

# Division of Multidisciplinary Chemistry – Polymer Materials Science –

[http://www.scl.kyoto-u.ac.jp/~kanaya2/e\\_index.html](http://www.scl.kyoto-u.ac.jp/~kanaya2/e_index.html)



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## 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

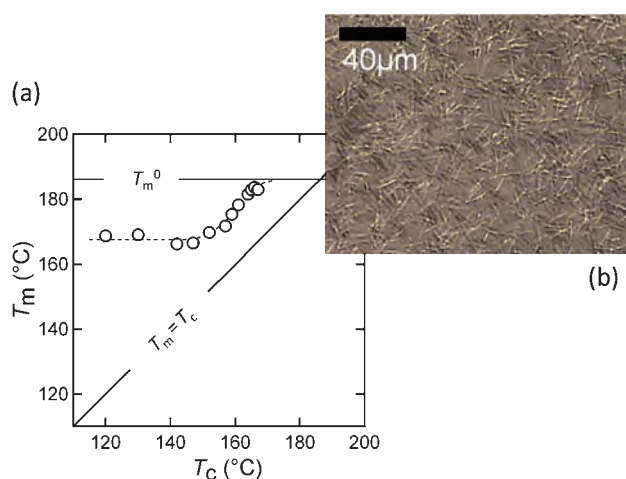
## Selected Publications

Xia, T.; Ogawa, H.; Inoue, R.; Nishida, K.; Yamada, N. L.; Li, G.; Kanaya, T., Dewetting Process of Deuterated Polystyrene and Poly(vinyl methyl ether) Blend Thin Films via Phase Separation, *Macromolecules*, **46**, 4540-4547 (2013).  
Kanaya, T., Polec, A. I.; Fujiwara, T.; Inoue, R.; Nishida, K.; Ogawa, H.; Ohta, N., Precursor of Shihi-Kebab above the Melting Temperature by Micro-beam X-ray Scattering, *Macromolecules*, **46**, 3031-3036 (2013).  
Mashita, R.; Kishimoto, H.; Inoue, R.; Kanaya, T., Small-angle X-ray and Neutron Scattering Analyses of Highly Crosslinked Rubber with Unsaturated Carboxylic Acid, *Polym. J.*, **45**, 57-63 (2013).  
Asakawa, H.; Nishida, K.; Kanaya, T.; Tosaka, M., Giant Single Crystal of Isotactic Polypropylene Showing near-equilibrium Melting Temperature, *Polym. J.*, **45**, 287-292 (2013).  
Inoue, R.; Kanaya, T., Heterogeneous Dynamics of Polymer Thin Films as Studied by Neutron Scattering, *Adv. Polym. Sci.*, **252**, 107-140 (2013).

## Specific Kinetic Pathway from Mesophase to Large Single Crystal of Polymer

Single crystals of polymer, especially large sized ones, have attracted the interest of researchers for many years. We have found a specific kinetic pathway to form giant single crystals of isotactic polypropylene (iPP) *via* the mesophase, whereas the crystal aggregate, the so-called spherulite, is usually obtained during the conventional crystallization of iPP from the molten state. In order to find such a kinetic pathway, multiple probes, such as wide-angle X-ray diffraction (WAXD), de-polarized light transmission (DPLT) and differential scanning calorimetry (DSC), were used in complementary.

The pre-quenched iPP mesophase was heated to 166°C at a rate of 75°C/min and maintained at this temperature for 24 h. The obtained crystallites exhibited a very high melting temperature,  $T_m$ , of 183.7°C, which is ca. 19°C higher than the iPP's nominal  $T_m$  (~165°C); namely, the observed  $T_m$  is immediately close to the literature value of iPP's equilibrium melting temperature,  $T_m^0$  (186.2°C). The crystallites have bamboo leaf-like or needle-like morphology and are ~35  $\mu\text{m}$  in length and ~3.5  $\mu\text{m}$  in width. The thickness of the crystallites was estimated to be 88 nm according to the melting temperature. The number density of the crystallites in a unit volume could be controlled by adjusting the heating rate. As the result, well-isolated single crystals of iPP with the above-mentioned morphology and dimension were obtained.

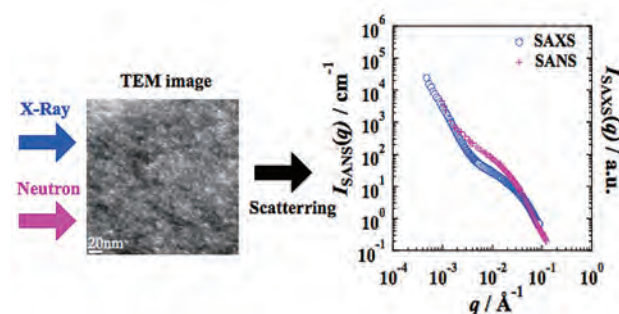


**Figure 1.** (a) Melting temperature,  $T_m$ , as a function of the annealing temperature,  $T_c$ . (b) Optical microscopic image of large single crystal of iPP.

## Small-angle X-ray and Neutron Scattering Analyses of Crosslinked Rubber with Metal Diacrylate

Many industries, including the automobile industry, require lightweight materials with high tensile strengths and high abrasion resistances to improve the manufacturing of commercial products. Therefore, controlling the morphology and structure of functional polymeric materials is indispensable to the development of next-generation materials.

The structure of rubber crosslinked with metal diacrylate has been extensively studied because such rubber exhibits so-called “reinforcement effect” without the addition of reinforcing materials such as carbon black, silica or clay. On the other hand the structure of the matrix rubber in itself, which is a main component in these rubber materials, has not been well studied because of its structural complexity. It is considered that elucidating the structure of the matrix rubber could provide a promising approach to improve the mechanical properties of these rubber materials, we then determined to study the structure of butadiene rubber (BR) crosslinked with metal diacrylate through the complementary use of small-angle X-ray scattering (SAXS) and small angle neutron scattering (SANS). In addition to the hierarchical structure of metal aggregates we first succeeded to reveal the existence of high crosslink density segment (HC-BR) in the matrix BR. Furthermore it was also found that HC-BR was related to mechanical strength of the present studied butadiene rubber by comparing the results of the tensile measurements with the structural information from both SAXS and SANS measurements.



**Figure 2.** TEM images, SAXS and SANS profiles obtained from butadiene rubber crosslinked with metal diacrylate.