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Effect of steady state shear on colloidal gelation

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Gels represent an industrially important state of matter. Here we study the effect of a simple shear on a colloidal scale gelation process with ultra small and small angle neutron scattering. The structural understanding of the effects of steady state shear on colloidal gelation has largely been inferred from oscillatory rheological studies, an essentially perturbative approach, and complementary computer simulation. In this study we examine directly the structural evolution of a gelling system in situ in a simple shear field (Couette flow) using neutron scattering over an extended range of scattering vectors. This range of scattering vectors contains information about the individual nano-scale sol particles and the network formed by the gelling particles. Gelation was initiated from a model system of silica nanoparticles where a slight adjustment of the pH modulated interparticle interactions. In the absence of shear we observe that the sol rapidly increases in viscosity until flow is arrested, in the case of an applied shear we observe that viscosity rapidly increases until it reaches a maximum, and then viscosity decreases. Scattering curves at constant shear rate were modelled to yield the growth and volume fraction of clusters. Derived structural parameters were used to calculate viscosities from a simple theoretical model5 to give excellent agreement with measured viscosities.

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