Nanoscale interactions between colloidal particles

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Colloids gels are found in a number of industrial applications ranging from high performance coatings to mineral recovery. Insight into the mechanisms of stress transmission through the microstructure is critical in developing a full understanding of the rheology of these materials and processes. Paramount to this is a thorough knowledge of the interparticle interactions. Currently, colloidal interactions are commonly understood in terms of the theory of Derjaguin-Landau-Verwey-Overbeek (DLVO). It has been shown, however, that the predictions of this theory fail for particles at nanometer separations. In this work we use optical trapping to perform in situ measurements of particle interactions in adhesive contact. We measure the linear bending elasticity of directly-assembled colloidal chains under various physico-chemical conditions. The simplified geometry of the aggregate allows us extract the single-bond elasticity which can then be related to the work of adhesion, W_{ad}, through the Johnson-Kendall-Roberts (JKR) theory. We find that W_{ad} is independent of ionic strength when a monovalent salt is used as the flocculant. However, more complex behavior is observed for divalent salts, which suggest that the adhesion is enhanced by the adsorption of divalent ions onto the particle surface. Furthermore, we find evidence that the adsorption isotherm is ion specific. This behavior implies that the work of adhesion between colloidal particles can be manipulated by the ion type or surfactant used to induce aggregation, which provides a method of tuning the strength and aging properties of colloidal gels.