

Muddy waters clear up in the deep sub-surface

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Unique properties of ambient liquid water are indispensable for soft matter including its most sophisticated form, life. Among them, the high dielectric constant of water has particularly diverse implications. It allows water to dissolve large amounts of electrolytes, and preferential adsorption of the electrolytes produces charged surfaces that govern various colloidal phenomena. One of the important consequences is that charged colloids remain dispersed stably in water due to electrostatic repulsion between the charged surfaces. Such colloidal dispersions are found everywhere from our daily lives to industrial processes.

The colloidal dispersions also play important roles in geological processes. For example, transportation of water-insoluble matters as colloidal dispersions is of enormous importance, and it is estimated that 9.3-58 Gt of the suspended sediment is delivered by all rivers to the oceans annually. An interesting aspect of natural colloidal systems is that they occur in a wide range of physicochemical conditions in terms of temperature and pressure. In deep subsurface where many geological processes proceed, temperature and pressure are significantly higher and it is likely that water is in a supercritical state ($T_c = 374\text{ }^\circ\text{C}$, $P_c = 22.1\text{ MPa}$, Fig. 1).

Properties of water change remarkably under such extreme conditions. The dielectric constant, for example, decreases from 78 to 6 at the critical point. It is obvious that such large change of the water properties affects the surface forces, and affects various colloidal phenomena. Indeed, it has been known for quite some time that dispersion stability of colloids is different in water under such extreme conditions. However, our knowledge on colloidal phenomena under such extreme conditions is very limited.

In the last several years, we have studied dispersion stability of model colloids in water at high temperatures and high pressures up to a supercritical state. The systems we have studied include polystyrene

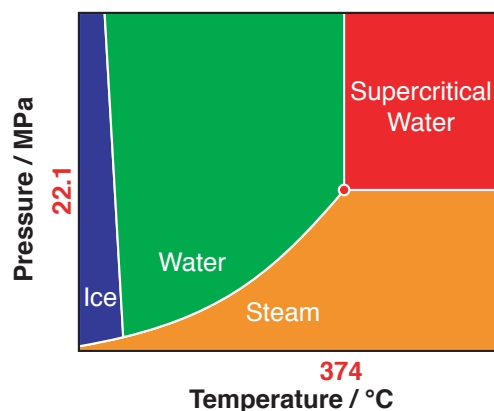


FIG. 1 Schematic phase diagram of water

latex, C_{60} nanoparticles, diamond nanocrystals, clay, and colloidal gold. Dynamic light scattering measurements revealed that all the colloids coagulate in water simply by heating under pressure. Numerical calculations showed that the coagulation is induced primarily by large decrease of the dielectric constant of water, and the heat-induced coagulation is a universal phenomena regardless of the type of the particle.

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