Control of Orientation of Fully Aromatic Polyimides Using Lyotropic Liquid-Crystalline Precursor

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I. INTRODUCTION

Fully aromatic polyimides (PI) are widely known as high-performance engineering plastics exhibiting high thermal stability, radiation resistance and mechanical strength. Controlling the orientation of PIs makes it possible to enhance physical properties such as large mechanical strength, small linear thermal expansion and high thermal diffusivity [1][2]. It has been known that the orientation of liquid crystal polymer chains can be easily controlled by external field such as shear flow. It was reported that NMP solution of precursor for PI, poly (amic ethyle ester)s (PAE) (Fig. 1), exhibited liquid crystalline property and are highly and uniformly oriented by shear flow [3]. Thereby, the high orientation PIs can be obtained by imidizing the highly oriented PAEs. In this study, we synthesized novel PAEs and evaluate the degree of the orientation order of PAEs and PIs.

II. EXPERIMENTAL

The chemical structure of the PAEs used in this study are shown in Fig. 2. PAE films were prepared by applying shear deformation of 50 wt% NMP solution of PAE between glass substrates and subsequent immersion in water and imidized at 350 °C (Fig. 2). The uniaxial order parameter S which represents the degree of molecular orientation, were measured by two-dimensional wide-angle X-ray diffraction (2D-WAXD) (Bruker D8 DISCOVER). S is defined as equation (1), where θ is the angle between the individual molecular-long-axis and the direction of shear flow, and $\langle\rangle$ represents the statistical average value.

$$S = 0.5\,(3\langle\cos^2\theta\rangle - 1) \qquad (1)$$

III. RESULT AND DISCUSSION

Fig. 3 shows the uniaxial orientational order parameter S of the PAE and PI films. The positive value of S suggests that PAEs were oriented by shear deformation except for BPDO. Moreover, S of PMDE and BPDE were simultaneously increased by imidization. We successfully prepared highly oriented PI films than previous sample using liquid crystalline precursor.

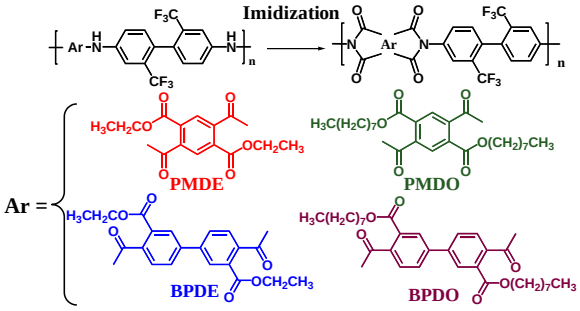

Figure 1. Chemical sturcture of the PAE precursors and PIs

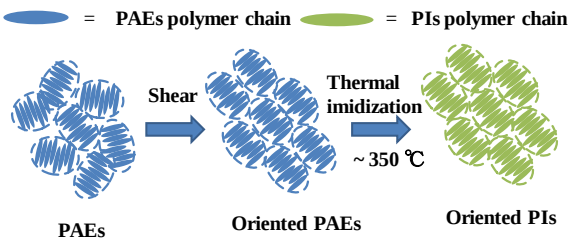

Figure 2. Schematic illustration of fabrication processes of the highly oriented PI films

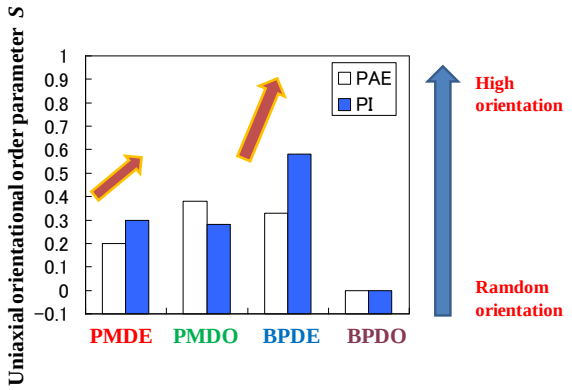

Figure 3. Uniaxial orientational order parameters, S, for the PAE and PI films

References

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