

Enhancing Optical and Dielectric Properties of Isosorbide-based Polyimides by Introducing Low- M_w PEG

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[Introduction] Isosorbide (ISS), a biobased cellulose derivative, has a rigid and V-shaped alicyclic structure. Polyimides (PIs) containing an ISS skeleton in the main chain can potentially improve their optical and dielectric properties owing to the bent backbone and reduced aggregation formation of PI chains [1]. Meanwhile, fully aromatic PIs cured with low-molecular-weight polyethylene glycol (PEG) exhibited isotropic main chain orientation and denser molecular packing [2]. In this study, a series of semi-alicyclic PIs (ISSD-PIs) and PEG-containing PIs (PEG-PIs) (**Fig. 1a**) were prepared from a diamine having an ISS core (ISSD). The effects of introducing PEG on the optical, thermal, and dielectric properties of ISSD-PIs were investigated in terms of the molecular structures and aggregation states.

[Experimental] Poly (amic acid)s (PAAs) as a precursor to PIs were prepared by adding dianhydrides to *N*-methyl pyrrolidone solution of ISSD under a nitrogen flow. PAA/PEG blend solution was prepared by adding 10 wt% PEG to a PAA solution and stirring for 1 day. These solutions were spin-coated onto a silicon substrate and thermally imidized at 320 °C for 1.5 h to obtain PI thin films.

[Results and Discussion] **Fig. 1b** shows the wavelength dispersions of average refractive indices (n_{av}) of ISSD-PIs. All of the n_{av} values at 1310 nm are smaller than 1.639, which is lower than aromatic PIs such as PMDA-ODA ($n_{av} = 1.652$). This originates from the expanded free volume around the ISS skeleton in ISSD-PIs [1], which also leads to a decrease in polarizability per unit volume. The average dielectric constant (D_k) of ISSD-PIs is 3.10 at 20 GHz, which is lower than that of PMDA-ODA (3.43) (**Fig. 1c**). The bent ISS skeleton effectively reduces intermolecular packing of ISSD-PI chains. In addition, PEG-PIs exhibited lower values of n_{av} and D_k than ISSD-PIs. Most of the PEG in PI films was evaporated during imidization, and the micropores thus generated enlarged intermolecular free volume.

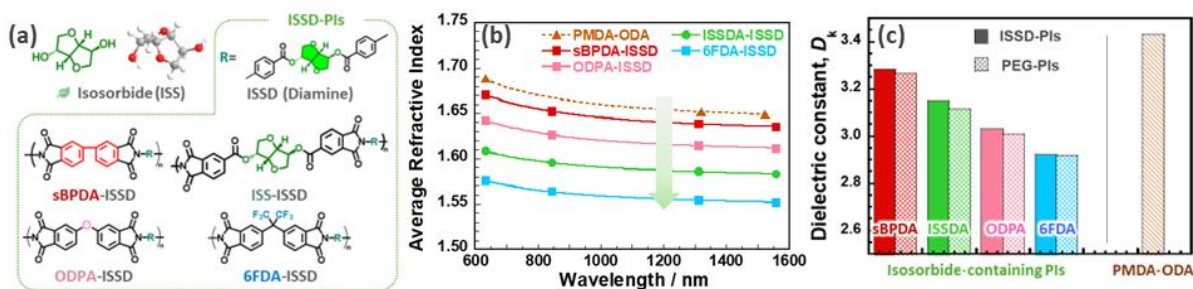


Figure 1 (a) Chemical structures of isosorbide and ISSD-PIs, (b) Wavelength dispersions of average refractive indices (n_{av}) of ISSD-PIs and PMDA-ODA, (c) Dielectric constants (D_k) of ISSD-PIs, PEG-PIs and PMDA-ODA measured at 20 GHz.

Keywords: Polyimide, Biobased polymer, Polyethylene glycol, Low dielectric constant, Low refractive index, Plasticization

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