



	Experiment title: Interparticle interaction strength dependence on the hydrodynamic behavior of charge stabilized colloidal suspensions	Experiment number: SC-1065
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Report:

The hydrodynamic behavior of charge stabilized colloidal suspensions was investigated. We concentrated our study on the interplay between the direct interactions and the indirect hydrodynamic interactions in extracting the hydrodynamic function of series of sample for which the strength of the direct interactions was varied. For charge stabilized systems, the interaction pair potential U between two macroions is described by a Screened Coulomb ("Yukawa") potential, given by eq. 1:

$$\frac{U(x)}{k_B T} = \begin{cases} \infty & , \quad x = r/\sigma \leq 1 \\ \psi_0 \frac{e^{-\kappa\sigma(x-1)}}{x} & , \quad x > 1 \end{cases} \quad (1)$$

where $\kappa\sigma$ is the screening parameter, $\psi_0 = Z^2 e^2 (\pi \epsilon_0 \epsilon_r \sigma (2 + \kappa\sigma)^2)^{-1}$ the contact potential ; where Z is the effective number of charges per macroion, ϵ_0 is the vacuum dielectric constant and ϵ_r the relative dielectric permittivity of the solvent. The parameter κ is the inverse of the Debye-Hückel screening length which is related to the total amount of charges which are present in the solution (the macroions and the added electrolyte ions if present). It is described by $\kappa^2 = e^2 (k_B T \epsilon_0 \epsilon_r)^{-1} (nZ + 2C_s)$ where C_s is the concentration of monovalent added electrolyte and n is the number density of macroions.

In order to change the direct interaction strength, one could either change the electrolyte concentration C_s at a given volume fraction, or change the volume fraction at fixed electrolyte concentration.

We choose to play with the volume fraction at constant electrolyte concentration by applying appropriate dilutions or concentration procedures (i.e. centrifugation

process) to a given deionized charge stabilized colloidal suspension. By proceeding in this way, we measured different samples made out of the same master suspensions, thus preserving identical particle size, polydispersity and number of charge per particle. The master suspension was consisting of silica particles dispersed in a water/glycerol mixture. The particle size $R = 780\text{\AA}$ and polydispersity $\sigma = 0.06$ were evaluated from the analysis of SAXS scattering intensity profile on a dilute screened sample. We used SAXS and XPCS to characterize the static and dynamic properties of each sample respectively. The volume fraction ranges between 0.03 and 0.15. For each volume fraction the static structure factor $S(Q)$ is extracted from the SAXS intensity profile and then fitted with an appropriate model to characterize the direct interactions. Each time XPCS was used to probe the effective diffusion coefficient $D(Q)$ on wavevectors covering the $S(Q)$ maximum. The corresponding hydrodynamic function $H(Q) = D(Q)S(Q)/D_0$ (where $D_0 = kT/(6\pi\eta R)$ is the Stokes–Einstein diffusion constant) were thus extracted from the experimental data.

As an example is shown here the results of the data obtained on the master suspension. Fig.1 (left) shows the static structure factor and the reduced inverse diffusion coefficient obtained using SAXS and XPCS respectively. Fig.1 (right) presents the corresponding hydrodynamic function $H(Q)$. The hydrodynamic functions shows a maximum located at the $S(Q)$ peak position which value is close to unity. In order to describe the hydrodynamics of colloidal suspensions, the major argument is the value at the peak of $H(Q)$. Whether or not it is larger than unity, clearly defines a typical hydrodynamic regime, as described in the proposal. Starting with this master suspension which presents a behavior for which $H(Q_{max}) \approx 1$ and applying various changes in volume fraction, we intend to observe the transition from $H(Q_{max}) > 1$ to $H(Q_{max}) < 1$ and to correlate it to the detailed description of the direct interactions present in the suspension from the analysis of the static structure factor.

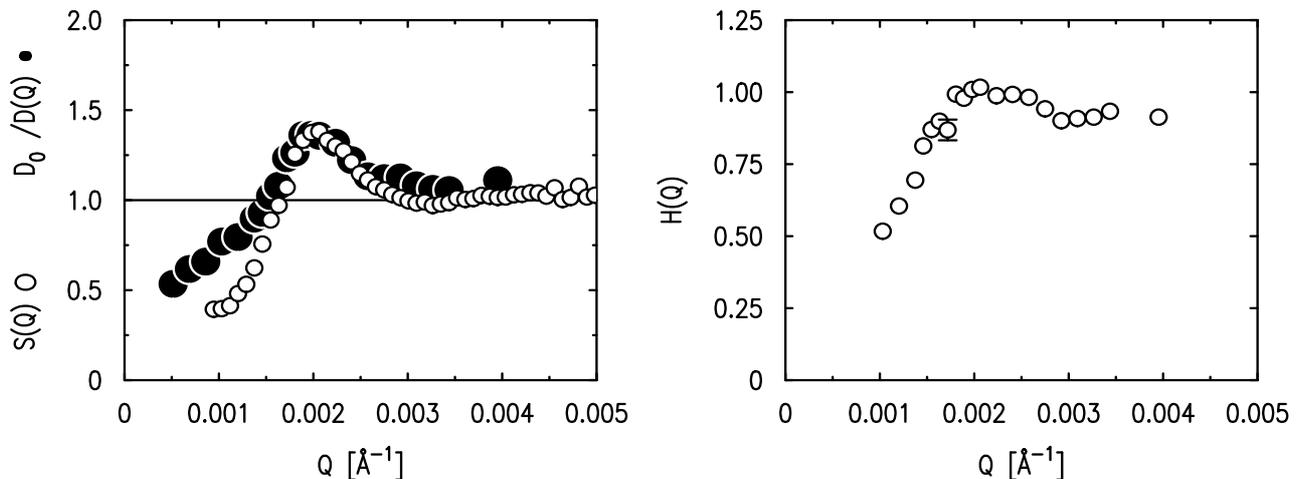


Figure 1. (Left): Comparison between the measured static structure factor $S(Q)$ (open symbol) obtained by SAXS and the reduced inverse diffusion coefficient $D_0/D(Q)$ (closed symbol) obtained from XPCS data. (Right): Hydrodynamic function $H(Q)$ obtained from the data (left).