The Potentials of Synchrotron Small Angle X-ray Scattering to Study Complex Adsorption and Swelling Processes in Latexes

Jörg Bolze and Tetsuro Fujisawa

SPring-8 / RIKEN

A synthetic polymer colloid (latex), is defined as a dispersion of polymer particles in a fluid medium. The particles are generally spherical, monodisperse with a size range of about 10 nm to 1000 nm in diameter.

Scattering techniques like neutron-, X-ray and light scattering are most useful techniques for structural studies on latexes. Compared to neutron works, the number of X-ray studies in this field is very limited by now. However, the validity of small angle X-ray scattering (SAXS) has been demonstrated [1]. In particular high flux synchrotron X-ray radiation should allow various kinetic studies and precise measurements even in the angular regions, where scattering is very low. These are clear advantages compared to neutron scattering experiments which should be taken into account. Furthermore, latexes show excellent stability in a high flux synchrotron X-ray beam.

We performed some test measurements on water based polymer latexes at RIKEN beamline BL45XU using a CCD camera/image intensifier detector system at a camera length of 2.2 m and λ = 1Å. The innermost part of the scattering pattern had to be masked due to the large dynamic range of the scattering curves [2].

After adding an excess amount of the anionic surfactant SDS to latexes made of polymethylmethacrylate (PMMA) or polystyrene (PS) the scattering pattern shows two distinct features [3]: a highly structured, fast decay in the inner part and a broad maximum at higher angles (see Fig. 1). These can be attributed to the scattering from the latex particles and the free surfactant micelles, respectively. The separation of the two scattering contributions is due to the large difference in particle sizes (ca. 80nm vs. 4nm) and allows us to analyze both species simultaneously *in situ*. From Fig. 1 it could be concluded, that SDS adsorbs on PS-particles but only to a very small extent on PMMA particles. This can be explained with the different polarities of the two polymers.

Figure 2 shows a study of the competitive swelling [4] of a PMMA latex and SDS micelles with toluene as monitored by SAXS. From the evaluation of the two scattering regions, the distribution of the swelling agent between the two species can be determined quantitatively. Time resolved measurements also allowed kinetic studies in this complex three phase system. The signal from the polymer particles in the swollen state is still very structured, which shows that they retain a uniform size, but larger than initially.

References

[1] N. Dingenouts *et al.*, Adv. Pol. Sci. **144** (1999) 1.

[2] T. Fujisawa *et al.*, 12th Ann. Meeting Jpn. Synchrtron. Rad. Soc., Photon Factory, (January 1999).

[3] J. Bolze *et al.*, Langmuir **12** (1996) 2906; J. Bolze *et al.*, Coll. Pol. Sci. **274** (1996) 1099.

[4] J. Bolze and M. Ballauff, Macromol. **28** (1995) 7429; J. Bolze *et al.*, Langmuir **13** (1997) 2960.

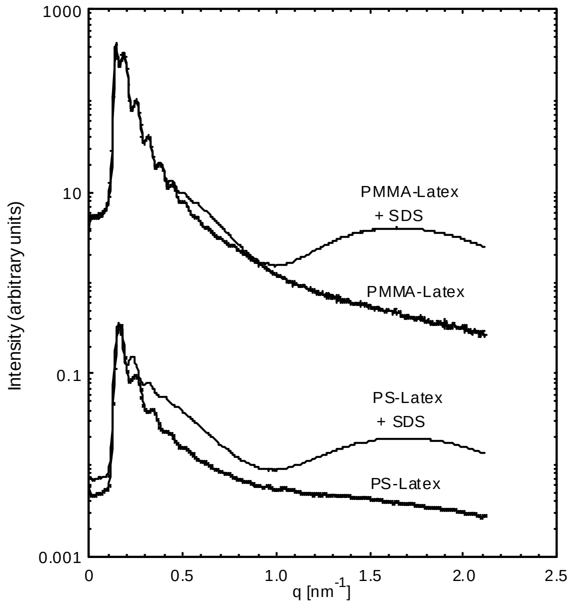

Fig. 1. Interaction of SDS with a PMMA- and a PS-latex. For clarity, the two lower curves were scaled with a suitable factor.

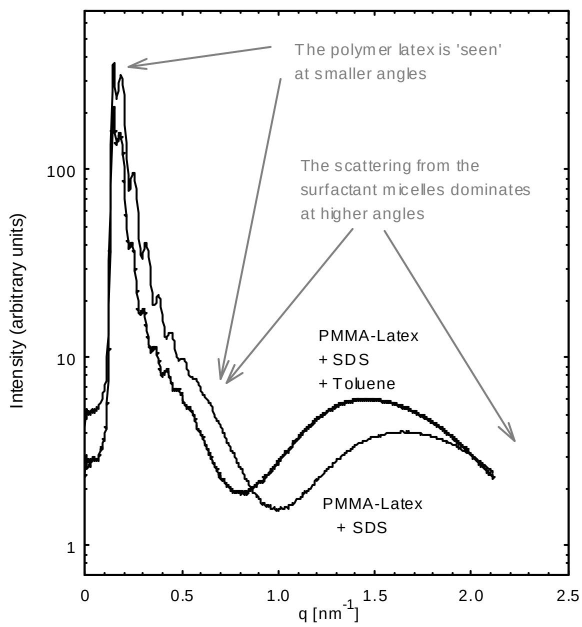

Fig. 2. Competitive swelling of PMMA latex particles and SDS surfactant micelles with toluene.

Scattering vector $q=(4\pi/\lambda)\sin(\theta/2)$ *with* λ*: wavelength of radiation,* θ*: scattering angle.*