Preparation and Characterization of Colorless and Highly Transparent Semi-aromatic Polyimide Films Derived from Alicyclic Dianhydride and Fluorinated Aromatic Diamines

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Aromatic polyimides are well recognized as high performance polymers owing to their excellent combination of thermal, mechanical, dielectric and chemical properties, which make them good candidates for microelectronics applications. However, one of the great disadvantages of the aromatic polyimide films for optical application is their yellowish nature due to the intra- and/or intermolecular charge transfer complex (CTC) formation [1]. It is well known that the commercial aromatic polyimide films, such as Kapton and Upilex, give strong coloration from yellowish-brown to blackish-brown. In recent years, many efforts have been made to improve the optical properties of polyimide films [2]. It has been demonstrated that the incorporation of fluorine groups and alicyclic moieties into the polymer structure could reduce the coloration of polyimide films [3-4].

In this study, a series of semi-aromatic polyimides were synthesized based on novel fluorinated aromatic diamines and alicyclic dianhydrides, aiming at development the colorless and highly transparent polyimide films for optoelectronics applications. The effect of the structure on the solubility, thermal and mechanical properties, as well as optical properties of these semi-aromatic polyimides was investigated. The results indicated that the semi-aromatic polyimide films containing fluorine and sulfonyl groups were transparent and essentially colorless even as the film with thickness of 70 μm, which is considerably different from the deep yellow or brown color of traditional aromatic polyimide films. The optical transparency of these the semi-aromatic polyimide films were evaluated by the UV-vis spectra and color intensities detected by a color-eye colorimeter. From the results shown in Fig.1 and Table 1, it is found that these films gave the UV cutoff wavelengths shorter than 314 nm and transmittance at 450 nm higher than 91%. It is contrasted sharply with the commercial available aromatic polyimide film, such as Kapton, which showed deep yellow color and exhibited λ_0 of 444 nm and transmittance at 450 nm of 2%. Moreover, these semi-aromatic polyimide films showed high lightness with L^* values over 90 and exhibited nearly zero a^* values combined with extremely low b^* values of 3.3-3.8, indicating the extremely transparent and essentially colorless of these films. Their excellent optical properties are attributed to the distorted molecular conformation combined with the weakened electron-accepting and electron-donating property of dianydride and diamines, which significantly restrained the formation of inter- and intra-molecular charge transfer interactions.

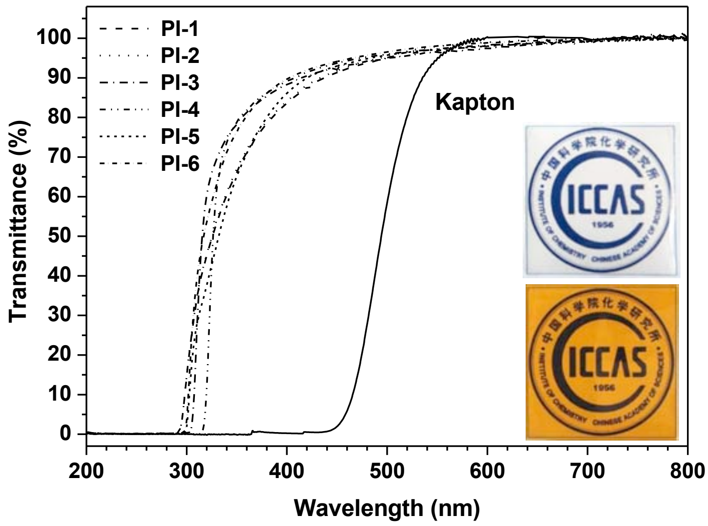

Fig. 1. UV-vis spectra of semi-aromatic polyimide films.

Table 1. Color coordinates of semi-aromatic polyimide films [a]

PIs	Film thickness (μm)	*L**	*a**	*b**
PI-1	51	91.9	-0.2	3.8
PI-2	53	92.0	-0.2	3.6
PI-3	52	92.6	0.2	3.7
PI-4	53	90.1	-0.2	3.8
PI-5	50	92.4	-0.1	3.3
PI-6	52	92.3	-0.2	3.4
Kapton	50	79.6	6.3	107.7

[a] The color parameters were calculated according to a CIE LAB equation. *L** refers to lightness; 100 means white, while 0 indicates black. A positive *a** means red color, a negative *a** indicates green color. A positive *b** means yellow color, a negative *b** indicates blue color.

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