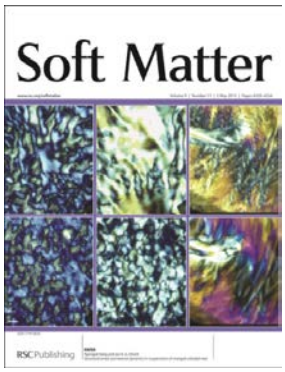
A glass in suspensions of long and thin, charged rods: particle- and texture- dynamics



K. Kang & J.K. G. Dhont, PRL 110, 015901 (2013) , SM 9, 4359 (2013)

A glass transition is observed in dispersions of long and thin, highly charged rod-like colloids (fd-virus particles), at low ionic strengths where thick (27 nm) electric double layers exist. Structural arrest as a result of particle-caging due to strong overlap of these extended double layers is observed by means of dynamic light scattering (see Fig.1). The glass-transition concentration is found to be far above the isotropic-nematic coexistence region (1.5-3.4 mg/ml), at an fd-concentration of 11.7 mgml. The morphology of the system therefore consists of chiral-nematic domains with different orientations. As the cuvette is filled with suspension, shear alignment occurs, leading to large nematic domains (see the two top-left images in Fig.2). Below the glass-transition concentration the initial morphology with large shear-aligned domains breaks up into smaller domains, and equilibrates after typically 80- 100 hours, as shown in the images in Fig.2 (where t he waiting time is the time after filling the cuvette), for two concentrations below the glass-transition concentration. With a technique that we termed "image-time correlation" (where transmitted-intensity correlation functions are constructed from a time series of depolarized images), the dynamics of the texture is quantified by the initial slope of these correlation functions. These relaxation rates are given on the left in Fig.2, as a function of the waiting time. As can be seen, equilibration is reached after 80-100 hours. A few image-time correlation functions are given in Fig.3 for various waiting times, and for three fd-concentrations, two below and one above the glass transition. Above the glass transition, the correlation function is frozen, and does not change with waiting times (see Fig.3c). This can also be seen in more detail from Fig.4. The relaxation rate jumps from a finite value below the glass concentrations to an essentially zero value above the glass concentration. Particle arrest and freezing of the texture occurs as a result of one and the same glass transition.

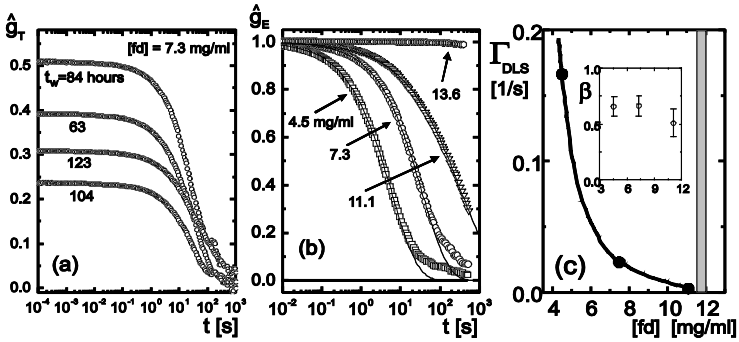


Fig.1: Dynamic light scattering: (a) A few time-averaged correlation functions taken at different positions in the sample. (b) Ensemble averaged functions for various fd-concentrations. (c) The relaxation rate (and stretched exponential parameter) as a function of the concentration.

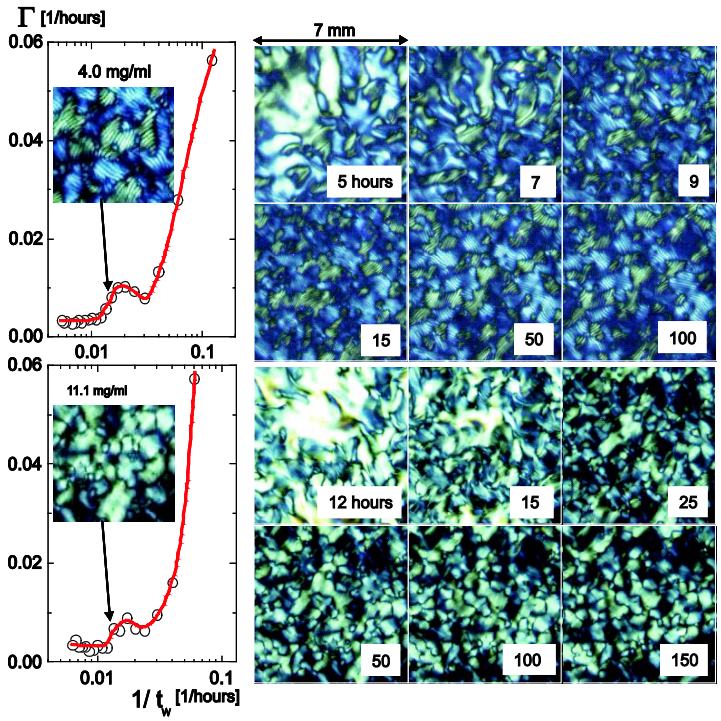


Fig.2: Depolarized images for different waiting times, and two fd-concentrations (4.0 and 11.1 mg/ml, both below the glass concentration. In the left panel, the initial image-correlation relaxation rate is plotted against the inverse waiting time (on a log-scale).

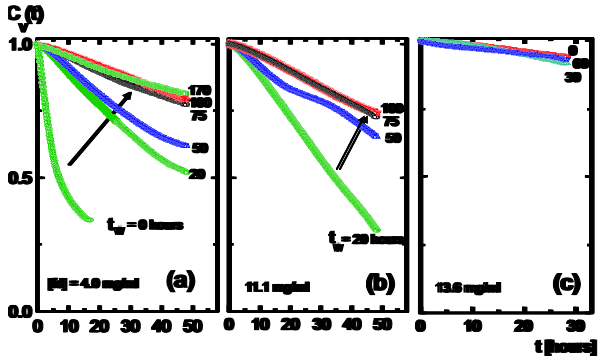


Fig.3: Image-time correlation functions for three concentrations, two below (on the left) and one above (on the right) the glas concentration.

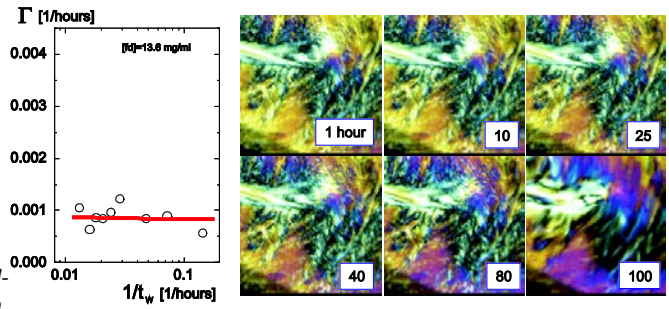


Fig.4: Same as in Fig.2, but now for a fd-concentration above the glass concentration.