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High-throughput characterisation of salt-induced aggregation and re-entry of silica nanoparticles

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Electrolytes form a critical component of many systems from biological processes to energy storage. The Debye Hückel Theory has been extensively used to describe simple aqueous electrolytes, yet many applications of electrolytes involve significantly more complex matrices containing salt mixtures, high concentrations, complex ions or other co-solutes. Hypersaline solutions is one area of complex electrolyte research which has received renewed interest due to the observation of underscreening behaviour across simulation,[1] surface force apparatus,[2] polymer brush [3] and colloidal stability experiments.[4] At sufficiently high concentration, there is a minimum in the electrostatic decay length beyond which the range of electrostatic interactions in solution exceeds those predicted by the classical Debye length.[5]

This electrolyte effect is dependent on both the ion identity and the electrolyte concentration, making systematic experimental characterisation using conventional approaches time consuming, costly and repetitive due to an extensive range of possible experimental conditions. Recently, automation has become an increasingly important tool in experimental design due to its capability to explore large sample spaces efficiently and the possibilities of integration of machine learning to facilitate autonomous research environments.[6]

We have used colloidal silica as a model system to develop a high-throughput approach to the preparation of colloidal samples and characterisation of their stability, enabling the characterisation of aggregation behaviour in more detail. Colloidal silica has long been known to aggregate in the presence of electrolyte, inducing changes in dispersion turbidity.[7] This turbidity change was measured via UV-visible spectroscopy on a microplate reader enabling fast characterisation of particle aggregation. Re-dispersion was observed in all electrolytes at high concentrations, and the aggregation behaviour differed depending on whether the particles were dispersed in the low or high concentration regime. The high data density achievable through this characterisation methodology enabled subsequent targeted condition selection for light scattering experiments and future neutron scattering work.

Topics

Chemistry and Crystallography

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