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FY2018 was the final year of the ImPACT program "Realizing Ultra-Thin and Flexible Tough Polymers". Through this program, six companies and eight academic groups conducted small-angle and wide-angle scattering measurements on the deformation and fracture of polymer materials. New polymer materials developed as part of this program were measured under various conditions. In addition to measurements under deformation using a beamline standard uniaxial tensile tester (Fig. 1), various other deformations were measured, including biaxial stretching, piercing, bulging, and fatigue.

X-ray photon correlation spectroscopy (XPCS), which was demonstrated using test samples (silica particles dispersed in a viscous liquid) in the previous year, was performed for several new materials such as nanovoid polymer films and blend polymer materials. For example, XPCS measurements were performed on polymer alloys (Toray Industries) of polyamide 6 / polyrotaxane, which has a greatly improved toughness performance by dispersing polyrotaxane on the nanoscale. The toughness varies greatly depending on the chemical composition and amount of the additive. However, the relationship with the molecular dynamics was unknown. Discussions of the time autocorrelation functions obtained by XPCS measurements revealed that the time scale of the fluctuations of the interface between the polyamide-rich phase and the polyrotaxane-rich phase depends on the composition of the additive (Fig. 2).

Hence, the data elucidated a significant correlation between the observed dynamics and toughness performance.

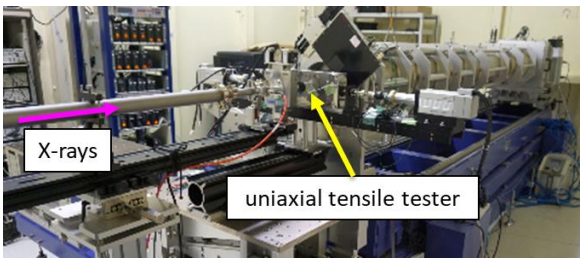

Fig. 1. Small- and wide-angle X-ray scattering measurements under uniaxial elongation.

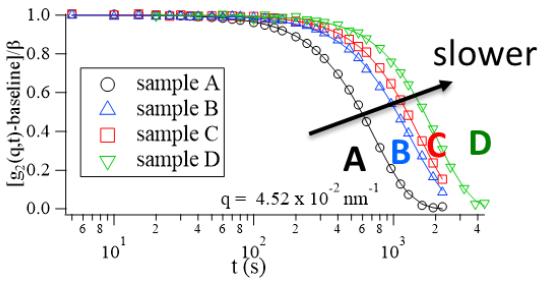

Fig. 2. Time-autocorrelation functions obtained from XPCS measurements for four types of polyamide 6 / polyrotaxane nanoalloys with different additives.

Taiki Hoshino

SR Imaging Instrumentation Team, Physical and Chemical Research Infrastructure Group, Advanced Photon Technology Division, RIKEN SPring-8 Center