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# Division of Multidisciplinary Chemistry – Polymer Materials Science –

<http://www.scl.kyoto-u.ac.jp/~polymat/index.html>



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## Scope of Research

The structure and molecular motion of polymer substances are studied, mainly using scattering methods such as X-ray, neutron, and light with intent to solve fundamentally important problems in polymer science. The main project are studied on 1) the morphologies and the dynamics of self-assembling processes in block copolymers, 2) the hierarchical structures in crystalline polymers, 3) the viscoelastic effects in glassy materials, 4) formation processes and structure of polymer gels, and 5) the structure and molecular motion of polyelectrolyte solutions.

### KEYWORDS

Polymer Physics  
Polymer Properties  
Self Assembly  
Softmatter  
Hierarchical Structure



## Selected Publications

Wang, Y. C.; Kim, M. I.; Akasaka, S.; Saijo, K.; Hasegawa, H.; Hikima, T.; Takenaka, M., Fddd Structure in Polystyrene-block-polyisoprene Diblock Copolymer/Polystyrene Homopolymer Blends, *Macromolecules*, **49** (6), 2257-2261 (2016).  
Matsumoto, K.; Terashima, T.; Sugita, T.; Takenaka, M.; Sawamoto, M., Amphiphilic Random Copolymers with Hydrophobic/Hydrogen-Bonding Urea Pendants: Self-Folding Polymers in Aqueous and Organic Media, *Macromolecules*, **49** (20), 7917-7927 (2016).  
Ogawa, H.; Takenaka, M.; Miyazaki, T.; Fujiwara, A.; Lee, B.; Shimokita, K.; Nishibori, E.; Takata, M., Direct Observation on Spin-Coating Process of PS-*b*-P2VP Thin Films, *Macromolecules*, **49**, 3471-3477 (2016).  
Ishige, R.; Ohta, N.; Ogawa, H.; Tokita, M.; Takahara, A., Fully Liquid-Crystalline ABA Triblock Copolymer of Fluorinated Side-Chain Liquid-Crystalline A Block and Main-Chain Liquid-Crystalline, B Block: Higher Order Structure in Bulk and Thin Film States, *Macromolecules*, **49**, 6061-6074 (2016).

## Formation of OBDD Structure in PS-PI-PDMS

Ordered bicontinuous double-diamond morphology (OBDD) was formed in cast film of polystyrene-*block*-polyisoprene-*block*-polydimethylsiloxane (SID) triblock copolymer from toluene solution. The following two step phase separation was found to occur during solvent cast: In the early stage of the cast process, hexagonally-packed polydimethylsiloxane (PDMS) cylinders were self-assembled in polystyrene (PS)/polyisoprene (PI) matrix order-order transition, then order-order transition was induced by microphase separation between PS and PI association with the increase of concentration.

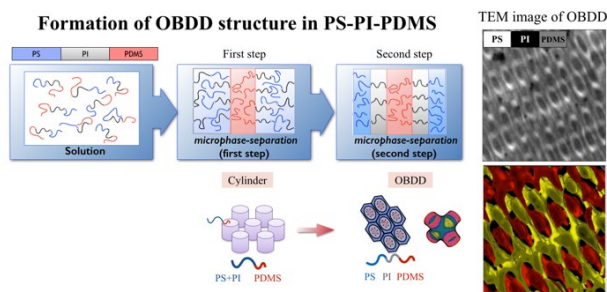


Figure 1. Formation of OBDD structure in PS-PI-PDMS.

## Quasi-Equilibrium Gelation Temperature of Aqueous Methylcellulose

Aqueous methylcellulose (MC) forms hydrogel upon heating and the gel dissolves upon cooling i.e. thermo-reversible gelation. However, the values of the gelation temperature differ depending on the sources of MC samples and on the methods of determination as well. In this study, we have obtained a lower limit of the gelation temperature for a specific MC below which aqueous MC does not form the gel, by dually extrapolating the holding time for gelation to infinite and the mechanical probing force to zero. The gelation temperature obtained in this manner decreased with increasing concentration of the MC; to cite a case, it was located at ca. 21 °C for 10 wt%, which is ca. 10 °C lower than a conditional value estimated after holding 1 h without these dual extrapolations.

## Direct Observation on Spin-coating Process of PS-*b*-P2VP Thin Films

During the spin-coating process of symmetric poly(styrene-*b*-2-vinylpyridine) (PS-*b*-P2VP) block copolymers, after the formation of the micelles in dilute solution, the

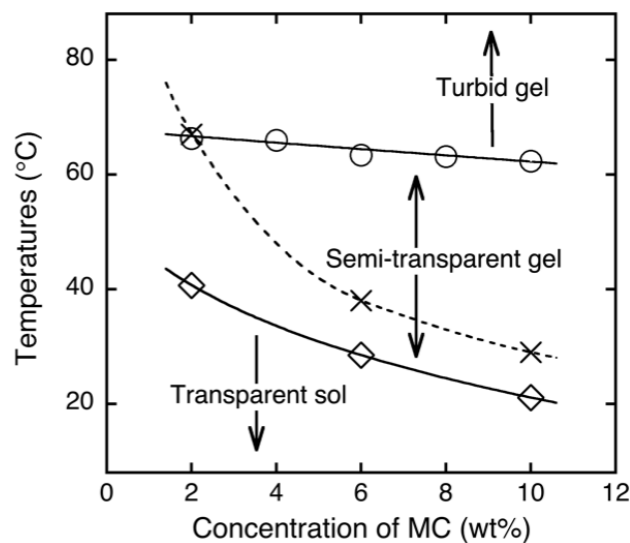


Figure 2. Lower limit of gelation temperature (diamond marks), lower limit of cloud point (open-circle marks) and conditional gelation temperature estimated by employing a stainless-steel ball after holding 1 h (cross marks). Lines are guide for eyes.

selective solvent induced two kinds of the morphological transition. Firstly, the disordered spherical micelles were transformed into a BCC lattice of spheres of which the (110) plane was oriented perpendicularly to the substrate surface. Secondly, further evaporation induced a transition from spheres on the BCC lattice into cylindrical structures. The orientation of the cylinders perpendicular to the substrate surface was induced by solvent convection perpendicular to the substrate, which occurs during rapid solvent evaporation. After this transition, vitrification of PS and P2VP prevented any further transition from cylinders to the more thermodynamically stable lamellar structures, as are generally observed as the bulk equilibrium state.

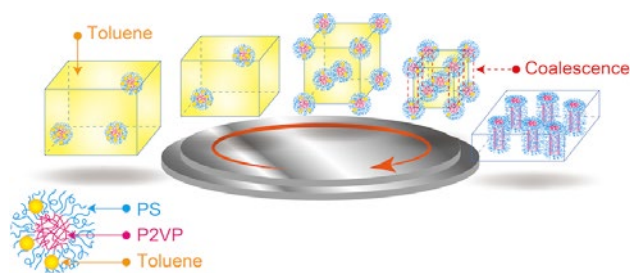


Figure 3. Spin-coating process of PS-P2VP thin film.