Characterization of protein induced flocculation of silica nanoparticles by analytical centrifugation

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Characterization of the dispersed state is of fundamental interest for the application of nanoparticle dispersions. Though in most cases colloidal stable dispersions are intended, in practice this is difficult to achieve. For example, enzyme coated silica particles have broad potential for different biotechnological applications. However, adsorption of biomolecules usually markedly changes the nature of particle interactions. For the adsorption of lysozyme onto nanosized silica particles such effects were recently studied by Bharti, Meißner and Findenegg (Protein-induced aggregation of silica nanoparticles, to be presented at this conference). Sedimentation analysis using multisample analytical centrifugation with photometric detection [1] is a rather simple but powerful method to characterize the dispersed state and particle size distribution as function of variables like ionic strength and pH. This method was used for additional characterization of the lysozyme modified silica nanodispersions.

For samples at fixed silica and protein concentrations a change of pH from acidic to alkaline causes a gradual transition from a stable dispersion to a flocculated network, which at high pH reverses to a polydisperse sedimentation, i.e. individual aggregates are settling (see Figure). Addition of NaCl has only a small effect on the dispersion state at neutral pH. Zone sedimentation and a large sediment height indicate the presence of a flocculated particle network. In addition to the sedimentation behaviour the compressional behaviour of the sediments and the particle size distributions were investigated.

left pH 7: flocculated network – zone sedimentation, right pH 10: individual aggregates – polydisperse sedimentation