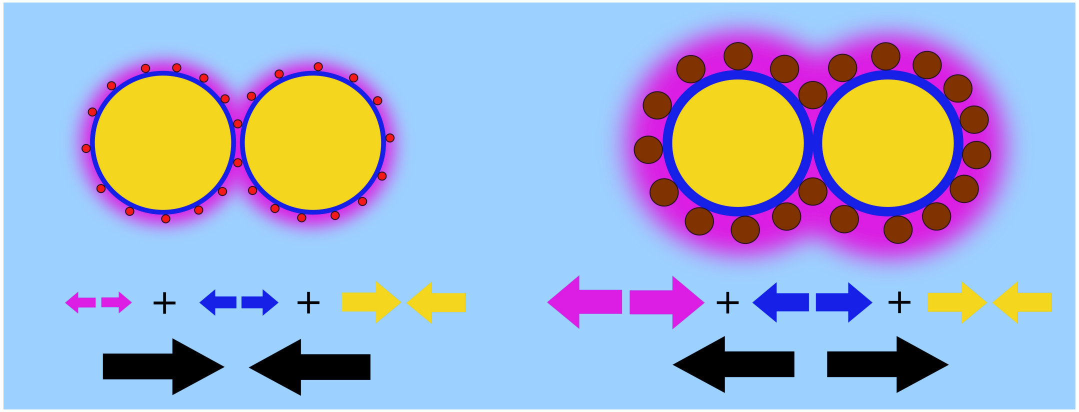
Large Counterions Boost the Solubility and Renormalized Charge of Suspended Nanoparticles

Guillermo Iván Guerrero-García, Pedro González-Mozuelos, and Mónica Olvera de la Cruz

Department of Materials Science & Engineering, Northwestern University, Evanston, IL, USA

ACS Nano, Just Accepted Manuscript DOI: 10.1021/nn404477b Publication Date (Web): November 1, 2013

Colloidal particles are ubiquitous in biology and in everyday products such as milk, cosmetics, lubricants, paints or drugs. The stability and aggregation of colloidal suspensions are of paramount importance in nature and in diverse nanotechnological applications, including the fabrication of photonic materials and scaffolds for biological assemblies, gene therapy, diagnostics, targeted drug delivery, and molecular labeling. Electrolyte solutions have been extensively used to stabilize and direct the assembly of colloidal particles. In electrolytes, the effective electrostatic interactions among the suspended colloids can be changed over various length scales by tuning the ionic concentration.



However, a major limitation is gelation or flocculation at high salt concentrations. This is explained by classical theories, which show that the electrostatic repulsion among charged colloids is significantly reduced at high electrolyte concentrations. As a result, these screened colloidal particles are expected to aggregate due to short-range attractive interactions or dispersion forces as the salt concentration increases.

We discuss here a robust, tunable mechanism for colloidal stability by which large counterions prevent highly charged nanoparticles from aggregating in salt solutions with concentrations up to 1 M. Large counterions are shown to generate a thicker ionic cloud in the proximity of each charged colloid, which strengthens short-range repulsions among colloidal particles, and also increases the corresponding renormalized colloidal charge perceived at larger separation distances. These effects thus provide a reliable stabilization mechanism in a broad range of biological and synthetic colloidal suspensions.

We thank the Quest computer cluster at Northwestern University for the computing time provided. GIGG thanks the support of the NSF MRSEC award No DMR-1121262, and PGM and MOC thank the support of the AFOSR Award FA9550-10-1-0167.

NORTHWESTERN UNIVERSITY