Analysis of Compression Behaviors of a Highly Crystalline Polyimide Prepared from Monomer Salts and Poly(amic acid)

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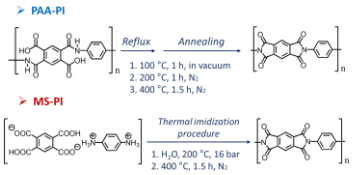
ABSTRACT

Polyimides (PI) are widely known as high-performance engineering plastics exhibiting high thermal stability, mechanical strength, and good flexibility. Physical properties of PIs are closely related to their molecular aggregation structures. We have been investigating the relationship between the optical properties and molecular aggregation structures of PIs at elevated pressures.[1] In this study, to understand pressure-induced variations in aggregation structures in solid-state PI materials, compression behaviors of the crystalline and amorphous regions of highly crystalline PI samples prepared from monomer salt (MS-PI) [2] and poly(amic acid) (PAA-PI) (**Scheme 1**) were investigated by wide-angle X-ray diffraction (WAXD) and infrared absorption (IR) spectroscopy under high pressure up to 4 GPa.

The crystallinity (X_c) and density (ρ) at atmospheric pressure for MS-PI (X_c = 0.90, ρ = 1.77 g/cm^3) and PAA-PI (X_c = 0.40, ρ = 1.74 g/cm^3) were estimated based on the WAXD intensity profiles. The volume compression of the crystal lattices of MS-PI and PAA-PI at 4.0 GPa were estimated as 14.0 % and 9.5 %, respectively. This result demonstrates that MS-PI exhibited a larger volume compressibility despite its higher density than PAA-PI. On the other hand, IR-band assignable to C=O asym. of the imide ring of PI chain in the amorphous region exhibited larger higher-frequency shifts than that in the crystalline region in each PI sample (**Fig. 1**). This result indicates that the compressibility of the amorphous region was larger than that of the crystalline region. In conclusion, volumetric compression of the crystal lattice in the highly crystalline PIs is dependent on the crystallinity because the compression stress can be significantly relaxed in the amorphous region.



Scheme 1 Synthesis scheme of highly crystalline PI samples.

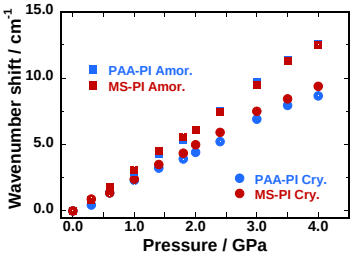


Fig. 1 Peak shifts of C=O asym. mode in crystalline and amorphous regions induced by pressure application.

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Short BIOGRAPHY

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