Analysis for micron-scale spatial distribution of molecular orientation by micro ATR-FTIR spectroscopic imaging method

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ABSTRACT

Polymeric materials have complicated hierarchical structures not only for multi-component systems of immiscible polymers (polymer blend forming phase separated structures) but also for single component systems, e.g. spherulite of semi-crystalline polymers, multi-grain structure in liquid crystalline polymers. Because these interfaces or grain boundaries are defects causing light scattering and breaking points, it is important to analyze the spatial distribution of them quantitatively. FTIR spectroscopy is one of the strongest methods to evaluate multi-component materials because it enables to detect different functional groups with high selectivity. Moreover, by using polarized incident light, it enables evaluation of orientation order of functional groups. FTIR imaging method, which is FTIR spectroscopy combined with imaging technique, can provide the spatial distribution of functional groups (chemical imaging) and also that of the molecular orientation by using polarizer [1,2]. Particularly, the latter is useful to visualize the defect structure. In this study, we applied polarized micro ATR-FTIR spectroscopic imaging (pATR-FTIR imaging) method with hemisphere Ge crystal to molecular orientation analyses of highly oriented films and fibers of aromatic polyimides (PI). Recently, Hikima *et al*. reported the analyses of the orientation distribution in semi-crystalline polymer by polarized FTIR imaging with a triangular diamond prism [2]. In our optical system, higher spatial resolution can be obtained by using a hemisphere Ge crystal, which has higher refractive index than the diamond prism and more focuses the incident light. From the pATR-FTIR imaging, spatial distributions of uniaxial orientation order parameter, *S*, of the main-chain were obtained from dichroic ratios evaluated from absorption spectrum in each pixel. In the PI film, the value of *S* was spatially homogeneous, although grain boundaries were observed in optical microscope observation. It is possibly because the size of the boundary region is smaller than the wavelength of IR light and comparable to that of visible light and only visible light was scattered by the defects. On the other hand, heterogeneous distribution of *S* value can be visualized for the PI fiber, which is very useful to analyze the detail inner structure of highly oriented fiber materials.

References

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