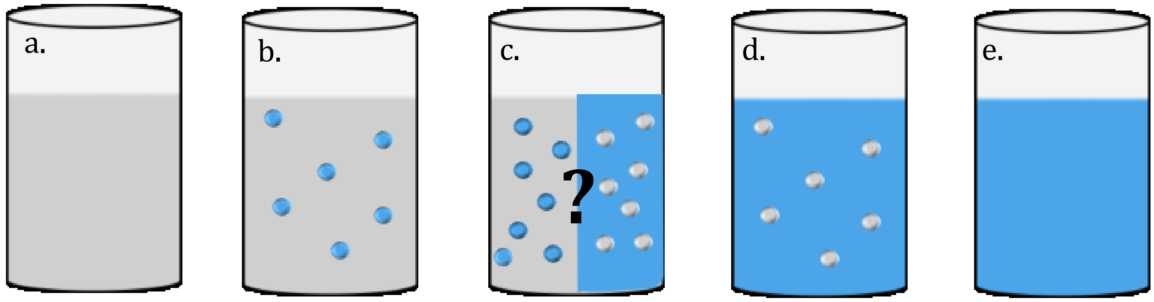


Figure 4-7. Glycerol + pentanol phase distribution in different regions of composition: (a) low viscosity pentanol-rich single phase, (b) low viscosity continuous phase with the other phase dispersed, (c), where both phases comprise ~ 0.5 volume fraction one or the other phase can be continuous and emulsions can form, (d) high viscosity continuous phase with other phase dispersed, (e) high viscosity glycerol-rich single phase

Heavy oil transport in pipelines using oil in water emulsions[59] or self-lubricated froth flow technology[60] rely on a low viscosity phase at pipe walls to reduce the resistance to flow and hence the apparent viscosity. In this work, we see the impact of this phenomenon and the shear rate and shear history impacts on the phase distribution on the measured viscosities. At fixed composition and temperature, order of magnitude differences in apparent viscosity can arise. If the high viscosity fluid is continuous or becomes continuous, the viscosity is larger or becomes larger. If the low viscosity fluid is continuous or becomes continuous, the viscosity is lower or becomes lower. In this work low shear rates and rest favor higher viscosity phase configurations while continuous shear and high shear favor lower viscosity phase configurations.

4.2 Phase Density Measurements

Single phase density measurements with glycerol + pentanol mixtures provide bases for computing liquid volume fractions in the LL region and excess volumes for saturated phases. Density data also provide input for discussion of the possible impact of buoyancy on phase distributions in the rheometer. Buoyancy may also be important for the interpretation of solvent aided bitumen production processes where for example, the density difference between bitumen-rich and propane-rich liquid phases is large[37]. Figure 4-8 and 4-9 provide density comparison for the glycerol-pentanol and glycerol-water mixtures.

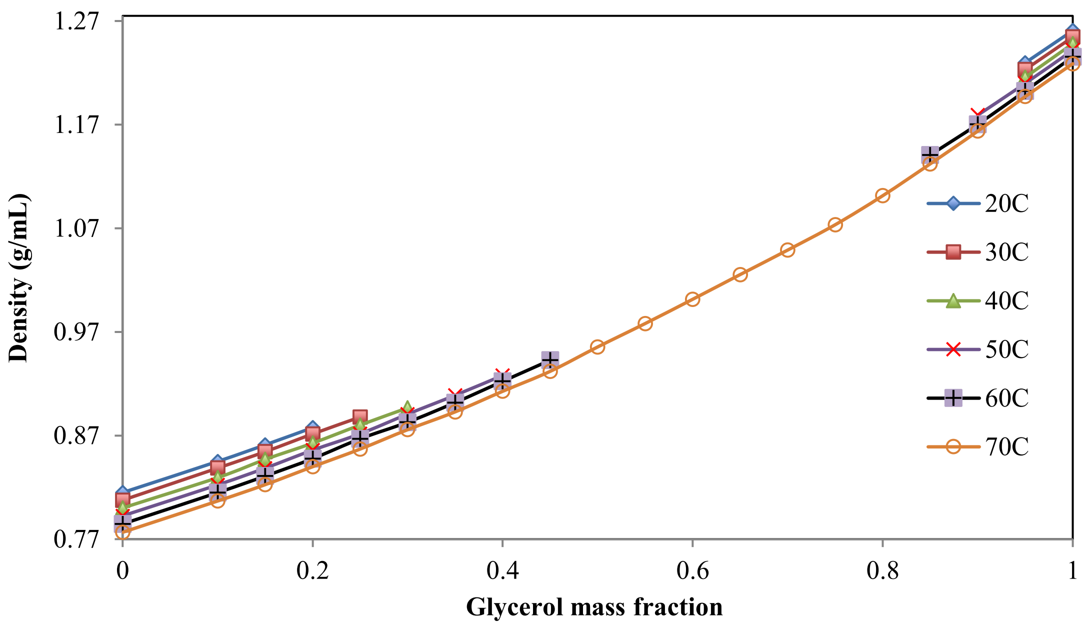


Figure 4-8. Density of single-phase glycerol + pentanol mixtures (20°C - 70°C)

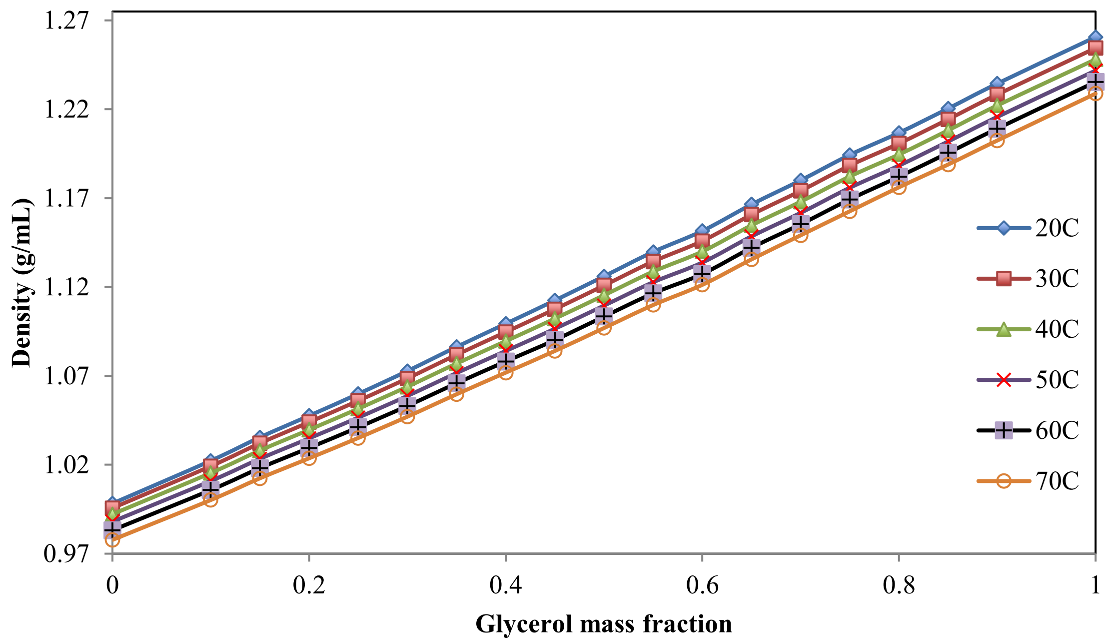


Figure 4-9. Reference densities for single-phase glycerol + water mixtures (20°C - 70°C)

Excess volumes, defined as:

$$\Delta V = \frac{1}{\rho_{12}} - \left(\frac{\omega}{\rho_1} - \frac{1-\omega}{\rho_2}\right)$$

Where, ΔV is the specific excess volume, ω is the glycerol mass fraction, ρ_{12} is the density of the mixture and ρ_1, ρ_2 are the densities of pure glycerol and pentanol respectively, which are provided in Figure 4-10 and tabulated in Appendix 1 (Table S-17). For mixtures of glycerol + pentanol, the excess volumes, with a maximum of 0.005 mL/g, are significantly lower than those obtained for Athabasca bitumen + propane[37] and are close to zero in the range of uncertainty of the measurement. Glycerol water system on the other hand displays negative excess volumes of the order 0.01 mL/g (Figure 4-11). Maximum uncertainty for glycerol + pentanol measurement was 0.003 mL/g, while that for glycerol + water was calculated as 0.001 mL/g. (See Table S-19 and S-20 for all values)

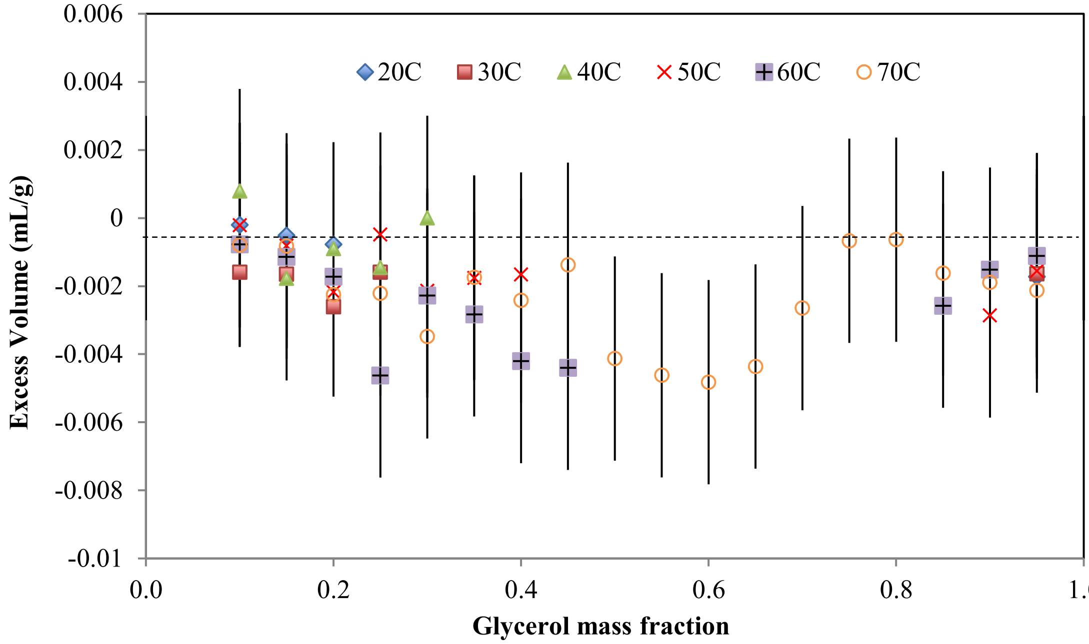


Figure 4-10. Excess volumes of single-phase glycerol + pentanol mixtures (20°C - 70°C)

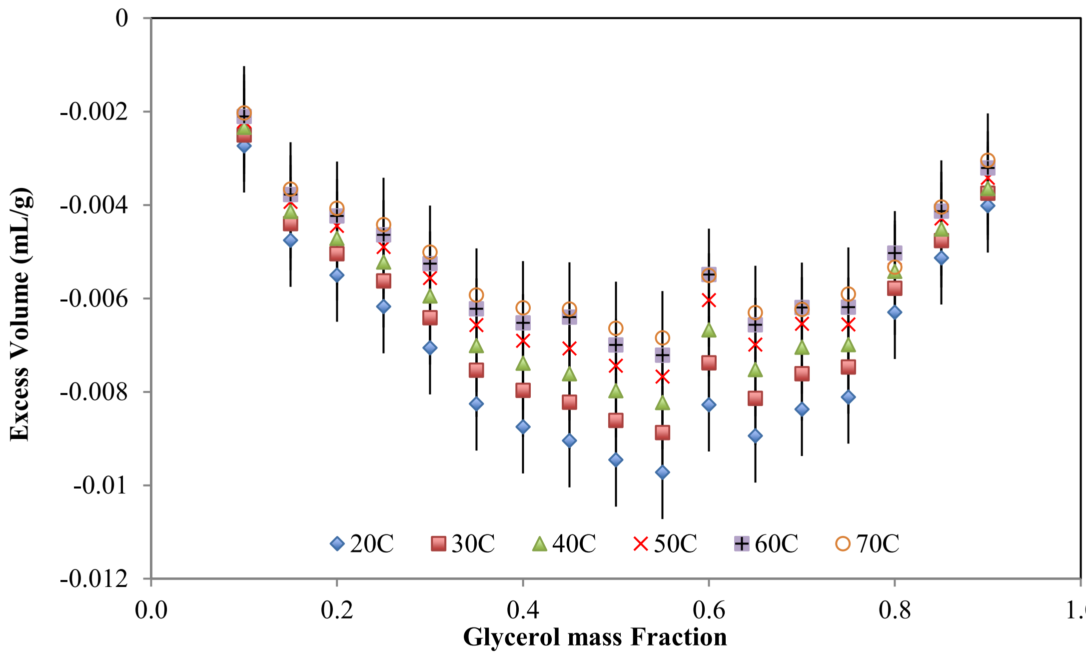


Figure 4-11. Reference excess volumes for single-phase glycerol + water mixtures (20°C - 70°C)

4.3 Predicting Liquid-Liquid Emulsion Viscosity

Viscosity is an important consideration in industrial operations from production to transportation and storage. Different correlations are used for hydrocarbon-hydrocarbon and hydrocarbon-water mixtures.[61] Ideal mixing is a prerequisite for application of most correlations[62]. Deviations from ideal mixing typically require the mixture to behave as one phase.[63] In this work, a mixture comprising two liquid phases is studied and viscosity values obtained from correlations employed in commercial software (Aspen HYSYS, VMGSim, STARS and WINProp[64–67]) for such mixtures are compared with viscosity data. The equations include:

1. **Einstein Equation**[68] – Einstein's equation (4-1) was one of the first attempts to theorize viscosity increase of emulsions as a function of dispersed particles.[69] Most

of the later developed equations for suspended particles simplify to Einstein's equation when non-interacting spherical particles at infinite dilution are considered. Due to the limited applicability this equation is not compared but a linear relationship is evident.

$$\eta_r = 1 + 2.5\phi \quad (4\text{-}1)$$

Where, ϕ - Phase volume fraction of dispersed phase

η_r - Viscosity ratio of slurry phase/ Continuous phase

2. **Thomas equation,** equation (4-2)[70] – extends the Einstein equation (similar to extensions used in VMGSim) to higher concentration of dispersed phase. The two-phase mixtures are assumed to be suspensions of non-interacting hard spheres in a Newtonian fluid. This equation is expected to be valid up to 0.60 volume fraction of dispersed phase.

$$\eta_r = 1 + 2.5\phi + 10.05\phi^2 + 0.00273exp(16.6\phi) \quad (4\text{-}2)$$

3. **Woelflin model** – Also an extension to Einstein equation, this equation is used in VMGSim and Aspen HYSYS for crude oil emulsions.[65] For comparison with mixture studied in this work, glycerol rich phase is used for oil viscosity (η_o) and pentanol rich phase as water viscosity (η_w). This equation has limited applicability up to 0.33 fraction of heavier dispersed phase as lighter component is considered as dispersed phase at higher oil fractions.

If oil (higher viscosity component) volume fraction is more than 1/3, water (lower viscosity component) is assumed as dispersed phase,

$$\eta_r = e^{3.6\phi} \tag{4-3}$$

If oil volume fraction is less than 1/3 then, oil phase is assumed as dispersed,

$$\eta_r = 1 + 2.5\phi\left(\frac{\eta_o+0.4\eta_w}{\eta_o+\eta_w}\right) \tag{4-4}$$

For Equations (4-1) to (4-4), ϕ is the volume fraction of the dispersed phase. Equations for calculation of volume fraction of dispersed phase and calculated values, based on experimental data and phase diagrams for the mixtures, are reported in Appendix 2 (Table C1-2).

Also,

$$\eta_r = \frac{\eta_s}{\eta_0} \tag{4-5}$$

Where, η_r is the normalized viscosity, η_0 is the viscosity of the saturated continuous liquid phase and η_s is the viscosity of the emulsion. Predicted normalized viscosities $\frac{\eta_s}{\eta_0}$, at steady state at 20°C (Figure 4-12) and 40°C (Figure 4-13) are based on saturated pentanol-rich phase as the continuous phase. Shear rate is a parameter. This modeling approach provides a first approximation for the viscosity trends of pentanol-rich liquid continuous emulsions, which appear to dominate the LL region. Qualitatively incorrect trends are obtained if glycerol-rich liquid continuous emulsions are presumed. Comparison between experimental normalized viscosity for glycerol-rich continuous phase and Thomas and Woelflin equation are shown for illustrating the point (Figure 4-14 and 4-15).

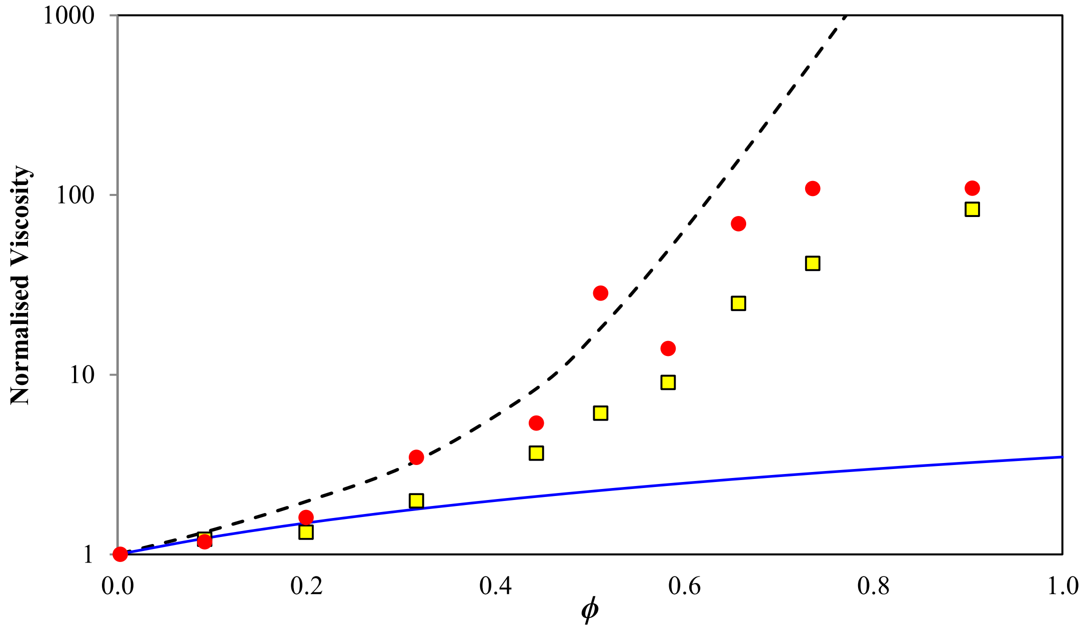


Figure 4-12. Einstein equation (Thomas modification) [- - - -] and Woelflin model [——] normalized viscosity for suspensions of glycerol-rich drops in pentanol-rich liquid compared with measured normalized viscosity at 250 Hz [□] and 50 Hz [●] for 70°C to 20°C

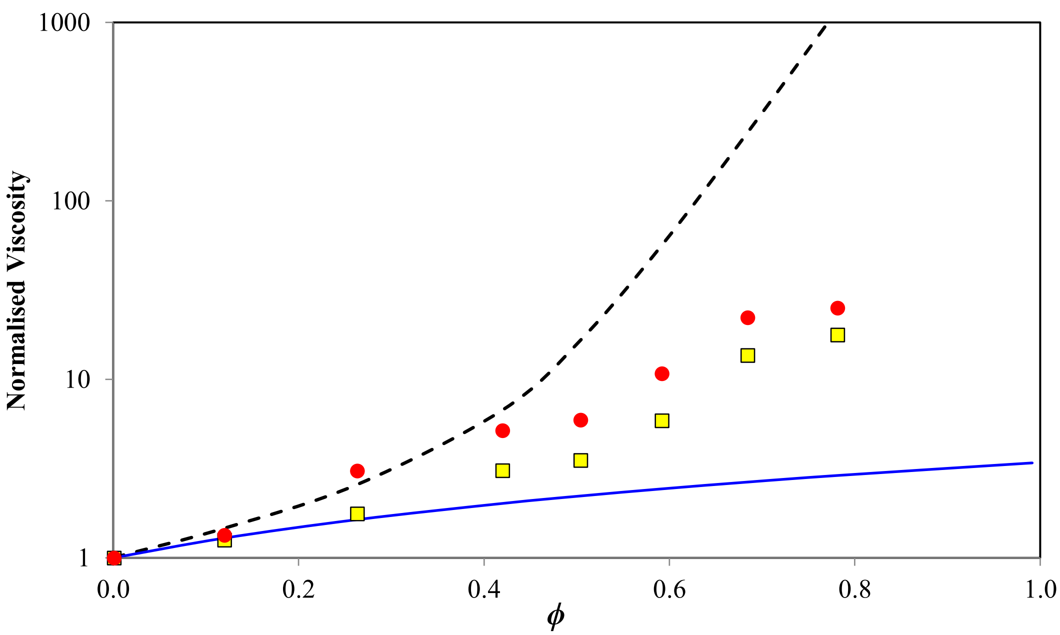


Figure 4-13. Einstein equation (Thomas modification) [- - - -] and Woelflin model [——] normalized viscosity for suspensions of glycerol-rich drops in pentanol-rich liquid compared with measured normalized viscosity at 250 Hz [□] and 50 Hz [●] for 70°C to 40°C

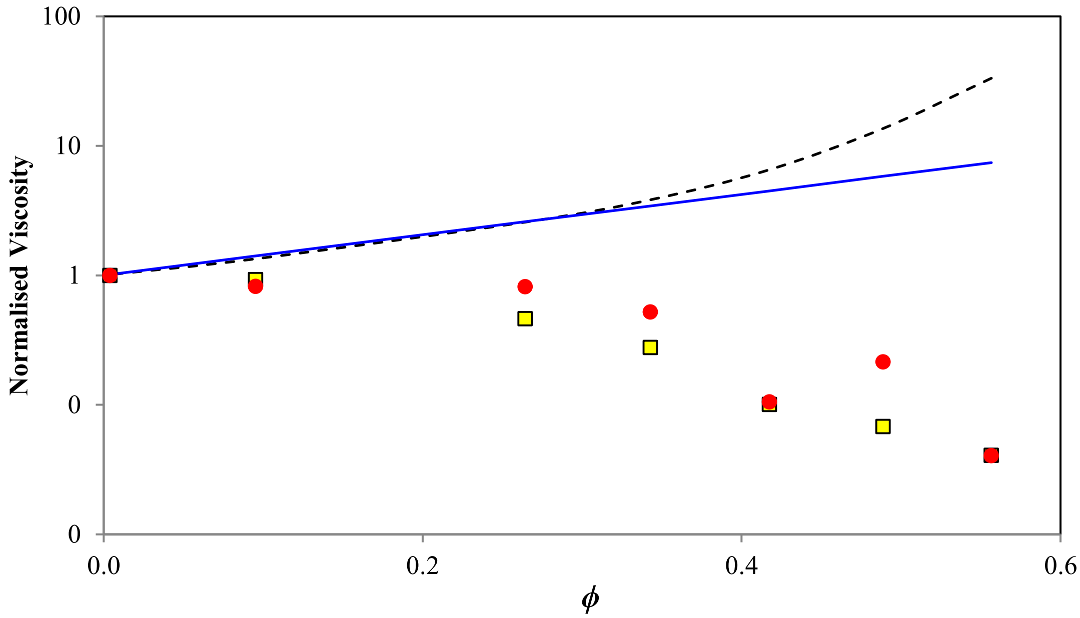


Figure 4-14. Einstein equation (Thomas modification) [- - - -] and Woelflin model [——] normalized viscosity for suspensions of pentanol-rich drops in glycerol-rich liquid compared with measured normalized viscosity at 250 Hz [□] and 50 Hz [●] for 70°C to 20°C

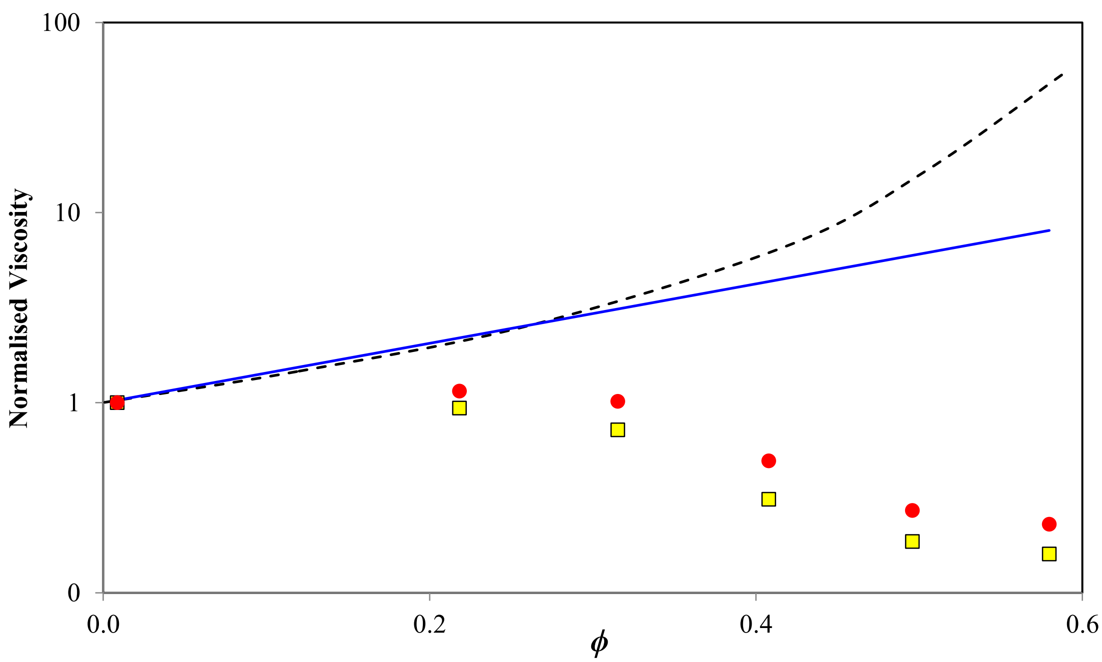


Figure 4-15. Einstein equation (Thomas modification) [- - - -] and Woelflin model [——] normalized viscosity for suspensions of pentanol-rich drops in glycerol-rich liquid compared with measured normalized viscosity at 250 Hz [□] and 50 Hz [●] for 70°C to 40°C

Strictly speaking the equations above apply to the rheology of particle in liquid suspensions. Equations for liquid-liquid emulsions are yet to be employed in commercial software but are included here for completeness and for discussion.

Phan-Thien and Pham equation[71]

$$\eta_r \left(\frac{2\eta_r+5k}{2+5k}\right)^{3/2} = (1-\phi)^{-2.5} \quad (4\text{-}6)$$

Equation by Pal[72] modifying the former and incorporating Krieger and Dougherty equation[73].

$$\eta_r \left(\frac{2\eta_r+5k}{2+5k}\right)^{3/2} = \left(1-\frac{\phi}{\phi_m}\right)^{-2.5\phi_m} \quad (4\text{-}7)$$

These equations were developed considering the dispersed phase viscosity and interactions between drops and are valid for nearly spherical drops (very low capillary number).[72] Predicted steady state results at 20°C (Figure 4-16) and 40°C (Figure 4-17) based on saturated pentanol-rich phase as the continuous phase are compared with measured data. Glycerol-rich continuous phase calculations were not performed because these equations predict increasing viscosity with dispersed phase volume fraction and qualitatively incorrect results are obtained.

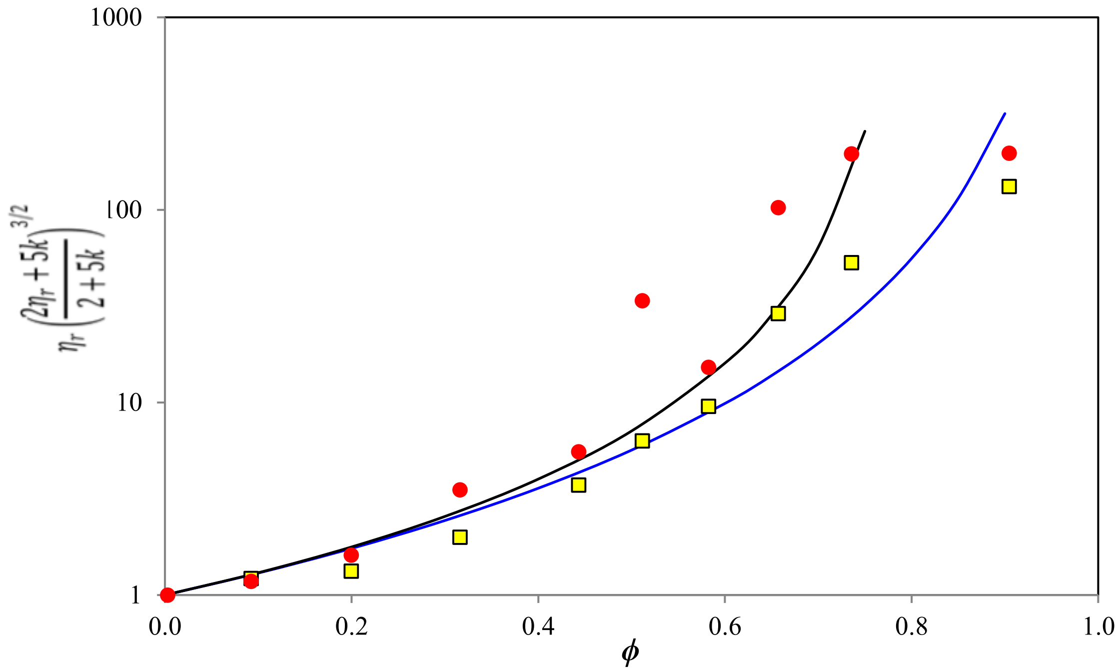


Figure 4-16. Pal equation [——] and Phan-Thien and Pham equation [——] RHS values for emulsions of glycerol-rich drops in pentanol-rich liquid compared with LHS calculated using experimental data at 250 Hz [□] and 50 Hz [●] for 70°C to 20°C

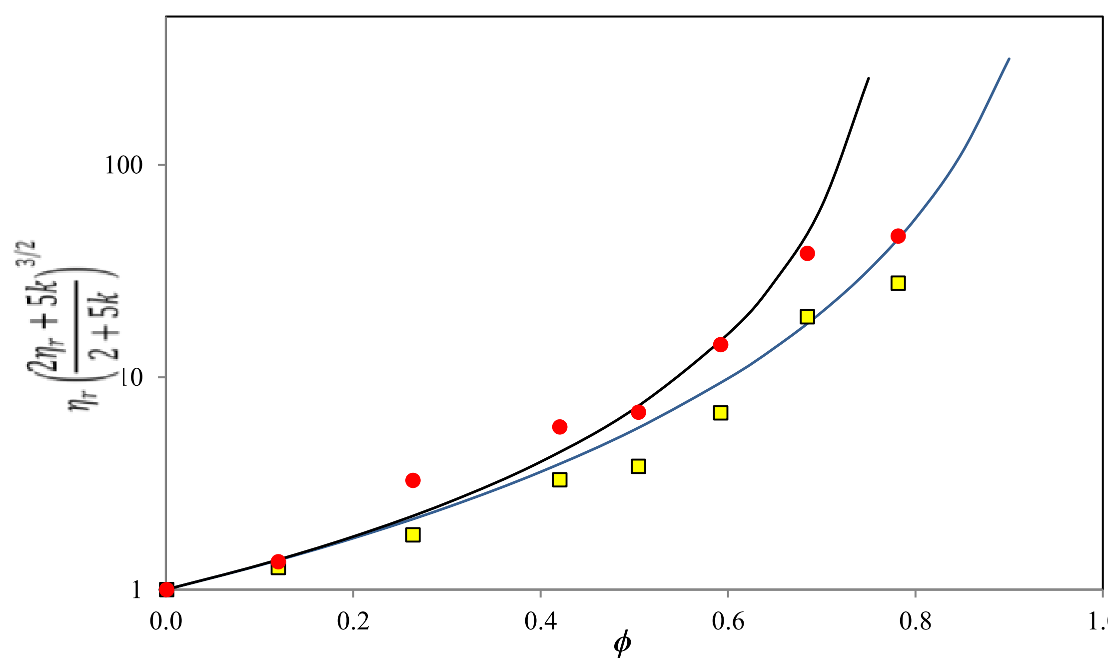


Figure 4-17. Pal equation [——] and Phan-Thien and Pham equation [——] RHS values for emulsions of glycerol-rich drops in pentanol-rich liquid compared with LHS calculated using experimental data at 250 Hz [□] and 50 Hz [●] for 70°C to 40°C

The Pal equations requires fitting of data using ϕ_m values. The author suggests use of ϕ_m as 0.74 wherever not available and also points to the range of ϕ_m values for emulsions as 0.68-0.86.[74] Bound shown in Figures 4-18 and 4-19 is obtained when ϕ_m values of 0.68 and 0.86 are used for the above data.

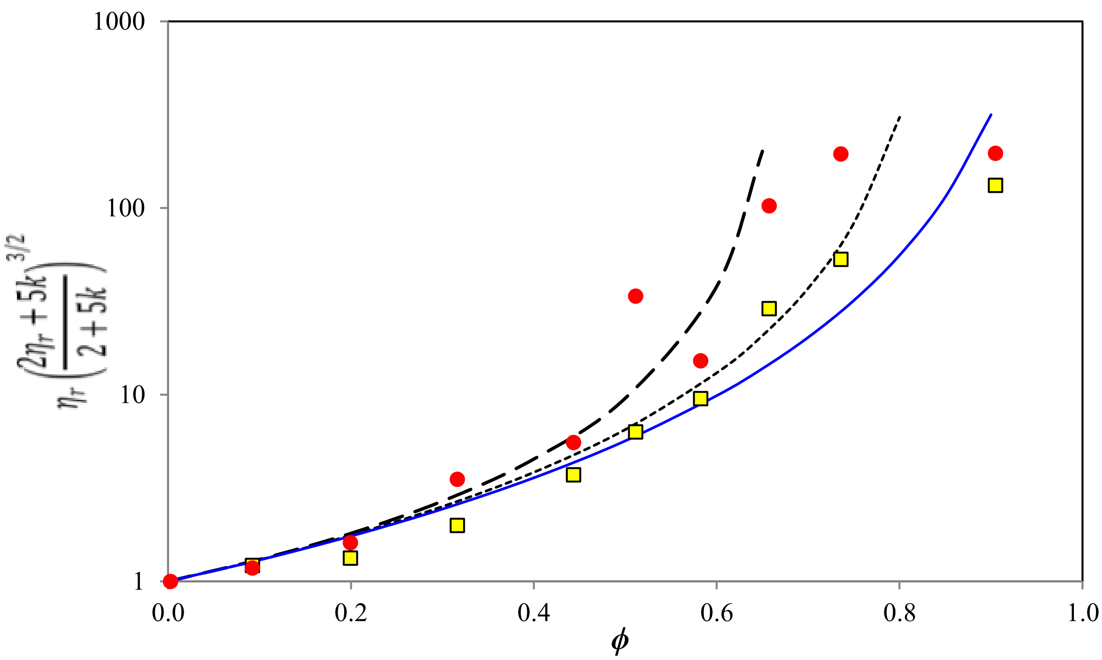


Figure 4-18. Pal equation upper [— —] and lower [-----] bounds and Phan-Thien and Pham equation [——] RHS values for emulsions of glycerol-rich drops in pentanol-rich liquid compared with LHS calculated using experimental data at 250 Hz [□] and 50 Hz [●] for 70°C to 20°C

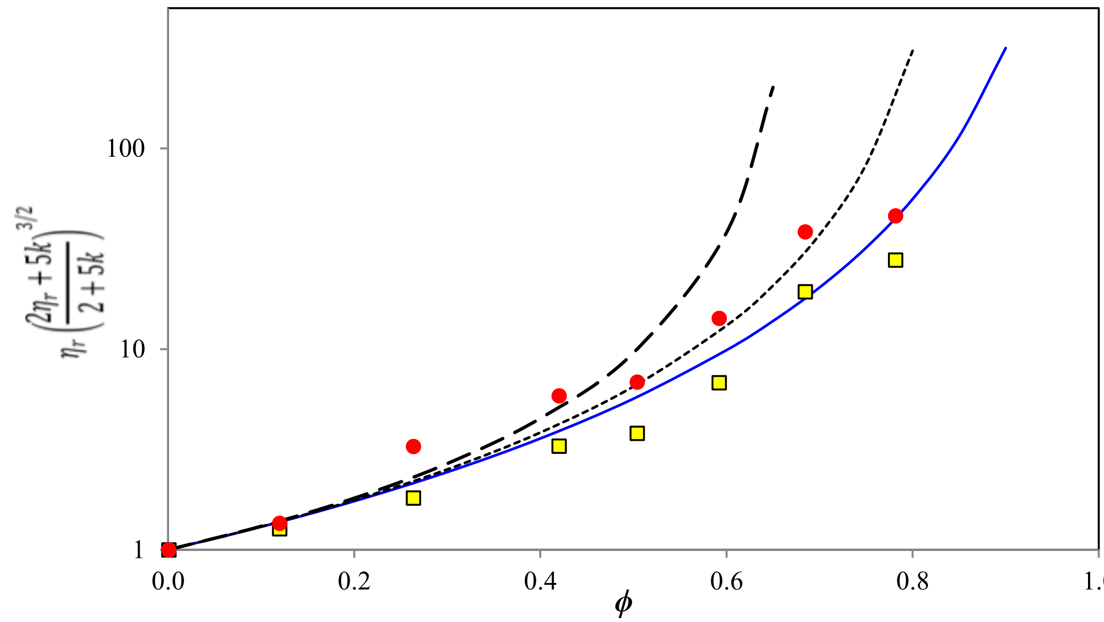


Figure 4-19. Pal equation upper [— —] and lower [-----] bounds and Phan-Thien and Pham equation [——] RHS values for emulsions of glycerol-rich drops in pentanol-rich liquid compared with LHS calculated using experimental data at 250 Hz [□] and 50 Hz [●] for 70°C to 40°C

4.4 General Discussion

The key observations of the present study can be summarized into the following points.

- **Saturated phase viscosities provide lower and upper limits for viscosity in the two-phase region**

Figures 4-5 a-c depict the peak viscosity values attained by emulsions. The peak viscosity values remain lower than the values of the saturated more viscous phase. Local peaks arise at 0.50 phase volume fraction, but do not exceed the viscosity of the saturated glycerol rich phase. Commonly used correlations for emulsion viscosity do not account for this behaviour. Correlations predict maximum viscosity values higher than saturation values as shown in Figures (4-12 – 4-15) and as evident from the literature.[75]

- **Inconsistent predictions of viscosity blending correlations**

The equations employed in commercial software tend to over predict the viscosity of emulsions (Thomas equation) or to predict qualitatively inconsistent trends (Woelflin equation). The Phan-Thien, and Pham and Pal equations predict qualitatively correct trends and the predicted values are closer to experimental data in the range of applicability of the equations. Pal equation follows the viscosity trend for lower shear rate viscosity at both temperatures but is unable to account for sudden increase in viscosity at 0.50 volume fraction. Figures 4-18 and 4-19, demonstrate the upper and lower bounds for Pal equation and how the Phan-Thien and Pham equations predict lower values compared to the Pal equation. The lower predictions of the Phan-Thien and Pham equations suggest that they can be applied to the mixtures in this work. Further the upper and lower bounds for the Pal equation capture almost all values for the experimental results and underscore the importance of drop viscosity and interactions for determining two-phase mixture viscosity.

- **Shear thinning behaviour of mixture at all compositions**

The two-phase mixtures in this study show shear thinning behavior for low dispersed phase volume fraction. This behavior is expected.[76] The correlations tested in this work (Pal and Phan-Thien and Pham) are applicable to fluids with low capillary numbers and therefore give better results at low shear values. Other correlations developed for higher capillary number fluids have limited applicability and require surface tension and drop size measurements to be applied.[77]

- **Apparent viscosity increase after phase separation and its implications**

As mixtures separate into their larger scale phase domains, the viscosity values show convergence toward viscosity values approaching those of the continuous phase. As a consequence, within the two-phase region phase separation can lead to a large range of apparent viscosities at a fixed global composition. This phenomenon has been observed in heavy oil studies where multiphase or emulsion flow was observed[19,31,32,78–81]. For example, two Industry VAPEX pilot projects reported failures with oil production rates of 1-10 m^3/day.[79,80] VAPEX relies on injection of pure solvent into the reservoir thus exposing the oil to high concentration of solvents. Occurrence of such emulsions stabilized by asphaltene precipitation could lead to lower oil recoveries. Butler et al[81] also observed increased asphaltene precipitation for solvent concentrations above 50% leading to reduced recovery further reinforcing the speculations. For an ES-SAGD field test, where the concentration of solvent used was between 4-8 volume%,[78] positive to “less interesting” productivity boosts were obtained.[82] At these low volume percent of solvent two-phase behavior is avoided, allowing for viscosity reductions. Stratified flow of oil and solvent phases with an interface immobilized by asphaltene may also reduce production rates.[50] by inhibiting heat transfer to an oil layer. For VAPEX processes in particular, the impact of the rheological and other impacts of the two-phase region must be considered.

- **Uncertainty in viscosity at constant composition and shear dependence**

At 0.50 phase volume fraction, mixtures show a broad range of viscosities as seen in Figures 4-5 a-c, particularly at lower shear rates or after a period of rest. These observations are important in the context of oil sand transport and highlight the uncertainty of continuous phase at 0.50 phase volume fractions. Oil in water and self lubricated transport employ the encapsulation method where the water phase is continuous and encapsulates the oil phase leading to an overall reduction in apparent viscosity.[59] If the solvent rich phase acts as dispersed phase in a non-Newtonian oil phase, the drops move toward the axis of flow making a layer of bitumen on the wall of pipelines.[60,83,84] The impact of bitumen layer on pipeline walls is already shown to cause increased fouling in pipeline walls[85]. These impacts have been studied with respect to water + oil flows to develop water assisted flow technology. Addition of another component (solvent) to this system could have unknown and unwanted effects. For example, this could break of oil in water emulsions or increase bitumen migration to walls leading to increased fouling, reduced life and increased operational costs[86]. Ternary mixtures of Athabasca bitumen + toluene + water[87] exhibit phase order inversion among other phenomena with toluene addition. This effect alone could impact phase distributions in production and transport environments.

- **Emulsion stability and possible consequences**

The results obtained in the present study are for unstable emulsions, which form bi-continuous/layered emulsions over time as shown in Figure 4-6 a-d. Applications investigated previously include numerous components. For such cases the emulsions formed are expected to be more stable, for model molecular mixtures, colloid + liquid mixtures,[50] and reservoir related fluids where asphaltenes as colloids or molecules stabilize emulsions[78]. Chung and Butler[16] found that water in oil emulsions found in produced oil have high viscosities, greater than the viscosity of oil itself.[75,88] In the VAPEX process solvent concentrations are expected to be high enough to reach the liquid-liquid region,[79–81,3] and asphaltene precipitation is expected. Asphaltene accumulation at oil-water interfaces stops water drops from coalescing and stabilizes emulsions.

None of these observed and potential impacts are included in conventional viscosity models for hydrocarbon production and transport applications.

4.5 Summary

Thermophysical properties of glycerol + pentanol and glycerol + water mixtures are presented. The results of rheological experiments of these mixtures were studied and impacts of phase distribution at steady state and their redistribution with time (at fixed composition and temperature) in response to fixed shear and variable shear environments are compared. Phase density measurements provided a basis for the comparison of measured rheological properties with emulsion models, and buoyancy driven impacts over time. They also provided better understanding of the physics of two-phase mixtures in diverse industrial environments where transitions from single phase to two-phase fluids arise. The key observations of present study are discussed with references to the literature and reflections on industrial implications are presented.

Chapter 5: Conclusions and Future Work

An apparatus was assembled, and atmospheric pressure proof of concept experiments were performed concerning the thermophysical properties and rheological responses of glycerol + pentanol mixtures, which exhibit both single and two-phase liquid behavior. These data were benchmarked using known behaviours of closely related single-phase glycerol + water mixtures. The apparatus can be used to explore a broad range of applications at atmospheric pressure, and with modifications presented below can be used to explore high-pressure cases of industrial interest.

5.1 Main Conclusions and Significance

One key finding of this work is that the apparent viscosities within the two-phase region for glycerol + pentanol mixtures are bounded by the viscosities of the individual saturated liquid phases. Apparent viscosities orders of magnitude greater than either of the two saturated liquid phases were anticipated: where the relative phase volumes are comparable and emulsions tend to form, and near the upper critical end point (UCTP) where the interfacial tension goes to zero and emulsions are expected to be more stable. The absence of this effect is significant and impacts both the flow and modelling of fluid flow in related industrially relevant environments.

This outcome supports the industrial practice of basing viscosities of multiphase reservoir fluids on "averaged" properties of mixture components. However, viscosity equations available in commercial software packages appear to yield order of magnitude differences from experimental values. Better predictions are obtained using correlations incorporating dispersed phase properties.

A second key finding of this work is that the apparent viscosity of a two-phase liquid mixture may differ significantly at fixed composition and temperature depending on which liquid phase is continuous. This implies that there is irreducible uncertainty of the flow properties of such mixtures irrespective of other details of the flow environment, in the absence of fluid specific knowledge.

5.2 Future Experimental Work and Recommended Equipment Upgrades

In order to work directly with two or multiphase mixtures with industrial relevance, such as mixtures of carbon dioxide + bitumen or liquid propane + bitumen envisioned in solvent aided production processes[4–8], the equipment must be adapted to operate at high-pressure. Exploring apparent viscosity impacts of L=V and L=L critical points, where interfacial tension goes to zero in such mixtures also requires fine control over composition and operating conditions (pressure and temperature). Proposed equipment modifications that would facilitate such studies are presented in Figure 5-1

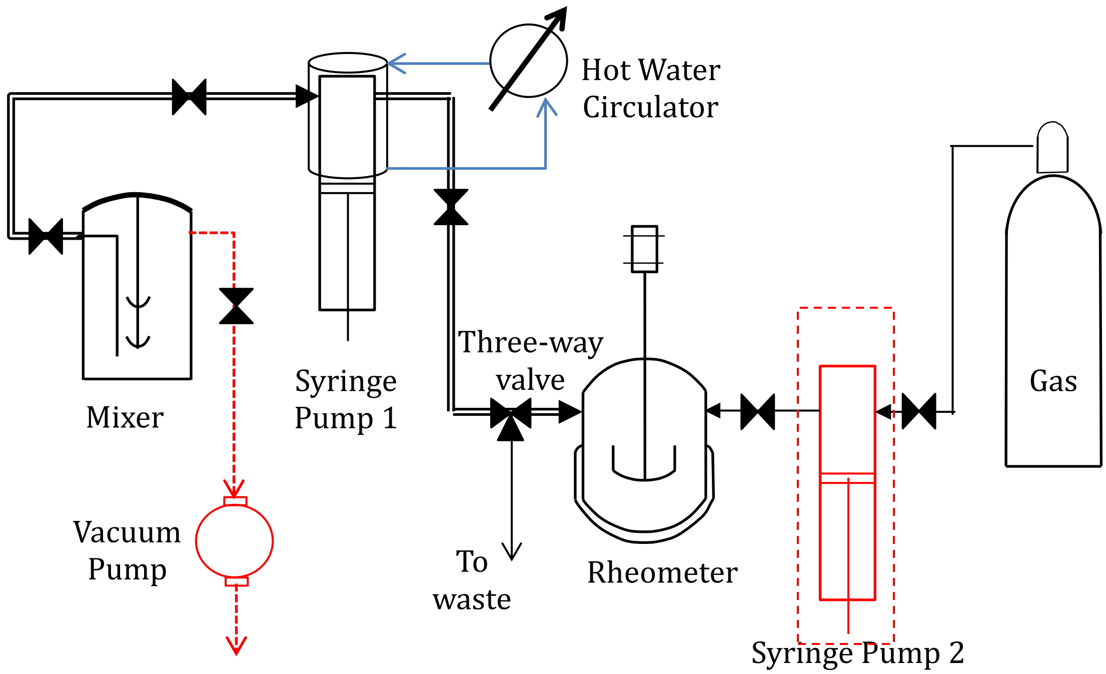


Figure 5-1. Experimental setup developed in this work. (==) Double lines indicate insulated and heated tubes. (---) Dashed red lines indicate additional possible arrangements or equipment additions.

Syringe pump 2 is suggested as an upgrade for more precise pressure control for mixtures under pressure and in cases where precise pressure variation is required at fixed temperature and global composition. With flexible connections, syringe pump 2 would be used to take care of other gas functions too. It could be connected to the gas outlet of the mixer instead of the present connection of syringe pump 1 to the liquid outlet to inject gas in the vapor space of mixer without the need of bubbling the gas through liquid sample. This would ensure no unwanted mixing of gas occurs in the sample before mixing is started.

Operating procedure modification following equipment upgrade:

As the major change is only the introduction of syringe pump 2, which operates similar to syringe pump 1, no additional safety features need to be installed. The only important addition to safety concerns is working with liquefied gases or supercritical gases such as propane and carbon dioxide. The maximum anticipated operating pressure with these gases (~ 80 bar) is well below 150 bar (the operating range of the present apparatus, set by the rheometer). The safety features already in place are adequate. Further, the maximum operating pressure can also be set by the pump. It is currently set at 100 bar. However, this maximum permissible pressure can be adjusted to ensure that the rheometer pressure never approaches 150 bar.

To liquefy gases with a high vapor pressure such as carbon dioxide or other gases and to saturate liquids with them in the upgraded apparatus, the following steps are required. The pump and the mixer valves are kept in their closed positions and gas is fed to the pump. A glycol-water mixture from the cooling circuit cools the pump. Once the pressure stabilizes, and the pump cylinder is filled with the required amount of liquefied gas, it can be transferred to the mixer.

To saturate liquids with gases in the mixer, gases can be introduced into the mixer from both the vacuum pump outlet and/or the liquid outlet. Syringe pump 2 has a flexible outlet, which can be connected either to the rheometer or mixer gas outlet. All the previous works (discussed in chapter 3) reported the bubbling of the gas from the liquid inlet, which is dipped inside the liquid. Using the gas outlet as an inlet, the gas and liquid can stay separate until the start of mixing, which helps control composition.

Supercritical states can also be important. For such cases, the syringe pump is filled to a maximum of 500 mL with carbon dioxide, for example, at a desired constant pressure. Syringe pump 2, can be discharged directly to the rheometer, providing precise pressure set points.

➢ Protocol for High Pressure:

At high pressure, steps 1 to 10 (Chapter 3, Section 3.2) are followed without modification.

1-10. Same as at atmospheric pressure.

1. The pump is filled with a condensable gas (e.g., propane or butane) and the temperature is set below the LV to L boundary at the pressure of interest. Once the gas is liquefied, the required volume is pumped into the mixer and mixed according to atmospheric protocol in step 7.
2. As the mixture is ready, the rest of the setup, the pump and the rheometer are maintained at the same pressure as the mixer pressure. The mixture pressure is then increased by 3 bar (with mixing stopped) to induce flow.
3. With the three-way valve, the inlet pump and outlet valves are kept open while the mixture liquid outlet valve is kept closed. Once the pressure in the mixer is 3 bar higher than the pressure at the downstream components, the outlet valve is opened and the sample flows to the three-way valve.

4. The three-way valve is opened to the rheometer for 2-5 seconds while monitoring the pressure and then closed again. The rheometer is then depressurized and checked for liquid. This is done until drops of liquid sample appear inside the rheometer pressure cell.
5. Once liquid reaches the rheometer, the three-way valve is closed and the pump is filled (25 mL) at 5-10 mL/min. The rheometer cell is then cleaned, sealed and re-pressurized to the mixer pressure, and prepared to receive sample. The atmospheric protocol described in step 12, Section 3.2 is applied.
6. Approximately 17.4 mL of liquid is pumped into the rheometer using the dispense mode of syringe pump 1 while the syringe pump 2 is used to maintain, increase or decrease the pressure as required. In this case 17.4 mL of liquid is pumped instead of 18 mL as the tubing connecting the three-way valve to rheometer is already filled with saturated liquid and thus its volume is subtracted. (18 mL volume as explained in section 3.2, step 15 includes 0.64 mL of curved tubing connecting the three-way valve to rheometer + 1.3 mL of rheometer inside tubing + 16 mL sample volume)
7. Atmospheric protocol step 16, section 3.2 is then followed. Changes can be made to the program in Table 3-1 as per requirement; Table 3-1 follows change in temperature and can be modified to study pressure change.

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Appendices

Appendix.1 Supplementary data

Table S-1. Glycerol viscosity value reproducibility at 20°C and 50 Hz (expected value 1372 ± 20 mPa.s[54])

Time (min)	Glycerol 100% (Test 1)		Glycerol 100% (Test 2)	
	Temperature (°C)	Viscosity (mPa.s)	Temperature (°C)	Viscosity (mPa.s)
0.2	69.9	50.3	69.9	49.5
0.3	68.9	53	68.8	50.8
0.5	67.3	50.9	67.2	53.4
0.7	65.8	51.6	65.7	52.6
0.8	64.3	53.5	64.2	53
1	63	56.8	62.9	55.5
1.2	61.7	56.9	61.7	55.7
1.3	60.6	60.8	60.5	57.9
1.5	59.5	63.2	59.4	60.6
1.7	58.4	64.1	58.4	61.8
1.8	57.4	64.1	57.4	65
2	56.5	66.1	56.5	67.7
2.2	55.6	70	55.6	68.9
2.3	54.7	72.4	54.7	72.9
2.5	53.9	74.6	53.9	74.6
2.7	53.1	77.4	53.1	77.1
2.8	52.3	80	52.4	79.7
3	51.6	82.8	51.6	82.9
3.2	50.9	86.9	50.9	85.8
3.3	50.2	90.3	50.2	89.6
3.5	49.6	95	49.6	92.4
3.7	48.9	97.1	49	96.1
3.8	48.3	100	48.3	99.9
4	47.7	105	47.7	103
4.2	47.1	106	47.2	107
4.3	46.5	110	46.6	112
4.5	46	113	46	115
4.7	45.4	118	45.5	119
4.8	44.9	123	45	123
5	44.4	129	44.4	128
5.2	43.9	132	43.9	132
5.3	43.4	138	43.4	138
5.5	42.9	141	42.9	142
5.7	42.4	145	42.5	148
5.8	41.9	149	42	151
6	41.5	154	41.5	157
6.2	41	160	41.1	161
6.3	40.6	164	40.6	166
6.5	40.2	169	40.2	172
6.7	39.7	175	39.8	178
6.8	39.3	181	39.3	183
7	38.9	186	38.9	191
7.2	38.5	192	38.5	194

7.3	38.1	198	38.1	200
7.5	37.7	205	37.7	208
7.7	37.3	212	37.3	213
7.8	36.9	218	36.9	219
8	36.5	225	36.5	226
8.2	36.1	232	36.2	233
8.3	35.7	238	35.8	241
8.5	35.4	245	35.4	246
8.7	35	253	35.1	253
8.8	34.6	260	34.7	260
9	34.3	268	34.3	268
9.2	33.9	275	34	277
9.3	33.6	284	33.6	283
9.5	33.2	292	33.3	292
9.7	32.9	300	32.9	299
9.8	32.6	309	32.6	308
10	32.2	317	32.3	318
10.2	31.9	326	32	325
10.3	31.6	335	31.6	334
10.5	31.3	344	31.3	343
10.7	31	354	31	352
10.8	30.6	363	30.7	362
11	30.3	372	30.4	371
11.2	30	385	30.1	382
11.3	29.7	392	29.8	392
11.5	29.4	402	29.5	402
11.7	29.1	413	29.2	415
11.8	28.8	423	28.9	424
12	28.5	434	28.6	435
12.2	28.3	445	28.3	446
12.3	28	456	28	458
12.5	27.7	467	27.7	471
12.7	27.4	478	27.4	482
12.8	27.1	490	27.1	495
13	26.9	501	26.9	506
13.2	26.6	514	26.6	520
13.3	26.3	526	26.3	533
13.5	26.1	538	26.1	545
13.7	25.8	551	25.8	559
13.8	25.5	564	25.5	572
14	25.3	577	25.3	587
14.2	25	591	25	601
14.3	24.8	604	24.8	614
14.5	24.5	618	24.5	630
14.7	24.3	633	24.3	645
14.8	24	647	24	658
15	23.8	662	23.8	674
15.2	23.5	677	23.5	690
15.3	23.3	693	23.3	706
15.5	23.1	708	23.1	723
15.7	22.8	724	22.8	738
15.8	22.6	740	22.6	754
16	22.4	756	22.4	774
16.2	22.1	773	22.1	789
16.3	21.9	790	21.9	806
16.5	21.7	807	21.7	824

16.7	21.5	825	21.5	842
16.8	21.2	843	21.2	860
17	21	861	21	879
17.2	20.8	880	20.8	898
17.3	20.6	899	20.6	917
17.5	20.4	917	20.4	937
17.7	20.2	937	20.2	957
17.8	20	956	20	977
18	19.8	976	19.8	998
18.2	19.6	995	19.6	1017
18.3	19.4	1015	19.4	1039
18.5	19.3	1035	19.3	1059
18.7	19.2	1054	19.2	1078
18.8	19	1073	19.1	1098
19	19	1092	19	1117
19.2	18.9	1110	18.9	1135
19.3	18.9	1127	18.9	1152
19.5	18.9	1142	19	1168
19.7	19	1157	19	1182
19.8	19.1	1169	19.1	1196
20	19.2	1179	19.2	1207
20.2	19.3	1188	19.3	1216
20.3	19.4	1197	19.4	1225
20.5	19.5	1205	19.5	1232
20.7	19.5	1212	19.5	1240
20.8	19.6	1217	19.6	1246
21	19.6	1223	19.6	1251
21.2	19.7	1229	19.7	1256
21.3	19.7	1233	19.7	1262
21.5	19.8	1238	19.8	1266
21.7	19.8	1242	19.8	1270
21.8	19.8	1247	19.8	1275
22	19.8	1251	19.8	1278
22.2	19.8	1255	19.8	1283
22.3	19.8	1259	19.9	1287
22.5	19.9	1262	19.9	1290
22.7	19.9	1266	19.9	1294
22.8	19.9	1269	19.9	1297
23	19.9	1273	19.9	1300
23.2	19.9	1276	19.9	1305
23.3	19.9	1279	19.9	1308
23.5	19.9	1282	19.9	1310
23.7	19.9	1285	19.9	1313
23.8	19.9	1288	19.9	1315
24	19.9	1291	19.9	1319
24.2	19.9	1294	19.9	1322
24.3	19.9	1297	19.9	1324
24.5	19.9	1299	19.9	1327
24.7	19.9	1302	19.9	1330
24.8	19.9	1304	19.9	1332
25	19.9	1307	19.9	1335
25.2	19.9	1309	19.9	1336
25.3	19.9	1311	19.9	1338
25.5	20	1314	20	1341
25.7	20	1316	20	1343
25.8	20	1318	20	1345

26	20	1320	20	1347
26.2	20	1322	20	1349
26.3	20	1324	20	1350
26.5	20	1325	20	1352
26.7	20	1328	20	1354
26.8	20	1329	20	1356
27	20	1331	20	1357
27.2	20	1333	20	1359
27.3	20	1334	20	1361
27.5	20	1336	20	1361
27.7	20	1337	20	1363
27.8	20	1338	20	1365
28	20	1339	20	1366
28.2	20	1341	20	1367
28.3	20	1342	20	1369
28.5	20	1343	20	1370
28.7	20	1345	20	1371
28.8	20	1346	20	1372
29	20	1347	20	1373
29.2	20	1348	20	1374
29.3	20	1349	20	1377
29.5	20	1350	20	1376
29.7	20	1351	20	1378
29.8	20	1353	20	1378
30	20	1353	20	1379
30.2	20	1354	20	1380
30.3	20	1355	20	1382
30.5	20	1355	20	1382
30.7	20	1356	20	1383
30.8	20	1357	20	1384
31	20	1358	20	1385
31.2	20	1359	20	1385
31.3	20	1361	20	1386
31.5	20	1360	20	1387
31.7	20	1361	20	1387
31.8	20	1362	20	1388
32	20	1363	20	1390
32.2	20	1364	20	1390
32.3	20	1365	20	1390
32.5	20	1365	20	1390
32.7	20	1365	20	1391
32.8	20	1366	20	1391
33	20	1366	20	1392
33.2	20	1367	20	1394
33.3	20	1368	20	1393
33.5	20	1368	20	1394
33.7	20	1370	20	1395
33.8	20	1369	20	1395
34	20	1370	20	1396
34.2	20	1370	20	1398
34.3	20	1372	20	1397
34.5	20	1374	20	1398
34.7	20	1373	20	1397
34.8	20	1372	20	1399
35	20	1375	20	1398
35.2	20	1373	20	1400

35.3	20	1373	20	1401
35.5	20	1375	20	1400
35.7	20	1376	20	1400
35.8	20	1376	20	1401
36	20	1376	20	1401
36.2	20	1377	20	1403
36.3	20	1377	20	1402
36.5	20	1376	20	1403
36.7	20	1378	20	1403
36.8	20	1377	20	1403
37	20	1378	20	1404
37.2	20	1378	20	1404
37.3	20	1380	20	1405
37.5	20	1378	20	1405
37.7	20	1379	20	1406
37.8	20	1380	20	1405
38	20	1380	20	1405
38.2	20	1380	20	1406
38.3	20	1381	20	1410
38.5	20	1380	20	1409
38.7	20	1381	20	1407
38.8	20	1383	20	1408
39	20	1383	20	1409
39.2	20	1383	20	1409
39.3	20	1382	20	1409
39.5	20	1382	20	1409
39.7	20	1383	20	1409
39.8	20	1383	20	1409
40	20	1384	20	1410
40.2	20	1383	20	1410
40.3	20	1384	20	1411
40.5	20	1384	20	1411
40.7	20	1384	20	1410
40.8	20	1385	20	1411
41	20	1384	20	1411
41.2	20	1385	20	1411
41.3	20	1385	20	1411
41.5	20	1386	20	1414
41.7	20	1386	20	1411
41.8	20	1386	20	1412
42	20	1386	20	1412
42.2	20	1385	20	1412
42.3	20	1386	20	1413
42.5	20	1388	20	1413
42.7	20	1386	20	1414
42.8	20	1386	20	1413
43	20	1386	20	1413
43.2	20	1386	20	1414
43.3	20	1387	20	1414
43.5	20	1387	20	1414
43.7	20	1386	20	1415
43.8	20	1389	20	1415
44	20	1387	20	1414
44.2	20	1387	20	1415
44.3	20	1387	20	1415
44.5	20	1389	20	1416

44.7	20	1389	20	1417
44.8	20	1387	20	1415
45	20	1387	20	1416
45.2	20	1388	20	1416
45.3	20	1389	20	1417
45.5	20	1388	20	1416
45.7	20	1388	20	1420
45.8	20	1387	20	1416
46	20	1387	20	1417
46.2	20	1389	20	1416
46.3	20	1390	20	1417
46.5	20	1388	20	1420
46.7	20	1388	20	1417
46.8	20	1387	20	1417
47	20	1389	20	1417
47.2	20	1389	20	1417
47.3	20	1387	20	1418
47.5	20	1387	20	1418
47.7	20	1388	20	1417
47.8	20	1388	20	1419
48	20	1390	20	1418
48.2	20	1388	20	1418
48.3	20	1389	20	1418
48.5	20	1390	20	1418
48.7	20	1389	20	1420
48.8	20	1389	20	1418
49	20	1388	20	1419
49.2	20	1389	20	1419
49.3	20	1388	20	1419
49.5	20	1389	20	1419
49.7	20	1390	20	1418
49.8	20	1389	20	1419
50	20	1389	20	1419

Table S-2. Cannon Standard S600 viscosity reproducibility at 250 Hz and 50 Hz (supplier certified value 1464 mPa.s)

Datapoint	**Viscosity Cannon S600 at 20°C (mPa.s)**			
	250 Hz		**50 Hz**	
	Run 1	**Run 2**	**Run 1**	**Run 2**
1	1497	1495	1528	1528
2	1497	1495	1528	1528
3	1495	1497	1528	1528
4	1494	1494	1532	1529
5	1498	1495	1528	1530
6	1494	1495	1528	1529
7	1494	1495	1530	1532
8	1494	1497	1526	1531
9	1494	1494	1531	1532
10	1496	1494	1529	1532
11	1497	1496	1530	1528
12	1496	1494	1529	1533
13	1495	1495	1531	1528
14	1494	1494	1529	1531

15	1496	1495	1529	1531
16	1498	1494	1529	1530
17	1494	1494	1526	1533
18	1497	1496	1530	1528
19	1495	1494	1535	1530
20	1495	1494	1527	1528
21	1497	1495	1527	1527
22	1494	1494	1529	1528
23	1495	1494	1530	1532
24	1494	1494	1531	1531
25	1494	1494	1527	1530
26	1494	1496	1526	1533
27	1494	1494	1528	1528
28	1495	1494	1534	1530
29	1496	1497	1526	1530
30	1494	1494	1529	1527
31	1496	1495	1531	1530
32	1494	1495	1531	1532
33	1495	1494	1531	1530
34	1495	1494	1527	1531
35	1494	1494	1527	1528
36	1495	1494	1530	1536
37	1495	1494	1530	1527
38	1494	1494	1528	1531
39	1496	1495	1528	1533
40	1494	1494	1529	1529
41	1495	1495	1529	1533
42	1495	1495	1527	1528
43	1494	1495	1531	1533
44	1495	1497	1529	1533
45	1494	1494	1532	1530
46	1496	1495	1529	1529
47	1496	1495	1530	1528
48	1494	1494	1532	1536
49	1495	1495	1529	1530
50	1494	1494	1531	1529
51	1495	1495	1527	1528
52	1495	1494	1528	1535
53	1493	1494	1528	1532
54	1495	1495	1531	1528
55	1494	1494	1530	1532
56	1494	1495	1531	1531
57	1496	1495	1527	1532
58	1494	1494	1527	1532
59	1495	1495	1528	1530
60	1495	1494	1529	1529

Table S-3. Viscosity values of Cannon Standard S600 for different loading volume at 250 Hz and 50 Hz (supplier certified value 1464 mPa.s)

Datapoint	Viscosity Cannon S600 at 20°C					
	250 Hz			50 Hz		
	15 mL	16 mL	17 mL	15 mL	16 mL	17 mL
1	1499	1497	1501	1513	1528	1543
2	1498	1497	1501	1514	1528	1534
3	1498	1495	1500	1515	1528	1535
4	1497	1494	1503	1524	1532	1540
5	1497	1498	1500	1516	1528	1539
6	1496	1494	1501	1514	1528	1543
7	1495	1494	1501	1532	1530	1542
8	1495	1494	1500	1517	1526	1536
9	1494	1494	1500	1518	1531	1544
10	1495	1496	1500	1517	1529	1538
11	1495	1497	1503	1517	1530	1536
12	1494	1496	1500	1530	1529	1540
13	1494	1495	1500	1522	1531	1545
14	1493	1494	1502	1517	1529	1540
15	1493	1496	1500	1517	1529	1537
16	1493	1498	1500	1520	1529	1537
17	1493	1494	1501	1520	1526	1535
18	1492	1497	1501	1522	1530	1544
19	1492	1495	1500	1520	1535	1535
20	1492	1495	1502	1523	1527	1537
21	1491	1497	1501	1525	1527	1542
22	1491	1494	1501	1532	1529	1539
23	1491	1495	1501	1520	1530	1543
24	1491	1494	1501	1522	1531	1548
25	1491	1494	1500	1522	1527	1541
26	1491	1494	1500	1522	1526	1538
27	1491	1494	1500	1526	1528	1542
28	1491	1495	1501	1520	1534	1547
29	1490	1496	1501	1521	1526	1539
30	1491	1494	1500	1526	1529	1547
31	1491	1496	1501	1527	1531	1534
32	1491	1494	1501	1521	1531	1539
33	1490	1495	1502	1520	1531	1539
34	1490	1495	1504	1521	1527	1536
35	1491	1494	1503	1524	1527	1542
36	1491	1495	1501	1533	1530	1546
37	1490	1495	1501	1522	1530	1546
38	1490	1494	1501	1525	1528	1552
39	1490	1496	1502	1532	1528	1540
40	1490	1494	1500	1525	1529	1538
41	1490	1495	1500	1525	1529	1549
42	1489	1495	1502	1527	1527	1548
43	1489	1494	1500	1522	1531	1537
44	1489	1495	1500	1531	1529	1548
45	1489	1494	1500	1533	1532	1544
46	1490	1496	1500	1522	1529	1547
47	1490	1496	1502	1525	1530	1548
48	1489	1494	1501	1525	1532	1549
49	1489	1495	1501	1526	1529	1545

50	1489	1494	1503	1525	1531	1538
51	1489	1495	1501	1523	1527	1543
52	1489	1495	1500	1526	1528	1543
53	1489	1493	1501	1531	1528	1541
54	1493	1495	1501	1525	1531	1540
55	1489	1494	1502	1522	1530	1539
56	1489	1494	1500	1523	1531	1541
57	1489	1496	1503	1521	1527	1538
58	1489	1494	1500	1526	1527	1536
59	1489	1495	1500	1524	1528	1540
60	1489	1495	1504	1526	1529	1540

Table S-4. Viscosity values of glycerol for different loading volume at 250 Hz and 50 Hz (expected value 1372 ± 20 mPa.s[54])

Datapoint	Viscosity Glycerol at 20°C (mPa.s)					
	250 Hz			50 Hz		
	15 mL	16 mL	17 mL	15 mL	16 mL	17 mL
1	1402	1402	1406	1432	1429	1430
2	1401	1402	1406	1434	1431	1431
3	1401	1402	1406	1435	1431	1431
4	1401	1402	1406	1434	1432	1432
5	1401	1402	1406	1435	1432	1432
6	1401	1402	1406	1435	1432	1433
7	1401	1402	1406	1433	1432	1433
8	1401	1402	1406	1435	1433	1433
9	1401	1402	1406	1434	1432	1433
10	1401	1402	1406	1434	1432	1433
11	1401	1402	1406	1435	1432	1433
12	1401	1402	1406	1435	1432	1433
13	1401	1402	1406	1435	1433	1433
14	1401	1402	1406	1435	1433	1433
15	1401	1402	1406	1434	1433	1434
16	1401	1402	1406	1435	1433	1433
17	1401	1402	1406	1435	1433	1433
18	1401	1402	1406	1434	1433	1434
19	1401	1402	1406	1435	1434	1434
20	1401	1402	1406	1435	1433	1434
21	1401	1402	1406	1435	1434	1434
22	1401	1402	1406	1436	1433	1434
23	1401	1402	1406	1435	1434	1434
24	1401	1402	1406	1435	1435	1434
25	1401	1402	1406	1435	1434	1434
26	1401	1402	1406	1435	1433	1434
27	1401	1402	1406	1434	1434	1434
28	1401	1402	1406	1434	1433	1434
29	1401	1402	1406	1435	1433	1434
30	1401	1402	1406	1435	1433	1434
31	1401	1402	1406	1436	1434	1434
32	1401	1402	1406	1435	1433	1434
33	1401	1402	1406	1434	1434	1434
34	1401	1402	1406	1434	1434	1434
35	1401	1402	1406	1434	1434	1434
36	1401	1402	1406	1434	1434	1434

37	1401	1402	1406	1434	1433	1435
38	1401	1402	1406	1434	1434	1435
39	1401	1402	1406	1434	1434	1435
40	1401	1402	1406	1435	1434	1434
41	1401	1402	1406	1434	1434	1434
42	1401	1402	1406	1434	1434	1435
43	1401	1402	1406	1434	1434	1435
44	1401	1402	1406	1434	1434	1435
45	1401	1401	1406	1434	1434	1435
46	1401	1402	1406	1434	1434	1435
47	1401	1402	1406	1434	1434	1435
48	1401	1402	1406	1434	1434	1436
49	1401	1401	1406	1434	1434	1436
50	1401	1401	1406	1434	1434	1436
51	1401	1401	1406	1434	1434	1437
52	1401	1401	1406	1434	1435	1436
53	1401	1401	1406	1434	1434	1436
54	1401	1402	1406	1434	1435	1436
55	1401	1402	1406	1433	1434	1436
56	1401	1402	1406	1434	1434	1436
57	1401	1402	1406	1433	1434	1436
58	1401	1402	1406	1433	1434	1436
59	1401	1402	1406	1433	1434	1436
60	1401	1402	1406	1432	1435	1437

Table S-5. Viscosity values for mixtures of glycerol + pentanol at 250 Hz and 50 Hz and for glycerol + water at 250 Hz in the temperature range 70°C-20°C (100%-20% glycerol by weight percent)

Time (min)	Temp. (°C)	1 Glycerol Viscosity (mPa.s)		0.95 Glycerol Viscosity (mPa.s)			0.90 Glycerol Viscosity (mPa.s)		
		G+P 250 Hz	G+P 50 Hz	G+P 250 Hz	G+P 50 Hz	G+W 250 Hz	G+P 250 Hz	G+P 50 Hz	G+W 250 Hz
0.2	69.8	52.5	49.5	40.6	42.1	26.7	35.7	32.9	15.7
0.3	68.6	52.5	50.8	41.1	42.6	26.8	36.1	33.1	15.8
0.5	67	53.2	53.4	41.6	42.4	27.2	36.2	35.9	15.9
0.7	65.4	54.2	52.7	41.5	44.2	27.6	36.8	34.2	16.1
0.8	64	55.4	53.1	42.4	45.1	28.1	37.4	34.7	16.5
1	62.6	56.9	55.6	44.1	45.2	28.8	38.4	35.7	16.8
1.2	61.4	58.7	55.7	44.8	47.3	29.5	39.6	36.4	17.2
1.3	60.2	60.5	58	46.3	48	30.3	40.3	37.5	17.6
1.5	59.1	62.3	60.7	47.2	49.4	31.1	41.4	38.9	18.1
1.7	58.1	64.5	61.9	48.8	51.2	32.1	42.6	40.0	18.5
1.8	57.1	66.5	65	50.4	51.9	33.1	43.8	41.1	19.0
2	56.1	68.9	67.7	51.8	54.3	34.1	45.2	42.5	19.6
2.2	55.2	71.3	68.9	53.5	56	35.2	46.5	43.8	20.2
2.3	54.4	73.7	72.9	55.2	56.7	36.2	48.3	45.1	20.7
2.5	53.6	76.5	74.6	57.1	59.6	37.4	49.7	46.6	21.3
2.7	52.8	79.1	77.1	59.1	61.4	38.6	51.3	48.0	21.9
2.8	52	82.1	79.8	60.7	63.1	39.8	53.0	49.8	22.5
3	51.3	85.1	83	62.7	66.2	41.1	54.6	51.8	23.1
3.2	50.6	88.3	85.9	65.5	67.7	42.4	56.6	53.5	23.8
3.3	49.9	91.4	89.6	67.1	69.8	43.7	58.5	55.5	24.5
3.5	49.2	94.6	92.4	69.3	73	45.2	60.3	57.5	25.2

3.7	48.6	98	96.2	71.6	75.3	46.6	62.0	59.8	25.9
3.8	48	101	100	74.1	78	48.1	64.4	62.4	26.7
4	47.4	105	103	76.6	80.7	49.6	66.5	64.6	27.4
4.2	46.8	108	107	79	83	51.1	68.8	66.8	28.2
4.3	46.2	113	112	81.7	86.3	52.7	70.7	68.5	29.0
4.5	45.6	116	115	84.3	89.1	54.4	72.9	70.7	29.7
4.7	45.1	120	119	87.1	91.7	55.9	75.5	72.8	30.6
4.8	44.6	125	123	89.9	95.4	57.6	77.8	76.7	31.4
5	44	129	127	92.7	98.5	59.5	80.3	76.5	32.2
5.2	43.5	133	132	95.8	101	61.2	82.3	79.0	33.1
5.3	43	138	137	99.1	105	63.1	84.6	81.5	34.0
5.5	42.5	144	142	102	109	65	87.1	84.0	34.9
5.7	42	149	148	105	113	66.9	89.4	86.3	35.9
5.8	41.6	154	151	108	117	68.8	92.0	88.7	36.8
6	41.1	159	157	112	120	70.8	94.6	91.2	37.7
6.2	40.6	164	161	115	124	72.9	97.2	94.1	38.7
6.3	40.2	170	166	119	129	74.9	100	97.1	39.7
6.5	39.8	175	172	123	132	77.1	103	99.6	40.7
6.7	39.3	180	178	126	136	79.2	106	103	41.7
6.8	38.9	186	183	130	141	81.5	109	106	42.7
7	38.5	192	191	135	145	83.9	112	109	43.8
7.2	38	198	194	138	150	86.2	116	113	45.0
7.3	37.6	204	201	142	156	88.5	119	116	46.1
7.5	37.2	211	208	147	159	91	123	120	47.2
7.7	36.8	217	213	151	167	93.5	127	124	48.4
7.8	36.4	224	219	155	169	96	131	128	49.5
8	36	231	227	159	174	98.7	136	133	50.7
8.2	35.7	238	233	164	179	101	140	137	52.0
8.3	35.3	245	241	169	184	104	145	142	53.2
8.5	34.9	252	246	173	189	107	149	147	54.4
8.7	34.5	260	253	178	195	110	154	152	55.7
8.8	34.2	267	260	183	201	113	159	157	57.0
9	33.8	276	268	188	207	116	164	163	58.4
9.2	33.4	284	277	194	213	118	168	167	59.7
9.3	33.1	292	283	199	219	122	173	172	61.1
9.5	32.7	300	292	204	225	125	178	177	62.5
9.7	32.4	309	299	210	232	128	183	182	63.9
9.8	32.1	318	308	216	237	131	188	187	65.4
10	31.7	327	318	221	245	134	193	192	66.9
10.2	31.4	336	325	227	251	138	199	197	68.3
10.3	31.1	345	334	233	258	141	204	203	69.8
10.5	30.7	355	343	239	265	144	210	208	71.4
10.7	30.4	365	352	245	272	148	215	214	72.9
10.8	30.1	375	362	252	279	152	221	221	74.5
11	29.8	385	372	258	288	155	227	227	76.2
11.2	29.5	396	382	265	295	159	233	233	77.8
11.3	29.2	407	392	272	302	163	239	240	79.5
11.5	28.9	418	403	279	311	167	245	245	81.2
11.7	28.6	429	415	286	319	171	251	251	82.9
11.8	28.3	440	425	293	327	175	257	258	84.6
12	28	452	435	300	336	179	264	263	86.4
12.2	27.7	464	447	307	343	183	270	270	88.2
12.3	27.4	476	458	315	353	187	277	277	90.0
12.5	27.1	488	471	322	362	191	284	284	91.9
12.7	26.8	501	482	330	370	196	291	291	93.7
12.8	26.5	513	495	338	380	200	298	298	95.7

13	26.3	526	506	347	389	205	305	305	97.7
13.2	26	540	520	355	399	209	312	313	99.6
13.3	25.7	553	533	363	409	214	319	320	102
13.5	25.4	566	545	372	418	219	327	327	104
13.7	25.2	581	559	380	429	224	334	336	106
13.8	24.9	595	572	389	439	229	342	343	108
14	24.6	609	587	398	449	234	350	351	110
14.2	24.4	624	601	408	460	239	358	360	112
14.3	24.1	639	614	417	471	244	366	367	114
14.5	23.9	655	630	426	482	249	374	376	116
14.7	23.6	670	645	436	494	254	382	385	119
14.8	23.4	686	658	446	505	260	391	393	121
15	23.1	702	675	456	516	265	399	401	123
15.2	22.9	718	690	466	528	271	408	410	125
15.3	22.7	735	706	476	540	276	417	418	128
15.5	22.4	752	723	486	552	282	426	427	130
15.7	22.2	769	738	497	565	288	435	436	133
15.8	21.9	787	754	508	577	294	444	445	135
16	21.7	804	774	518	590	300	453	454	137
16.2	21.5	822	789	530	603	306	463	464	140
16.3	21.3	841	806	541	616	312	472	474	142
16.5	21	859	824	552	629	318	481	483	145
16.7	20.8	878	842	564	643	324	491	493	148
16.8	20.6	897	860	575	656	331	501	503	150
17	20.4	916	879	587	671	337	511	513	153
17.2	20.2	936	898	599	685	344	521	522	156
17.3	20	956	917	612	699	351	531	533	158
17.5	19.8	976	937	624	714	357	541	543	161
17.7	19.6	996	957	637	729	364	552	553	164
17.8	19.4	1016	977	649	744	371	563	562	167
18	19.3	1036	998	662	759	378	574	573	169
18.2	19.2	1056	1017	674	774	385	584	584	172
18.3	19.1	1075	1039	687	789	392	595	593	175
18.5	19	1093	1059	699	803	399	607	604	178
18.7	19	1111	1078	711	817	406	617	614	180
18.8	19	1128	1098	723	832	412	628	623	183
19	19	1142	1117	734	845	418	636	632	185
19.2	19.1	1156	1135	744	858	424	647	641	188
19.3	19.1	1168	1152	754	869	430	656	651	190
19.5	19.2	1179	1168	762	880	435	663	658	192
19.7	19.3	1188	1182	770	889	439	671	663	193
19.8	19.4	1196	1196	776	897	443	677	673	195
20	19.5	1203	1207	782	904	447	677	684	196
20.2	19.6	1210	1216	787	910	450	674	686	197
20.3	19.6	1216	1225	792	917	453	663	682	198
20.5	19.7	1221	1232	796	921	455	639	673	199
20.7	19.7	1226	1240	800	928	457	642	683	200
20.8	19.7	1232	1246	803	930	459	684	688	201
21	19.8	1236	1251	807	934	461	708	683	201
21.2	19.8	1241	1256	810	938	463	720	692	202
21.3	19.8	1245	1262	813	942	464	727	696	203
21.5	19.8	1249	1266	815	945	466	732	702	203
21.7	19.8	1253	1270	818	948	467	737	705	204
21.8	19.9	1257	1275	821	952	468	740	706	204
22	19.9	1261	1278	823	954	470	744	697	205
22.2	19.9	1264	1283	826	957	471	747	699	205

22.3	19.9	1268	1287	828	960	472	750	705	206
22.5	19.9	1271	1290	830	963	473	752	705	206
22.7	19.9	1275	1294	832	965	475	755	704	207
22.8	19.9	1278	1297	834	967	476	757	700	207
23	19.9	1280	1300	836	970	477	760	713	207
23.2	19.9	1284	1305	838	972	478	762	738	208
23.3	19.9	1286	1308	840	974	479	764	760	208
23.5	19.9	1288	1310	842	976	480	766	760	209
23.7	19.9	1291	1313	844	978	481	767	761	209
23.8	19.9	1294	1315	845	980	482	768	757	209
24	19.9	1297	1319	847	983	483	771	747	210
24.2	19.9	1299	1322	849	985	483	771	763	210
24.3	19.9	1301	1324	850	986	484	772	759	210
24.5	19.9	1304	1327	851	988	485	775	759	211
24.7	19.9	1306	1330	853	990	486	777	767	211
24.8	20	1308	1332	854	992	487	777	774	211
25	20	1310	1335	856	993	487	778	780	212
25.2	20	1312	1336	857	995	488	780	781	212
25.3	20	1314	1338	858	996	489	781	782	212
25.5	20	1315	1341	860	998	490	783	789	212
25.7	20	1317	1343	861	999	490	784	790	213
25.8	20	1319	1345	863	1001	491	786	792	213
26	20	1321	1347	864	1002	491	786	790	213
26.2	20	1322	1349	865	1003	492	787	789	213
26.3	20	1324	1350	866	1005	493	788	795	214
26.5	20	1326	1352	867	1006	493	790	797	214
26.7	20	1327	1354	868	1007	494	792	806	214
26.8	20	1328	1356	869	1008	494	792	807	214
27	20	1330	1357	870	1009	495	793	804	214
27.2	20	1332	1359	871	1010	495	794	804	215
27.3	20	1332	1361	871	1012	496	795	807	215
27.5	20	1334	1361	872	1013	496	795	807	215
27.7	20	1335	1363	873	1014	497	795	806	215
27.8	20	1336	1365	874	1015	497	797	807	215
28	20	1337	1366	875	1016	498	799	807	216
28.2	20	1338	1367	876	1017	498	801	807	216
28.3	20	1340	1369	876	1018	498	801	807	216
28.5	20	1341	1370	877	1018	499	801	808	216
28.7	20	1341	1371	878	1019	499	801	814	216
28.8	20	1343	1372	878	1020	500	802	814	216
29	20	1344	1373	879	1021	500	803	820	216
29.2	20	1345	1374	880	1022	500	805	820	217
29.3	20	1346	1377	880	1023	501	805	819	217
29.5	20	1347	1376	881	1024	501	805	818	217
29.7	20	1348	1378	882	1025	501	805	821	217
29.8	20	1349	1378	882	1025	502	806	819	217
30	20	1349	1379	883	1026	502	806	818	217
30.2	20	1350	1380	883	1027	502	806	820	217
30.3	20	1351	1382	884	1027	502	806	821	218
30.5	20	1351	1382	884	1028	503	807	820	218
30.7	20	1352	1383	885	1029	503	808	823	218
30.8	20	1353	1384	886	1030	503	808	822	218
31	20	1354	1385	886	1030	504	808	822	218
31.2	20	1355	1385	887	1031	504	809	820	218
31.3	20	1355	1386	887	1031	504	810	814	218
31.5	20	1356	1387	888	1032	504	811	822	218

31.7	20	1357	1387	888	1032	505	811	823	218
31.8	20	1357	1388	889	1033	505	811	824	218
32	20	1358	1390	889	1034	505	811	823	219
32.2	20	1358	1390	890	1034	505	810	823	219
32.3	20	1359	1390	890	1035	506	811	821	219
32.5	20	1360	1390	891	1035	506	813	827	219
32.7	20	1360	1391	891	1036	506	813	825	219
32.8	20	1361	1391	891	1036	506	814	829	219
33	20	1361	1392	892	1037	506	814	829	219
33.2	20	1362	1394	892	1037	507	814	828	219
33.3	20	1363	1393	892	1038	507	814	828	219
33.5	20	1363	1394	893	1038	507	815	837	219
33.7	20	1364	1395	893	1038	507	815	839	220
33.8	20	1364	1395	894	1039	507	815	837	220
34	20	1365	1396	894	1039	508	816	831	220
34.2	20	1365	1398	894	1040	508	816	831	220
34.3	20	1366	1397	894	1040	508	817	831	220
34.5	20	1366	1398	895	1041	508	818	835	220
34.7	20	1367	1397	895	1041	508	818	836	220
34.8	20	1367	1399	896	1042	508	818	827	220
35	20	1368	1398	896	1042	509	818	835	220
35.2	20	1368	1400	896	1042	509	818	838	220
35.3	20	1368	1401	897	1043	509	819	845	220
35.5	20	1368	1400	897	1043	509	821	847	220
35.7	20	1369	1400	897	1043	509	821	846	220
35.8	20	1370	1401	898	1044	509	820	850	220
36	20	1370	1401	898	1044	510	821	849	220
36.2	20	1370	1403	898	1044	510	821	845	220
36.3	20	1371	1402	899	1045	510	821	847	220
36.5	20	1371	1403	899	1045	510	822	847	221
36.7	20	1372	1403	899	1045	510	822	843	221
36.8	20	1372	1403	899	1046	510	823	844	221
37	20	1372	1404	899	1046	510	824	839	221
37.2	20	1373	1404	900	1048	511	823	837	221
37.3	20	1373	1405	900	1047	511	824	835	221
37.5	20	1373	1405	900	1048	511	824	829	221
37.7	20	1374	1406	901	1048	511	825	831	221
37.8	20	1374	1405	901	1048	511	825	837	221
38	20	1374	1405	901	1049	511	825	837	221
38.2	20	1375	1406	901	1050	511	826	845	221
38.3	20	1375	1410	902	1049	511	826	846	221
38.5	20	1375	1409	901	1050	511	826	843	221
38.7	20	1376	1407	902	1050	512	825	844	221
38.8	20	1376	1408	902	1050	512	826	847	221
39	20	1377	1409	902	1050	512	827	849	221
39.2	20	1377	1409	902	1051	512	826	849	221
39.3	20	1377	1409	903	1051	512	827	846	221
39.5	20	1377	1409	903	1051	512	827	849	221
39.7	20	1377	1409	903	1051	512	828	849	222
39.8	20	1378	1409	903	1052	513	827	849	222
40	20	1378	1410	904	1052	513	827	849	222
40.2	20	1378	1410	903	1053	513	828	849	222
40.3	20	1379	1411	904	1053	513	828	844	222
40.5	20	1379	1411	904	1053	513	829	846	222
40.7	20	1379	1410	904	1053	513	828	845	222
40.8	20	1379	1411	904	1053	513	829	838	222

41	20	1380	1411	904	1054	513	830	842	222
41.2	20	1380	1411	905	1054	513	830	848	222
41.3	20	1380	1411	905	1054	513	830	846	222
41.5	20	1381	1414	905	1055	514	830	846	222
41.7	20	1381	1411	905	1055	514	831	840	222
41.8	20	1381	1412	905	1055	514	831	852	222
42	20	1381	1412	906	1056	514	832	862	222
42.2	20	1381	1412	906	1056	514	831	868	222
42.3	20	1381	1413	906	1056	514	832	868	222
42.5	20	1382	1413	907	1056	514	833	870	222
42.7	20	1382	1414	907	1056	514	832	866	222
42.8	20	1382	1413	907	1056	514	832	868	222
43	20	1383	1413	906	1056	514	833	869	222
43.2	20	1383	1414	907	1056	514	833	862	222
43.3	20	1383	1414	907	1057	515	833	860	222
43.5	20	1383	1414	907	1057	515	833	860	222
43.7	20	1384	1415	907	1057	515	835	861	222
43.8	20	1384	1415	907	1058	515	834	858	222
44	20	1384	1414	907	1058	515	835	860	222
44.2	20	1384	1415	908	1058	515	835	859	222
44.3	20	1385	1415	908	1059	515	835	864	223
44.5	20	1385	1416	908	1058	515	835	866	223
44.7	20	1385	1417	908	1058	515	836	863	223
44.8	20	1386	1415	908	1058	515	836	862	223
45	20	1385	1416	909	1058	515	837	858	223
45.2	20	1385	1416	909	1059	515	837	857	223
45.3	20	1386	1417	909	1059	515	837	857	223
45.5	20	1386	1416	909	1059	515	838	857	223
45.7	20	1386	1420	909	1059	515	839	859	223
45.8	20	1386	1416	909	1060	516	840	857	223
46	20	1387	1417	910	1060	516	840	856	223
46.2	20	1387	1416	910	1060	516	840	861	223
46.3	20	1387	1417	910	1060	516	840	857	223
46.5	20	1387	1420	910	1060	516	840	858	223
46.7	20	1387	1417	910	1060	516	839	860	223
46.8	20	1387	1417	910	1061	516	839	860	223
47	20	1387	1417	910	1061	516	839	857	223
47.2	20	1388	1417	910	1061	516	840	856	223
47.3	20	1388	1418	910	1061	516	840	853	223
47.5	20	1388	1418	910	1061	516	841	857	223
47.7	20	1388	1417	911	1061	516	841	855	223
47.8	20	1388	1419	911	1061	516	840	857	223
48	20	1389	1418	911	1061	517	841	856	223
48.2	20	1389	1418	911	1061	517	841	866	223
48.3	20	1389	1418	911	1061	517	842	868	223
48.5	20	1390	1418	912	1062	517	841	869	223
48.7	20	1390	1420	912	1062	517	842	871	223
48.8	20	1389	1418	911	1062	517	842	868	223
49	20	1390	1419	911	1062	517	843	869	223
49.2	20	1390	1419	912	1062	517	842	870	223
49.3	20	1390	1419	912	1062	517	843	866	223
49.5	20	1390	1419	912	1062	517	844	866	223
49.7	20	1390	1418	912	1062	517	844	863	223
49.8	20	1391	1419	912	1062	517	844	856	223
50	20	1391	1419	913	1062	517	844	857	223

0.80 Glycerol Viscosity (mPa.s)			0.75 Glycerol Viscosity (mPa.s)			0.70 Glycerol Viscosity (mPa.s)		
G+P 250 Hz	G+P 50 Hz	G+W 250 Hz	G+P 250 Hz	G+P 50 Hz	G+W 250 Hz	G+P 250 Hz	G+P 50 Hz	G+W 250 Hz
24.1	28.6	6.7	19.4	16.6	5.5	16.9	12.6	3.4
24.3	30.0	6.8	19.4	20.0	5.4	16.8	11.9	3.5
24.7	29.3	6.8	19.3	17.6	5.4	17.1	12.1	3.6
25.0	29.7	6.9	19.7	16.8	5.3	17.7	12.8	3.6
25.5	31.0	6.9	20.0	17.3	5.6	17.9	12.3	3.5
26.2	31.0	7.0	20.5	18.1	5.8	18.1	12.8	3.6
26.7	32.4	7.3	21.2	18.2	6.0	18.6	13.2	3.6
27.5	33.4	7.4	21.6	18.5	5.9	19.7	13.3	3.8
28.3	33.8	7.5	22.2	18.7	5.9	19.8	14.0	3.7
29.1	35.3	7.8	23.1	22.5	6.0	20.3	14.7	4.0
30.0	36.4	8.1	23.8	21.0	6.1	21.0	16.8	4.3
30.9	38.1	8.1	24.6	21.7	6.2	22.0	16.1	4.6
31.9	39.5	8.3	25.5	22.9	6.4	22.4	16.7	4.5
33.1	40.4	8.6	26.3	23.5	6.4	23.1	17.4	4.4
34.2	41.7	8.8	27.3	25.3	6.5	23.8	18.6	4.7
35.7	43.8	8.8	28.2	25.9	6.6	25.3	19.1	4.4
37.2	44.9	9.1	29.0	26.8	6.8	25.2	20.2	4.6
39.0	46.4	9.4	30.0	28.4	6.8	25.6	20.8	4.8
40.7	48.8	9.6	30.9	29.8	7.0	26.3	21.9	4.9
42.4	50.0	9.8	31.9	30.7	7.1	27.3	23.4	5.0
44.5	51.6	10.1	32.6	32.1	7.2	28.8	24.6	5.0
46.4	53.7	10.4	33.6	33.3	7.8	28.6	25.5	5.2
48.2	55.0	10.6	34.8	34.4	8.0	29.6	26.5	5.5
50.0	57.4	10.8	36.0	36.1	8.0	30.8	27.7	5.6
51.9	62.3	11.2	37.1	37.4	8.3	32.0	28.5	5.4
53.8	61.1	11.4	38.4	38.5	8.3	32.9	30.1	5.9
55.7	64.0	11.5	39.5	39.5	8.6	33.9	30.8	5.9
57.6	66.0	11.8	40.8	41.1	9.0	35.0	32.0	5.7
59.5	68.0	12.1	41.9	43.9	9.0	36.0	33.4	5.9
61.4	71.4	12.4	43.0	45.4	9.3	37.1	33.8	6.0
63.4	73.4	12.5	44.6	48.3	9.5	38.0	35.0	6.3
65.5	75.6	12.8	46.0	53.0	9.6	38.6	34.9	6.3
67.6	79.4	13.2	47.3	52.8	9.8	39.8	35.9	6.2
69.8	81.7	13.6	48.0	54.9	10.1	41.3	37.7	6.4
71.9	85.0	13.8	50.4	55.9	10.2	41.9	39.1	6.5
74.1	88.6	14.1	52.1	53.7	10.4	42.9	40.1	6.7
76.4	91.9	14.4	53.8	54.2	10.5	44.1	40.8	7.0
78.3	95.4	14.7	55.4	54.1	10.9	45.4	42.0	7.2
76.7	98.9	14.9	57.1	52.3	10.9	46.1	42.9	7.2
79.3	102	15.3	58.9	57.4	11.1	47.0	45.3	7.3
82.7	108	15.6	61.5	57.7	11.3	48.4	48.3	7.4
86.1	109	16.1	63.8	59.9	11.6	49.8	49.7	7.5
89.3	112	16.3	66.0	60.3	11.7	50.8	50.7	7.7
90.6	116	16.6	66.5	60.6	11.9	51.9	51.1	7.7
91.1	120	17.1	68.7	64.8	12.1	53.4	49.7	7.8
93.8	124	17.4	71.2	63.6	12.3	54.3	53.2	8.0
98.8	128	17.6	73.6	60.8	12.4	55.0	51.3	8.2
103	132	18.0	76.8	62.6	12.7	55.8	51.2	8.1
107	136	18.4	79.1	61.2	12.9	57.1	52.8	8.5
108	140	18.6	80.7	62.9	13.1	58.0	52.8	8.5

112	144	19.0	83.7	66.6	13.3	59.0	53.3	8.7
112	149	19.4	84.7	75.2	13.4	59.5	54.6	8.8
114	153	19.9	89.9	80.9	13.7	61.1	54.3	9.0
119	156	20.3	92.9	95.8	14.1	62.3	54.0	9.2
124	161	20.5	94.9	95.4	14.2	63.8	54.7	9.3
130	166	21.0	98.7	89.3	14.3	64.7	55.6	9.4
135	169	21.5	100	85.1	14.6	64.9	54.1	9.7
137	175	21.7	104	85.6	14.9	66.3	53.0	9.9
141	179	22.1	106	88.9	15.3	65.4	50.7	10.0
145	183	22.6	110	90.2	15.6	65.0	48.9	10.1
148	188	23.0	113	89.6	15.8	65.7	48.9	10.2
149	193	23.3	114	90.7	16.1	66.6	48.8	10.5
155	197	23.7	114	90.6	16.3	66.5	49.0	10.7
162	202	24.2	119	95.5	16.7	66.6	49.7	10.8
164	207	24.7	122	96.6	16.9	66.8	50.4	11.0
161	212	25.1	125	97.5	17.1	66.3	51.9	11.2
168	217	25.6	129	99.3	17.5	64.7	52.7	11.4
172	224	26.1	130	98.6	17.6	64.6	50.9	11.6
178	226	26.5	130	98.8	17.9	65.0	53.2	11.8
185	231	26.8	132	99.0	18.3	65.4	54.3	12.0
189	234	27.3	135	97.1	18.5	66.1	53.4	12.1
192	238	27.9	140	101	18.8	66.7	53.2	12.3
186	243	28.2	145	102	19.0	67.1	53.0	12.6
189	245	28.7	149	104	19.3	67.4	53.1	12.8
193	251	29.2	152	103	19.6	68.7	54.8	13.0
200	255	29.8	152	102	19.8	68.9	55.1	13.2
206	259	30.2	156	100	20.3	69.5	55.1	13.4
212	262	30.7	157	103	20.4	70.5	56.1	13.6
216	264	31.2	164	104	20.8	71.2	57.0	13.7
212	267	31.7	166	108	21.0	72.0	57.9	13.9
206	267	32.0	166	112	21.3	72.9	58.2	14.2
211	274	32.6	162	116	21.6	73.7	58.0	14.4
219	285	33.3	163	117	21.8	74.4	59.6	14.6
217	280	33.8	167	122	22.2	75.2	60.4	14.6
223	294	34.4	171	124	22.5	76.2	60.6	14.8
227	292	34.9	173	124	22.7	76.8	62.5	15.0
232	311	35.4	176	125	23.2	77.7	63.3	15.2
240	323	36.0	180	128	23.5	78.6	64.4	15.4
247	320	36.6	184	130	23.9	79.3	67.0	15.7
246	325	37.1	186	135	24.1	79.9	68.1	15.9
243	329	37.7	185	137	24.4	80.6	69.8	16.0
247	334	38.3	185	140	24.8	80.8	71.4	16.3
252	342	38.8	181	145	25.2	80.7	71.5	16.5
261	352	39.3	182	147	25.5	81.6	71.8	16.7
270	361	40.0	183	145	25.8	81.7	73.9	16.9
279	369	40.6	186	143	26.2	82.7	77.0	17.2
287	373	41.2	185	143	26.4	82.8	79.9	17.4
295	385	41.8	187	145	26.6	83.2	79.8	17.6
299	383	42.4	191	142	27.1	83.6	82.6	17.8
304	361	43.1	194	150	27.5	84.1	84.2	18.0
309	318	43.7	197	157	27.8	84.6	84.9	18.2
313	323	44.3	197	167	28.2	85.1	83.2	18.5
317	332	45.0	202	175	28.6	85.7	81.2	18.7
322	341	45.6	204	183	28.9	86.4	82.7	18.9
329	390	46.1	206	188	29.2	87.1	85.2	19.1
338	383	46.9	206	196	29.6	87.5	87.4	19.3

344	421	47.5	211	198	29.9	88.2	88.0	19.6
328	437	48.2	214	203	30.2	88.9	89.9	19.9
332	471	48.9	217	215	30.5	89.5	92.3	20.2
338	496	49.5	220	213	30.8	89.8	93.3	20.2
342	516	50.2	223	226	31.4	90.2	94.7	20.5
350	529	50.7	227	233	31.7	90.6	96.9	20.7
358	537	51.3	229	233	32.1	91.1	98.7	20.9
361	545	51.9	232	225	32.2	91.5	100	21.0
367	582	52.6	234	212	32.6	91.6	102	21.2
371	583	52.9	235	209	32.9	91.7	104	21.3
374	577	53.3	236	200	33.0	92.0	106	21.5
377	582	53.8	237	196	33.3	92.0	107	21.6
380	588	54.2	239	198	33.4	91.9	108	21.6
383	596	54.5	240	224	33.5	91.9	109	21.7
386	611	54.8	242	243	33.6	91.9	109	21.8
392	622	55.1	243	249	33.7	91.8	110	21.8
392	596	55.3	243	254	33.9	91.7	110	22.0
396	611	55.5	244	257	34.0	91.7	109	22.0
394	617	55.6	244	260	34.3	91.6	109	22.2
394	632	55.8	244	263	34.4	91.6	111	22.2
394	642	55.9	243	265	34.4	91.4	112	22.3
391	637	55.9	243	266	34.5	91.1	112	22.2
391	648	56.2	244	269	34.5	91.1	111	22.3
396	650	56.4	244	271	34.5	91.1	111	22.4
401	661	56.5	244	271	34.6	90.9	111	22.4
404	662	56.6	245	273	34.6	90.7	108	22.5
406	623	56.8	245	274	34.5	90.5	100	22.5
409	645	56.8	245	274	34.7	90.5	95.2	22.4
411	665	56.9	245	277	34.7	90.3	101	22.4
411	681	56.9	245	275	34.7	90.2	92.0	22.7
412	674	57.1	245	276	34.7	90.2	82.7	22.7
415	671	57.2	245	279	34.9	90.0	75.5	22.6
415	672	57.1	246	278	35.0	90.1	67.7	22.6
418	675	57.4	246	281	34.9	89.9	53.3	22.8
417	683	57.5	246	280	34.9	89.6	45.1	22.9
416	693	57.6	246	281	35.0	89.8	35.0	22.8
416	710	57.6	246	281	35.0	89.3	35.2	22.8
418	693	57.7	247	258	35.0	89.0	34.4	23.0
418	705	57.7	247	246	35.0	88.7	34.4	22.9
419	704	57.9	247	247	35.1	88.6	33.8	22.9
420	715	57.9	248	267	35.3	88.5	31.4	22.9
421	717	57.9	248	271	35.2	88.8	31.4	23.1
422	725	58.0	248	280	35.3	88.3	30.8	23.0
422	721	58.1	249	283	35.4	88.3	30.4	23.0
420	715	58.0	249	286	35.3	88.3	30.7	23.1
421	728	58.3	249	288	35.3	88.1	30.5	23.1
334	732	58.3	249	297	35.4	88.0	30.0	23.1
336	732	58.5	249	307	35.3	87.8	31.0	23.1
340	733	58.4	249	310	35.4	88.0	30.2	23.1
342	734	58.5	249	320	35.5	87.6	31.0	23.1
343	731	58.6	249	324	35.3	87.4	31.7	23.1
342	741	58.7	249	330	35.4	87.2	30.9	23.1
348	747	58.6	249	331	35.6	87.0	31.7	23.1
353	750	58.6	249	338	35.6	87.1	32.4	23.1
357	752	58.8	249	350	35.5	86.9	31.9	23.2
354	760	58.7	249	361	35.6	86.9	32.6	23.2

338	759	58.8	249	378	35.6	86.7	32.3	23.3
340	752	58.9	249	424	35.6	86.7	32.5	23.3
338	756	58.9	249	450	35.6	86.8	33.5	23.2
336	766	59.0	249	475	35.8	86.3	33.2	23.1
335	770	59.0	249	491	35.7	86.6	33.4	23.3
335	773	59.2	250	503	35.6	87.4	34.4	23.4
337	780	59.1	250	509	35.7	87.4	33.7	23.3
343	787	59.1	250	513	35.7	87.2	34.8	23.2
350	793	59.1	250	513	35.7	87.0	35.2	23.3
356	794	59.2	250	508	35.8	87.2	34.8	23.4
354	797	59.2	249	510	35.8	87.0	35.7	23.4
353	796	59.2	249	515	35.8	86.8	36.2	23.4
357	798	59.3	249	516	35.9	86.6	35.9	23.3
360	794	59.3	249	519	35.8	86.4	37.3	23.4
361	794	59.4	249	518	35.8	86.3	37.1	23.5
360	793	59.5	249	519	35.8	86.2	37.1	23.4
343	801	59.4	249	518	35.9	85.8	38.3	23.5
343	806	59.5	249	520	35.8	85.6	37.8	23.5
342	807	59.5	249	523	35.8	85.5	38.3	23.4
343	810	59.5	249	524	35.9	85.3	39.1	23.5
341	812	59.4	250	525	35.9	85.1	41.4	23.5
341	814	59.6	250	524	35.9	85.0	39.7	23.5
340	813	59.7	250	523	36.0	85.7	40.3	23.5
340	818	59.6	250	523	36.0	85.3	39.5	23.5
340	823	59.7	250	522	35.9	85.4	40.3	23.5
340	830	59.7	251	525	35.9	85.6	40.7	23.5
343	828	59.8	251	522	36.0	85.7	40.6	23.5
346	829	59.8	251	518	35.9	85.9	42.0	23.5
347	831	59.8	251	516	35.9	85.8	41.7	23.5
349	828	59.8	251	506	35.9	85.6	41.6	23.5
355	828	59.9	251	510	35.9	85.5	42.5	23.4
370	827	59.8	251	512	36.0	85.3	42.0	23.6
366	826	59.9	252	516	36.1	85.1	42.5	23.6
351	827	59.9	252	520	36.0	84.9	43.3	23.6
352	827	60.0	252	521	36.2	84.7	43.0	23.6
353	828	60.0	252	522	36.0	84.4	44.0	23.6
357	828	60.0	252	521	36.0	84.3	44.5	23.6
358	832	60.0	252	524	36.0	84.1	44.1	23.5
358	830	60.0	252	524	36.1	83.7	44.7	23.6
353	829	60.1	252	520	36.1	83.6	44.5	23.5
349	827	60.0	252	511	36.0	83.4	44.7	23.6
350	828	60.1	252	510	36.0	83.2	46.2	23.5
352	827	60.1	252	515	36.0	83.1	45.7	23.6
353	828	60.0	252	519	36.1	82.9	46.0	23.7
354	831	60.1	252	522	36.1	82.8	47.0	23.6
355	828	60.2	252	526	36.1	82.7	46.6	23.7
355	827	60.2	252	528	36.3	82.6	47.1	23.7
354	827	60.2	252	527	36.2	82.4	47.9	23.6
354	825	60.2	252	527	36.1	82.3	47.4	23.7
353	817	60.3	251	529	36.2	82.4	48.0	23.6
353	827	60.3	251	529	36.2	82.2	49.3	23.5
353	828	60.3	249	529	36.2	82.1	48.7	23.7
352	827	60.3	249	526	36.2	82.0	49.0	23.7
352	824	60.3	250	528	36.1	82.0	50.0	23.7
351	826	60.2	250	528	36.2	81.7	49.3	23.8
351	828	60.3	252	533	36.2	81.6	50.8	23.9

351	828	60.3	252	536	36.2	81.5	51.3	23.8
351	812	60.4	252	538	36.2	81.5	51.0	23.8
351	805	60.4	252	539	36.3	81.3	52.0	23.8
351	805	60.4	252	541	36.3	81.2	52.1	23.9
351	809	60.4	252	541	36.2	81.1	52.6	23.8
351	810	60.4	253	542	36.2	80.9	53.1	23.5
353	813	60.4	253	542	36.2	80.9	53.3	23.7
354	816	60.4	253	542	36.3	80.8	53.8	23.7
356	814	60.5	253	547	36.2	80.7	54.5	23.6
358	818	60.4	253	547	36.2	80.7	54.4	23.5
359	817	60.4	253	546	36.3	80.6	54.6	23.6
361	819	60.4	253	547	36.3	80.5	55.3	23.7
362	818	60.5	247	546	36.3	80.3	55.1	23.6
363	821	60.7	250	548	36.5	80.3	56.3	23.6
364	832	60.7	251	543	36.5	80.3	56.8	24.1
365	849	60.6	251	541	36.5	80.2	56.8	24.0
367	854	60.6	251	539	36.4	80.1	61.6	23.9
377	855	60.6	251	536	36.5	79.9	58.7	23.9
381	855	60.6	250	537	36.6	79.9	58.1	24.0
382	855	60.7	251	537	36.5	79.9	59.1	23.9
383	855	60.7	250	535	36.5	79.8	59.3	23.9
368	853	60.7	250	534	36.6	79.7	59.8	23.9
362	851	60.6	251	536	36.7	79.7	60.8	24.0
361	852	60.6	251	535	36.7	79.6	60.9	24.0
361	852	60.7	251	532	36.8	79.6	61.3	24.0
361	852	60.7	250	536	36.9	79.4	62.0	24.0
361	849	60.7	252	534	36.9	79.6	61.6	24.0
361	849	60.7	252	533	36.7	80.5	62.6	24.0
361	845	60.6	252	537	36.7	81.3	64.1	23.9
362	840	60.6	253	542	36.7	81.9	64.0	24.0
362	837	60.6	253	543	36.9	82.5	67.1	23.9
362	842	60.7	253	545	36.7	82.9	65.7	23.9
362	844	60.7	253	545	36.7	83.1	64.9	23.8
362	841	60.7	253	546	36.8	83.2	65.4	23.9
362	845	60.7	250	546	36.7	83.1	66.0	23.7
362	850	60.7	243	548	36.8	82.8	66.2	23.7
362	853	60.7	240	551	36.8	82.4	67.0	23.6
362	853	60.7	248	552	36.9	82.1	67.4	23.6
361	854	60.7	248	552	36.8	81.7	67.9	23.6
361	852	60.7	247	553	36.9	81.5	68.3	23.6
361	851	60.7	246	554	36.9	81.2	68.9	23.6
360	847	60.6	246	553	36.8	80.9	69.6	24.1
360	845	60.7	251	554	36.8	80.6	72.1	24.0
360	843	60.7	252	554	36.8	80.3	72.6	24.1
360	836	60.7	252	553	37.4	80.0	70.3	24.1
360	830	60.7	252	554	37.3	79.7	71.0	24.0
360	839	60.7	252	554	37.5	79.4	70.0	24.0
360	845	60.7	252	553	37.3	79.1	70.9	24.0
360	845	60.8	252	552	37.3	78.8	71.6	24.1
360	843	60.7	252	551	37.4	78.6	71.4	24.0
359	844	60.7	252	552	37.2	78.3	72.6	24.1
359	843	60.7	243	551	37.2	78.2	72.7	24.0
359	839	60.7	238	548	37.1	77.9	72.6	24.1
359	838	60.7	237	545	37.2	77.7	74.0	24.0
359	839	60.7	245	542	37.1	77.5	74.9	24.1
359	840	60.7	246	541	37.1	77.4	76.1	24.1

359	843	60.7	244	541	37.1	77.4	79.7	24.1
359	842	60.7	246	536	37.2	77.2	76.2	24.1
359	836	60.8	246	536	37.1	77.0	75.8	24.2
359	837	60.8	246	537	37.0	76.9	76.7	24.1
359	836	60.9	244	531	37.1	76.8	75.9	24.0
359	827	60.8	246	529	37.1	76.8	76.9	24.2
359	841	60.8	244	525	36.9	76.5	77.5	24.1
359	875	60.8	246	513	36.9	76.4	76.8	24.1
358	875	60.7	244	514	36.9	76.3	77.8	24.1
359	873	60.7	244	522	37.0	76.2	78.4	24.1
358	871	60.8	245	523	37.0	76.2	77.9	24.1
358	871	60.8	245	522	37.0	76.1	79.2	24.1
358	870	60.8	244	528	37.0	75.9	79.0	24.1
358	869	60.7	242	530	37.0	75.8	79.1	24.1
358	867	60.8	240	527	37.0	75.7	80.7	24.2
358	860	60.9	244	531	36.9	75.6	80.7	24.2
359	869	60.8	243	534	37.1	75.5	80.3	24.0
358	871	60.8	241	532	37.0	75.6	82.3	24.0
359	870	60.8	240	532	36.9	75.3	82.5	24.0
359	868	60.8	243	536	36.8	75.2	82.4	23.9
360	867	60.8	245	536	36.9	75.1	83.7	23.8
361	866	60.7	242	532	36.9	75.0	83.7	23.9
362	863	60.8	244	535	36.9	74.9	84.5	23.9
364	856	60.8	241	539	36.9	74.8	86.0	23.8
365	864	60.8	239	536	36.9	74.7	86.8	23.8
365	865	60.8	242	534	36.9	74.6	88.8	23.9

0.65 Glycerol			**0.60 Glycerol**			**0.50 Glycerol**		
Viscosity (mPa.s)			**Viscosity (mPa.s)**			**Viscosity (mPa.s)**		
G+P 250 Hz	**G+P 50 Hz**	**G+W 250 Hz**	**G+P 250 Hz**	**G+P 50 Hz**	**G+W 250 Hz**	**G+P 250 Hz**	**G+P 50 Hz**	**G+W 250 Hz**
13.6	9.6	2.1	11.3	8.9	1.4	7.2	8.5	1.6
13.7	9.9	2.2	11.1	9.8	1.4	7.2	4.6	1.7
13.8	9.8	2.2	11.2	9.2	1.3	7.2	4.7	1.5
14.1	9.9	2.2	11.3	10.0	1.3	7.4	5.3	1.5
14.3	10.5	2.3	11.6	9.1	1.3	7.4	5.0	1.6
14.5	10.6	2.4	11.9	9.7	1.4	7.7	6.2	1.6
15.1	10.9	2.4	12.0	11.5	1.4	7.6	5.8	1.6
15.4	11.3	2.3	12.2	10.4	1.4	7.8	5.2	1.7
15.7	11.5	2.5	12.5	10.9	1.5	8.0	8.2	1.6
16.2	12.6	2.6	12.9	10.7	1.6	8.3	5.7	1.5
16.6	12.9	2.6	13.2	11.2	1.7	8.5	5.4	1.5
17.2	13.5	2.7	13.5	12.5	1.9	8.6	6.3	1.6
17.6	14.3	2.7	14.1	12.3	1.9	8.7	6.5	1.5
18.2	15.0	2.8	14.7	12.5	2.0	8.9	7.8	1.5
18.7	15.5	2.8	15.1	13.0	2.1	9.1	6.9	1.4
19.1	16.3	2.9	15.4	14.5	2.1	9.4	6.5	1.5
19.6	16.7	3.0	15.7	14.1	2.1	9.6	7.7	1.5
20.0	17.8	3.1	15.9	14.2	2.3	9.7	7.2	1.6
20.4	19.1	3.3	16.3	14.9	2.4	9.9	7.3	1.6
21.3	20.0	3.1	16.6	16.5	2.4	10.2	7.8	1.6
21.4	20.9	3.3	17.0	16.3	2.5	10.4	7.7	1.7
21.7	22.4	3.3	17.3	18.9	2.5	10.8	7.9	1.7
22.2	23.3	3.4	17.7	19.1	2.5	10.8	8.7	1.6

22.9	24.7	3.4	18.0	21.1	2.5	11.0	10.7	1.8
23.3	26.1	3.6	18.2	19.9	2.6	11.3	9.0	1.8
23.7	26.8	3.7	18.7	22.3	2.6	11.4	9.4	1.7
24.4	28.9	3.8	19.4	21.4	2.6	11.6	9.4	1.8
25.0	30.2	3.8	19.6	22.5	2.5	11.9	10.5	1.9
25.4	31.4	3.9	19.8	23.9	2.6	12.1	10.4	1.9
25.8	32.1	3.9	20.1	24.8	2.7	12.2	10.6	1.9
26.2	33.1	4.0	20.1	25.9	2.7	12.4	10.6	2.0
26.7	33.8	4.0	20.6	25.6	2.9	12.6	13.4	2.1
27.3	34.8	4.2	20.9	26.5	2.8	12.9	14.8	2.1
27.6	36.0	4.3	21.2	27.5	2.9	13.1	12.1	2.1
28.2	35.9	4.4	21.6	31.0	2.9	13.2	13.2	2.0
28.9	37.0	4.6	22.0	26.8	3.0	13.3	14.1	2.1
29.6	37.3	4.4	22.0	27.3	3.0	13.6	13.5	2.1
29.7	37.8	4.6	22.3	28.6	3.3	13.8	15.7	2.4
30.1	38.7	4.6	22.6	28.2	3.3	13.8	13.8	2.1
30.6	39.6	4.8	22.9	29.4	3.4	14.2	14.3	2.0
31.0	40.1	4.8	23.0	29.5	3.4	14.2	16.1	2.4
31.6	42.4	4.9	23.2	30.4	3.5	14.4	17.5	2.2
31.9	42.0	5.0	23.7	31.5	3.6	14.6	15.3	2.2
32.4	41.1	5.0	23.6	32.3	3.7	14.6	16.6	2.3
32.9	42.7	5.1	23.8	31.1	3.7	14.7	15.6	2.3
33.2	41.9	5.4	24.1	31.1	3.8	14.8	16.9	2.3
33.8	42.6	5.5	24.3	31.0	4.2	14.9	17.3	2.5
34.3	45.2	5.5	24.9	31.4	4.0	15.0	17.0	2.5
34.7	44.8	5.5	24.9	31.4	3.9	15.1	18.3	2.5
35.2	45.0	5.7	25.3	32.7	4.0	15.1	21.9	2.6
35.5	46.4	5.8	25.4	32.4	4.2	15.3	17.5	2.6
36.1	44.2	5.9	25.8	36.3	4.1	15.6	18.7	2.5
36.6	44.4	6.0	26.0	33.1	4.3	15.5	18.9	2.7
37.2	46.9	6.1	26.3	33.4	4.5	15.5	18.4	2.8
37.5	45.0	6.2	26.4	34.1	4.6	15.8	21.0	2.8
37.9	45.9	6.3	26.9	35.4	4.7	15.8	21.0	2.8
38.4	47.6	6.4	27.0	33.6	4.6	15.9	21.0	2.9
39.0	45.5	6.5	27.1	34.5	4.8	15.8	20.8	2.9
39.2	48.2	6.6	27.3	35.2	4.9	15.9	22.7	3.0
39.8	49.2	6.7	27.7	35.1	4.8	16.1	21.6	3.0
40.1	47.2	6.8	28.3	37.7	4.8	16.2	22.0	3.1
40.5	47.6	7.0	28.0	39.1	4.9	16.1	20.7	3.1
41.0	48.0	7.1	28.5	35.3	5.1	16.1	22.2	3.1
41.4	48.2	7.2	28.5	37.1	5.2	16.4	21.8	3.2
42.0	52.1	7.3	28.9	37.4	5.2	16.4	23.3	3.2
42.4	51.1	7.4	28.8	37.9	5.2	16.4	22.5	3.3
42.8	49.6	7.4	29.4	41.2	5.2	16.4	24.5	3.2
43.3	53.3	7.4	29.4	36.0	5.3	16.4	22.2	3.2
43.7	50.8	7.5	29.6	36.3	5.4	16.7	23.4	3.3
44.1	50.5	7.7	29.8	38.8	5.4	16.6	24.3	3.3
44.6	53.4	7.8	30.0	37.6	5.6	16.7	22.2	3.5
45.1	55.4	8.0	30.2	36.8	5.7	16.8	25.3	3.5
45.4	57.0	8.3	30.4	37.6	5.7	16.7	23.6	3.6
46.0	60.0	8.4	30.7	38.7	5.8	16.9	25.7	3.7
46.2	60.0	8.5	30.9	40.0	5.9	17.1	23.4	3.7
46.6	59.8	8.7	31.1	39.7	5.9	16.9	23.6	3.6
47.2	63.7	8.8	31.3	37.4	6.0	17.0	24.9	3.8

47.9	62.6	8.9	31.4	38.4	6.2	17.0	23.7	3.8
48.2	63.9	8.9	31.6	39.3	6.4	17.0	24.2	3.8
48.5	70.1	9.1	31.8	43.2	6.4	17.6	23.4	3.8
48.7	68.1	9.2	31.9	40.2	6.4	17.2	25.5	3.9
49.2	71.0	9.3	32.1	39.0	6.5	17.3	25.0	4.0
49.6	73.3	9.4	32.3	38.5	6.6	17.4	25.7	4.0
50.0	71.5	9.4	32.3	42.4	6.6	17.4	24.6	4.1
50.3	73.6	9.5	32.4	40.3	6.9	17.5	24.7	4.2
50.8	74.8	9.7	32.5	38.7	7.0	17.4	25.3	4.2
51.3	76.8	9.8	32.6	38.3	6.8	17.4	27.5	4.2
51.6	80.5	10.2	33.1	39.1	7.0	17.4	24.5	4.2
52.1	80.1	10.2	33.1	39.8	7.2	17.5	24.2	4.2
52.5	81.9	10.3	33.2	40.6	7.3	17.5	26.0	4.4
52.9	88.2	10.4	33.3	39.9	7.4	17.5	27.7	4.4
53.4	88.0	10.5	33.6	38.9	7.3	17.6	24.8	4.4
53.7	89.2	10.7	33.8	41.2	7.4	17.8	26.1	4.5
54.2	90.9	10.8	34.0	40.5	7.4	17.8	25.1	4.6
54.7	92.7	11.0	34.1	39.2	7.7	17.9	25.0	4.6
55.1	95.0	11.0	34.3	40.8	7.9	17.8	26.4	4.7
55.5	99.6	11.1	34.5	41.6	8.0	17.9	25.8	4.7
55.9	99.5	11.4	34.7	41.3	8.1	18.0	25.7	4.7
56.3	102	11.5	34.8	39.5	8.0	18.2	26.6	4.8
56.7	108	11.6	35.0	39.2	8.2	18.2	26.1	4.9
57.1	107	11.8	35.1	39.8	8.3	18.2	25.6	5.0
57.6	110	11.9	35.3	42.3	8.4	18.2	25.9	5.0
57.9	112	12.1	35.4	39.6	8.4	18.3	25.2	5.0
58.3	115	12.3	35.6	39.0	8.5	18.5	27.4	5.0
58.8	117	12.4	35.7	41.1	8.7	18.3	26.3	5.1
59.3	123	12.5	35.9	41.8	8.7	18.5	27.3	5.2
59.6	123	12.7	36.0	40.8	8.9	18.8	25.3	5.3
59.9	125	12.8	36.2	40.3	8.9	18.9	27.1	5.3
60.2	128	12.9	36.5	38.5	9.1	18.8	25.6	5.4
60.6	131	13.1	36.5	41.0	9.1	18.8	26.2	5.4
60.9	133	13.2	37.1	38.4	9.1	18.9	25.1	5.5
61.2	135	13.4	36.8	38.9	9.2	19.1	24.9	5.5
61.3	136	13.5	36.9	40.7	9.4	19.1	25.3	5.6
61.5	139	13.6	36.9	38.3	9.4	18.9	24.6	5.6
61.7	143	13.7	37.0	39.1	9.4	19.0	24.4	5.6
61.9	144	13.8	37.0	40.6	9.5	19.2	24.7	5.7
61.8	145	13.8	37.0	37.6	9.5	19.3	24.5	5.7
61.9	145	13.9	36.8	36.7	9.7	19.2	24.3	5.7
62.1	147	14.0	36.9	37.5	9.8	19.1	27.1	5.8
62.1	148	14.0	36.8	37.1	9.9	19.1	24.1	5.9
62.0	149	14.0	37.1	37.0	9.9	19.2	23.2	5.9
61.9	149	14.1	36.8	38.5	9.9	19.4	24.9	5.9
61.9	155	14.2	36.8	36.2	10.0	19.1	26.2	5.8
61.9	154	14.2	36.6	37.5	10.0	19.2	23.6	5.9
61.8	153	14.2	36.6	36.1	10.0	19.1	23.9	6.0
61.8	153	14.3	37.0	34.6	10.1	19.0	23.7	5.9
61.6	155	14.3	36.7	34.4	10.0	19.1	22.6	5.9
61.6	156	14.4	36.9	34.2	10.1	19.2	24.8	6.0
61.5	157	14.4	36.3	34.6	10.3	19.2	22.0	6.0
61.4	157	14.5	36.2	35.6	10.2	19.1	22.2	6.0
61.3	158	14.4	36.5	34.2	10.3	19.1	22.6	6.1

61.3	164	14.5	36.1	33.4	10.2	19.0	23.1	6.1
61.2	162	14.5	36.0	34.7	10.3	19.2	21.0	6.1
61.1	162	14.6	35.9	33.0	10.2	19.1	21.0	6.0
60.9	162	14.6	36.3	32.3	10.1	19.1	20.7	6.1
60.9	163	14.6	35.8	32.4	10.2	19.1	23.8	6.1
61.0	164	14.6	35.7	32.8	10.3	19.0	21.0	6.1
60.9	166	14.7	35.6	32.0	10.4	19.1	19.3	6.1
60.7	166	14.7	35.6	31.8	10.2	19.2	20.7	6.1
60.6	168	14.8	35.6	31.6	10.4	19.3	22.7	6.1
60.5	169	14.8	35.5	30.8	10.5	19.2	19.2	6.1
60.5	168	14.8	35.4	31.6	10.5	19.1	19.8	6.2
60.5	170	14.8	35.2	31.3	10.4	19.0	19.5	6.3
60.2	171	14.9	35.1	29.8	10.5	19.0	18.6	6.3
60.1	171	14.8	35.0	30.6	10.7	19.1	22.0	6.2
60.0	173	14.8	35.2	32.7	10.5	19.0	20.8	6.2
60.0	174	14.9	34.8	29.7	10.7	19.1	18.4	6.2
59.9	174	14.9	34.7	29.2	10.5	19.0	18.1	6.2
59.8	179	14.8	34.7	29.0	10.5	19.0	19.7	6.3
59.8	177	14.9	34.9	28.7	10.6	19.0	18.0	6.3
59.8	177	15.0	34.5	31.2	10.6	19.2	18.4	6.3
59.7	178	15.0	34.5	30.5	10.5	19.0	17.8	6.3
59.6	180	14.9	34.5	28.1	10.5	19.0	17.8	6.3
59.7	181	15.0	34.3	29.9	10.5	19.0	17.6	6.3
59.5	189	15.0	34.3	29.4	10.4	18.9	20.5	6.3
59.4	192	15.0	34.0	27.8	10.4	18.9	18.4	6.3
59.3	195	15.0	34.0	30.7	10.4	19.0	18.1	6.3
59.2	205	15.1	34.0	26.6	10.4	19.0	18.7	6.3
59.1	208	15.0	33.8	26.7	10.5	19.0	18.0	6.3
59.0	208	15.1	33.8	26.3	10.4	19.0	19.3	6.3
58.8	207	15.0	33.7	27.2	10.4	18.9	17.1	6.3
58.7	207	15.1	33.5	26.9	10.5	19.0	18.3	6.4
58.5	206	15.0	33.5	26.2	10.5	18.9	18.0	6.5
58.3	205	15.1	33.4	26.2	10.4	18.9	18.4	6.4
58.2	201	15.1	33.5	25.9	10.5	18.9	17.5	6.4
58.2	202	15.0	33.2	26.0	10.6	19.1	18.4	6.5
58.1	203	15.1	33.1	25.3	10.5	18.9	17.4	6.4
58.0	203	15.1	33.1	26.7	10.4	18.9	18.3	6.3
57.8	204	15.1	32.9	26.7	10.4	18.9	17.8	6.4
57.7	204	15.1	33.2	24.7	10.5	19.0	16.9	6.3
57.6	205	15.1	32.7	24.7	10.5	19.0	18.3	6.3
57.6	217	15.1	32.8	24.5	10.5	19.0	20.9	6.4
57.6	221	15.1	32.7	24.0	10.5	19.0	17.0	6.4
57.6	220	15.1	32.5	26.0	10.5	18.9	17.3	6.5
57.5	222	15.2	32.4	26.3	10.6	18.9	18.7	6.5
57.5	222	15.1	32.3	23.8	10.6	19.0	16.9	6.4
57.4	223	15.2	32.2	23.7	10.7	19.0	19.4	6.5
57.4	224	15.2	32.2	24.7	10.7	18.9	17.3	6.5
57.4	224	15.2	32.0	23.6	10.7	18.9	17.4	6.5
57.4	224	15.2	31.9	23.0	10.8	18.9	18.3	6.4
57.2	228	15.1	31.7	23.2	10.9	18.9	19.3	6.4
57.2	226	15.2	31.8	22.7	10.6	19.0	17.1	6.4
57.0	224	15.1	31.9	22.8	10.6	18.9	17.0	6.4
56.9	224	15.2	31.6	23.3	10.7	18.9	17.0	6.5
57.0	222	15.2	31.4	23.1	10.7	18.9	18.6	6.5

56.8	214	15.2	31.6	24.1	10.7	18.9	17.7	6.5
56.7	210	15.3	31.3	23.6	10.7	18.9	17.2	6.5
56.6	207	15.2	31.1	22.4	10.7	19.0	17.7	6.5
56.5	205	15.2	31.0	22.4	10.7	19.0	19.6	6.6
56.4	206	15.3	30.9	21.4	10.6	18.9	17.2	6.6
56.4	203	15.2	30.8	22.0	10.7	18.9	17.7	6.6
56.4	201	15.2	30.8	25.0	10.7	18.9	17.7	6.5
56.2	199	15.2	30.8	21.8	10.7	18.8	16.6	6.5
56.1	197	15.3	30.8	22.5	10.6	19.0	19.5	6.5
56.1	196	15.3	30.4	22.3	10.7	19.0	17.6	6.5
56.0	196	15.2	30.3	21.3	10.8	19.0	18.0	6.5
55.9	192	15.2	30.2	21.9	10.7	18.9	16.7	6.5
55.8	191	15.3	30.2	21.5	10.7	18.9	19.6	6.6
55.7	190	15.3	30.0	20.8	10.6	19.0	16.4	6.6
55.6	187	15.3	29.9	22.2	10.8	19.0	17.0	6.6
55.7	185	15.3	29.9	22.1	10.8	19.0	17.2	6.6
56.0	184	15.3	29.8	20.9	10.8	19.0	16.6	6.7
55.4	182	15.4	29.7	21.5	10.8	18.9	17.9	6.6
55.4	182	15.3	29.8	20.9	10.9	18.9	19.0	6.6
55.4	182	15.3	29.6	20.4	11.0	19.1	16.7	6.6
55.2	177	15.4	29.5	22.1	10.7	19.0	16.9	6.7
55.2	176	15.3	29.5	21.4	10.7	19.2	17.7	6.6
55.1	174	15.3	29.4	20.4	11.0	19.0	16.6	6.6
55.0	171	15.3	29.3	22.1	10.9	18.9	18.4	6.7
54.8	170	15.3	29.3	20.7	10.8	18.9	16.5	6.7
54.8	168	15.4	29.2	21.3	11.0	19.2	16.5	6.6
54.8	165	15.4	29.2	20.3	11.1	19.0	17.7	6.6
54.6	164	15.4	29.1	20.7	10.9	19.0	19.3	6.7
54.5	163	15.5	29.0	20.5	10.9	19.0	16.6	6.7
54.6	159	15.3	29.0	21.8	11.0	18.9	17.0	6.7
54.4	157	15.3	29.0	19.8	10.9	19.0	16.4	6.6
54.4	155	15.4	28.8	20.3	10.8	18.9	16.4	6.7
54.3	153	15.3	28.7	21.6	11.0	19.0	16.5	6.7
54.3	152	15.3	28.6	20.6	10.9	18.9	16.4	6.7
54.3	150	15.3	28.5	20.2	11.0	18.9	16.3	6.7
54.3	148	15.3	28.5	20.3	11.0	18.9	17.6	6.8
54.0	148	15.4	28.6	20.0	10.9	19.0	16.4	6.7
53.9	144	15.3	28.5	20.3	11.0	19.0	16.6	6.6
53.8	142	15.4	29.2	24.7	11.0	18.9	16.5	6.7
53.8	140	15.4	28.6	20.0	11.0	18.9	16.1	6.8
53.7	138	15.4	28.3	20.1	11.0	18.9	17.9	6.8
53.9	137	15.4	28.3	21.6	10.9	18.9	16.4	6.7
53.6	138	15.4	28.5	19.7	11.0	19.0	15.7	6.7
53.5	132	15.5	28.1	19.8	11.0	19.1	15.9	6.7
53.5	118	15.5	28.1	20.1	10.7	19.1	19.7	6.7
53.3	116	15.5	28.3	19.0	10.7	19.1	16.6	6.7
53.1	111	15.3	28.0	19.3	10.7	19.1	15.9	6.7
53.0	108	15.5	28.2	21.0	10.6	19.0	15.7	6.8
52.9	106	15.4	28.0	19.6	10.6	19.0	15.2	6.7
52.9	104	15.5	27.9	19.5	10.7	19.0	16.5	6.7
53.0	102	15.4	27.9	20.1	10.7	19.4	16.7	6.7
52.7	104	15.5	27.8	19.8	11.2	19.5	15.0	6.8
52.6	102	15.5	27.8	19.1	11.1	19.1	16.8	6.8
52.4	102	15.4	27.7	19.3	11.1	19.0	17.9	6.8

52.3	100	15.3	27.7	19.2	11.1	19.1	17.3	6.8
52.2	97.5	15.3	27.7	21.5	11.2	19.1	21.0	6.7
52.2	96.8	15.3	27.7	20.7	11.1	19.1	17.9	6.8
52.0	95.6	15.2	27.6	19.9	11.1	19.2	17.3	6.7
52.9	94.6	15.2	27.6	19.3	11.2	19.1	18.5	6.8
52.2	95.2	15.2	27.6	19.0	11.1	19.2	19.2	6.8
51.7	92.3	15.7	27.6	18.7	10.9	19.2	16.7	6.8
51.4	90.0	15.6	27.5	18.8	11.1	19.1	17.6	6.8
51.9	88.9	15.6	27.5	18.5	11.2	19.2	16.9	6.8
51.6	86.7	15.6	27.4	18.0	11.1	19.2	16.2	6.9
52.0	84.4	15.5	27.4	19.6	11.2	19.2	20.2	6.8
51.0	83.1	15.4	27.3	19.2	11.2	19.1	17.0	6.8
51.0	80.8	15.5	27.3	18.4	11.1	19.1	16.8	6.8
50.9	73.3	15.3	27.3	18.3	11.0	19.1	18.9	6.8
51.0	66.0	15.3	27.3	17.8	11.0	19.1	18.5	6.8
50.8	59.7	15.2	27.3	17.6	10.9	19.2	16.9	6.9
50.6	58.9	15.2	27.2	20.8	10.8	19.1	17.5	6.9
50.6	58.0	15.2	27.3	17.4	10.7	19.2	16.5	6.8
50.3	57.1	15.2	27.3	17.8	10.6	19.3	18.2	6.9
50.3	56.1	15.2	27.2	20.4	10.7	20.2	16.7	6.9
50.2	56.1	15.3	27.1	18.3	10.7	19.3	16.9	6.9
50.2	54.2	15.5	27.1	18.2	10.6	19.2	17.9	6.9
49.9	54.9	15.4	27.2	19.0	10.7	19.2	20.6	7.0
50.0	54.5	15.3	27.3	19.0	10.7	19.7	16.5	6.9
50.4	52.4	15.6	27.1	19.5	10.7	19.5	16.8	7.0
49.7	51.8	15.5	27.0	18.9	10.7	19.3	16.1	7.0
49.5	50.9	15.5	27.1	19.4	10.7	19.2	15.9	6.9
49.5	50.3	15.4	27.0	19.3	10.7	19.3	20.3	7.0
49.7	50.3	15.4	26.9	19.7	11.1	19.3	17.7	7.0
49.2	49.8	15.5	26.9	18.5	11.2	19.3	16.0	7.0
49.0	48.9	15.4	27.0	18.7	11.0	19.4	18.0	6.9
49.0	51.3	15.3	26.9	18.9	11.1	19.7	17.4	6.9
48.8	48.4	15.5	27.0	18.5	11.2	19.3	15.7	7.0
48.6	48.0	15.5	27.1	18.5	11.1	19.4	16.0	7.0
48.6	47.6	15.4	26.7	19.2	11.0	19.4	15.8	7.0
48.5	47.4	15.5	26.9	18.4	11.1	19.3	16.3	7.0
48.7	47.2	15.6	27.1	19.6	11.0	19.6	16.2	7.0
48.1	50.9	15.6	26.8	19.8	11.0	19.4	18.3	7.0
48.1	47.0	15.5	26.7	18.1	11.0	19.4	15.2	7.0
48.1	46.5	15.5	26.8	18.4	11.1	19.5	17.5	7.0
48.0	47.4	15.4	26.9	18.6	11.1	19.4	16.9	7.0
47.9	45.9	15.4	26.7	19.1	11.0	19.5	15.9	7.0
47.6	46.0	15.4	26.7	23.9	11.0	19.4	16.3	7.0
47.4	46.0	15.6	26.8	21.0	10.9	19.5	15.3	7.0
47.3	45.6	15.8	26.7	19.0	10.8	19.5	16.9	7.0
47.4	45.8	15.9	26.6	19.2	10.8	19.4	18.4	7.1
47.5	48.2	15.8	26.6	18.8	10.7	19.4	15.7	7.0
47.0	46.7	15.9	26.7	18.1	10.8	19.5	15.5	7.1
46.8	45.3	15.9	26.7	18.3	10.8	19.5	16.2	7.0
46.8	45.6	15.9	26.7	18.6	10.7	19.5	15.5	7.0
46.7	45.0	15.9	26.8	19.3	10.6	19.6	16.0	7.0
46.5	45.0	15.9	26.7	23.6	10.7	19.6	15.9	7.1
46.4	45.0	15.8	26.6	20.0	10.7	19.6	15.2	7.0
46.2	44.6	15.5	26.6	18.0	10.7	19.6	17.0	7.0

46.2	45.9	15.5	26.8	19.0	10.7	19.6	19.9	7.0
46.0	47.0	15.5	26.7	18.8	10.7	19.8	14.7	7.1
45.8	44.5	15.5	26.7	18.4	10.8	19.6	15.3	7.1
45.7	44.7	15.8	26.7	18.9	10.8	19.7	16.0	7.0
45.5	44.5	15.8	26.6	18.7	10.8	19.6	15.1	7.1
45.4	44.4	15.7	26.7	20.7	10.8	19.6	16.9	7.0
45.3	45.3	15.8	27.0	22.8	10.8	19.7	15.1	7.0

0.40 Glycerol Viscosity (mPa.s)			0.30 Glycerol Viscosity (mPa.s)			0.20 Glycerol Viscosity (mPa.s)		
G+P 250 Hz	G+P 50 Hz	G+W 250 Hz	G+P 250 Hz	G+P 50 Hz	G+W 250 Hz	G+P 250 Hz	G+P 50 Hz	G+W 250 Hz
4.8	-2.1	3.5	3.2	-3.2	1.0	2.1	0.9	2.3
4.8	-1.7	3.1	3.2	-2.9	1.0	2.1	0.9	2.3
4.8	-2.0	3.1	3.2	-3.3	1.3	2.1	0.9	2.3
5.0	-1.6	3.5	3.3	-3.1	2.0	2.1	0.3	2.1
4.9	-0.2	3.4	3.3	-3.5	1.3	2.2	0.3	2.4
5.0	-1.9	3.1	3.3	-2.7	1.4	2.2	-0.6	2.3
5.0	-1.0	3.4	3.3	-3.3	1.3	2.2	1.6	3.3
5.1	-1.2	3.1	3.4	-2.9	1.1	2.3	1.3	2.5
5.2	-2.4	3.4	3.5	-2.3	1.1	2.4	0.2	2.4
5.2	-1.4	3.8	3.6	-3.0	1.1	2.4	0.9	2.2
5.3	-1.2	3.5	3.6	-2.7	1.2	2.4	1.3	2.4
5.4	-1.6	3.8	3.7	-2.3	1.2	2.3	1.1	2.2
5.5	-0.7	3.4	3.7	-3.3	1.4	2.4	0.9	2.4
5.6	-1.1	3.9	3.8	-2.7	1.7	2.5	1.2	2.2
5.8	-0.7	3.9	3.9	-3.0	1.6	2.5	1.7	2.5
5.9	-0.7	3.4	4.0	-2.7	1.4	2.5	1.0	2.2
6.0	-1.0	3.7	4.0	-2.0	1.5	2.5	2.8	2.1
6.2	-0.6	3.2	4.1	-1.0	2.1	2.6	1.2	2.3
6.3	0.0	3.4	4.2	-3.0	2.5	2.7	2.3	2.3
6.4	-0.5	3.3	4.2	-1.7	2.1	2.7	0.4	2.4
6.5	-0.1	3.2	4.4	-2.4	2.4	2.8	3.1	2.6
6.6	0.2	3.5	4.5	-2.3	1.6	2.8	2.4	2.6
6.8	-0.4	3.7	4.5	-1.7	1.6	3.0	1.7	2.9
6.8	0.3	4.2	4.6	-2.4	3.3	2.9	0.0	3.6
7.0	0.4	3.8	4.8	1.5	2.5	3.1	1.1	2.5
7.1	0.3	3.6	4.9	-1.6	1.5	3.1	0.8	2.5
7.1	1.4	3.3	4.9	-0.8	2.6	3.1	-0.7	2.8
7.3	0.7	3.3	5.1	-0.9	2.4	3.1	-0.3	2.5
7.6	0.5	3.2	5.1	-1.3	3.0	3.2	-2.6	2.3
8.0	1.5	3.8	5.2	-1.6	2.7	3.2	-2.2	2.4
7.7	1.4	5.1	5.2	-0.6	1.9	3.3	-1.2	2.5
7.9	1.2	4.3	5.3	-0.5	2.8	3.3	-2.0	2.7
8.0	1.9	3.8	5.6	-1.3	2.1	3.4	-1.5	2.7
8.4	1.2	3.6	5.6	0.3	2.3	3.4	-2.1	2.3
8.4	1.5	3.8	5.7	1.8	3.0	3.5	-1.9	2.4
8.2	2.8	4.5	5.7	-0.1	2.2	3.6	-2.7	2.8
8.5	1.7	4.7	6.0	-0.3	1.9	3.7	-3.0	2.7
8.7	4.1	4.6	6.0	-0.6	2.1	3.7	-2.6	2.9
8.8	2.6	5.3	6.1	-0.4	2.1	3.8	-1.6	2.9
8.8	2.3	4.3	6.2	-0.2	2.5	3.8	-1.9	4.8
8.9	3.8	4.2	6.3	0.5	2.4	3.8	-2.6	4.6
9.1	2.7	4.5	6.4	2.0	3.2	3.9	-2.3	4.7

9.2	3.1	4.2	6.5	1.0	3.4	4.0	-3.2	3.5
9.3	3.1	4.4	6.6	0.8	2.5	4.1	-2.4	5.6
9.5	2.8	3.9	6.7	0.0	1.9	4.1	-1.7	5.4
9.7	3.5	3.9	6.8	1.6	2.3	4.1	-2.1	3.3
9.9	3.9	3.9	7.0	1.4	2.5	4.2	-1.7	5.1
9.8	2.6	4.2	7.0	1.4	2.0	4.3	-2.2	5.1
9.8	2.4	4.1	7.1	1.0	2.4	4.4	-2.5	5.8
10.1	3.8	4.5	7.3	1.5	2.2	4.4	-2.1	5.6
10.1	3.0	5.0	7.5	1.9	2.1	4.5	-2.8	5.5
10.4	3.6	5.9	7.6	2.4	2.1	4.5	-2.5	5.2
10.2	3.6	6.6	7.6	1.8	2.3	4.6	-2.7	5.8
10.4	3.7	4.3	7.7	2.1	2.5	4.6	-2.6	3.7
10.4	4.0	4.6	7.8	2.5	2.5	4.7	-2.3	3.6
10.6	4.3	4.4	8.0	2.1	2.1	4.8	-3.0	4.8
10.6	4.2	4.1	8.1	2.1	2.3	5.0	-2.7	5.3
10.7	4.6	6.2	8.2	2.2	2.3	4.9	-2.7	4.5
10.8	4.7	4.4	8.3	3.3	2.8	4.9	-2.5	5.0
10.8	4.9	5.2	8.5	2.8	2.9	5.1	-2.6	4.5
10.8	5.0	5.4	8.5	3.7	2.6	5.2	-2.3	6.7
10.9	4.2	4.6	8.6	2.4	2.7	5.2	-2.3	4.9
10.9	5.1	5.1	8.7	2.2	2.9	5.2	-2.1	4.5
11.0	5.9	5.6	9.0	2.4	3.6	5.3	-2.6	5.0
11.1	3.7	3.7	8.9	3.9	4.2	5.4	-2.3	4.1
11.1	3.5	4.0	9.0	3.4	4.0	5.5	-2.0	3.3
11.2	4.7	4.5	9.1	3.7	3.7	5.5	-1.5	3.3
11.2	5.7	5.3	9.3	3.7	3.5	5.6	-1.6	3.7
11.2	2.9	4.6	9.3	3.6	4.2	5.7	-0.9	4.8
11.4	3.0	4.0	9.3	6.8	3.1	5.8	-1.6	8.3
11.4	4.6	4.4	9.4	4.0	2.9	5.8	0.2	4.8
11.5	4.7	4.4	9.5	3.4	2.9	6.0	-1.9	3.3
11.5	4.5	4.5	9.6	3.4	2.9	6.0	-1.8	3.2
11.5	5.6	3.5	9.6	4.0	2.7	6.1	-1.8	3.5
11.6	4.6	4.0	9.7	2.8	3.1	6.1	-1.9	3.4
11.7	4.5	4.3	9.8	3.1	3.4	6.2	-2.2	3.4
11.7	5.3	3.8	9.8	3.4	3.2	6.2	-1.8	6.5
11.7	5.2	4.3	9.9	3.9	2.8	6.5	-1.5	3.3
11.8	5.3	5.7	10.0	3.4	2.6	6.4	-1.7	3.4
11.9	5.8	4.4	10.1	4.0	2.7	6.4	-1.3	3.2
12.0	4.3	4.2	10.4	4.9	2.8	6.5	-1.3	3.2
11.9	6.0	4.1	10.3	3.5	2.7	6.6	-1.4	3.2
11.9	6.3	3.9	10.3	3.5	3.6	6.8	-0.9	3.0
12.1	5.8	4.0	10.3	6.2	3.1	6.7	-0.9	3.1
12.2	5.5	4.5	10.6	3.8	2.7	6.8	-1.1	3.5
12.3	5.9	4.2	10.7	3.9	3.1	6.9	-1.1	3.8
12.1	6.0	3.7	10.7	2.5	2.9	7.0	-0.8	3.5
12.2	6.3	4.3	10.8	3.6	4.8	7.0	-0.8	3.3
12.3	6.6	4.7	10.8	2.9	3.2	7.0	-0.9	3.4
12.3	6.1	4.7	10.9	3.2	3.2	7.2	-0.7	3.0
12.4	6.4	4.1	11.0	4.5	2.7	7.3	-0.9	2.9
12.4	7.1	4.3	11.1	3.1	2.7	7.3	-0.7	3.0
12.5	6.6	6.0	11.1	3.5	2.7	7.4	-0.6	3.0
12.5	6.5	4.1	11.2	2.5	3.4	7.5	-0.7	3.1
12.5	7.2	4.3	11.2	3.5	3.4	7.6	0.0	3.4
12.6	6.5	4.2	11.5	3.6	3.3	7.7	-0.4	3.2
12.6	7.8	4.0	11.4	3.6	2.6	7.7	-0.3	3.5
12.8	7.1	4.6	11.4	3.3	2.4	7.8	-0.6	2.9

12.7	7.2	4.0	11.4	3.3	2.4	7.9	-0.6	3.0
12.8	6.9	4.6	11.5	2.9	2.7	7.9	-0.1	3.0
12.7	7.0	4.6	11.6	2.9	2.7	8.0	0.2	3.9
13.0	7.1	4.5	11.7	3.7	2.7	8.1	0.2	3.4
12.8	6.9	4.6	11.6	3.1	3.5	8.2	-0.2	3.7
12.8	6.7	4.4	11.8	5.5	3.0	8.3	0.2	3.6
13.0	6.9	4.4	11.9	3.8	3.0	8.3	0.2	3.4
13.2	7.5	4.5	11.9	3.5	2.7	8.3	0.2	3.3
13.0	9.0	4.3	11.9	4.5	3.0	8.4	0.1	3.7
13.1	9.2	4.6	12.0	4.8	3.4	8.6	0.4	4.3
13.1	9.4	5.1	12.0	4.8	3.2	8.6	0.9	4.3
13.2	10.2	4.5	12.1	6.5	3.5	8.7	0.4	2.6
13.2	8.6	4.6	12.1	7.9	2.9	8.8	0.6	3.4
13.3	10.4	4.6	12.1	6.5	3.0	8.8	1.8	4.5
13.2	10.7	5.1	12.1	8.5	2.7	8.9	0.9	3.3
13.2	8.4	5.1	12.3	9.2	4.2	8.9	0.9	3.2
13.4	8.3	4.6	12.4	8.6	3.0	9.0	1.8	3.3
13.4	8.6	5.1	12.3	8.7	3.1	9.0	1.2	3.1
13.3	9.2	5.1	12.3	8.3	2.8	9.1	1.2	3.7
13.3	9.6	5.1	12.2	7.6	3.5	9.0	1.5	3.3
13.4	8.5	5.3	12.3	7.7	3.3	9.0	1.6	3.5
13.5	7.7	5.4	12.3	6.0	3.6	9.1	1.5	3.0
13.4	7.2	5.8	12.2	6.4	3.1	9.3	1.3	3.6
13.3	6.9	6.8	12.3	6.5	2.9	9.2	1.6	4.5
13.3	6.9	5.3	12.2	7.6	3.3	9.2	1.5	4.3
13.3	6.4	5.4	12.2	5.5	3.0	9.3	1.4	4.7
13.3	6.6	5.6	12.2	6.2	2.5	9.3	1.4	5.4
13.2	6.7	5.3	12.2	5.8	2.6	9.3	1.5	6.4
13.2	8.2	4.9	12.2	5.9	2.8	9.2	1.5	4.3
13.3	9.7	5.3	12.2	6.8	3.0	9.2	1.1	4.4
13.2	12.9	5.3	12.1	5.4	3.0	9.4	1.3	3.5
13.2	10.0	5.1	12.1	8.3	3.6	9.3	1.7	3.3
13.1	10.0	5.7	12.1	6.6	2.9	9.3	1.1	4.2
13.1	10.3	5.3	12.1	6.8	2.9	9.3	1.6	3.7
13.2	10.5	5.4	12.2	7.4	2.6	9.5	1.2	3.8
13.0	11.0	5.7	12.1	5.5	3.7	9.4	1.1	3.7
13.1	9.2	5.8	12.1	6.6	3.4	9.4	1.5	3.3
13.0	9.3	5.3	12.0	6.5	3.3	9.3	1.2	5.7
13.3	11.1	5.2	12.0	7.6	4.0	9.4	1.9	3.5
13.2	10.1	5.7	12.1	5.7	3.7	9.5	1.7	3.9
12.9	10.1	5.4	12.0	6.4	3.7	9.6	1.4	3.4
13.0	11.0	5.1	12.1	6.0	4.1	9.5	2.0	4.7
13.1	9.2	5.5	12.0	6.5	4.1	9.6	1.0	3.3
12.9	9.2	5.5	12.0	9.4	3.6	9.5	0.9	3.4
12.9	8.9	5.1	11.9	7.6	4.5	9.5	1.1	4.5
12.9	9.0	6.1	12.0	6.0	4.2	9.6	1.6	4.6
12.9	8.3	5.7	12.0	5.5	4.2	9.8	1.7	3.4
12.9	6.8	5.5	11.9	4.6	5.1	9.6	1.6	5.2
12.8	6.9	5.4	11.9	6.1	4.3	9.6	1.5	3.8
12.7	7.4	6.4	11.9	4.8	4.5	9.6	1.3	3.5
12.7	8.0	5.9	11.9	5.2	4.7	9.6	2.2	3.8
12.8	7.1	5.7	11.9	5.1	5.1	9.6	1.0	3.8
12.7	7.6	5.0	11.9	5.4	4.6	9.7	1.8	4.2
12.6	7.5	5.2	11.9	4.9	3.9	9.6	2.2	4.3
12.6	7.1	5.2	11.9	6.0	3.8	9.7	2.2	4.3
12.6	7.2	5.5	11.9	4.6	3.5	9.6	2.3	4.6

12.6	6.1	5.3	11.9	4.6	3.4	9.6	2.0	5.4
12.6	6.5	5.6	11.9	4.8	3.7	9.6	1.2	3.7
12.5	6.6	5.7	11.9	4.2	3.1	9.7	3.7	6.1
12.5	6.4	5.8	11.9	4.2	3.1	9.6	2.5	4.9
12.5	6.5	5.7	11.7	5.1	3.8	9.6	2.2	4.6
12.4	6.4	5.3	11.8	4.1	3.3	9.6	1.9	3.6
12.3	6.2	5.5	11.8	5.2	3.4	9.7	2.0	3.4
12.4	6.4	5.6	11.9	5.4	5.7	9.7	1.8	3.2
12.3	7.3	5.0	11.9	5.5	4.7	9.7	2.3	3.2
12.3	6.5	5.7	11.8	6.5	5.4	9.7	1.7	4.2
12.3	6.4	6.1	11.8	4.0	4.5	9.8	1.5	4.8
12.3	6.0	5.6	11.9	4.0	4.1	9.7	2.2	3.7
12.3	6.5	5.8	11.9	4.4	4.2	9.8	2.1	4.5
12.3	6.5	5.8	11.8	4.8	3.9	9.7	2.3	3.6
12.2	6.0	5.0	11.7	4.5	3.6	9.8	2.5	3.8
12.1	5.8	6.1	11.7	4.8	3.6	9.7	1.8	5.0
12.2	5.9	5.8	11.8	4.9	4.0	9.7	2.2	4.0
12.2	6.0	5.6	11.8	4.7	4.2	9.8	2.2	4.0
12.1	5.6	5.8	11.8	5.4	4.1	9.8	1.7	4.4
12.1	6.1	5.9	11.8	4.5	4.1	9.8	2.0	4.1
12.1	5.2	6.1	11.8	4.2	4.2	9.8	1.7	4.3
12.0	5.7	5.6	12.1	4.7	4.2	9.8	1.6	3.9
12.0	5.8	6.6	11.7	4.2	5.8	9.8	2.0	3.9
12.0	5.2	5.8	11.7	5.9	4.8	9.8	1.2	6.4
12.0	5.1	5.7	11.7	5.8	4.4	9.8	1.8	6.2
12.1	5.0	5.5	11.7	4.3	4.2	9.8	1.9	4.0
11.9	5.0	5.9	11.8	5.2	4.5	9.8	1.9	7.3
12.0	5.8	5.7	11.7	4.3	3.8	9.8	4.6	4.3
11.9	4.7	6.1	11.8	4.5	4.0	9.8	2.1	3.9
11.9	5.0	6.3	11.7	4.7	4.6	9.8	2.1	3.4
11.9	5.3	5.9	11.7	4.1	4.0	9.8	2.3	4.1
11.9	4.6	5.4	11.7	4.3	3.9	9.9	1.9	5.0
11.8	4.7	6.0	11.8	5.4	4.3	9.8	1.8	4.0
11.8	5.1	5.6	11.7	4.4	4.3	9.8	2.1	3.7
11.9	4.8	5.6	11.6	4.8	4.5	9.7	1.8	3.7
11.9	4.2	5.8	11.7	4.5	4.3	9.8	1.3	3.8
11.8	4.7	6.2	11.8	4.0	4.2	9.8	1.6	8.8
11.8	4.4	5.9	12.0	4.7	4.6	9.8	0.4	3.8
11.7	4.4	5.8	11.9	3.9	4.1	9.8	0.4	3.5
11.7	4.0	5.7	11.7	3.3	3.7	9.8	0.0	5.5
11.7	3.7	6.0	11.7	3.9	4.2	9.8	-0.1	5.2
11.7	4.5	5.8	11.7	3.9	4.4	9.8	0.4	4.1
11.7	4.4	5.7	11.8	3.9	4.5	9.9	1.1	4.5
11.7	3.8	5.8	11.8	3.8	4.4	9.8	-0.4	4.7
11.7	3.8	5.9	11.7	4.0	5.6	9.8	0.6	6.9
11.6	3.5	5.2	11.7	3.7	4.7	9.9	1.2	4.1
11.7	3.7	6.1	11.7	4.2	4.3	9.8	0.2	12.6
11.7	4.1	5.7	11.7	3.7	4.0	9.8	0.9	4.6
11.6	3.4	5.5	11.7	4.4	4.2	9.9	1.3	4.1
11.6	3.4	5.7	11.8	4.8	4.2	9.9	0.5	4.4
11.6	4.0	5.9	12.0	3.9	4.2	9.8	1.2	5.4
11.6	3.5	6.0	11.7	4.1	3.7	10.0	0.7	4.4
11.6	3.5	6.1	11.7	4.2	4.0	9.8	0.5	3.9
11.6	3.6	5.5	11.7	4.2	4.1	9.9	1.5	4.6
11.5	2.8	6.2	11.8	4.4	4.3	9.8	1.2	4.6
11.6	3.7	6.0	11.7	4.5	3.9	9.9	1.8	3.9

11.5	3.5	5.4	11.7	3.9	3.9	9.9	1.5	4.1
11.5	6.1	6.0	11.7	4.6	4.5	9.8	1.3	5.3
11.6	3.2	6.0	11.6	4.1	4.2	9.8	1.1	5.4
11.6	2.9	5.9	11.7	4.1	4.0	9.9	1.8	4.2
11.6	3.0	5.7	11.7	4.8	4.6	9.9	1.7	5.5
11.6	3.3	5.9	11.6	3.8	3.7	9.9	1.9	4.2
11.5	3.0	5.5	11.7	3.7	3.9	9.9	2.3	4.4
11.6	2.7	5.9	11.7	3.5	3.6	9.9	1.9	10.6
11.6	3.1	5.8	11.6	4.0	3.8	10.0	2.3	8.2
11.5	3.1	5.6	11.6	4.4	4.3	9.9	1.5	5.3
11.4	2.6	5.5	11.7	4.5	3.5	9.9	1.0	4.4
11.4	2.9	5.5	11.7	4.0	3.3	9.9	1.7	3.6
11.5	2.5	5.5	11.7	3.6	3.5	9.9	1.9	4.2
11.6	3.2	5.5	11.6	3.7	3.6	9.9	1.6	4.3
11.4	2.8	6.2	11.7	3.8	3.4	9.8	1.7	4.7
11.5	2.6	5.3	11.6	3.3	3.6	10.0	1.0	7.8
11.5	2.4	5.8	11.8	3.9	3.4	9.8	1.0	4.7
11.5	3.3	5.6	11.7	4.2	4.5	10.0	1.4	5.4
11.5	2.4	5.3	11.6	3.7	3.2	9.9	1.2	4.9
11.5	2.9	5.8	11.6	4.5	3.1	9.8	1.3	4.5
11.5	2.6	6.0	11.6	4.0	3.2	10.0	1.8	4.3
11.5	2.2	5.8	11.6	3.9	3.2	10.0	2.1	4.8
11.4	2.5	5.8	11.7	4.2	3.4	9.9	2.3	5.3
11.4	2.6	6.0	11.7	3.8	3.5	9.8	2.3	5.9
11.5	2.7	5.8	11.6	3.7	3.8	9.9	0.6	5.5
11.5	3.1	5.4	11.8	5.3	3.8	9.9	1.6	5.4
11.5	2.3	5.3	11.8	4.0	3.8	9.9	1.7	6.1
11.4	2.6	5.4	11.7	4.5	4.0	9.9	1.5	7.6
11.4	2.7	5.3	11.7	4.7	3.3	9.9	1.7	6.4
11.5	2.1	5.6	11.6	4.4	3.6	10.0	1.1	4.5
11.5	2.2	5.5	11.7	4.4	3.3	9.9	0.4	4.0
11.4	2.2	6.3	11.7	4.5	3.3	9.9	1.1	5.0
11.4	1.7	6.0	11.8	3.9	3.3	9.9	1.0	4.8
11.4	2.5	6.0	11.6	4.6	3.5	9.9	0.8	4.2
11.5	2.3	5.2	11.7	4.5	3.6	10.0	1.2	5.0
11.4	2.2	5.4	11.8	3.8	3.3	9.9	0.9	5.1
11.4	2.4	5.9	11.7	4.9	3.6	9.9	1.1	6.0
11.5	2.5	5.9	11.6	5.1	3.6	9.9	1.1	4.7
11.5	2.3	6.6	11.8	4.6	4.4	9.9	-0.1	4.8
11.4	2.7	5.8	11.8	4.7	5.1	9.9	0.9	4.7
11.4	2.2	5.8	11.7	4.2	4.1	9.9	1.4	7.2
11.4	2.1	6.0	11.8	5.1	3.5	9.9	1.5	5.3
11.4	2.5	6.4	11.7	5.4	3.7	9.9	1.3	4.3
11.4	2.0	5.5	11.7	5.2	3.5	10.0	0.7	4.5
11.3	1.9	6.0	11.7	5.4	4.6	9.9	0.9	4.0
11.4	2.0	5.6	11.7	6.0	4.9	10.0	1.4	4.8
11.3	1.9	5.6	11.8	6.1	4.4	10.0	1.9	4.3
11.3	2.4	6.0	11.7	6.8	4.3	9.9	1.2	4.6
11.3	2.4	5.3	11.7	6.6	4.7	10.0	1.7	10.1
11.4	1.8	5.4	11.8	7.0	4.7	9.9	4.7	6.0
11.5	2.0	6.0	11.7	7.3	4.9	9.9	1.5	5.0
11.4	2.2	6.1	11.7	6.6	5.2	10.1	1.7	5.8
11.4	2.0	5.6	11.7	5.6	5.0	9.9	1.0	5.9
11.4	2.1	6.1	11.8	5.4	4.9	10.0	1.1	5.2
11.4	1.7	5.5	11.7	4.7	4.8	9.9	1.2	6.2
11.4	1.9	6.2	11.7	5.1	4.6	9.9	1.6	8.1

11.4	2.5	5.7	11.7	5.8	4.4	9.9	1.5	5.7
11.4	1.8	5.8	11.7	4.9	4.2	9.9	0.9	5.3
11.4	2.2	5.7	11.8	5.0	4.3	9.9	0.5	5.8
11.4	2.2	5.6	11.7	5.0	4.4	9.9	1.1	4.7
11.5	1.8	5.1	11.7	4.7	4.4	10.0	1.1	5.5
11.4	2.4	5.7	11.7	4.8	4.4	9.9	0.9	8.4
11.4	2.5	5.8	11.7	4.6	4.8	9.9	1.4	4.5
11.3	1.7	6.1	11.6	4.6	4.3	10.1	3.6	6.1
11.4	1.9	5.5	11.7	4.5	4.4	10.0	1.6	7.1
11.6	2.6	5.4	11.7	4.6	4.3	9.9	1.5	7.0
11.4	2.2	5.4	11.7	4.3	4.1	9.9	0.3	5.7
11.5	1.9	5.3	11.7	4.4	5.1	10.1	1.0	5.1
11.4	1.8	6.1	11.6	4.1	4.3	10.0	1.2	8.8
11.3	1.8	5.9	11.7	4.5	4.8	9.9	1.4	6.4
11.4	2.5	5.7	11.8	4.3	4.3	9.9	1.5	6.9
11.4	2.1	6.1	11.7	4.3	4.2	10.1	1.3	5.3
11.4	2.0	5.3	11.7	4.1	4.1	10.0	0.6	4.8
11.5	2.5	5.5	11.6	4.9	4.3	9.9	2.2	4.7
11.3	1.6	5.7	11.7	4.2	4.0	9.9	2.3	4.4
11.4	2.2	5.3	11.8	4.3	4.1	10.0	1.8	4.5
11.3	2.6	5.7	11.7	6.9	4.3	10.2	1.8	6.0
11.3	1.5	5.7	11.7	4.0	4.6	10.1	1.8	4.7
11.3	2.0	5.4	11.6	4.2	4.1	9.9	2.0	5.8
11.3	2.5	6.1	11.7	4.0	4.3	10.0	1.7	5.9
11.3	2.9	5.9	11.6	3.7	4.1	9.9	0.7	5.6
11.4	2.6	5.5	11.7	3.8	3.9	10.1	1.5	6.4
11.3	1.8	5.5	11.6	3.5	4.1	9.9	1.3	4.5
11.3	2.0	5.6	11.7	3.5	4.5	9.9	1.5	4.7
11.4	2.1	5.9	11.7	3.5	4.6	10.0	1.4	6.0
11.3	2.3	5.8	11.6	3.3	4.2	9.9	1.1	4.9
11.4	1.8	6.1	11.7	3.5	4.5	9.9	1.2	5.1
11.3	1.6	5.8	11.6	3.3	3.9	9.9	1.3	4.9
11.2	1.7	5.3	11.6	3.2	3.9	9.9	1.8	4.1
11.3	1.9	5.8	11.7	3.6	4.0	9.9	1.3	4.8

Table S-6. Viscosity values for glycerol + pentanol at 250 Hz and 50 Hz and for glycerol + water mixtures at 250 Hz with temperature change from 70°C to 40°C

Time (min)	Temp. (°C)	1 Glycerol Viscosity (mPa.s)		0.95 Glycerol Viscosity (mPa.s)			0.90 Glycerol Viscosity (mPa.s)		
		G+P 250 Hz	G+P 50 Hz	G+P 250 Hz	G+P 50 Hz	G+W 250 Hz	G+P 250 Hz	G+P 50 Hz	G+W 250 Hz
0.2	69.9	52.6	51.8	40.9	64.2	27.2	30.8	23.8	16.0
0.3	68.7	52.8	52.1	40.5	62.2	27.4	30.5	20.9	16.1
0.5	67.1	53.5	53.9	41.8	61.7	27.6	31.6	23.8	16.3
0.7	65.5	54.9	54.6	42.4	62.6	28.2	31.4	27.6	16.5
0.8	64.1	56.0	55.1	42.5	61.3	28.7	32.1	32.0	16.8
1	62.7	57.2	57.4	43.5	62.9	29.4	32.9	34.3	17.1
1.2	61.5	58.9	59.0	45.1	65.1	30.2	33.8	28.6	17.5
1.3	60.3	60.8	62.9	45.7	66.6	30.9	34.7	25.8	17.9
1.5	59.2	62.7	65.1	47.3	68.2	31.9	36.6	25.4	18.4
1.7	58.1	64.7	65.0	48.8	68.1	32.9	36.7	28.2	18.8
1.8	57.1	67.0	67.7	50.7	68.7	33.8	37.3	32.0	19.4
2	56.2	69.3	69.3	52.2	70.3	34.9	38.9	38.1	20.0
2.2	55.3	71.9	71.8	53.4	71.1	36.0	39.9	35.1	20.6

2.3	54.4	74.5	74.7	55.4	75.1	37.2	41.0	35.4	21.2
2.5	53.6	77.2	76.8	57.3	75.9	38.2	42.2	41.4	21.8
2.7	52.8	80.4	84.1	58.9	76.3	39.5	43.9	35.0	22.3
2.8	52	83.2	84.5	61.2	81.6	40.9	45.3	35.3	23.1
3	51.3	86.2	88.5	63.1	80.4	42.2	46.7	40.0	23.7
3.2	50.6	89.3	88.1	64.9	83.6	43.6	48.2	41.0	24.3
3.3	49.9	92.8	94.8	67.3	86.3	45.0	50.0	41.8	25.0
3.5	49.3	96.2	96.3	69.7	88.7	46.5	51.5	45.0	25.7
3.7	48.6	100	102	72.1	92.3	48.1	53.0	48.6	26.5
3.8	48	103	104	74.0	93.4	49.5	54.7	50.6	27.3
4	47.4	107	108	76.7	95.8	51.2	56.4	49.9	28.0
4.2	46.8	111	116	80.2	95.3	52.8	58.3	48.6	28.9
4.3	46.2	115	124	82.3	99.9	54.5	60.1	49.2	29.7
4.5	45.7	119	121	84.9	103	56.1	62.1	53.2	30.4
4.7	45.1	123	121	87.6	107	58.0	63.9	56.0	31.3
4.8	44.6	128	127	90.7	111	59.8	65.9	57.1	32.1
5	44	132	131	93.6	111	61.7	67.9	59.3	33.0
5.2	43.5	137	136	96.6	117	63.5	70.1	60.5	34.0
5.3	43	142	140	99.4	118	65.5	72.4	63.1	34.8
5.5	42.5	146	144	103	123	67.5	75.1	64.4	35.8
5.7	42.1	151	154	106	128	69.5	77.4	67.2	36.8
5.8	41.6	157	159	110	130	71.5	79.8	68.9	37.8
6	41.2	162	159	113	132	73.6	81.7	73.2	38.8
6.2	40.8	167	165	116	135	75.7	84.4	75.6	39.8
6.3	40.4	172	170	120	143	77.9	87.0	76.4	40.8
6.5	40	178	176	124	145	80.1	90.2	85.4	41.8
6.7	39.7	183	184	127	149	82.2	92.8	83.8	42.8
6.8	39.5	188	185	131	153	84.3	95.5	86.1	43.7
7	39.4	193	191	134	154	86.3	98.9	88.5	44.6
7.2	39.3	198	202	137	159	88.2	101	90.0	45.5
7.3	39.2	202	203	140	160	90.0	105	92.1	46.3
7.5	39.3	206	205	143	164	91.7	108	96.0	47.1
7.7	39.3	210	208	146	168	93.2	109	105	47.9
7.8	39.4	214	213	149	172	94.6	111	105	48.6
8	39.5	217	218	151	174	95.9	115	105	49.3
8.2	39.5	220	226	154	176	97.0	115	105	49.7
8.3	39.6	223	222	155	178	98.2	116	107	50.2
8.5	39.6	226	225	158	180	99.3	118	106	50.8
8.7	39.7	228	233	159	182	100	119	108	51.2
8.8	39.7	231	233	161	187	101	121	111	51.5
9	39.7	233	232	162	187	102	123	115	52.0
9.2	39.7	235	234	164	188	103	123	113	52.4
9.3	39.7	237	237	165	191	104	125	119	52.8
9.5	39.8	240	244	167	193	105	126	114	53.2
9.7	39.8	242	247	168	193	106	127	116	53.6
9.8	39.8	243	243	169	194	106	128	120	54.0
10	39.8	245	246	171	197	107	129	118	54.3
10.2	39.8	247	250	172	198	108	130	119	54.4
10.3	39.8	249	249	173	199	108	131	119	54.8
10.5	39.8	250	253	174	202	109	132	123	55.1
10.7	39.9	252	254	175	202	110	133	123	55.3
10.8	39.9	253	257	177	203	110	134	124	55.5
11	39.9	254	260	178	203	111	134	123	55.8
11.2	39.9	256	261	179	205	111	135	123	56.0
11.3	39.9	257	257	179	205	112	136	124	56.3
11.5	39.9	258	262	180	209	112	137	127	56.4

11.7	39.9	260	266	181	208	113	138	132	56.6
11.8	39.9	261	262	182	210	113	138	126	57.0
12	39.9	262	264	183	212	113	139	129	57.1
12.2	39.9	263	267	183	214	114	139	133	57.2
12.3	39.9	264	271	184	212	114	140	128	57.4
12.5	39.9	264	272	184	213	115	140	128	57.5
12.7	39.9	265	278	185	216	115	141	129	57.6
12.8	39.9	266	272	186	215	115	142	131	57.8
13	39.9	267	270	186	214	116	142	135	58.0
13.2	39.9	268	274	187	216	116	143	132	58.2
13.3	39.9	269	273	187	216	116	143	133	58.3
13.5	39.9	269	274	188	216	116	144	132	58.4
13.7	39.9	270	275	189	217	117	144	135	58.7
13.8	39.9	271	280	189	216	117	144	135	58.7
14	39.9	271	281	190	217	117	145	131	58.7
14.2	39.9	272	276	190	219	117	145	132	58.8
14.3	40	273	275	190	221	118	146	133	58.9
14.5	40	273	280	191	221	118	146	135	59.0
14.7	40	274	280	191	219	118	146	135	59.2
14.8	40	274	285	192	223	118	146	135	59.4
15	40	275	277	192	222	118	147	136	59.6
15.2	40	275	280	192	220	119	147	134	59.6
15.3	40	276	285	193	221	119	147	137	59.6
15.5	40	276	286	193	222	119	148	135	59.6
15.7	40	277	283	193	220	119	148	135	59.7
15.8	40	277	283	194	223	119	148	138	59.7
16	40	278	287	194	224	120	148	140	59.8
16.2	40	278	281	194	224	120	149	136	59.9
16.3	40	278	288	195	225	120	149	134	59.9
16.5	40	279	285	195	225	120	149	134	60.0
16.7	40	279	288	195	223	120	149	137	60.1
16.8	40	279	288	195	225	120	149	134	60.1
17	40	280	290	195	223	120	149	134	60.3
17.2	40	280	285	196	224	120	149	138	60.2
17.3	40	280	285	196	226	121	150	139	60.2
17.5	40	280	284	196	227	121	150	135	60.4
17.7	40	281	290	196	226	121	150	135	60.4
17.8	40	281	291	196	227	121	150	135	60.4
18	40	281	287	197	226	121	150	134	60.4
18.2	40	282	288	197	227	121	150	139	60.5
18.3	40	282	297	197	226	121	150	136	60.5
18.5	40	282	292	197	227	121	151	137	60.6
18.7	40	282	293	197	228	121	151	135	60.6
18.8	40	283	288	197	228	121	151	139	60.6
19	40	283	287	198	226	122	151	138	60.7
19.2	40	283	292	198	228	122	151	135	60.7
19.3	40	283	295	198	228	122	151	134	60.8
19.5	40	283	286	198	228	122	152	134	60.9
19.7	40	283	292	198	230	122	151	135	60.8
19.8	40	284	294	198	227	122	151	135	60.8
20	40	284	299	198	227	122	152	137	60.9
20.2	40	284	294	199	228	122	152	138	60.8
20.3	40	284	293	199	229	122	152	135	61.0
20.5	40	284	292	199	228	122	152	136	61.0
20.7	40	284	296	199	229	122	152	136	61.1
20.8	40	285	301	199	230	122	152	134	61.2

21	40	285	288	199	230	122	152	136	61.1
21.2	40	285	292	199	230	122	152	137	61.1
21.3	40	285	295	199	231	122	153	138	61.2
21.5	40	285	300	199	233	123	152	136	61.1
21.7	40	285	297	200	234	123	152	135	61.1
21.8	40	285	291	200	228	123	152	136	61.1
22	40	285	295	200	233	123	152	135	61.2
22.2	40	286	296	200	232	123	153	135	61.3
22.3	40	286	294	200	228	123	153	135	61.2
22.5	40	286	290	200	231	123	153	137	61.3
22.7	40	286	297	200	228	123	152	136	61.4
22.8	40	286	302	200	231	123	153	135	61.4
23	40	286	303	200	232	123	153	139	61.4
23.2	40	286	301	200	230	123	153	135	61.4
23.3	40	286	291	200	231	123	153	134	61.4
23.5	40	286	296	201	231	123	153	135	61.4
23.7	40	286	300	200	230	123	153	135	61.4
23.8	40	286	301	201	234	123	153	135	61.5
24	40	287	299	201	232	123	153	139	61.5
24.2	40	287	301	201	232	123	153	138	61.5
24.3	40	287	304	201	232	123	153	135	61.4
24.5	40	287	304	201	232	123	154	136	61.6
24.7	40	287	296	201	230	123	153	135	61.8
24.8	40	287	297	201	232	123	153	135	61.6
25	40	287	300	201	230	123	154	135	61.5
25.2	40	287	305	201	231	123	153	136	61.6
25.3	40	287	294	201	231	124	153	136	61.5
25.5	40	287	301	201	232	123	153	138	61.6
25.7	40	287	306	201	232	123	153	138	61.6
25.8	40	288	305	201	234	123	153	138	61.6
26	40	288	309	202	235	123	153	135	61.7
26.2	40	287	310	202	234	124	153	135	61.7
26.3	40	288	302	202	233	124	153	135	61.6
26.5	40	288	303	202	233	124	153	136	61.8
26.7	40	288	299	202	235	124	153	136	61.8
26.8	40	288	299	202	234	124	153	137	61.7
27	40	288	298	202	236	124	153	142	61.7
27.2	40	288	298	202	234	124	153	137	61.7
27.3	40	288	300	202	232	124	153	135	61.7
27.5	40	288	302	202	232	124	153	137	61.7
27.7	40	288	305	202	233	124	153	135	61.8
27.8	40	288	297	202	233	124	153	137	61.9
28	40	288	295	202	233	124	154	137	61.8
28.2	40	288	312	202	233	124	154	136	61.8
28.3	40	288	300	202	233	124	153	137	61.9
28.5	40	288	302	202	232	124	153	140	62.0
28.7	40	288	309	202	235	124	154	136	61.8
28.8	40	289	306	202	234	124	153	135	61.8
29	40	289	301	202	235	124	154	135	61.9
29.2	40	289	301	202	237	124	154	137	61.9
29.3	40	289	304	202	237	124	154	135	61.9
29.5	40	289	305	202	236	124	153	141	61.9
29.7	40	289	294	203	237	124	153	135	61.9
29.8	40	289	297	203	240	124	153	137	62.3
30	40	289	305	202	236	124	153	138	62.0
30.2	40	289	303	203	236	124	153	135	62.0

30.3	40	289	301	203	236	124	153	134	62.3
30.5	40	289	306	203	235	124	153	135	62.1
30.7	40	289	305	203	236	124	153	136	61.9
30.8	40	289	305	203	234	124	153	137	61.9
31	40	289	307	203	236	124	153	140	62.0
31.2	40	289	312	203	234	124	153	135	62.0
31.3	40	289	297	203	235	124	153	134	61.9
31.5	40	289	308	203	235	124	153	136	62.0
31.7	40	289	310	203	234	124	153	135	62.2
31.8	40	289	310	203	237	124	153	135	62.3
32	40	289	295	203	236	124	153	136	62.1
32.2	40	289	316	203	239	124	153	135	62.2
32.3	40	289	306	203	237	124	153	138	62.5
32.5	40	289	299	203	236	124	153	140	62.0
32.7	40	289	308	203	236	124	153	137	62.0
32.8	40	289	307	203	237	124	153	135	62.0
33	40	289	307	203	236	124	153	136	62.0
33.2	40	289	295	204	239	124	153	136	62.1
33.3	40	289	304	204	238	124	153	139	62.1
33.5	40	290	309	203	239	124	153	136	62.3
33.7	40	290	297	203	239	124	153	139	62.7
33.8	40	290	304	203	238	124	154	143	62.4
34	40	290	320	203	240	124	153	137	62.2
34.2	40	290	299	203	238	124	153	134	62.6
34.3	40	290	313	203	239	125	153	136	62.3
34.5	40	290	302	203	239	124	153	135	62.1
34.7	40	290	317	204	242	124	153	136	62.0
34.8	40	290	329	203	238	124	153	136	62.1
35	40	290	330	203	237	124	153	137	62.1

0.80 Glycerol Viscosity (mPa.s)			0.75 Glycerol Viscosity (mPa.s)			0.70 Glycerol Viscosity (mPa.s)		
G+P 250 Hz	G+P 50 Hz	G+W 250 Hz	G+P 250 Hz	G+P 50 Hz	G+W 250 Hz	G+P 250 Hz	G+P 50 Hz	G+W 250 Hz
24.2	38.4	6.8	19.7	23.6	5.2	16.8	13.4	3.6
24.2	38.1	6.8	19.5	21.8	5.1	16.6	13.8	3.6
24.4	38.6	6.9	19.8	22.0	5.1	16.9	13.8	3.5
24.8	42.4	6.9	20.3	24.8	5.3	16.8	13.8	3.6
25.3	42.6	7.1	20.8	24.6	5.3	16.8	14.4	3.6
25.8	44.0	7.2	21.0	21.9	5.3	17.0	14.4	3.7
26.5	41.8	7.4	21.5	24.4	5.6	17.3	15.6	3.8
27.2	43.4	7.5	22.0	22.5	5.6	17.7	16.1	3.9
28.1	44.6	7.6	22.6	23.0	5.6	18.3	16.4	3.9
28.9	42.2	8.0	23.4	26.7	5.7	19.0	17.5	4.0
29.8	43.5	8.1	24.1	25.2	5.9	20.0	17.9	4.0
30.7	43.2	8.2	25.0	27.4	6.0	20.8	18.4	4.2
31.7	44.8	8.5	25.9	29.1	6.1	21.5	19.2	4.3
33.0	46.2	8.7	26.7	31.4	6.2	22.5	20.2	4.3
34.4	48.5	8.8	28.1	30.6	6.4	23.0	20.9	4.4
35.8	48.7	9.4	29.0	32.2	6.6	24.4	22.0	4.6
37.5	50.2	9.4	29.9	31.4	6.8	25.2	22.8	4.7
39.2	51.6	9.6	31.0	33.4	7.0	25.0	23.7	4.7
41.0	54.1	9.9	32.0	35.7	7.1	25.9	25.0	4.9
42.7	56.9	10.1	32.9	37.0	7.3	26.0	26.9	5.0
44.4	59.3	10.3	33.8	39.0	7.4	26.4	28.2	5.1

46.1	60.5	10.6	34.8	39.5	7.5	27.1	29.3	5.2
47.9	62.4	10.8	35.7	39.0	7.6	27.9	30.5	5.3
49.6	66.3	11.0	37.2	40.3	7.8	29.0	31.5	5.4
51.4	68.0	11.2	38.7	42.0	7.9	29.8	32.7	5.6
53.3	68.9	11.5	39.7	44.4	8.0	30.7	34.0	5.7
55.3	72.6	11.9	40.1	46.7	8.3	31.7	35.6	5.8
57.1	71.4	12.0	40.6	47.3	8.5	33.1	36.4	5.8
58.9	72.6	12.4	42.2	52.0	8.8	34.0	37.6	5.8
60.8	73.6	12.6	43.0	53.8	9.0	35.2	37.8	6.0
62.8	76.2	12.8	44.7	57.0	9.2	35.8	38.4	6.1
64.8	76.7	13.1	46.0	59.2	9.3	36.4	40.3	6.2
66.8	77.9	13.4	47.5	61.1	9.5	36.8	40.4	6.3
68.9	80.6	13.6	49.0	63.5	9.7	37.4	41.1	6.4
70.9	84.7	14.0	51.4	67.4	10.0	37.5	42.3	6.5
73.1	85.4	14.3	53.4	67.1	10.1	38.4	42.6	6.8
72.5	88.9	14.5	56.4	63.2	10.3	39.3	42.0	7.0
73.9	94.0	14.8	59.6	61.1	10.4	39.7	42.1	6.9
75.9	98.3	15.2	61.0	59.2	10.7	40.6	43.0	7.6
78.7	100	15.5	62.9	56.5	10.8	41.2	43.7	7.4
81.1	103	15.9	64.3	56.3	11.0	42.4	43.2	7.5
82.6	104	16.3	65.4	52.5	11.2	43.1	44.7	7.5
83.4	105	16.5	67.8	46.4	11.2	43.8	45.9	7.8
85.8	111	16.8	70.2	46.0	11.5	44.2	45.2	7.8
88.9	112	17.1	72.0	42.8	11.6	44.8	46.2	8.0
90.5	114	17.3	73.0	38.1	11.8	45.0	45.8	8.1
93.9	114	17.4	75.1	39.7	11.9	44.2	46.4	8.2
96.8	112	17.6	77.3	43.4	11.9	43.7	46.9	8.1
98.9	110	17.6	77.6	39.0	12.0	44.2	46.1	8.2
99.0	107	17.8	79.1	50.9	12.2	44.5	46.3	8.2
99.7	101	18.0	81.3	49.2	12.2	44.4	46.7	8.4
101	92.5	18.0	83.1	54.3	12.3	44.6	46.7	8.4
105	86.7	18.3	83.4	57.6	12.4	44.8	46.1	8.5
106	78.3	18.3	84.9	59.6	12.5	45.3	45.8	8.5
108	81.5	18.5	86.6	68.6	12.4	45.9	45.5	8.5
109	85.3	18.7	87.4	82.9	12.4	45.8	44.9	8.6
111	87.8	18.8	87.6	91.8	12.7	46.3	44.4	8.7
110	85.2	18.7	88.7	94.0	12.7	47.0	43.7	8.7
113	94.2	18.9	89.2	99.1	12.8	47.5	43.7	8.8
115	92.3	19.0	90.0	99.6	12.8	47.4	43.5	8.8
116	104	19.0	92.7	109	12.9	46.6	42.8	8.8
116	117	19.0	93.6	113	12.9	47.6	42.3	9.1
117	125	19.1	96.3	116	13.0	47.1	41.9	8.8
118	126	19.3	96.8	116	13.1	46.3	41.0	8.9
119	130	19.3	96.7	129	13.1	46.4	41.1	8.8
119	131	19.4	98.7	127	13.2	46.6	40.9	9.0
120	132	19.4	98.5	127	13.2	46.5	41.1	9.0
120	132	19.6	98.9	126	13.1	46.3	40.1	9.0
121	128	19.6	99.6	127	13.3	46.3	40.5	8.9
121	128	19.7	101	125	13.3	46.6	39.3	9.0
121	127	19.6	101	125	13.4	47.3	38.4	9.3
121	125	19.6	101	126	13.3	47.2	38.3	9.3
122	128	19.6	102	124	13.3	47.1	35.6	9.3
124	125	19.7	103	125	13.4	47.1	34.8	9.3
125	126	20.0	102	126	13.4	47.4	34.6	9.2
126	130	19.9	103	123	13.4	47.7	33.8	9.2
126	126	19.9	105	123	13.5	46.7	33.9	9.2

126	126	20.1	106	125	13.5	46.0	32.8	9.3
126	126	20.0	107	124	13.5	47.1	32.4	9.3
127	127	20.1	107	123	13.5	46.9	32.9	9.3
127	131	20.1	106	122	13.6	46.3	32.8	9.3
127	134	20.0	105	121	13.6	46.2	32.9	9.3
127	126	20.1	106	125	13.6	46.7	33.5	9.3
129	127	20.2	104	127	13.7	47.0	34.0	9.4
128	125	20.1	106	126	13.7	46.9	33.9	9.4
129	127	20.2	107	126	13.7	46.8	34.0	9.4
130	125	20.3	106	120	13.6	47.2	35.2	9.4
129	128	20.3	107	124	13.8	48.0	34.6	9.4
130	127	20.3	105	136	13.7	47.5	34.6	9.6
130	134	20.4	106	141	13.7	46.9	34.9	9.7
130	128	20.5	106	141	13.6	47.0	37.0	9.6
131	126	20.5	106	141	13.8	47.1	36.0	9.4
131	130	20.4	105	142	13.9	46.6	34.9	9.4
131	132	20.5	105	141	13.9	46.1	34.0	9.4
131	128	20.5	106	141	13.9	46.1	33.8	9.4
132	134	20.4	106	141	13.8	46.4	36.3	9.4
132	129	20.4	105	141	13.9	46.2	35.6	9.4
131	133	20.6	103	143	13.8	46.0	32.2	9.5
131	143	20.5	103	143	13.8	46.0	32.1	9.4
131	139	20.6	102	144	13.9	46.9	30.9	9.4
131	139	20.6	100	144	13.9	47.1	31.6	9.5
132	141	20.7	102	146	13.8	46.4	32.9	9.5
132	141	20.6	102	146	13.9	46.3	32.8	9.5
132	145	20.6	101	147	13.9	46.6	32.4	9.5
133	147	20.6	101	146	14.0	47.3	32.2	9.5
133	141	20.8	98.8	147	14.0	45.8	33.8	9.5
133	140	20.7	97.5	146	14.0	45.8	31.7	9.5
133	141	20.6	95.3	146	14.0	45.6	29.7	9.6
136	138	20.7	97.3	145	14.0	46.0	29.6	9.7
137	137	20.7	96.7	146	14.0	45.7	32.2	9.7
137	142	20.7	94.2	145	14.1	45.4	34.8	9.7
137	141	20.8	95.0	141	14.1	45.8	35.7	9.7
137	149	20.9	95.2	144	14.1	46.3	36.0	9.8
137	150	20.8	94.8	148	14.0	46.2	33.5	9.6
137	147	20.9	96.5	144	14.1	45.7	35.0	9.6
137	147	20.9	97.1	145	14.1	46.0	36.2	9.7
137	152	20.7	97.7	147	14.1	46.6	29.2	9.6
136	151	20.9	99.6	143	14.1	46.4	29.9	9.6
136	149	20.8	101	142	14.1	45.3	29.3	9.7
137	152	20.8	102	141	14.1	45.4	30.4	9.7
138	152	20.8	103	140	14.1	45.4	34.6	9.7
137	153	20.9	103	146	14.1	45.5	31.4	9.7
137	153	20.9	102	147	14.1	44.8	32.7	9.7
137	151	20.8	103	142	14.2	44.8	36.8	9.7
137	155	20.9	102	142	14.2	45.4	40.0	9.8
138	158	21.0	103	142	14.2	45.1	41.5	9.7
137	153	20.9	103	141	14.1	44.9	43.2	9.7
138	155	20.8	103	143	14.1	44.9	43.7	9.7
138	156	20.9	103	142	14.2	45.0	46.1	9.7
139	155	20.9	103	142	14.2	46.2	46.8	9.9
139	158	20.9	103	147	14.2	45.1	44.4	9.8
139	156	20.9	102	142	14.2	44.7	44.0	9.6
140	155	21.0	102	143	14.1	44.8	44.3	9.6

139	157	21.0	101	142	14.2	44.7	44.9	9.5
139	157	21.0	101	141	14.3	44.4	45.6	9.7
140	156	21.2	101	142	14.2	43.4	45.4	9.8
140	158	21.2	101	145	14.2	44.0	45.6	9.8
140	159	21.0	102	142	14.2	44.1	47.6	9.7
140	162	20.9	101	142	14.2	44.0	45.4	9.7
140	161	21.0	101	143	14.3	43.7	45.6	9.8
139	162	21.0	101	142	14.2	43.8	45.7	9.8
139	162	21.1	100	142	14.2	44.3	46.2	9.9
139	160	21.1	99	141	14.3	44.3	46.7	9.8
139	162	21.1	99	141	14.2	44.3	47.2	9.8
139	165	21.1	98	142	14.1	44.0	48.2	10.0
139	161	21.1	98	147	14.2	43.9	47.9	9.9
139	161	21.1	97	140	14.3	44.5	47.5	9.8
139	161	21.1	97	145	14.3	43.8	47.5	9.8
139	160	21.0	98	142	14.3	43.5	47.3	9.9
139	161	21.0	99	143	14.3	43.4	47.6	9.8
139	162	21.0	101	142	14.3	43.4	47.1	9.8
139	160	21.1	103	142	14.2	43.7	47.6	9.8
139	161	21.1	104	144	14.3	43.2	49.6	9.8
139	161	21.0	105	143	14.3	43.6	48.6	9.8
139	160	21.0	107	147	14.3	43.7	51.3	9.8
139	160	21.3	108	144	14.1	43.7	50.6	9.8
140	159	21.3	110	143	14.2	43.9	52.2	9.8
140	161	21.2	110	143	14.4	44.1	56.1	9.8
140	161	21.1	109	142	14.4	45.3	54.6	9.8
140	160	21.1	110	144	14.3	44.2	56.0	9.9
140	159	21.2	110	143	14.3	43.7	57.6	9.9
140	159	21.0	110	146	14.3	43.7	58.9	9.8
140	159	21.0	110	145	14.3	43.1	61.5	9.8
140	159	21.2	111	144	14.3	42.5	61.2	9.8
141	159	21.1	111	144	14.3	42.1	60.3	9.8
140	162	21.2	111	144	14.3	42.0	62.3	9.8
140	161	21.1	111	145	14.3	42.2	60.7	9.8
141	159	21.2	111	147	14.3	42.1	61.0	9.8
141	159	21.2	110	147	14.3	41.7	59.8	9.8
141	159	21.1	111	146	14.4	42.0	59.5	9.8
141	159	21.1	110	144	14.4	42.6	59.2	9.8
141	160	21.2	109	145	14.4	42.8	64.9	9.9
140	159	21.1	109	145	14.4	42.5	60.3	9.9
141	158	21.0	109	144	14.5	42.0	60.8	9.9
141	159	21.1	108	143	14.4	42.4	61.0	9.9
142	158	21.1	108	144	14.4	42.7	62.1	10.0
142	158	21.1	108	145	14.4	41.0	61.8	10.1
142	157	21.1	108	148	14.4	41.4	62.5	10.1
142	156	21.2	107	147	14.4	41.6	62.7	9.9
141	157	21.2	107	148	14.2	41.6	63.1	9.9
141	158	21.2	108	149	14.4	41.9	63.7	9.9
141	157	21.2	108	147	14.5	41.0	63.0	9.9
141	157	21.2	107	149	14.4	41.8	63.3	9.9
141	156	21.2	107	148	14.4	42.3	63.5	10.0
141	160	21.3	107	148	14.4	42.1	64.0	9.9
141	158	21.3	108	148	14.4	41.9	63.8	9.9
141	157	21.4	107	147	14.3	42.3	67.1	10.0
141	157	21.3	107	146	14.4	42.2	64.8	10.0
141	159	21.2	107	145	14.4	42.1	65.0	10.0

141	158	21.2	106	146	14.4	41.0	64.7	9.9
141	157	21.3	106	147	14.3	41.0	65.4	10.0
141	157	21.3	106	146	14.4	42.0	65.0	10.0
141	157	21.2	106	146	14.4	41.1	65.9	9.9
141	159	21.3	105	147	14.5	41.1	66.1	10.0
141	158	21.2	105	146	14.5	40.8	65.8	10.0
141	159	21.2	105	148	14.5	41.2	66.2	10.0
140	158	21.1	105	147	14.5	41.5	65.3	9.9
140	158	21.2	105	148	14.4	41.1	65.1	10.0
140	159	21.3	105	147	14.3	41.4	64.5	10.0
140	161	21.2	105	147	14.4	41.7	64.0	10.0
140	159	21.3	105	148	14.5	41.9	64.1	9.9
140	159	21.3	104	146	14.4	41.6	64.4	9.9
140	159	21.2	103	146	14.4	41.0	64.8	9.9
140	159	21.3	103	149	14.4	41.2	64.3	9.9
139	160	21.3	103	148	14.4	41.7	65.7	9.9
138	158	21.3	103	146	14.5	40.6	64.1	10.0
139	160	21.3	102	146	14.5	40.4	63.8	10.0
139	162	21.2	103	147	14.5	40.6	63.1	10.0
139	163	21.1	103	147	14.4	40.3	63.4	10.0
139	161	21.3	102	147	14.4	40.7	64.2	10.0

0.65 Glycerol Viscosity (mPa.s)			0.60 Glycerol Viscosity (mPa.s)			0.50 Glycerol Viscosity (mPa.s)		
G+P 250 Hz	G+P 50 Hz	G+W 250 Hz	G+P 250 Hz	G+P 50 Hz	G+W 250 Hz	G+P 250 Hz	G+P 50 Hz	G+W 250 Hz
12.5	12.9	2.0	11.4	12.4	1.5	7.2	8.3	1.6
12.7	12.5	2.0	11.4	12.1	1.6	7.3	8.4	1.7
12.5	12.6	2.1	11.4	12.5	1.6	7.3	8.4	1.5
12.8	13.1	2.2	11.9	12.9	1.5	7.3	8.4	1.5
13.0	13.4	2.2	11.8	12.7	1.4	7.5	9.0	1.6
13.1	14.1	2.3	12.2	12.9	1.6	7.7	8.6	1.6
13.6	13.7	2.3	12.5	13.3	1.7	7.7	8.8	1.6
13.8	13.7	2.4	12.8	13.4	1.7	7.9	10.0	1.7
14.0	13.6	2.4	13.1	13.5	1.8	8.0	9.3	1.6
14.3	14.2	2.4	13.4	13.9	1.8	8.2	9.5	1.5
15.1	14.2	2.6	13.7	14.4	1.7	8.5	9.9	1.5
15.4	14.8	2.6	14.1	14.9	1.7	8.4	9.8	1.6
15.8	14.9	2.6	14.4	15.4	1.9	8.6	10.3	1.5
16.2	16.0	2.7	14.7	16.2	1.9	8.9	10.2	1.5
16.5	16.8	2.9	15.1	16.7	1.9	9.2	10.6	1.4
17.2	17.0	3.0	15.4	16.8	1.9	9.4	11.0	1.5
17.6	18.0	3.0	15.8	17.2	2.2	9.5	10.9	1.5
17.9	18.9	3.1	16.1	17.9	2.2	9.8	10.8	1.6
18.6	20.2	3.1	16.6	18.6	2.2	10.1	11.6	1.6
18.7	20.7	3.2	16.8	19.4	2.1	10.1	11.6	1.6
19.0	21.9	3.3	17.2	19.9	2.4	10.4	12.0	1.7
19.7	22.4	3.3	17.4	20.4	2.5	10.5	12.4	1.7
19.4	23.2	3.4	17.7	21.2	2.4	10.8	12.5	1.6
20.0	24.6	3.4	18.1	22.3	2.4	11.0	12.7	1.8
20.4	25.5	3.4	18.4	23.3	2.6	11.0	13.0	1.8
20.7	27.0	3.6	18.6	24.1	2.7	11.2	13.4	1.7
21.3	29.3	3.7	19.0	25.7	2.8	11.5	13.6	1.8
21.9	30.5	3.8	19.4	26.2	2.8	11.8	13.8	1.9
22.2	31.2	3.8	19.7	27.1	2.9	11.9	14.0	1.9

22.4	33.9	4.0	20.1	28.2	2.9	12.1	14.4	1.9
23.1	34.0	4.0	20.5	29.9	2.9	12.3	14.6	2.0
23.2	34.8	4.0	20.9	29.9	3.1	12.6	14.9	2.1
23.5	35.7	4.2	21.1	30.4	3.1	12.8	15.0	2.1
24.0	36.4	4.3	21.5	31.4	3.1	12.8	15.6	2.1
24.2	37.0	4.3	21.8	32.4	3.2	13.0	15.9	2.0
24.8	37.6	4.4	22.1	32.2	3.3	13.2	16.3	2.1
25.0	38.6	4.5	22.4	33.6	3.3	13.5	16.8	2.1
25.2	38.7	4.6	22.6	33.3	3.5	13.6	17.0	2.4
25.6	39.4	4.7	22.8	34.8	3.5	13.8	17.2	2.1
26.1	39.8	4.8	23.1	34.0	3.5	13.8	17.4	2.0
26.2	39.9	4.8	23.4	34.4	3.6	13.9	17.9	2.4
26.5	40.3	4.9	23.6	34.6	3.6	14.1	17.9	2.2
27.0	40.2	5.0	23.9	35.2	3.6	14.1	18.6	2.2
27.2	40.7	5.0	24.0	35.1	3.7	14.1	18.3	2.3
27.9	40.7	5.1	24.2	35.4	3.7	14.3	18.5	2.3
27.8	40.5	5.2	24.5	35.5	3.8	14.4	18.5	2.3
27.9	40.5	5.2	24.6	35.4	3.7	14.3	18.5	2.5
28.0	39.8	5.2	24.9	35.3	4.0	14.3	19.1	2.5
28.2	39.5	5.3	25.0	35.3	4.0	14.3	19.3	2.5
28.1	39.9	5.4	25.1	35.1	4.1	14.2	19.0	2.6
27.7	39.6	5.4	25.1	35.3	4.1	14.3	19.6	2.6
27.8	39.3	5.4	25.1	34.6	4.1	14.3	19.3	2.5
28.0	38.8	5.5	25.1	34.8	4.1	14.1	19.3	2.7
28.2	38.4	5.5	25.0	34.5	4.1	14.0	21.1	2.8
28.3	38.0	5.5	25.1	34.4	4.0	14.0	19.6	2.8
28.2	37.8	5.5	24.8	34.3	4.2	14.1	19.6	2.8
28.4	37.5	5.6	24.6	34.1	4.2	14.0	19.9	2.9
28.5	37.3	5.6	24.7	34.5	4.2	14.0	19.7	2.9
28.4	36.9	5.6	24.7	34.4	4.2	14.0	19.7	3.0
28.7	36.5	5.6	24.6	33.9	4.3	13.9	19.6	3.0
28.5	36.5	5.6	24.5	33.7	4.3	13.9	19.6	3.1
28.5	37.0	5.7	24.6	33.3	4.3	13.8	20.7	3.1
28.6	36.8	5.7	24.7	33.2	4.3	13.7	19.6	3.1
28.6	35.7	5.8	24.7	33.3	4.2	13.7	20.2	3.2
28.4	35.3	5.8	24.7	32.8	4.1	13.8	19.8	3.2
28.4	34.7	5.8	24.7	32.9	4.1	13.6	19.7	3.3
28.5	34.5	5.8	24.7	32.9	4.3	13.5	20.3	3.2
28.5	34.3	5.8	24.6	32.6	4.3	13.5	19.6	3.2
28.5	33.8	5.9	24.6	32.4	4.2	13.5	19.5	3.3
28.4	34.0	5.9	24.6	32.4	4.3	13.4	20.8	3.3
28.4	34.0	5.9	24.6	33.0	4.3	13.5	19.3	3.5
28.3	33.4	5.9	24.4	32.0	4.4	13.3	19.4	3.5
28.4	33.0	6.0	24.5	32.0	4.3	13.2	19.4	3.6
28.2	32.9	6.0	24.4	31.6	4.5	13.2	19.3	3.7
28.1	32.5	6.0	24.3	31.2	4.2	13.2	19.1	3.7
28.0	32.3	6.1	24.3	31.2	4.3	13.1	19.4	3.6
28.0	32.2	6.1	24.2	31.0	4.3	13.0	19.1	3.8
28.3	33.1	6.1	24.1	31.1	4.3	13.1	19.5	3.8
27.9	31.9	6.0	23.9	30.8	4.4	13.0	19.3	3.8
28.0	31.7	6.0	23.9	30.7	4.6	13.0	19.1	3.8
27.9	31.9	6.1	23.9	30.5	4.5	12.9	19.2	3.9
27.8	30.9	6.1	23.9	30.1	4.6	12.9	18.8	4.0
27.8	30.7	6.1	23.9	30.3	4.6	12.9	18.9	4.0
27.8	30.7	6.1	23.9	29.9	4.5	12.8	18.8	4.1
27.6	30.7	6.1	23.9	29.6	4.6	12.8	18.4	4.2

27.6	34.9	6.2	23.8	29.7	4.5	12.7	18.7	4.2
27.6	29.8	6.2	23.8	29.2	4.5	12.7	18.8	4.2
27.5	30.5	6.2	23.7	28.8	4.6	12.7	18.5	4.2
27.5	29.5	6.2	23.6	28.5	4.5	12.6	18.4	4.2
27.5	29.1	6.2	23.5	28.3	4.5	12.6	18.4	4.4
27.5	28.7	6.1	23.6	29.3	4.6	12.6	18.1	4.4
27.3	28.4	6.2	23.4	28.3	4.6	12.7	18.2	4.4
27.2	29.0	6.2	23.2	27.4	4.5	12.5	18.1	4.5
27.1	28.6	6.2	23.2	27.3	4.7	12.4	17.8	4.6
27.1	29.8	6.2	23.6	27.4	4.6	12.5	17.8	4.6
27.0	31.9	6.2	23.1	26.9	4.6	12.4	18.1	4.7
26.9	28.4	6.2	23.0	26.7	4.6	12.5	17.5	4.7
26.8	28.4	6.2	22.9	26.5	4.6	12.4	17.9	4.7
26.9	29.4	6.2	23.0	26.3	4.6	12.3	17.7	4.8
26.9	30.0	6.2	22.7	25.9	4.4	12.5	17.3	4.9
26.6	30.5	6.2	22.8	25.8	4.4	12.4	17.4	5.0
26.6	31.4	6.2	22.6	25.9	4.6	12.5	17.3	5.0
26.7	29.5	6.2	22.4	27.1	4.6	12.4	16.9	5.0
26.4	30.2	6.2	22.5	26.1	4.6	12.3	17.1	5.0
26.4	29.2	6.3	22.3	25.4	4.5	12.3	16.9	5.1
26.3	28.8	6.2	22.1	25.0	4.6	12.4	16.4	5.2
26.4	28.5	6.2	22.2	25.6	4.6	12.4	16.8	5.3
26.2	28.3	6.3	22.0	24.1	4.7	12.2	16.4	5.3
26.1	27.9	6.3	22.3	24.2	4.7	12.1	16.3	5.4
26.2	31.4	6.3	21.9	24.4	4.6	12.2	16.4	5.4
26.1	29.7	6.3	21.9	23.8	4.7	12.2	16.3	5.5
26.0	27.2	6.3	21.7	23.7	4.7	12.3	16.4	5.5
26.1	28.1	6.3	21.7	24.0	4.6	12.1	16.0	5.6
25.8	27.0	6.3	21.5	23.1	4.7	12.0	15.9	5.6
25.8	26.5	6.3	21.6	27.1	4.8	12.1	15.9	5.6
25.8	26.2	6.3	21.7	22.7	4.7	12.1	15.5	5.7
25.7	26.4	6.4	21.5	22.4	4.7	12.2	15.6	5.7
25.9	25.9	6.3	21.5	23.8	4.7	12.1	15.6	5.7
25.5	27.6	6.3	21.4	22.1	4.7	12.1	15.4	5.8
25.5	26.3	6.4	21.2	21.9	4.7	12.1	15.3	5.9
25.4	25.0	6.4	21.2	23.1	4.7	12.0	15.6	5.9
25.2	24.8	6.4	21.1	21.3	4.6	12.0	15.3	5.9
25.1	24.5	6.4	21.1	21.4	4.8	12.0	15.2	5.8
25.2	22.3	6.4	21.0	21.5	4.6	12.0	15.6	5.9
25.2	23.0	6.3	22.0	21.1	4.5	12.0	15.3	6.0
24.9	26.2	6.3	21.0	21.1	4.7	12.0	15.2	5.9
25.1	25.4	6.3	20.8	20.6	4.8	12.0	15.3	5.9
24.8	25.7	6.4	20.7	20.2	4.7	12.1	15.1	6.0
24.5	26.3	6.3	20.7	20.6	4.7	12.1	15.2	6.0
24.5	26.8	6.3	20.7	19.7	4.7	12.0	14.9	6.0
24.7	27.4	6.3	20.5	19.9	4.7	11.9	14.7	6.1
24.7	27.7	6.4	20.3	20.0	4.8	12.0	15.0	6.1
24.4	27.4	6.4	20.5	19.1	4.8	12.0	15.0	6.1
24.1	31.3	6.3	20.3	19.4	4.7	12.0	15.0	6.0
24.3	29.0	6.4	20.2	19.0	4.7	11.9	15.1	6.1
24.2	28.2	6.4	20.1	18.7	4.7	11.9	14.9	6.1
24.3	27.4	6.4	20.0	18.5	4.7	11.9	14.7	6.1
24.1	27.1	6.3	20.0	18.4	4.7	12.0	14.8	6.1
23.9	26.8	6.5	19.8	18.2	4.8	11.9	14.7	6.1
23.9	27.0	6.5	19.7	17.7	4.7	12.0	14.6	6.1
23.9	27.0	6.4	19.8	17.5	4.7	11.9	14.7	6.1

23.9	30.7	6.4	19.9	17.4	4.7	11.9	14.2	6.2
23.6	28.5	6.5	19.6	17.3	4.7	11.8	14.7	6.3
23.4	27.9	6.5	19.5	17.3	4.8	11.8	14.2	6.3
23.4	26.8	6.5	19.5	17.3	4.7	11.9	14.4	6.2
23.4	26.4	6.4	19.3	17.1	4.7	12.0	14.6	6.2
23.4	26.5	6.5	19.3	17.1	4.8	12.1	14.3	6.2
23.2	26.5	6.5	19.2	17.4	4.7	12.0	14.3	6.2
23.1	26.4	6.5	18.9	17.3	4.7	11.9	14.6	6.3
22.9	27.7	6.5	19.0	17.0	4.8	11.9	14.4	6.3
22.8	30.3	6.4	18.9	17.5	4.8	12.0	14.4	6.3
22.9	27.3	6.6	19.0	17.1	4.5	11.8	14.9	6.3
22.7	26.4	6.5	18.8	17.6	4.5	11.9	14.2	6.3
22.6	26.7	6.5	18.8	17.5	4.7	11.9	14.0	6.3
23.2	26.5	6.5	18.6	16.5	4.7	12.1	14.1	6.3
22.5	26.4	6.5	18.5	16.7	4.8	11.8	14.0	6.3
22.5	26.3	6.5	18.6	17.6	4.7	11.8	14.3	6.3
22.5	26.0	6.4	18.4	16.5	4.8	11.9	14.5	6.3
22.5	28.4	6.4	18.2	16.8	4.7	11.9	14.2	6.3
22.3	26.7	6.5	18.2	16.3	4.6	12.0	14.1	6.3
22.0	25.9	6.4	18.0	16.2	4.6	11.9	13.9	6.3
21.9	26.0	6.5	18.2	16.4	4.7	11.8	14.1	6.4
21.8	26.0	6.5	18.3	16.0	4.7	11.8	14.6	6.5
21.7	26.0	6.5	18.1	16.6	4.6	11.8	14.4	6.4
21.9	25.7	6.5	18.0	16.0	4.6	11.7	14.4	6.4
22.0	27.1	6.5	17.8	16.2	4.6	11.7	14.4	6.5
21.7	27.5	6.5	18.0	16.0	4.6	11.9	14.3	6.4
21.7	28.5	6.5	17.8	16.1	4.5	11.8	14.3	6.3
21.6	26.0	6.5	17.7	17.0	4.6	11.7	14.7	6.4
21.6	27.0	6.5	17.6	16.7	4.7	11.6	14.3	6.3
21.5	26.0	6.5	17.7	16.8	4.7	11.6	14.3	6.3
21.5	25.7	6.5	17.6	17.2	4.6	11.8	14.4	6.4
21.3	25.5	6.4	17.6	16.6	4.7	11.7	13.8	6.4
21.2	25.7	6.5	17.4	16.2	4.7	11.7	14.0	6.5
21.3	25.9	6.5	17.4	16.1	4.7	11.6	14.1	6.5
21.2	25.9	6.5	17.4	15.7	4.6	11.7	13.8	6.4
21.1	25.7	6.5	17.4	16.5	4.6	11.6	14.1	6.5
20.9	26.0	6.5	17.3	16.5	4.7	11.7	13.9	6.5
21.1	25.8	6.5	17.2	15.6	4.7	11.7	14.2	6.5
20.9	25.2	6.5	17.2	18.2	4.4	11.8	14.0	6.4
20.8	25.4	6.5	17.1	16.7	4.5	11.7	14.0	6.4
20.7	25.7	6.5	17.1	15.5	4.5	11.6	14.2	6.4
20.5	27.8	6.5	16.9	16.5	4.5	11.6	13.9	6.4
20.8	26.1	6.5	17.1	15.4	4.5	11.6	13.9	6.5
21.0	25.7	6.4	17.0	15.3	4.7	11.6	13.8	6.5
20.6	25.4	6.4	16.9	15.3	4.6	11.6	13.7	6.5
20.4	25.8	6.5	16.7	15.2	4.6	11.6	13.9	6.5
20.3	26.1	6.5	16.9	17.8	4.5	11.6	13.8	6.5
20.4	25.3	6.4	17.0	16.1	4.6	11.6	13.8	6.6
20.3	25.2	6.5	16.8	15.5	4.6	11.6	13.9	6.6
20.3	27.5	6.5	16.7	16.1	4.6	11.5	13.3	6.6
20.1	27.8	6.5	16.6	15.5	4.6	11.6	13.4	6.5
20.2	26.4	6.5	16.7	15.5	4.6	11.6	13.4	6.5
20.2	26.0	6.5	16.8	15.8	4.7	11.6	13.1	6.5
20.0	26.0	6.5	16.5	15.6	4.6	11.6	13.4	6.5
19.9	30.0	6.4	16.4	15.4	4.6	11.5	13.3	6.5
19.8	28.3	6.5	16.7	15.8	4.6	11.5	13.0	6.5

19.8	27.0	6.5	16.6	16.5	4.5	11.6	13.1	6.6
19.8	27.5	6.5	16.5	16.1	4.5	11.5	12.9	6.6
19.6	29.1	6.5	16.6	15.7	4.6	11.5	12.5	6.6
19.8	26.6	6.5	16.5	15.7	4.8	11.5	12.8	6.6
19.7	26.7	6.6	16.6	16.5	4.8	11.5	12.9	6.7
19.3	27.0	6.7	16.5	16.2	4.8	11.5	12.7	6.6
19.5	26.2	6.6	16.3	15.7	4.8	11.5	12.8	6.6
19.7	27.9	6.6	16.5	16.9	4.6	11.5	12.6	6.6
19.4	27.7	6.7	16.5	15.8	4.7	11.5	12.6	6.7
19.3	26.6	6.6	16.6	15.6	4.6	11.5	12.6	6.6
19.3	26.5	6.6	16.6	15.9	4.6	11.5	12.4	6.6
19.2	27.5	6.6	16.6	16.1	4.6	11.4	12.5	6.7
19.2	26.5	6.7	16.5	15.7	4.6	11.5	12.7	6.7

0.40 Glycerol Viscosity (mPa.s)			**0.30 Glycerol Viscosity (mPa.s)**	**0.20 Glycerol Viscosity (mPa.s)**
G+P 250 Hz	**G+P 50 Hz**	**G+W 250 Hz**	**G+P 250 Hz**	**G+P 250 Hz**
5.1	4.3	4.2	3.1	2.2
5.0	4.2	2.9	3.1	2.1
5.1	3.5	2.9	3.1	2.1
5.1	4.4	3.1	3.2	2.1
5.1	4.4	3.9	3.2	2.2
5.0	3.5	3.5	3.2	2.2
5.1	3.5	3.1	3.2	2.4
5.3	5.3	3.0	3.3	2.2
5.6	4.2	2.7	3.4	2.3
5.7	6.3	3.5	3.7	2.3
5.9	5.9	3.7	3.5	2.4
5.9	5.1	3.1	3.5	2.5
5.9	3.8	3.9	3.7	2.5
6.0	3.5	3.0	3.8	2.5
6.0	4.4	2.9	3.8	2.6
6.1	4.6	3.1	4.1	2.7
6.3	6.2	3.6	3.9	2.6
6.4	5.1	3.5	4.0	2.7
6.5	7.3	3.7	4.1	2.8
6.6	5.2	4.0	4.2	2.8
6.6	5.2	4.0	4.3	2.8
6.9	5.3	3.7	4.4	2.9
7.0	5.8	4.0	4.5	2.9
7.1	5.8	4.0	4.5	3.0
7.0	6.3	4.0	4.5	3.1
7.3	6.6	3.8	4.8	3.1
7.4	6.8	4.4	4.8	3.3
7.5	9.7	4.1	4.8	3.2
7.8	6.7	4.0	4.9	3.4
7.7	6.4	3.8	5.0	3.5
8.0	6.6	3.9	5.0	3.3
8.3	7.0	3.8	5.3	3.4
8.2	6.7	3.9	5.5	3.5
8.2	8.0	3.7	5.4	3.5
8.4	6.8	3.6	5.5	3.6
8.6	11.5	4.5	5.6	3.7
8.7	8.6	3.8	5.8	3.8

8.8	6.9	3.7	5.8	3.7
9.0	7.4	4.7	6.0	3.9
8.9	7.5	3.7	6.0	3.9
9.1	7.4	3.1	6.0	3.9
9.2	9.5	4.0	6.2	4.0
9.3	9.1	3.4	6.2	4.1
9.4	8.9	3.0	6.4	4.0
9.4	8.5	3.3	6.4	4.1
9.6	8.7	3.7	6.4	4.1
9.7	8.4	3.2	6.5	4.3
9.6	9.0	3.3	6.6	4.3
9.8	8.8	3.0	6.6	4.3
9.7	8.5	3.9	6.6	4.3
9.8	10.1	2.9	6.7	4.3
9.7	10.5	3.3	6.8	4.3
9.8	9.1	3.8	6.9	4.3
10.1	9.2	3.3	6.9	4.4
9.9	9.0	2.9	7.0	4.4
9.9	8.9	3.2	7.0	4.4
9.8	9.6	3.3	7.1	4.4
9.9	10.0	4.8	7.1	4.4
10.0	13.8	2.8	7.1	4.5
9.9	10.6	2.9	7.1	4.5
9.9	10.9	3.1	7.1	4.6
9.9	12.0	2.7	7.2	4.5
9.9	11.6	4.0	7.2	4.6
9.9	9.3	3.3	7.2	4.7
9.9	9.6	3.3	7.2	4.7
9.9	9.8	4.8	7.3	4.7
9.9	10.8	4.2	7.3	4.6
9.8	12.1	3.7	7.4	4.7
9.8	10.0	3.4	7.3	4.6
9.8	10.3	3.7	7.4	4.6
9.8	11.0	8.8	7.3	4.6
10.0	9.7	6.3	7.3	4.7
9.9	9.1	4.1	7.4	4.7
9.8	9.5	4.1	7.3	4.6
9.8	10.5	4.2	7.6	4.7
9.9	12.5	4.6	7.4	4.7
9.9	13.2	4.2	7.5	4.6
9.7	9.3	3.9	7.5	4.7
9.7	9.2	3.4	7.6	4.7
9.7	10.4	3.5	7.5	4.7
10.1	9.1	3.7	7.5	4.7
9.8	9.1	4.0	7.6	4.7
9.7	9.4	5.7	7.6	4.7
9.7	12.4	3.9	7.6	4.8
9.6	10.2	3.4	7.6	4.7
9.7	10.3	4.5	7.6	4.7
10.3	8.7	3.9	7.6	4.8
9.5	8.8	5.1	7.6	4.7
9.6	9.3	3.6	7.7	4.8
9.6	10.4	3.6	7.6	5.0
9.6	8.7	3.3	7.6	4.7
9.6	9.1	3.5	7.6	4.8
9.4	10.1	3.6	7.6	4.8

9.4	12.5	4.4	7.7	4.8
9.4	7.8	3.7	7.6	4.9
9.5	8.4	3.2	7.7	4.8
9.4	8.4	3.5	7.7	4.9
9.5	9.0	5.0	7.8	4.8
9.5	8.6	3.8	7.6	5.0
9.4	9.1	4.0	7.6	4.9
9.3	8.8	3.9	7.7	4.9
9.3	10.1	3.5	7.8	4.8
9.3	8.4	4.8	7.8	4.8
9.2	9.3	3.3	7.7	4.8
9.2	7.3	3.2	7.7	4.8
9.2	7.8	3.6	7.8	4.9
9.2	9.4	3.4	7.8	4.9
9.1	9.0	3.2	8.0	4.8
9.1	9.4	3.4	7.8	4.9
9.2	9.5	4.7	7.7	4.8
9.2	8.1	3.5	7.8	4.8
9.1	8.1	3.8	7.7	4.9
9.1	7.1	3.3	7.7	4.9
9.1	7.2	3.4	7.7	4.8
9.1	7.2	3.5	7.7	4.8
9.0	8.9	3.5	7.7	4.8
9.0	9.8	3.5	7.7	4.9
9.0	8.6	3.6	7.7	4.8
9.2	7.1	3.6	7.7	4.8
8.9	7.6	3.9	7.8	4.8
8.9	8.0	3.7	7.8	4.8
8.9	7.5	3.5	7.7	4.8
9.0	7.6	3.5	7.8	4.8
8.8	8.1	3.9	7.8	4.9
8.9	9.5	3.6	7.9	4.9
8.9	8.4	3.7	7.8	4.9
8.9	6.9	3.6	7.8	4.8
8.9	6.7	6.3	7.8	4.8
8.8	7.8	3.6	7.9	4.9
8.8	7.4	3.7	7.9	4.9
8.9	7.5	4.1	7.8	4.9
8.9	7.2	3.5	7.8	4.9
8.8	8.7	3.6	8.0	4.9
8.8	7.1	3.5	8.0	4.9
8.9	9.6	3.6	8.0	4.9
8.8	7.3	3.4	7.8	4.9
8.9	6.5	3.5	7.7	4.9
8.8	7.6	4.8	8.1	5.0
8.8	7.2	4.3	7.9	4.9
8.9	6.8	3.9	7.9	4.8
8.8	7.2	3.9	7.8	4.9
8.9	8.6	3.7	8.0	5.0
9.0	7.3	3.5	7.8	4.9
8.9	7.2	3.6	7.9	4.9
8.9	6.7	3.6	7.8	4.9
8.8	6.6	3.4	7.8	4.9
8.9	6.8	4.5	7.8	4.9
8.8	9.7	9.2	7.8	4.9
8.7	6.5	3.8	7.8	4.9

8.8	8.0	3.5	7.9	4.9
8.8	7.1	3.5	7.9	4.9
8.8	7.5	4.0	7.9	4.9
8.7	7.3	3.4	7.9	4.9
8.7	6.4	3.9	7.8	5.0
8.8	6.7	4.1	7.9	5.0
8.8	7.0	9.0	8.1	5.0
8.7	6.8	4.8	8.1	4.9
8.7	8.1	4.0	8.2	4.9
8.8	7.3	3.5	8.0	5.0
8.8	7.2	4.2	8.0	4.9
8.8	6.6	4.8	7.9	5.0
8.7	6.9	4.8	7.9	5.0
8.6	6.0	4.0	8.0	5.0
8.7	6.7	3.6	7.9	5.0
8.8	7.3	4.0	7.8	5.0
8.7	7.7	3.4	7.9	4.9
8.7	7.2	4.1	7.8	5.1
8.7	7.2	4.3	7.8	5.1
8.7	6.5	3.8	7.8	4.9
8.8	7.1	4.2	8.0	4.9
8.6	7.5	3.9	7.9	5.0
8.7	7.0	3.8	7.9	5.1
8.8	7.0	4.2	7.8	5.0
8.6	7.6	3.7	7.8	5.0
8.6	7.8	3.8	8.1	5.0
8.6	8.3	4.3	7.9	5.0
8.8	7.0	3.7	8.0	5.0
8.7	6.7	3.7	7.9	5.0
8.6	6.9	4.0	8.0	5.0
8.6	7.9	3.5	7.9	5.0
8.7	6.5	4.7	7.9	5.0
8.7	8.8	4.0	8.0	5.0
8.6	6.8	6.9	7.9	5.0
8.5	8.0	6.4	7.9	5.2
8.8	6.1	3.8	7.9	5.1
8.6	6.6	3.4	7.8	4.9
8.6	6.9	3.9	7.8	5.0
8.6	8.0	3.8	7.9	5.0
8.6	7.1	4.3	7.9	5.0
8.7	7.6	3.8	7.8	5.0
8.7	8.4	3.6	7.9	5.0
8.7	7.7	4.0	7.9	5.0
8.6	7.1	3.9	7.9	5.0
8.6	7.4	3.8	7.9	5.0
8.7	6.1	3.9	7.9	5.0
8.6	6.9	3.6	7.8	5.0
8.5	8.8	4.4	7.9	5.0
8.6	8.0	3.8	7.9	5.1
8.6	7.0	3.8	7.9	5.0
8.7	6.4	4.2	7.9	5.1
8.6	6.3	4.6	7.8	5.0
8.7	6.2	4.1	7.9	5.1
8.6	6.7	3.6	7.9	5.0
8.6	5.9	3.7	7.9	5.0
8.6	6.5	4.4	7.9	5.0

8.6	9.3	4.1	7.9	5.2
8.6	7.2	4.2	7.8	5.1
8.6	7.3	4.0	7.8	5.0
8.6	7.2	3.4	7.9	5.0
8.5	6.0	3.8	8.1	5.1

Table S-7. Viscosity values for glycerol + pentanol at 250 Hz and for glycerol + water mixtures at 250 Hz with temperature change from 70°C-60°C

Time (min)	Temp. (°C)	1 Glycerol Viscosity (mPa.s)		0.95 Glycerol Viscosity (mPa.s)		0.90 Glycerol Viscosity (mPa.s)		0.80 Glycerol Viscosity (mPa.s)	
		250 Hz	50 Hz	G+P 250 Hz	G+W 250 Hz	G+P 250 Hz	G+W 250 Hz	G+P 250 Hz	G+W 250 Hz
0.2	69.8	52.2	53.7	41.4	27.0	34.0	15.8	24.5	6.7
0.3	68.6	52.6	54.0	41.8	27.1	34.2	15.9	24.5	6.6
0.5	67	53.2	53.2	42.2	27.4	34.3	16.0	24.7	6.6
0.7	65.4	54.1	55.9	42.6	27.8	35.1	16.2	25.2	7.0
0.8	64	55.5	55.1	43.3	28.4	35.7	16.7	25.7	7.0
1	62.7	56.9	59.5	44.4	29.1	36.5	17.2	26.3	7.1
1.2	61.4	58.5	61.0	45.5	29.9	37.7	17.5	27.0	7.2
1.3	60.4	60.2	59.6	46.6	30.7	38.5	17.8	27.7	7.4
1.5	59.6	62.0	67.0	47.8	31.5	39.4	18.3	28.6	7.4
1.7	59.1	63.9	65	48.9	32.3	40.4	18.6	29.2	7.6
1.8	58.9	65.6	69.3	50.2	33.1	41.4	18.9	29.9	7.7
2	58.9	67.0	68.5	51.4	33.8	42.3	19.3	30.5	8.0
2.2	59.2	68.1	69.7	52.2	34.4	43.1	19.6	31.0	8.0
2.3	59.5	69.3	71.4	53.1	34.8	44.0	19.7	31.5	8.1
2.5	59.7	70.3	76.6	53.7	35.2	44.3	19.9	31.9	8.2
2.7	59.7	70.9	77.5	54.2	35.5	44.7	20.3	32.2	8.2
2.8	59.7	71.9	71.6	54.6	35.8	45.0	20.4	32.5	8.2
3	59.7	72.6	74.8	54.7	36.2	45.4	20.6	32.9	8.3
3.2	59.6	73.3	73.4	55.8	36.5	46.0	20.8	33.1	8.4
3.3	59.6	73.9	73.5	55.9	36.8	46.8	20.8	33.4	8.4
3.5	59.7	74.5	79.2	56.6	37.1	46.6	21.1	33.7	8.5
3.7	59.8	75.1	76.8	57.1	37.4	47.0	21.1	34.0	8.5
3.8	59.8	75.6	76.8	57.0	37.6	47.2	21.2	34.2	8.6
4	59.8	76.0	81.4	58.0	37.8	47.5	21.3	34.5	8.6
4.2	59.9	76.6	76.9	58.6	38.0	47.7	21.3	34.7	8.6
4.3	59.9	76.9	76.7	58.9	38.2	47.9	21.5	34.9	8.7
4.5	59.9	77.3	81.0	59.1	38.3	48.2	21.6	35.1	8.7
4.7	59.9	78.0	77.8	59.3	38.6	48.6	21.7	35.3	8.7
4.8	59.9	78.3	80.5	59.7	38.6	49.0	21.9	35.5	8.7
5	59.9	78.6	82.2	60.4	38.9	49.2	22.1	35.7	8.8
5.2	59.9	78.8	80.6	59.8	39.0	49.7	21.6	35.9	8.8
5.3	59.9	79.1	79.2	59.9	39.1	49.5	22.0	36.1	8.9
5.5	59.9	79.3	82.0	60.1	39.2	49.7	22.3	36.2	8.8
5.7	59.9	79.6	82.1	60.3	39.4	49.7	22.1	36.4	8.9
5.8	59.9	80.0	84.6	60.5	39.4	49.8	22.2	36.6	8.9
6	59.9	80.3	83.0	60.4	39.7	50.2	22.3	36.7	8.9
6.2	59.9	80.4	80.5	60.6	39.6	50.2	22.3	36.8	9.0
6.3	59.9	80.9	81.4	60.8	39.7	50.3	22.3	37.1	8.9
6.5	59.9	81.1	81.6	61.1	39.8	50.4	22.6	37.2	9.0
6.7	59.9	81.3	83.7	61.0	40.0	50.6	22.5	37.3	9.0
6.8	60	81.4	84.7	61.0	40.1	51.0	22.7	37.3	8.9
7	60	81.5	84.8	61.5	40.1	50.8	22.6	37.4	9.0

7.2	60	81.8	85.5	61.6	40.1	50.9	22.4	37.5	9.0
7.3	60	81.8	81.7	62.1	40.2	51.2	22.6	37.7	9.0
7.5	60	82.2	84.1	62.4	40.4	51.2	22.8	37.8	9.1
7.7	60	82.3	83.6	62.4	40.4	51.4	22.6	37.9	9.0
7.8	60	82.4	83.2	62.1	40.5	51.3	22.6	38.0	9.1
8	60	82.6	84.8	62.4	40.5	51.3	22.7	38.1	9.1
8.2	60	83.0	82.7	62.2	40.6	51.5	22.7	38.2	9.0
8.3	60	82.9	83.9	62.4	40.6	51.4	22.8	38.3	9.1
8.5	60	82.9	85.6	62.5	40.7	51.5	22.8	38.4	9.1
8.7	60	83.0	83.8	62.6	40.7	51.5	22.8	38.4	9.0
8.8	60	83.1	85.4	62.5	40.7	51.7	22.9	38.7	9.1
9	60	83.2	85.5	62.5	40.9	51.6	22.8	38.6	9.1
9.2	60	83.4	83.9	62.6	40.9	51.6	22.8	38.7	9.1
9.3	60	83.5	87.2	62.8	40.9	51.8	23.0	38.7	9.1
9.5	60	83.6	86.0	63.0	40.9	52.0	22.8	38.8	9.1
9.7	60	83.8	85.0	63.0	41.0	52.0	22.8	38.9	9.2
9.8	60	83.8	86.3	63.0	41.0	52.0	22.9	38.9	9.2
10	60	83.9	86.0	62.8	41.1	52.2	22.9	39.0	9.1
10.2	60	84.1	87.3	63.3	41.1	52.0	23.0	39.0	9.1
10.3	60	83.9	86.9	63.4	41.1	52.3	23.1	39.1	9.2
10.5	60	84.2	89.4	63.3	41.2	52.4	22.9	39.1	9.0
10.7	60	84.2	87.7	63.9	41.2	52.2	23.2	39.2	9.2
10.8	60	84.2	88.0	64.0	41.2	52.2	23.1	39.1	9.1
11	60	84.4	90.6	63.9	41.2	52.5	22.9	39.1	9.2
11.2	60	84.4	89.4	64.0	41.4	52.5	23.1	39.3	9.2
11.3	60	84.5	85.7	64.2	41.2	52.3	23.2	39.4	9.2
11.5	60	84.4	86.3	63.9	41.4	52.3	23.1	39.5	9.3
11.7	60	84.4	86.7	63.6	41.4	52.4	23.1	39.6	9.3
11.8	60	84.7	87.5	63.3	41.4	52.6	23.0	39.5	9.3
12	60	84.8	86.2	63.6	41.4	52.5	23.1	39.5	9.2
12.2	60	84.7	87.1	63.6	41.4	52.5	23.2	39.5	9.2
12.3	60	84.9	87.1	64.0	41.4	52.6	23.0	39.5	9.2
12.5	60	84.8	88.2	63.6	41.5	52.7	23.0	39.6	9.2
12.7	60	84.8	85.0	63.8	41.5	52.7	23.3	39.6	9.2
12.8	60	84.8	86.5	64.1	41.4	52.7	23.2	39.7	9.3
13	60	84.9	85.6	64.2	41.4	52.8	23.1	39.7	9.3
13.2	60	84.9	86.4	64.2	41.5	52.9	23.2	39.7	9.3
13.3	60	84.9	87.3	63.9	41.6	52.8	23.2	39.8	9.3
13.5	60	85.0	86.4	64.3	41.6	52.9	23.1	39.9	9.3
13.7	60	85.1	89.7	63.8	41.6	52.8	23.1	40.0	9.5
13.8	60	85.1	89.0	64.5	41.5	52.9	23.1	39.9	9.3
14	60	85.2	88.3	64.7	41.6	52.9	23.2	39.9	9.3
14.2	60	85.0	86.6	64.8	41.5	52.8	23.3	40.0	9.4
14.3	60	85.1	88.8	64.8	41.6	52.8	23.1	40.3	9.3
14.5	60	85.0	87.5	64.2	41.7	52.9	23.2	40.0	9.3
14.7	60	85.2	88.9	64.4	41.7	53.1	23.5	40.1	9.3
14.8	60	85.3	89.3	64.3	41.6	52.9	23.2	40.0	9.3
15	60	85.3	88.7	64.4	41.6	53.0	23.1	40.1	9.3
15.2	60	85.3	92.0	64.4	41.7	53.4	23.3	40.1	9.3
15.3	60	85.6	90.6	64.3	41.6	53.1	23.2	40.1	9.2
15.5	60	85.3	89.0	64.3	41.6	53.0	23.2	40.1	9.3
15.7	60	85.4	87.6	64.5	41.7	53.0	23.2	40.1	9.3
15.8	60	85.3	85.8	64.5	41.8	53.2	23.2	40.2	9.3
16	60	85.4	87.1	64.4	41.7	53.3	23.4	40.1	9.3
16.2	60	85.5	88.4	64.6	41.7	53.2	23.2	40.2	9.3
16.3	60	85.5	91.6	64.6	41.7	53.2	23.2	40.2	9.3

16.5	60	85.6	87.3	64.5	41.8	53.0	23.4	40.5	9.3
16.7	60	85.4	89.3	64.3	41.8	53.2	23.2	40.3	9.3
16.8	60	85.5	86.4	64.2	41.8	53.2	23.1	40.3	9.4
17	60	85.7	89.7	64.9	41.8	53.1	23.2	40.3	9.4
17.2	60	85.6	89.0	64.6	41.8	53.2	23.3	40.4	9.4
17.3	60	85.7	88.3	64.8	41.7	53.5	23.2	40.5	9.4
17.5	60	85.5	86.6	64.8	41.7	53.2	23.2	40.4	9.3
17.7	60	85.8	88.8	64.8	41.8	53.4	23.1	40.4	9.3
17.8	60	85.6	87.5	64.7	41.8	53.2	23.2	40.4	9.4
18	60	85.5	88.9	64.7	41.8	53.5	23.2	40.5	9.3
18.2	60	85.7	89.3	64.8	41.8	53.4	23.2	40.4	9.4
18.3	60	85.7	88.7	64.8	41.8	53.3	23.3	40.4	9.5
18.5	60	85.7	92.0	64.7	41.8	53.2	23.3	40.4	9.4
18.7	60	85.8	90.6	64.8	41.8	53.2	23.2	40.5	9.3
18.8	60	85.8	89.0	64.8	41.8	53.4	23.2	40.4	9.3
19	60	86.1	87.6	64.9	41.8	53.3	23.3	40.5	9.4
19.2	60	86.0	85.8	64.9	41.8	53.2	23.2	40.5	9.4
19.3	60	85.9	87.4	64.8	41.8	53.1	23.2	40.5	9.4
19.5	60	85.8	88.4	64.8	41.8	53.5	23.3	40.5	9.3
19.7	60	85.7	91.6	64.8	41.8	53.4	23.3	40.6	9.4
19.8	60	85.7	87.3	65.1	41.9	53.4	23.3	40.7	9.5
20	60	85.8	89.3	65.0	41.8	53.4	23.3	40.6	9.4

0.75 Glycerol Viscosity (mPa.s)		0.70 Glycerol Viscosity (mPa.s)		0.65 Glycerol Viscosity (mPa.s)		0.60 Glycerol Viscosity (mPa.s)		0.50 Glycerol Viscosity (mPa.s)	
G+P 250 Hz	G+W 250 Hz	G+P 250 Hz	G+W 250 Hz	G+P 250 Hz	G+W 250 Hz	G+P 250 Hz	G+W 250 Hz	G+P 250 Hz	G+W 250 Hz
20.0	4.9	16.0	3.3	12.9	2.1	11.0	1.3	7.4	2.0
20.0	4.9	16.0	3.3	12.9	2.1	11.2	1.3	7.4	1.8
20.3	5.0	16.2	3.3	12.8	2.1	11.4	1.3	7.6	1.7
20.6	4.9	16.4	3.3	13.0	2.0	11.3	1.3	7.7	1.7
21.0	4.9	16.7	3.4	13.6	2.1	11.6	1.4	7.9	1.7
21.5	5.1	17.0	3.5	13.7	2.2	11.8	1.4	8.0	1.8
22.0	5.2	17.5	3.6	15.1	2.3	12.1	1.3	8.2	1.9
22.5	5.3	17.9	3.6	14.8	2.3	12.4	1.5	8.3	2.1
23.2	5.5	18.4	3.7	15.2	2.4	12.5	1.6	8.4	2.0
23.8	5.6	19.0	3.8	15.6	2.4	13.0	1.6	8.6	1.9
24.3	5.6	19.6	3.8	16.1	2.4	13.3	1.5	8.7	2.0
24.9	5.7	19.9	3.9	16.5	2.4	13.6	1.7	8.8	2.0
25.4	5.7	20.3	4.0	16.9	2.5	13.7	1.8	9.1	1.8
26.0	5.8	20.7	4.0	16.7	2.6	13.8	1.7	9.2	1.7
26.7	5.8	21.0	4.0	16.9	2.6	14.1	1.7	9.2	1.7
26.9	5.8	21.3	4.1	16.6	2.5	14.4	1.8	9.3	1.7
27.1	5.9	21.7	4.1	16.8	2.6	14.5	1.8	9.5	1.7
27.5	6.0	21.8	4.1	17.1	2.7	14.4	1.8	9.4	1.7
27.7	6.1	22.1	4.1	17.1	2.7	14.6	1.8	9.5	1.9
27.9	6.1	22.3	4.0	17.4	2.6	14.8	1.7	9.6	2.0
28.3	6.1	22.5	4.1	17.4	2.6	14.9	1.8	9.8	1.8
28.6	6.1	22.6	4.2	17.5	2.7	15.0	1.8	9.5	1.8
29.0	6.1	22.7	4.1	17.6	2.7	14.8	1.7	9.6	2.0
29.1	6.2	22.8	4.0	17.5	2.6	15.1	1.8	9.7	1.8
29.5	6.2	22.9	4.2	17.7	2.7	15.0	1.8	9.7	1.7
29.7	6.2	23.0	4.2	17.8	2.7	15.6	1.8	9.8	1.7
30.0	6.3	23.2	4.2	17.9	2.7	15.2	1.8	9.9	1.7

30.5	6.2	23.2	4.2	17.9	2.7	15.3	1.9	9.7	1.7
30.6	6.4	23.3	4.2	17.8	2.7	15.4	1.8	9.8	1.8
30.7	6.4	23.3	4.2	17.9	2.8	15.4	1.8	9.8	1.8
30.8	6.4	23.3	4.2	18.0	2.7	15.5	1.8	9.9	2.0
31.0	6.3	23.4	4.3	17.9	2.8	15.7	1.8	9.9	2.0
31.2	6.4	23.4	4.2	17.9	2.8	15.6	1.9	9.8	1.8
31.2	6.4	23.5	4.4	18.0	2.8	15.5	1.8	9.9	1.9
31.2	6.3	23.6	4.3	18.0	2.8	15.5	1.9	9.8	1.8
31.4	6.4	23.6	4.4	18.0	2.7	15.6	2.0	9.9	1.7
31.4	6.5	23.7	4.3	18.1	2.8	15.5	2.0	10.0	1.6
31.3	6.4	23.7	4.3	18.2	2.8	15.5	2.0	10.0	1.7
31.3	6.4	23.7	4.3	18.3	2.8	15.8	1.9	9.9	1.7
31.5	6.5	23.8	4.4	18.2	2.7	15.7	2.0	10.0	1.8
31.9	6.4	23.8	4.4	18.2	2.9	15.7	1.9	10.0	1.8
32.1	6.5	23.8	4.4	18.2	2.8	15.9	1.9	10.0	1.8
32.4	6.5	23.8	4.3	18.2	2.7	15.8	1.9	10.0	1.9
32.1	6.5	23.9	4.4	18.2	2.7	15.6	2.0	10.0	1.8
32.0	6.5	23.8	4.4	18.2	2.8	15.7	1.9	10.0	1.7
31.9	6.4	23.8	4.5	18.2	2.7	15.8	1.9	10.1	1.9
31.9	6.4	23.8	4.5	18.2	2.7	15.8	1.9	10.1	1.7
31.9	6.5	23.8	4.3	18.2	2.7	15.8	1.9	10.0	1.6
32.0	6.5	23.9	4.5	18.2	2.8	15.8	1.9	10.1	1.7
32.2	6.4	23.7	4.3	18.2	2.8	15.8	1.9	10.2	1.7
32.0	6.5	23.7	4.3	18.3	2.7	15.7	2.0	10.1	1.7
32.0	6.5	23.6	4.3	18.4	2.8	15.8	1.9	10.1	1.7
32.2	6.5	23.6	4.3	18.2	2.9	15.8	1.9	10.2	1.8
32.3	6.5	23.6	4.4	18.2	2.9	15.7	1.9	10.2	1.9
32.4	6.5	23.5	4.4	18.1	2.8	15.8	2.0	10.1	1.9
32.6	6.5	23.6	4.5	18.2	2.7	15.8	2.0	10.2	1.8
32.7	6.5	23.5	4.4	18.2	2.8	15.9	1.9	10.2	1.7
32.7	6.5	23.5	4.4	18.3	2.7	15.8	2.0	10.2	1.7
32.8	6.4	23.4	4.4	18.1	2.7	15.8	2.0	10.2	1.7
32.8	6.5	23.4	4.5	18.2	2.7	15.8	2.1	10.2	1.7
32.7	6.5	23.4	4.4	18.1	2.8	15.8	2.0	10.2	1.7
32.4	6.4	23.3	4.4	18.2	2.7	15.8	2.0	10.2	1.7
32.6	6.4	23.4	4.4	18.2	2.7	15.9	2.1	10.2	1.7
32.6	6.4	23.3	4.4	18.2	2.7	15.8	2.1	10.3	1.8
32.6	6.5	23.4	4.4	18.1	2.8	15.8	1.9	10.2	1.9
32.5	6.5	23.4	4.4	18.1	2.7	15.9	2.0	10.5	1.9
32.8	6.5	23.4	4.4	18.1	2.7	15.9	2.0	10.3	1.8
32.5	6.5	23.4	4.5	18.3	2.8	15.8	2.0	10.5	1.7
32.5	6.5	23.4	4.4	18.2	2.7	15.7	1.9	10.3	1.6
32.8	6.5	23.5	4.4	18.2	2.7	15.9	1.9	10.3	1.7
33.0	6.5	23.5	4.4	18.2	2.7	15.8	2.0	10.2	1.6
33.0	6.5	23.5	4.4	18.2	2.7	15.7	2.0	10.5	1.7
33.1	6.5	23.5	4.4	18.3	2.8	15.6	1.9	10.4	1.7
33.0	6.5	23.5	4.4	18.3	2.8	15.7	2.0	10.3	1.8
32.8	6.4	23.5	4.4	18.3	2.7	15.8	2.0	10.3	1.8
32.7	6.3	23.6	4.3	18.3	2.7	15.7	2.0	10.4	1.7
32.7	6.4	23.6	4.3	18.4	2.8	15.7	2.0	10.4	1.8
32.7	6.5	23.6	4.3	18.5	2.8	15.8	1.9	10.6	1.9
32.7	6.5	23.6	4.3	18.4	2.8	15.7	2.1	10.5	1.7
32.6	6.6	23.6	4.4	18.4	2.7	15.8	2.0	10.5	1.7
32.6	6.7	23.9	4.4	18.5	2.7	15.8	1.9	10.7	1.7
32.7	6.6	23.7	4.4	18.4	2.7	15.7	2.0	10.4	1.6
32.7	6.5	23.8	4.4	18.4	2.8	15.8	2.0	10.8	1.7

32.8	6.5	23.7	4.4	18.3	2.8	15.8	1.9	10.8	1.7
32.8	6.6	23.9	4.4	18.4	2.8	15.8	2.0	10.5	1.7
32.7	6.6	23.9	4.5	18.4	2.7	15.7	1.9	10.5	1.7
32.7	6.6	23.9	4.5	18.3	2.7	15.7	2.0	10.4	1.6
32.8	6.6	24.0	4.4	18.2	2.7	15.7	1.9	10.4	1.8
32.8	6.6	24.1	4.4	18.3	2.8	15.7	1.9	10.4	1.8
32.8	6.6	24.0	4.5	18.3	2.8	15.7	2.0	10.4	1.7
33.0	6.8	24.2	4.5	18.3	2.8	15.8	2.1	10.3	1.6
32.9	6.7	24.1	4.5	18.3	2.7	15.8	2.1	10.4	1.6
33.0	6.7	24.1	4.4	18.3	2.8	15.8	1.9	10.4	1.7
33.0	6.7	24.3	4.5	18.3	2.8	15.7	1.9	10.4	1.7
33.1	6.7	24.6	4.6	18.3	2.8	15.8	2.0	10.3	1.7
33.0	6.7	24.3	4.5	18.3	2.7	15.9	1.9	10.4	1.8
32.9	6.6	24.3	4.4	18.3	2.8	15.9	2.0	10.4	1.8
33.0	6.6	24.4	4.4	18.3	2.6	15.8	2.0	10.5	1.7
33.0	6.6	24.3	4.5	18.4	3.0	15.7	1.9	10.3	1.7
33.0	6.5	24.3	4.5	18.3	2.9	15.8	1.9	10.4	1.7
33.0	6.5	24.3	4.6	18.3	2.9	15.7	1.9	10.4	1.8
33.1	6.5	24.3	4.7	18.4	2.9	15.7	2.0	10.5	1.7
33.2	6.5	24.4	4.6	18.4	2.9	15.7	1.9	10.3	1.6
33.2	6.6	24.4	4.4	18.3	3.0	15.9	1.9	10.3	1.7
33.1	6.5	24.4	4.5	18.3	3.0	15.8	1.9	10.4	1.6
33.1	6.4	24.3	4.6	18.5	2.9	15.7	2.0	10.4	1.7
33.1	6.4	24.4	4.6	18.4	2.9	15.7	2.0	10.4	1.7
33.2	6.5	24.5	4.5	18.3	2.9	15.7	1.9	10.3	1.7
33.0	6.4	24.4	4.5	18.3	2.9	15.8	1.9	10.3	1.8
33.1	6.5	24.3	4.5	18.3	2.9	15.8	1.9	10.4	1.7
33.1	6.5	24.3	4.5	18.3	2.9	15.8	2.0	10.3	1.8
33.1	6.4	24.4	4.5	18.3	2.9	15.8	1.9	10.3	1.8
33.3	6.5	24.4	4.5	18.2	3.0	15.8	1.9	10.4	1.7
33.1	6.6	24.4	4.5	18.2	2.8	15.9	2.0	10.5	1.6
33.0	6.6	24.4	4.4	18.4	2.9	15.7	2.0	10.7	1.6
33.3	6.5	24.5	4.5	18.3	3.0	15.7	1.9	10.7	1.7
33.4	6.5	24.4	4.4	18.2	2.9	15.8	2.1	10.9	1.6
33.3	6.5	24.5	4.5	18.3	2.9	15.7	2.2	10.5	1.6
33.3	6.6	24.5	4.6	18.3	2.9	15.8	2.0	10.5	1.6
33.2	6.6	24.6	4.5	18.3	3.0	15.8	2.0	10.5	1.7

0.40 Glycerol	**0.30 Glycerol**	**0.20 Glycerol**
Viscosity (mPa.s)	**Viscosity (mPa.s)**	**Viscosity (mPa.s)**
G+P 250 Hz	**G+P 250 Hz**	**G+P 250 Hz**
4.8	3.1	2.1
4.8	3.1	2.0
4.7	3.1	2.1
4.9	3.2	2.1
4.9	3.3	2.1
5.0	3.3	2.2
5.0	3.2	2.3
5.1	3.3	2.3
5.2	3.4	2.3
5.3	3.5	2.4
5.4	3.7	2.4
5.5	3.6	2.5
5.6	3.6	2.4

5.5	3.8	2.5
5.6	3.8	2.5
5.6	3.8	2.5
5.5	3.7	2.5
5.7	3.7	2.5
5.8	3.8	2.5
5.7	3.9	2.5
5.7	3.8	2.5
5.8	3.9	2.6
5.9	3.8	2.5
6.1	3.9	2.7
5.8	4.0	2.6
5.8	3.8	2.6
5.9	3.9	2.5
5.9	4.0	2.8
6.0	3.9	2.7
5.9	3.8	2.7
6.0	3.9	2.6
5.9	4.0	2.7
6.0	3.9	2.6
6.0	3.9	2.6
6.1	3.9	2.6
6.1	4.0	2.7
6.1	3.9	2.6
6.1	3.9	2.8
6.1	3.9	2.6
6.1	3.9	2.9
6.1	3.9	2.6
6.1	3.9	2.7
6.2	3.9	2.6
6.1	3.9	2.7
6.2	4.0	2.6
6.4	4.0	2.6
6.3	4.0	2.7
6.2	3.9	2.7
6.1	4.0	2.6
6.2	4.0	2.6
6.1	4.0	2.6
6.4	4.0	2.6
6.2	4.2	2.6
6.2	4.0	2.6
6.2	4.1	2.7
6.3	4.3	2.6
6.2	4.0	2.9
6.2	4.1	2.6
6.2	4.0	2.6
6.2	4.1	2.6
6.3	4.0	2.7
6.4	4.0	2.6
6.5	4.0	2.7
6.4	4.1	2.7
6.4	4.0	2.7
6.3	4.0	2.7
6.3	4.0	2.6
6.3	4.0	2.6
6.4	4.2	2.7

6.4	4.1	2.7
6.3	4.0	2.6
6.3	4.0	2.6
6.4	4.0	2.6
6.3	4.1	2.8
6.3	4.1	2.6
6.3	4.1	2.7
6.3	4.0	3.0
6.3	4.1	2.7
6.4	4.1	2.6
6.2	4.1	2.6
6.3	4.2	2.6
6.4	4.0	2.7
6.3	4.1	2.7
6.3	4.1	2.6
6.3	4.1	2.7
6.3	4.0	2.7
6.3	4.0	2.7
6.3	4.0	2.6
6.3	4.1	2.7
6.3	4.1	2.7
6.3	4.1	2.6
6.3	4.1	2.6
6.3	4.1	2.7
6.3	4.0	2.7
6.3	4.1	2.7
6.3	4.0	2.7
6.2	4.1	2.6
6.3	4.1	2.7
6.3	4.1	2.7
6.6	4.1	2.7
6.3	4.1	2.6
6.3	4.0	2.5
6.3	4.0	2.7
6.3	4.0	2.7
6.3	4.1	2.7
6.3	4.0	2.7
6.3	4.0	2.8
6.4	4.1	2.9
6.3	4.1	2.7
6.3	4.1	2.7
6.3	4.0	2.8
6.3	4.0	3.0
6.2	4.0	2.7
6.3	4.1	2.7
6.3	4.1	2.7
6.3	4.1	2.9
6.4	4.1	2.8
6.3	4.1	2.7
6.4	4.1	2.8
6.4	4.1	2.7

Table S-8. Viscosity values for glycerol and pentanol mixtures. Steady shear viscosity for end of phase transition and after interval of rest (step 10) in the temperature range 70°C-20°C

Glycerol Mass Fraction	G+P 250 Hz, 20°C		G+P 50 Hz, 20°C	
	Phase transition steady state viscosity (mPa.s)	Maximum viscosity after intervals of rest (mPa.s)	Phase transition steady state viscosity (mPa.s)	Maximum viscosity after intervals of rest (mPa.s)
0.20	9.9	10.1		
0.30	11.6	11.7		
0.40	11.3	11.4	2.05	1.5
0.50	19.6	14.1	16.1	13.0
0.60	26.6	85.8	19.8	19.6
0.65	45.9	180	45.0	447
0.70	75.0	215	84.1	467
0.75	242	643	534	864
0.80	360	603	865	966
0.90	842	911	865	959
0.95	911	927	1061	1077

Table S-9. Viscosity values for glycerol and pentanol mixtures. Steady shear viscosity for end of phase transition and after interval of rest (step 10) in the temperature range 70°C-40°C

Glycerol Mass Fraction	G+P 250 Hz, 40C		G+P 50 Hz, 40C	
	Transition phase steady state viscosity (mPa.s)	Maximum viscosity after Intervals of rest (mPa.s)	Transition phase steady state viscosity (mPa.s)	Maximum viscosity after Intervals of rest (mPa.s)
0.30	8.1	8		
0.40	8.5	8.6	7.02	2.87
0.50	11.2	10.1	10.7	10.5
0.60	16.4	17.6	15.2	14.1
0.65	17.2	38.9	26.72	37.4
0.70	38.1	73.9	72.55	101
0.75	87.5	133	149	169
0.80	140	175	172	179
0.90	154	158	145	160
0.95	204	205	230	228

Table S-10. Maximum Viscosity values (mPa.s) for glycerol + pentanol mixtures and glycerol water mixtures at 20°C, 40°C and 60°C

Glycerol Mass Fraction	Glycerol + Pentanol 250 Hz			Glycerol + Water 250 Hz			Glycerol + Pentanol 50 Hz	
	20°C	40°C	60°C	20°C	40°C	60°C	20°C	40°C
1.00	1388	291	86				1420	
0.95	912	205	66.4	517	125	42.1	1062	244
0.90	843	154	54.6	223	63.0	23.5	871	150
0.80	422	144	41.3	60.9	21.6	9.6	874	173
0.75	253	111	35.1	37.5	14.6	6.8	554	153
0.70	92.0	48.0	27.3	24.2	10.3	4.5	112	74.4
0.65	62.1	28.7	19.2	15.9	6.8	2.8	227	40.7
0.60	37.1	25.1	16.2	11.2	4.9	2.0	43.2	35.5
0.50	20.2	14.4	12.3	7.1	3.7	1.7	27.7	21.1
0.40	13.5	10.3	6.7	6.8			12.9	9.2
0.30	12.4	8.2	5.0	5.8			9.4	6.9
0.20	10.2	5.3	3.6	4.4			8.0	
0.10	6.2	3.3	2.2					

Table S-11. Einstein equation (Thomas modification) normalized viscosity data for suspensions and actual viscosity at 250 Hz and 50 Hz at 20°C

Glycerol Mass Fraction	20°C Einstein normalised viscosity (mPa.s)		20°C, 250 Hz Actual normalised viscosity (mPa.s)		20°C, 50 Hz Actual normalised viscosity (mPa.s)	
	P side	G side	P side	G side	P side	G side
0.20	1.00		1.00		1	
0.30	1.33		1.22		1.18	
0.40	1.97		1.33		1.61	
0.50	3.31		1.98		3.46	
0.60	8.37	33.64	3.65	0.04	5.39	0.04
0.65	18.17	13.72	6.11	0.07	28.44	0.21
0.70	49.13	6.58	9.06	0.10	13.98	0.11
0.75	156.44	3.84	24.91	0.28	69.18	0.52
0.80		2.58		0.46		0.82
0.90		1.34		0.92		0.82
0.95		1.00		1.00		1.00

Table S-12. Einstein equation (Thomas modification) normalized viscosity data for suspensions and actual viscosity at 250 Hz and 50 Hz at 40°C

Glycerol	40°C Einstein normalised viscosity (mPa.s)		40°C, 250 Hz Actual normalised viscosity (mPa.s)		40°C, 50 Hz Actual normalised viscosity (mPa.s)	
	P side	G side	P side	G side	P side	G side
0.30	1.00		1.00		1.00	
0.40	1.47		1.26		1.34	
0.50	2.57		1.77		3.07	
0.60	6.75		3.08		5.16	
0.65	16.60	14.95	3.52	0.19	5.91	0.27
0.70	56.79	6.07	5.88	0.31	10.79	0.49
0.75		3.30		0.72		1.02
0.80		2.13		0.94		1.15
0.90		1.03		1.00		1.00

Table S-13. Woelflin calculated normalized viscosity and Phan-Thien and Pham and Pal equation calculated LHS values for experimental data and predicted RHS values at 250 Hz and 50 Hz at 20°C

Dispersed phase volume fraction	Woelflin (η_r)	Pal and Phan LHS (250Hz)	Pal and Phan LHS (50Hz)	Pal RHS	Phan RHS
0.00	1.01	1.00	1.00	1.01	1.01
0.09	1.23	1.22	1.18	1.28	1.27
0.20	1.50	1.33	1.61	1.78	1.74
0.32	1.79	2.00	3.52	2.73	2.59
0.44	7.42	3.72	5.55	5.03	4.33
0.51	5.81	6.32	33.79	7.68	5.99
0.58	4.49	9.55	15.21	13.54	8.88
0.66	3.43	28.98	102.81	31.41	14.54
0.74	2.59	53.28	195.36	154.58	27.83
0.90	1.41	132.27	196.60	1600	357.43
1.00	1.01	147.78	264.26		

Table S-14. Woelflin calculated normalized viscosity and Phan-Thien and Pham and Pal equation calculated LHS values for experimental data and predicted RHS values at 250 Hz and 50 Hz at 40°C

Dispersed phase volume fraction	Woelflin (η_r)	Pal and Phan LHS (250Hz)	Pal and Phan LHS (50Hz)	Pal RHS	Phan RHS
0.00	1.00	1.00	1.00	1.00	1.00
0.12	1.29	1.27	1.35	1.38	1.38
0.26	1.64	1.81	3.27	2.22	2.15
0.42	8.06	3.29	5.84	4.44	3.91
0.50	5.96	3.80	6.84	7.32	5.78
0.59	4.34	6.80	14.23	14.83	9.42
0.68	3.11	19.28	38.34	48.06	17.90
0.78	2.19	27.74	46.18	257.03	44.90
0.99	1.03	30.42	37.30		

Table S-15. Density (g/mL) for single-phase glycerol and pentanol mixtures in the temperature range 20°C-70°C

Glycerol Mass Fraction	Temperature (°C)					
	20	30	40	50	60	70
0.00	0.814966	0.807592	0.800105	0.792467	0.784645	0.776607
0.10	0.844982	0.83854	0.82935	0.822359	0.814871	0.806791
0.15	0.860983	0.854382	0.846906	0.838518	0.83086	0.822538
0.20	0.877572	0.871519	0.862656	0.855884	0.847648	0.839886
0.25	**0.895546**	0.887797	0.88011	0.871655	0.866861	0.856914
0.30	**0.912516**	**0.905833**	0.896661	0.890658	0.882858	0.875641
0.35	**0.931061**	**0.923676**	**0.91537**	0.908838	0.901811	0.89281
0.40	**0.949923**	**0.942906**	**0.935088**	0.928007	0.922291	0.912667
0.45	**0.968715**	**0.963663**	**0.955585**	**0.948869**	0.942677	0.931925
0.50	**0.989118**	**0.982519**	**0.975574**	**0.970257**	**0.961479**	0.955476
0.55	**1.007933**	**1.003134**	**0.99588**	**0.990288**	**0.985705**	0.978076
0.60	**1.027327**	**1.022517**	**1.015752**	**1.010854**	**1.008486**	1.001481
0.65	**1.051848**	**1.044466**	**1.03901**	**1.032849**	**1.028151**	1.025338
0.70	**1.067783**	**1.061069**	**1.057967**	**1.052622**	**1.052744**	1.048976
0.75	**1.153238**	**1.137542**	**1.120637**	**1.097022**	**1.079265**	1.073426
0.80	**1.165068**	**1.155376**	**1.144655**	**1.118503**	**1.107465**	1.1014
0.85	**1.182499**	**1.168819**	**1.161682**	**1.153881**	1.140731	1.132176
0.90	**1.201132**	**1.194633**	1.183218	1.179144	1.170358	1.163739
0.95	1.22973	1.223155	1.215747	1.209854	1.202516	1.197084
1.00	1.260692	1.254486	1.248139	1.241815	1.2354	1.228801

Note: Density values in bold signify density values in double phase region (not shown in Fig 4-8)

Table S-16. Density (g/mL) for single-phase glycerol and water mixtures in the temperature range 20°C-70°C

Glycerol Mass Fraction	Temperature (°C)					
	20	30	40	50	60	70
0.00	0.998219	0.995655	0.99222	0.988039	0.983198	0.977776
0.10	1.022289	1.019223	1.015393	1.010897	1.00581	1.000192
0.15	1.035464	1.032112	1.02806	1.023386	1.018155	1.01242
0.20	1.047585	1.04397	1.039711	1.034879	1.029518	1.023676
0.25	1.059913	1.056031	1.051564	1.046565	1.041072	1.035113
0.30	1.072769	1.068617	1.063935	1.058763	1.053134	1.04708
0.35	1.086321	1.081889	1.076985	1.071636	1.065865	1.059689
0.40	1.099358	1.094666	1.089556	1.084042	1.078141	1.071864
0.45	1.112475	1.107538	1.10223	1.096527	1.090197	1.084032
0.50	1.126054	1.12088	1.11538	1.109552	1.103404	1.096947
0.55	1.139777	1.134382	1.128702	1.122729	1.116466	1.109911
0.60	1.151564	1.14591	1.139993	1.133802	1.127353	1.121249
0.65	1.166465	1.160702	1.154715	1.148509	1.142109	1.135562
0.70	1.180034	1.174106	1.167998	1.161716	1.155319	1.149105
0.75	1.194356	1.188356	1.182192	1.175852	1.169331	1.162627
0.80	1.206773	1.200729	1.194562	1.188311	1.182079	1.176125
0.85	1.220412	1.214355	1.208167	1.201878	1.195479	1.188931
0.90	1.234445	1.228289	1.222137	1.215719	1.209147	1.202429
1.00	1.260643	1.254439	1.248094	1.241773	1.235371	1.228808

Table S-17. Excess volume values (mL/g) for single-phase glycerol and pentanol mixtures in the temperature range 20°C-70°C

Glycerol Mass Fraction	Temperature (°C)					
	20	30	40	50	60	70
0.00	0	0	0	0	0	0
0.10	-0.00020	-0.00159	0.00079	-0.00021	-0.00077	-0.00079
0.15	-0.00051	-0.00165	-0.00177	-0.00081	-0.00114	-0.00083
0.20	-0.00077	-0.00261	-0.00090	-0.00218	-0.00173	-0.00224
0.25	**-0.00195**	-0.00159	-0.00145	-0.00049	-0.00462	-0.00221
0.30	**-0.00102**	**-0.00196**	0.00001	-0.00213	-0.00227	-0.00348
0.35	**-0.00116**	**-0.00123**	**-0.00036**	-0.00176	-0.00283	-0.00175
0.40	**-0.00080**	**-0.00125**	**-0.00096**	-0.00166	-0.00420	-0.00242
0.45	**0.00047**	**-0.00204**	**-0.00147**	**-0.00252**	-0.00440	-0.00137
0.50	**0.00087**	**0.00010**	**-0.00048**	**-0.00292**	**-0.00189**	-0.00413
0.55	**0.00369**	**0.00124**	**0.00105**	**-0.00094**	**-0.00421**	-0.00462
0.60	**0.00665**	**0.00440**	**0.00384**	**0.00135**	**-0.00387**	-0.00482
0.65	**0.00565**	**0.00590**	**0.00424**	**0.00311**	**0.00041**	-0.00436
0.70	**0.01316**	**0.01297**	**0.00942**	**0.00775**	**0.00094**	-0.00265
0.75	**-0.03455**	**-0.02833**	**-0.02100**	**-0.00787**	**0.00085**	-0.00067
0.80	**-0.02166**	**-0.01984**	**-0.01730**	**-0.00254**	**0.00051**	-0.00064
0.85	**-0.01262**	**-0.00774**	**-0.00767**	**-0.00712**	-0.00257	-0.00162
0.90	**-0.00405**	**-0.00417**	-0.00090	-0.00286	-0.00152	-0.00189
0.95	-0.00172	-0.00164	-0.00109	-0.00156	-0.00112	-0.00213
1.00	0	0	0	0	0	0

Note: values in bold signify values in double phase region (not shown in Figure 4-10)

Table S-18. Reference excess volume data (mL/g) for glycerol and water mixtures in the temperature range 20°C-70°C

Glycerol Mass Fraction	Temperature (°C)					
	20	30	40	50	60	70
0.00	0	0	0	0	0	0
0.10	-0.00273	-0.00250	-0.00234	-0.00220	-0.00210	-0.00203
0.15	-0.00475	-0.00440	-0.00414	-0.00394	-0.00378	-0.00366
0.20	-0.00550	-0.00504	-0.00471	-0.00445	-0.00424	-0.00407
0.25	-0.00618	-0.00562	-0.00522	-0.00490	-0.00464	-0.00442
0.30	-0.00706	-0.00642	-0.00595	-0.00557	-0.00526	-0.00501
0.35	-0.00826	-0.00754	-0.00701	-0.00657	-0.00622	-0.00593
0.40	-0.00875	-0.00797	-0.00739	-0.00691	-0.00652	-0.00620
0.45	-0.00905	-0.00822	-0.00761	-0.00707	-0.00640	-0.00623
0.50	-0.00946	-0.00861	-0.00798	-0.00744	-0.00699	-0.00664
0.55	-0.00972	-0.00887	-0.00823	-0.00768	-0.00722	-0.00684
0.60	-0.00828	-0.00738	-0.00667	-0.00603	-0.00549	-0.00551
0.65	-0.00894	-0.00814	-0.00752	-0.00699	-0.00657	-0.00630
0.70	-0.00837	-0.00762	-0.00704	-0.00655	-0.00620	-0.00623
0.75	-0.00811	-0.00747	-0.00699	-0.00655	-0.00619	-0.00591
0.80	-0.00630	-0.00578	-0.00542	-0.00513	-0.00503	-0.00533
0.85	-0.00513	-0.00477	-0.00451	-0.00429	-0.00413	-0.00404
0.90	-0.00402	-0.00375	-0.00364	-0.00342	-0.00321	-0.00304
1.00	0	0	0	0	0	0

Table S-19. Excess volume uncertainty values (mL/g) for single-phase glycerol and pentanol mixtures in the temperature range 20°C-70°C

Glycerol Mass Fraction	Temperature (°C)					
	20	30	40	50	60	70
0.00	0	0	0	0	0	0
0.10	0.0030	0.0030	0.0031	0.0031	0.0032	0.0032
0.15	0.0029	0.0029	0.0030	0.0030	0.0031	0.0031
0.20	0.0027	0.0028	0.0028	0.0029	0.0029	0.0030
0.25	0.0026	0.0027	0.0027	0.0028	0.0028	0.0029
0.30	0.0025	0.0026	0.0026	0.0027	0.0027	0.0028
0.35	0.0024	0.0025	0.0025	0.0026	0.0026	0.0026
0.40	0.0023	0.0024	0.0024	0.0024	0.0025	0.0025
0.45	0.0022	0.0023	0.0023	0.0023	0.0024	0.0024
0.50	0.0021	0.0022	0.0022	0.0022	0.0023	0.0023
0.55	0.0020	0.0021	0.0021	0.0021	0.0022	0.0022
0.60	0.0019	0.0020	0.0020	0.0020	0.0020	0.0021
0.65	0.0018	0.0019	0.0019	0.0019	0.0019	0.0020
0.70	0.0018	0.0018	0.0018	0.0018	0.0018	0.0019
0.75	0.0016	0.0016	0.0016	0.0017	0.0017	0.0018
0.80	0.0015	0.0015	0.0016	0.0016	0.0016	0.0016
0.85	0.0014	0.0015	0.0015	0.0015	0.0015	0.0015
0.90	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
0.95	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
1.00	0	0	0	0	0	0

Table S-20. Excess volume uncertainty data (mL/g) for glycerol and water mixtures in the temperature range 20°C-70°C

Glycerol Mass Fraction	Temperature (°C)					
	20	30	40	50	60	70
0.00	0	0	0	0	0	0
0.10	0.00086	0.00086	0.00087	0.00088	0.00089	0.00089
0.15	0.00086	0.00087	0.00087	0.00088	0.00089	0.00090
0.20	0.00087	0.00087	0.00088	0.00089	0.00090	0.00090
0.25	0.00087	0.00088	0.00089	0.00089	0.00090	0.00091
0.30	0.00088	0.00088	0.00089	0.00090	0.00091	0.00092
0.35	0.00088	0.00089	0.00090	0.00090	0.00091	0.00092
0.40	0.00089	0.00090	0.00090	0.00091	0.00092	0.00093
0.45	0.00089	0.00090	0.00091	0.00092	0.00093	0.00094
0.50	0.00090	0.00091	0.00092	0.00092	0.00093	0.00094
0.55	0.00091	0.00092	0.00092	0.00093	0.00094	0.00095
0.60	0.00092	0.00092	0.00093	0.00094	0.00095	0.00096
0.65	0.00092	0.00093	0.00094	0.00095	0.00096	0.00097
0.70	0.00093	0.00094	0.00095	0.00096	0.00097	0.00097
0.75	0.00094	0.00095	0.00095	0.00096	0.00097	0.00098
0.80	0.00095	0.00096	0.00096	0.00097	0.00098	0.00099
0.85	0.00096	0.00096	0.00097	0.00098	0.00099	0.00100
0.90	0.00097	0.00097	0.00098	0.00099	0.00100	0.00101
0.95	0.00097	0.00098	0.00099	0.00099	0.00100	0.00101
1.00	0	0	0	0	0	0

Appendix 2. Calculations

C1: Phase Volume Calculations

From the phase diagram for glycerol + pentanol mixture (Figure 3-7) at 20°C, the phase boundaries are at 0.20 and 0.95 glycerol mass fraction. Therefore, at any composition between these mass fractions and constant temperature of 20°C, the system is assumed to split in two phases with glycerol mass fraction of 0.20 (G_1) and 0.95 (G_2) respectively.

For one gram of 'A' glycerol mass fraction mixture:

Total mass of phase 1 = $(G_2\text{-}A)/(G_2\text{-}G_1)$

Total mass of phase 2 = $(A\text{-}G_1)/(G_2\text{-}G_1)$

Table C1-1. Density and Composition of Saturated phase boundaries at 20°C and 40°C

	20°C		40°C	
	Density (g/mL)	**Glycerol Mass Fraction**	**Density (g/mL)**	**Glycerol Mass Fraction**
Phase 1	0.877572	0.20	0.896661	0.29
Phase 2	1.22973	0.95	1.183218	0.90

<u>Volume of each phase can then be calculated by dividing the mass by density at that temperature</u>:
Volume of phase1 = (total mass phase 1/ saturated liquid density phase 1)

And then total volume of phases can be calculated by addition (assuming ideal mixing, as excess volume is very low).

Phase volume fraction = suspended phase/liquid phase

Table C1-2. Phase Volume Fractions of dispersed phases at 20°C and 40°C

Glycerol Mass Fraction	**20°C**		**40°C**	
	Suspended Phase (Assumed)			
	Phase 2	**Phase 1**	**Phase 2**	**Phase 1**
0.20	0			
0.30	0.09		0	
0.40	0.20		0.12	
0.50	0.32		0.26	
0.60	0.44		0.42	
0.65	0.51	0.49	0.50	0.50
0.70	0.58	0.42	0.59	0.41
0.75	0.66	0.34	0.68	0.32
0.80	0.74	0.26	0.78	0.22
0.90	0.90	0.10	0.99	0
0.95	1.00	0		