



Experiment title:

Systematic study of the dynamic behavior of charge-stabilized colloidal suspensions with reversibly screenable particle interactions

Experiment number:

SC2552

Beamline: ID10A	Date of experiment: from: 01.10.2008 to: 06.10.2008	Date of report: 26.01.2009
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Names and affiliations of applicants (* indicates experimentalists):

Fabian Westermeier*
 Wojciech Roseker*
 Olaf Leupold*
 Sergio Funari*
 Gerhard Grübel

Hasyllab/DESY, Notkestrasse 85, 22607 Hamburg, Germany

Report:

In colloidal suspensions, direct particle interactions, like electrostatic or steric repulsion are introduced to avoid agglomeration due to the attractive van-der-Waals force. In addition to these interactions, indirect, hydrodynamic interactions mediated by the solvent play an important role for the dynamic behavior of these systems. However, while the hydrodynamic interactions in the case of steric stabilized colloids are well understood and explained both by theory and experiment, the publications of the last decade [1-5] reveal evident discrepancies between experiments and existing theories of the more complex electrostatically stabilized systems.

Therefore we studied the direct and indirect particle interactions of a novel charge-stabilized system – synthesized via a copolymerisation of a fluoro- and a silyl-methacrylate. To avoid beam damage of the sample system, the experiments were carried out in a flow through set-up, allowing thus to reduce the time for the samples to be exposed to the collimated beam. This flow-through set-up consists of a quartz glass capillary attached to a flexible, circulatory tube system including a pump device as shown in fig. 1. A switching mechanism for salt injection give the possibility to add a defined amount of electrolyte to screen the direct particle interactions in the suspension, being thus able to change the direct particle interactions without changing the volume fraction Φ of the sample.

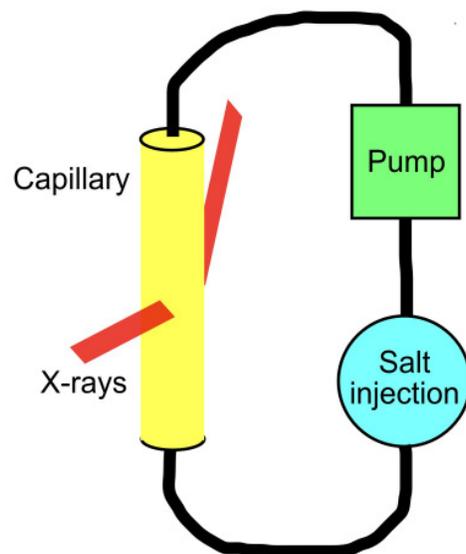


Fig. 1: Flow system with the flow-through glass capillary attached to a pumping system.

The sample system investigated consisted of charge-stabilized colloids having a mean particle diameter of 112 nm. The volume

fractions investigated ranged from $\Phi = 0.3$ to $\Phi = 0.08$, while the added electrolyte concentration was varied between 0 μM and 150. mM potassium chloride. For all of these samples static and dynamic scattering experiments were performed, using either Small Angle X-ray Scattering (SAXS) or X-ray Photon Correlation Spectroscopy (XPCS). In a static scattering experiment, the measured intensity $I(Q)$ is given by $I(Q) = S(Q)/P(Q)$ where $S(Q)$ is the static structure factor and $P(Q)$ is the particle form-factor. Measuring a completely screened sample showing no direct particle interactions ($S(Q) = 1$), the particle form-factor was obtained. For the samples showing direct particle interactions the static structure factor was extracted by dividing the measured intensity by the particle form factor.

The extracted static structure factors for three samples (A: $\Phi = 0.3$, 1000 μM KCl, B: $\Phi = 0.3$, 3500 μM KCl and C: $\Phi = 0.3$, 35.000 μM KCl) are shown in fig. 2. The static structure factors described by rescaled mean spherical approximation [6] yielding an average charge of 780 e^- per colloidal particle.

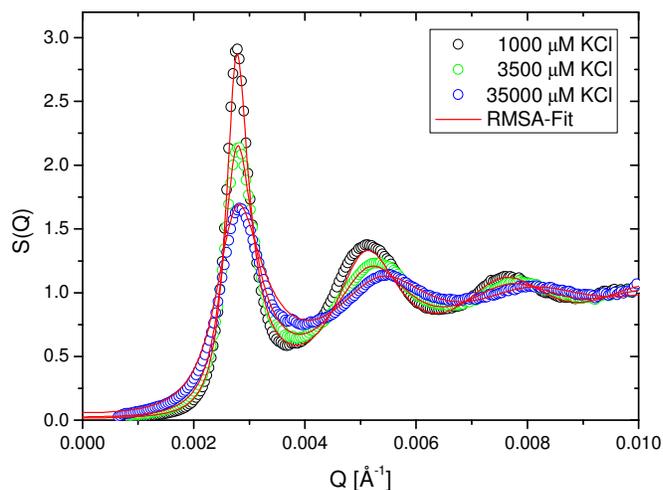


Fig. 2: Static structure factors and corresponding RMSA-fits for three samples of the same volume fraction $\Phi = 0.3$ and three different salt concentrations.

To study the dynamics of the system, autocorrelation functions were measured at different momentum transfers using a scintillation detector. From these autocorrelation functions the dynamic structure factor $D_0/D(Q)$ was extracted and the hydrodynamic functions $H(Q) = [S(Q) \times D(Q)]/D_0$ were calculated.

Fig. 3 shows the hydrodynamic functions for three samples (A: $\Phi = 0.08$, 0 μM KCl, B: $\Phi = 0.15$, 0 μM KCl and C: $\Phi = 0.3$, 1000 μM KCl). These hydrodynamic functions show an extreme slowing down of the system especially for concentrated colloidal suspensions, which is currently not supported by any theoretical model. Even the recently developed accelerated stokesian dynamics model [5] cannot explain the dramatic slowing down of the particles' mobility which we observe in our model system. The analysis of this effect is still ongoing – the measured hydrodynamic functions are currently compared with previous results and theoretical models.

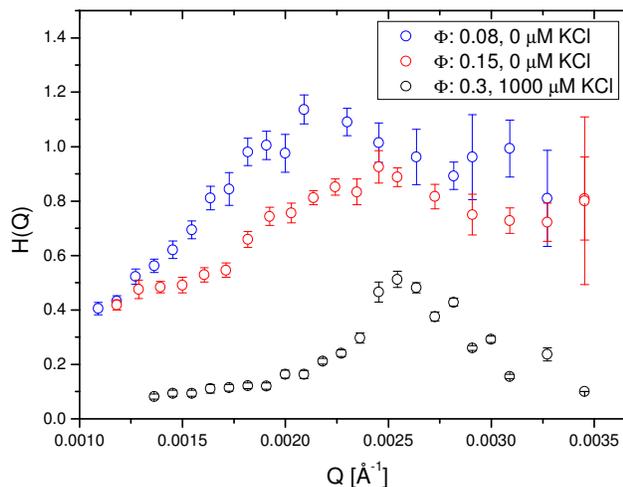


Fig. 3: Hydrodynamic functions of three investigated samples.

References

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