Cement and DNA

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Abstract

Charged particles or macromolecules play an important role in solution chemistry with many examples from both biology and technology. The general picture of two equally charged macromolecules, e.g. two proteins, is that the electrostatic interactions stabilize the system through a mutual repulsion. This is the all-accepted picture coming from colloid science - the DLVO theory. The latter is an approximate theory valid for weakly coupled systems. In practise this means that the theory is applicable in aqueous solutions with monovalent ions, while it fails completely in the presence of, for example, multivalent ions. The breakdown manifests itself as a net attractive interaction between equally charged aggregates. Examples are legio: negatively charged proteins precipitate in the presence of trivalent lantanide ions, DNA goes into a compact state when spermine or spermidine is added, cement grains attract eachother at sufficiently high pH etc etc.

Thus, strongly coupled systems, high surface charge density and/or multivalent ions, which violate the general DLVO theory occur quite frequently in nature as well as in technical formulations and it is important to have a proper understanding of this phenomenon. A simple explanation based on a competition between entropy and energy will be presented.