

RHEOLOGY AND DYNAMICS OF PH-RESPONSIVE MICROGEL SYSTEMS

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The colloidal phenomenon of soft particles is an important field of research due to the growing interest in a variety of important systems found in biological science, such as vesicles, bi-layers, membranes, and living cells. Synthetic mono-dispersed colloidal suspensions in the nano to micron size range are increasingly becoming important model systems for the study of a variety of phenomena observed in soft condensed matter physics, such as glass transitions and crystal nucleation. In order to understand the behavior of these complex systems, we need to elucidate the relationship between the microscopic and macroscopic properties of these systems. In this presentation, we report on a study of a microgel system that offers us a platform to understand these relationships, and the physical forces that control their behavior.

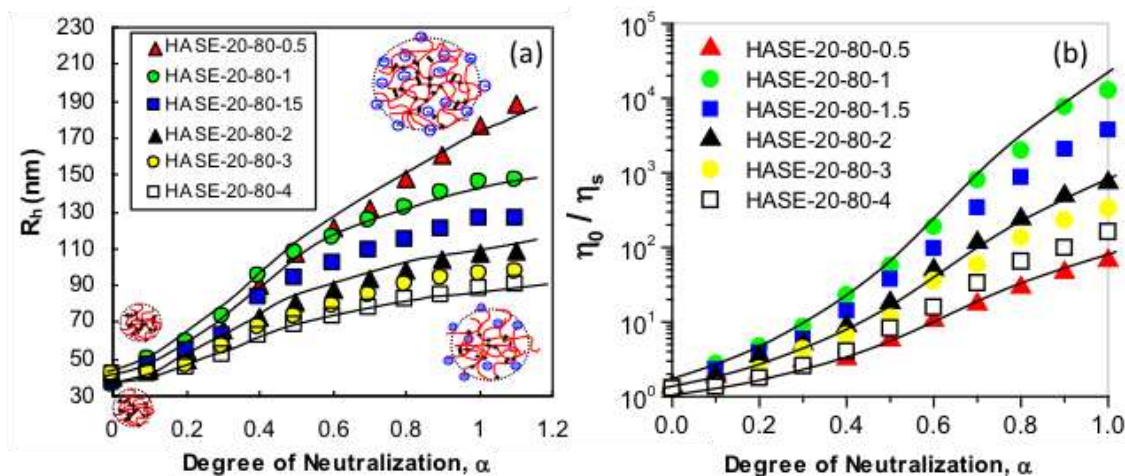


Figure 1: Microstructure (size) and macroscopic (viscosity) properties of a series of microgel systems

The pH-responsive microgel particles containing 20 mol% methacrylic acid (MAA) at varying cross-linked densities were characterized in dilute salt-free solution using the Brookhaven dynamic light scattering (DLS) system for neutralization degree (α) ranging from 0 to 1. In the unneutralized state, the particles exhibited a microstructure close to that of a model hard sphere with a hydrodynamic radius R_h of ~ 40 nm. The pH-dependent hydrodynamic radius, R_h , displayed a continuous increase as α was increased from 0 to 1.0, representing the steady expansion of particles due to enhanced osmotic pressure exerted by the counter-ions trapped inside the polymeric network as depicted in Fig. 1(a). The swelling characteristics at $\alpha < 0.4$ were fairly similar for all the seven microgel systems with 20 mol% MAA but different cross-linked densities. The R_h began to deviate when α exceeded 0.4, which suggests a change in conformation of the microgel particles during the neutralization process. Fig. 1(b) depicts the low-shear relative viscosity η_r (η_0/η_s) versus the degree of neutralization, α , for salt-free solution containing 5 wt.% microgel with 20 mol% MAA and different cross-linked densities. We observed that at $\alpha=0$, where the colloidal particles were in the form of a compact sphere, the viscosities for all microgel systems were nearly identical to the viscosity of water (i.e., solvent), where $\eta_r \sim 1$. The viscosity increased continuously as α increased from 0 to 1.0, and microgel HASE-20-80-1 exhibited the largest viscosity increase. A similar trend was observed where the viscosity began to increase at a faster rate as reflected by the sharp increase in η_r at $\alpha \sim 0.4$, which further points to a transition region reflecting the conformational change of microgel particles during the neutralization process. The relationship between the microscopic and macroscopic properties will be discussed in the presentation.