17c Enhanced Aggregation of Alginate-Coated Hematite Nanoparticles

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Alginate is a naturally occurring polysaccharide which undergoes inter-polymer binding to form a gel network in the presence of calcium cations. In this study, hematite nanoparticles are synthesized through forced hydrolysis of ferric chloride. They are suspended in alginate solution under suitable pH condition to promote maximum adsorption. Time-resolved dynamic light scattering (DLS) is utilized to determine the absolute aggregation rate constants of the alginate-coated hematite nanoparticles over a range of monovalent (sodium chloride) and divalent (calcium and magnesium chlorides) electrolyte concentrations. Stability curves of the alginate-coated hematite nanoparticles in sodium and magnesium chloride salts show distinct diffusion- and reaction-limited regimes. Under favorable aggregation conditions, the rate constants of coated nanoparticles in sodium and magnesium chloride salts are found to be similar to those for bare hematite nanoparticles. These observations confirm electrostatic destabilization to be the main aggregation mechanism. However, in the presence of calcium chloride, the aggregate growth rate of alginate-coated hematite nanoparticles is almost an order of magnitude higher than what diffusion controlled aggregation predicts. No distinct regimes are observed in the stability curve within the range of calcium chloride concentration employed. Transmission electron microscope (TEM) imaging of the aggregates indicates the growth of alginate network around the hematite nanoparticles. The effect is to increase their effective collision radii, hence enhancing the aggregate growth rate. It is also established that NaCl as a background electrolyte is detrimental to the calcium-induced enhanced aggregation.