Study of pattern formation in drying colloidal suspensions with varying pH and different parameters on various substrates.

Abstract

Colloidal suspensions have profound implications in our daily life starting from human body fluids, to paint, pharmaceutical, food, printing, and many other industrial applications. The interesting pattern left by the colloidal particle during desiccation draws our attention to study the desiccation of a colloidal suspension. Most of our studies are on Laponite, which is a synthetic clay and available in pure form. In this thesis, I have studied one of the lesser studied parameters-the role of pH that affects the desiccation pattern of colloidal suspensions, in particular aqueous Laponite. I have experimentally investigated the effect of varying pH on two geometries of the interface of aqueous Laponite suspension: (1) a desiccating droplet and (2) desiccating film.

We have exposed the importance of aqueous solution preparation protocol and its profound influence on final desiccation patterns, especially, in the case of drying droplets. Depending on the preparation protocol final dried pattern changes. The variation in the final deposited pattern is developed by different stirring methods namely, stirring by Magnetic stirrer and ultrasonication. Various degrees of stirring the solution during preparation affect the aggregation process of particles resulting in different drying patterns.

When the droplet of aqueous Laponite solution of different pH was studied. The droplet was allowed to evaporate on substrates of different hydrophobicity, they left interesting residue after drying. In the case of a hydrophobic substrate, a clear coffee ring is noticed in the acidic range and the pH is basic, salt crystals formed on Laponite particles and accumulated at the center of the residue after drying. The picture is however different for hydrophilic substrates. The role of pH in the desiccation crack pattern in films of aqueous Laponite has been investigated experimentally. The pH of the colloidal solution varied between 0.445 and 13.45. The crack patterns changed from distinctly fractal to hierarchical tree-like patterns as the solution pH was changed from highly acidic to basic values. Cracks appear to be suppressed around the pH corresponding to zero charge of the Laponite particles in solution. The changes in the crack patterns are analyzed of particle shape, changes in surface charge distribution, and aggregation geometry. For a critical combination of pH and particle concentration, lace-like crystallization patterns were observed after the complete drying of the film. Lastly, as an application of the role of pH in the desiccating film of aqueous Laponite, we have reported a novel technique for the fabrication of transparent conducting sheets. The crack network of different geometries has been used as the template for TCSs and was generated by modulating the pH of the suspension. Topological measure, Euler characteristics, and tortuosity of the template were measured and addressed in association with the suspension pH. The fabricated TCSs show selective transmission for particular pH values.

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