POLYMER PROGRAM SEMINARS

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"Synchrotron X-ray Scattering and Spectroscopy Applied to Soft Matter"

Synchrotron radiation (SR) produces light that is highly brilliant than conventional X-ray sources. Photon energy covers from soft X-ray, tender X-ray to hard X-ray. By utilizing wide energy range and high quality of light, various scattering and spectroscopic methods can be applied to various soft materials. In this presentation, our recent researches on appliation of synchrotron X-ray scattering and spectroscopy to soft matter are summarized.

Structure of polymer-grafted nanoparticles (SPNP) film consisting of a spherical silica core and densely-grafted polymer chains bearing hydrogen-bonding side-groups capable of physically crosslinking, was investigated by *in-situ* ultra-small angle X-ray scattering(USAXS) during uniaxial stretching process. USAXS revealed that the molded SPNP formed a highly oriented twinned fcc lattice structure and a [111] plane was aligned nearly parallel to the film surface at initial state. Structural analysis of *in-situ* USAXS using a model of uniaxial deformation induced by rearrangements of the nanoparticles revealed that the fcc lattice was distorted in the stretching direction being proportional to the macroscopic strain until the strain reached 35%.

Grazing incidence X-ray diffraction (GIXD) is a powerful tool to characterize the surface molecular aggregation states of polymer films. Tender X-ray with wavelength of 0.25-0.62 nm has potential advantage that penetration depth gradually increases above the critical angle. Tender X-ray GIXD was successfully applied to side chain crystalline polymer films for depth profiling of the crystalline state.

X-ray emission spectroscoppy (XES) was employed to characterize the local hydrogen-bonding structure of water confined in a charged polyelectrolyte brush. Even at room temperature, a majority of the water molecules confined in the polycationic brush exhibited one type of hydrogen-bonding configuration: a slightly distorted, albeit ordered configuration. On the other hand, water molecules in sulfobetaine polymer brush showed hydrogen-bonding configuration similar to bulk water.

X-ray photon correlation spectroscopy (XPCS) is a technique, which allows us to characterize the dynamics of materials with coherent X-ray source. The dynamical behavior of polystyrene-grafted silica nanoparticles dispersed in a polystyrene matrix was studied using XPCS. While at low temperatures the particle motion was hyperdiffusive, the motion became subdiffusive with increasing temperature. This crossover may be a result of the competition between the dynamical heterogeneity of a polymer matrix around the glass transition temperature, and the interaction between the polymer brushes and the polymer matrix.

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