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A novel surface interaction force between water droplets in organic media

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ABSTRACT

Droplets are one of the important elements of many industrial and biological processes, including in the production of petroleum, food, cosmetics, and therapeutics, and their presence has given rise to the advent of the field of droplet dynamics. In various oil-in-water and water-in-oil systems, deformable droplets interact with different components, such as solid surfaces or other droplets; consequently, their behaviour dramatically impacts the stability of the emulsion. Besides, various species, such as surfactants, polymers, and solid particles, can adsorb on the surface of the droplets. Hence, various droplet behaviours are expected to be observed during the interaction between the droplets or between droplets and solids.

Numerous internal and external factors influence the behaviour of droplets within aqueous or organic solutions. The internal factor pertains to the Laplace pressure of the droplets, and the external factors incorporate the hydrodynamic pressure and pressures attributed to the surface interactions between two droplets or a droplet and a solid surface (i.e., disjoining pressure). The balance between these factors determines the stability of the droplet in the solution.

Diverse experimental investigations using different techniques, such as atomic force microscopy (AFM) and dynamic force apparatus (DFA), have been carried out to examine the behaviour of the droplets within various solutions. Furthermore, the Stokes–Reynolds and augmented Young–Laplace equations are implemented to model the film drainage dynamics between the surfaces and the droplet deformation, respectively. Most investigations have centered around the use of water as the continuous phase, where different surface interactions have been detected. The number of studies on water-in-oil systems has been less abundant. Water droplets submerged in oil solutions behave differently than the oil droplets in aqueous media. Furthermore, several studies reported an unusual behaviour between water droplets in organic solutions at nanometer separations, where droplets attract each other with a relatively larger interaction force, and the source of this force is unknown. In this research, a new theory has been developed to explain this phenomena during the interaction of water droplets in organic solutions at small separations. The results of the numerical calculations are in excellent agreement with the experimental observations, which demonstrate that the new theory can accurately predict the behaviour of the water droplets within organic solutions.

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