XPCS Measurements of the Equilibrium Dynamics within a Concentrated Coconut and Palm Kernel Oil Emulsion

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Emulsions represent a subclass of colloids formed from a suspension of one liquid in another and occur in many common foodstuffs such as milk and mayonnaise [1]. We have performed XPCS measurements on an emulsion consisting of concentrated coconut and palm kernel oil (CPK) in sugar solution: a starting material used for the manufacture of Kraft© Cool Whip©. The emulsion is sterically stabilized against flocculation with sodium caseinate.

The average radius of the emulsion was 250 nm as measured by light scattering on dilute solutions. A Guinier plot of the circularly averaged static small angle scattering pattern for the CPK emulsion is shown in Fig. 1. If there were a narrow distribution of sphere radii, one would expect to find oscillations in the scattering pattern. Their absence implies a minimum polydispersity of 30%.

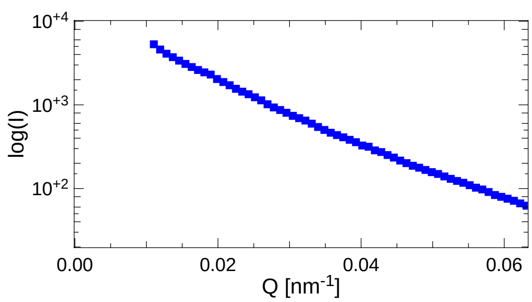

FIG. 1. A plot of of small angle scattering from CPK emulsion.

A plot of the measured intensity autocorrelation function $g_2(t)$ for the CPK emulsion is shown in Fig. 2. Scattering could be measured for time delays as short as 3 ms due to the large electron density contrast between the oil and sugar solution. It was not possible to fit the correlation function with a simple exponential form. This indicates that the dynamics are strongly effected by polydispersity and by particle interactions. In such circumstances, an examination of the shape of the intermediate scattering function $F = \sqrt{(g_2 - 1)}$ can yeild further insight into the details of the diffusion behavior [2]. The log of this function is shown if Fig. 3. We have plotted for comparison the intermediate scattering function for a dense (52% volume fraction) but mono-disperse latex colloid [3] and both of data have been scaled to their characteristic diffusion times given by $\tau_c = 1/D_s Q^2$ where Q is the scattering wavevector and D_s is the short time diffusion coefficient [4].

Data from these different systems show a number of similarities. They both crossover from a fast to a slow decay at similar reduced times, and the ratio of slopes for these two modes is also quite similar. Further measurements at varying concentration will hopefully permit the separation of the effects of polydispersity and particle interactions, allowing a more detailed comparison.

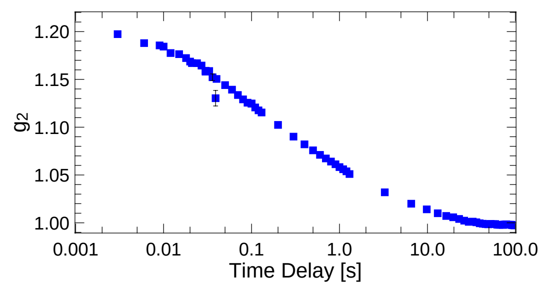

FIG. 2. Autocorrelations, $g_2(Q,t)$ for a CPK emulsion at a wavevector of Q=.018 nm^{-1}.

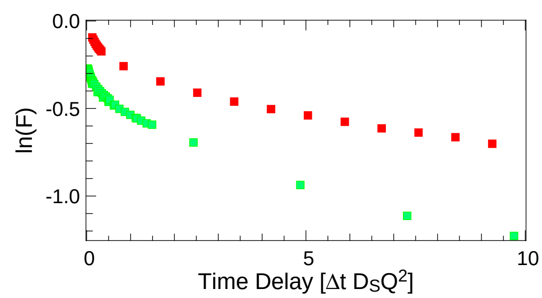

FIG. 3. Log of the intermediate scattering function vs. scaled time, for polystyrene latex at a volume fraction of 52 % (green) and CPK emulsion (red). Latex data offset by -0.25 for clarity. Both data sets are at QR=3.2.

[1] A. M. Donald, Rep. Prog. Phys. **57**, 1081 (1994).

[2] P. N. Segre and P. N. Pusey, Phys. Rev. Lett. **77**, 771 (1996).

[3] L. B. Lurio, D. Lumma, P. Falus, M. A. Borthwick, S. G. J. Mochrie, J. F. Pelletier, M. Sutton, L. Regan, A. Malik, and G. B. Stephenson (unpublished).

[4] P. N. Pusey, *Liquids, freezing and the glass transition* (North-Holland, Amsterdam, 1991).