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Insights into the complex interaction between hydrophilic nanoparticles and ionic surfactants at the liquid/air interface

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Combinations of nanoparticle and surfactant have been widely employed in many industrial processes, i.e., boiling and condensation in heat transfer and hydraulic fracturing in shale oil and gas production, etc.. However, the underlying mechanism for various phenomena resulted from the addition of nanoparticles into the surfactant solutions is still unclear. For instance, there are contradictory conclusions from the literatures regarding the variations of surface tension upon the addition of nanoparticles into surfactant solutions. In this work, the dominating factors, determining if the surface activity of the surfactant solution will increase or conversely decrease when adding certain kinds of nanoparticle, have been investigated. Two typical hydrophilic nanoparticles, SiO_2 and TiO_2 with anionic or cationic surfactants, respectively, have been considered. It was found that the surface tension of ionic surfactant solution can be further reduced only if nanoparticles of same charge were added. For instance, a system containing 0.25 CMC SDS and 1 wt% SiO_2 behaves similar to a 0.34 CMC SDS-only solution. Interestingly, the observed synergistic effect is found to be more significant if the surfactant concentration is much lower than its CMC for a given nanoparticle content. Moreover, the effect is perfectly reversible. If nanoparticles of opposite charge were added, however, the surface tension of surfactant solution will increase. Zeta potential measurement and centrifugal treatment have been employed to reveal the interplay between nanoparticle and surfactant and the adsorption behavior of their assemblies at the liquid/air interface. Based on the experimental outcomes, a possible physical mechanism was proposed. It was concluded that the electrostatic repulsion between surfactant molecules and nanoparticles should be of the dominant factor responsible for the observed reversible synergistic effect. Our study is expected to contribute to a better understanding of the interfacial phenomenon in nanoparticle-surfactant complex systems.

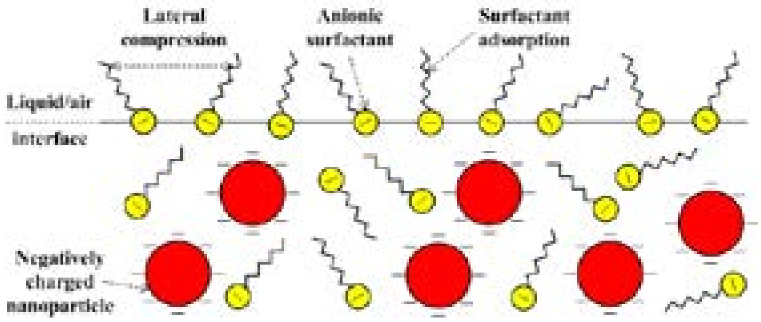

Fig: Illustration of the mechanism for explaining the effect of interaction between hydrophilic nanoparticles and anionic

Recent Publications

1. Jin J et al. (2018) Time-dependent scattering of incident light of various wavelengths in ferrofluids under external magnetic field. Journal of Magnetism & Magnetic Material. 447:124-133. Doi:10.1016/j.jmmm.2017.09.066.
2. Jin J, Hatami M and Jing D (2018) Experimental investigation and prediction of the thermal conductivity of water-based oxide nanofluids with low volume fractions. Journal of Thermal Analysis and Calorimetry. Doi:10.1007/s1097.
3. Hatami M et al. (2018) Uniform magnetic field (UMF) effect on the heat transfer of a porous half-annulus enclosure filled by Cu-water nanofluid considering heat generation. Current Nanoscience. 14(3):187-198. Doi:10.2174/157341371466617 1222112425.

4. Jin J and Jing D (2017) A novel liquid optical filter based on magnetic electrolyte nanofluids for hybrid photovoltaic/thermal solar collector application. Solar Energy. 155:51-61. Doi:10.1016/j.solener.2017.06.030.
5. Song D et al. (2016) Sedimentation of particles and aggregates in colloids considering both streaming and seepage. Journal of Physics D Applied Physics. 49(42):2715-2719. Doi:10.1615/TFEC2017.mnt.018015.

Biography

Jingyu Jin mainly focuses on the interfacial properties and response behaviors under radiation, thermal, or magnetic field of nanoparticle suspensions. He has clarified the effect of the interaction between hydrophilic nanoparticles and ionic surfactants on the surface tension of liquid/air interface. A novel liquid optical filter based on the magnetic nanofluids has been proposed by him and can be used in the hybrid solar photovoltaic/thermal (PV/T) system. He has also investigated the relaxation behaviors of ferrofluids under magnetic field. Moreover, a modified multi-sphere Brownian model has been developed by him for thermal conductivity prediction in low volume fraction nanofluids. His studies are expected to contribute to a better understanding of various physical properties of nanofluids and its application in the future.

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