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

Scope of Research

Research Activities (Year 2005)

Presentations


Phase Separation of Hetero Polyelectrolyte Solutions, Nishida K, Tsubouchi T, Kanaya T, 54th Symposium on Macromolecules, Yamagata, 21 September.

Crystallization of Poly(L-lactic acid), Kawai T, Kanaya T, European Discussion Meeting on Polymer Physics, Polymer Crystallization, Waldau, Germany, 7 October.

Crystallization from Mesomorphic Phase of Isotactic Polypropylene, Konishi T, Nishida K, Matsuba G, Kanaya T, European Discussion Meeting on Polymer Physics, Polymer Crystallization, Waldau, Germany, 7 October.

Neutron Scattering Researches on Soft Condensed Matter, Kanaya T (invited), International Conference on Neutron Scattering, Sydney, Australia, 28 November.

Grants

Kanaya T, Collaboratory on Electron Correlation toward...
Phase Inversion in Blend of Aqueous Polyelectrolytes Due to Imbalanced Charge Densities

Most of polymeric materials of different kind or their solutions are difficult to dissolve each other. Even in an exceptional case, such a blend usually shows upper critical solution temperature (UCST) type phase behavior, i.e. the blend is in one phase region and in two phase region above and below the critical temperature, respectively. It is still more rare that the blend shows lower critical solution temperature (LCST) type one, since the entropy loss by demixing in the higher temperature region causes a great penalty for the free energy. We have found that a blend of aqueous solutions of different polyelectrolytes (PSSNa/PVSNa/water) having imbalanced charge densities is a promising system to show the LCST type behavior. When the charge densities of different polyelectrolytes are balanced, normal UCST type behavior is observed. However, as the charge densities of different polyelectrolytes become imbalanced, the phase behavior suddenly changed from the UCST to LCST type (Fig. 1). It is considered that the entropy loss in the higher temperature region is compensated by special repulsive interaction that stabilizes the structure between different polymers.

Crystallization of Poly(L-lactic acid)

Poly (L-lactic acid), PLLA, is one of environmentally friendly polymers that attracted significant interest in recent years. We found novel crystalline form of PLLA (α’ phase). In Fig. 2, wide angle X-ray diffraction (WAXD) profiles at higher crystallization temperatures, TcS, above 120 °C are assigned to be of α-form (10 helix, pseudo-orthorhombic, a=10.05Å, b=6.1Å, c=28.8Å), while some reflections including (10 10) are absent in lower TcS below 90°C. The results strongly suggest that the disordered α’ phase, which has hexagonal lattice (10 helix, a=6.2Å, c=28.8Å), is formed at lower temperatures. The disordered α’ phase is transformed into the ordered a phase upon heating (Fig. 3). One can see clearly in the WAXD profiles that phase transformation takes place at 150°C. Each reflection shifts to higher q as well as the increase in the number of reflections, which are due to the change in the lattice size and the space group, respectively. The profiles above 150°C were obviously the same as that of high Tc samples (ordered a phase). Moreover, two-step decrease in diffraction intensity has been observed during the melting process. It is reasonable, therefore, to consider that ordered α phase grows through the melting–reorganization or melting–recrystallization mechanism.

Figure 1. Phase diagrams for blends of aqueous solutions of different polyelectrolytes. Phase inversion occurs when the charge densities of different polyelectrolytes becomes imbalanced.

Figure 2. WAXD profiles of PLLA crystallized at various TcS from the melt.

Figure 3. 2D WAXD profiles upon heating at 10°C/min. The sample was pre-crystallized at 80°C.