Division of Multidisciplinary Chemistry
– Polymer Materials Science –

http://www.scl.kyoto-u.ac.jp/~kanaya2/e_index.html

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Dr JENG, U-Ser National Synchrotron Radiation Research Center, Hsinchu, Taiwan, 30 May

Scope of Research

The structure and molecular motion of polymer substances are studied using mainly scattering methods such as neutron, X-ray and light with intension of solving fundamentally important problems in polymer science. The main projects are the mechanism of structural development in crystalline polymers from glassy or molten state to spherulites, the dynamics in disordered polymer materials including low-energy excitation, glass transition and local segmental motions; formation processes and structure of polymer gels; the structure and molecular motion of polyelectrolyte solutions.

KEYWORDS

Polymer Physics
Polymer Properties
Scattering
Neutron Scattering

Selected Publications

Kawabata, J.; Matsuba, G.; Nishida, K.; Inoue, R.; Kanaya, T., Melt Memory Effects on Recrystallization of Polyamide 6 Revealed by Depolarized Light Scattering and Small-Angle X-ray Scattering, *J. Appl. Polym. Sci.*, **122,** 1913-1920 (2011).

Masunaga, H.; Ogawa, H.; Takano, T.; Sasaki, S.; Goto, S.; Tanaka, T.; Seike, T.; Takahashi, S.; Takashita, K.; Nariyama, N.; Ohashi, H.; Ohta, T.; Furukawa, Y.; Matsushita, T.; Ishizawa, Y.; Yagi, N.; Takata, M.; Kitamura, H.; Sakurai, K.; Tashiro, K.; Takahara, A.; Amamiya, Y.; Horie, K.; Takenaka, M.; Kanaya, T.; Jinnai, H.; Okuda, H.; Akiba, I.; Takahashi, I.; Yamamoto, K.; Hikosaka, M.; Sakurai, S.; Shinohara, Y.; Okuda, A.; Sugihara, Y., Multipurpose Soft-Material SAXS/WAXS/GISAXS Beamline at SPring-8, *Polymer Journal*, **43,** 1-7 (2011).

Asakawa, H.; Nishida, K.; Matsuba, G.; Kanaya, T.; Ogawa, H., Crystallization of Isotactic Polypropylene from Mesomorphic Phase: A Constant Heating Rate Study, *Journal of Physics*: *Conf. Ser.*, **272,** [012024-1]-[012024-4] (2011).

Inoue, R.; Kawashima, K.; Matsui, K.; Nakamura, M.; Nishida, K.; Kanaya, T.; Yamada, N. L., Interfacial Properties of Polystyrene Thin Films as Revealed by Neutron Reflectivity, *Phys. Rev.*, **E84,** [031802-1]- [031802-7] (2011).

Nishida, K.; Okada, K.; Asakawa, H.; Matsuba, G.; Ito, K.; Kanaya, T.; Kaji, K., In Situ Observations of the Mesophase Formation of Isotactic Polypropylene -A Fast Time-resolved X-ray Diffraction Study, *Polymer Journal*, **44,** 95-101 (2012).

Precursor of Shish-kebab by Micro-beam WAXS

It is well known that when semi-crystalline polymers are crystallized under shear flow or elongational flow the so-called shish-kebab structure is formed. It is considered that the shish-kebabs consist of extended chain crystals (shish) and folded chain lamella crystals (kebab) grown on the extended chain crystals. It is believed that the shish-kebab is a structure basis of ultra-high modulus and ultra-high strength fiber, and hence many studies have been performed on the shish-kebab. One of the recent topics in the field is precursor of the shish-kebab. In order to understand the role of the precursor we studied structure formation process of isotactic polystyrene (iPS) after applying pulse shear above the nominal melting temperature T_m using depolarized light scattering (DPLS), polarized optical microscope (POM) and small- and wide angle scattering (SAXS, WAXS), and found that precursors were formed in μm scale above T_m. Although we did not observe any signs of crystals in normal WAXS measurements, we could not reach a final conclusion that the precursors did not include crystals. In this work inner structure of the precursor of iPS was studied above T_m using *micro-beam WAXS*. The result of *micro-beam WAXS* mapping on the precursor is shown in Figure 1. Symbols or no symbols in the mapping area indicate that we could observe the Bragg diffractions or no Bragg diffractions (see also Figure 2), showing that the precursor certainly includes crystallites which can survive at temperatures even above the nominal melting temperature.

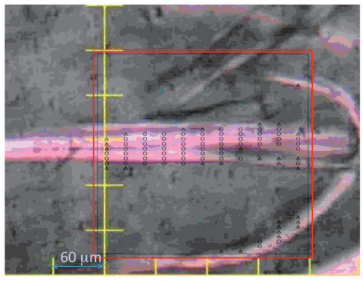

Figure 1. POM image of precursor of iPS for micro-beam WAXS mapping.

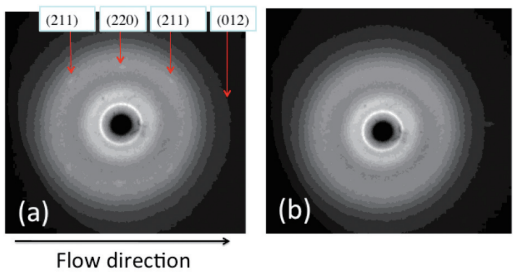

Figure 2. Micro-beam diffraction patterns. (a) beam is on the precursor, (b) beam is out of precursor.

Fast Time-Resolved X-Ray Scattering Measurements of Mesophase Formation of Isotactic Polypropylene

Isotactic polypropylene (iPP) has a mesophase, besides major three kinds of crystalline modifications, such as alpha-, beta- and gamma-forms. Mesophase iPP in appearance is transparent like a glassy polymer and the structure in wide-angle X-ray diffraction (WAXD) scale is intermediate one between amorphous and crystal. In small-angle X-ray scattering (SAXS) scale, the mesophase iPP is characterized by the so-called "nodule" of spherical or polygonal shape with the diameter of ca. 10 nm. The mesophase iPP is obtained empirically by dropping thin molten iPP rapidly into ice water. Namely, the formation speed of the mesophase iPP is particularly high and the formation process finishes for a short period of time. Even so, ex-situ preparation of the mesophase iPP is rather readily achieved; accordingly the finished form of the mesophase iPP from various viewpoints has been extensively studied so far. However, in-situ observation of the formation process of the mesophase iPP during such a short period has been a challenging issue up to the present. Combining effectively a rapid temperature-jump technique and a synchrotron radiation X-ray scattering technique, we have accomplished in-situ WAXD and SAXS observations during the rapid cooling of iPP from molten state.

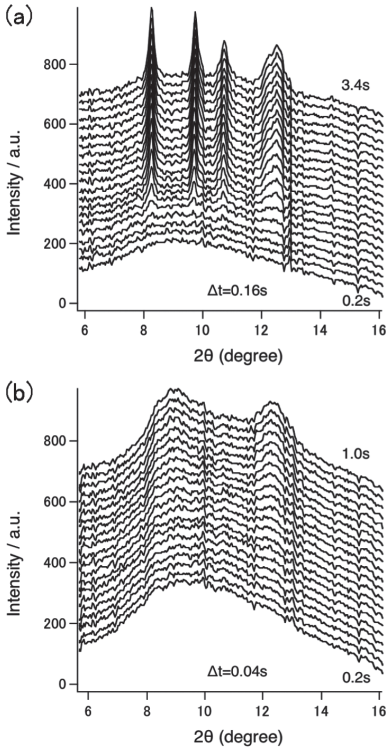

Figure 3. Time evolution of WAXD profiles during the molten iPP is rapidly cooled to (a) 80°C and (b) –10°C.