Dielectric Properties of Various Polyimides in the mmWave Range

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Abstract:

Polyimides (PIs) are essential in 5G/6G technologies, serving as a critical material for high-frequency applications because of their outstanding dielectric properties. In this study, the dielectric constants (D_k) and dissipation factors (D_f) of 11 types of PIs were systematically measured at mmWave frequencies (25–330 GHz) using Fabry–Pérot resonators. As the frequency increased, all the PIs exhibited a continuous decrease in D_k and a consistent increase in D_f. Notably, no distinct peaks were observed over the entire frequency range. The decrease in D_k with frequency gradually approached the square of the refractive index (n^2) in the near-infrared region. Additionally, based on the correlation between the dielectric dispersion and dielectric polarization (P_t), D_k showed a stronger correlation with the electronic polarization (P_e) at the higher frequencies than with the dipolar orientational polarization (P_d). Moreover, in fluorine-containing PIs, D_k declined faster with increasing frequency as the fluorine content (*F%*) increased. In particular, a perfluorinated PI (**8**) [1] showed the lowest D_k and D_f in the whole range. Meanwhile, the increase in D_f showed a negative correlation with the weight fraction of polar groups (*polar%*), and the PIs containing $-CF_3$ groups in the diamine moieties exhibited a similar rapid increase in D_f with frequency, suggesting characteristic absorptions in the terahertz domain.

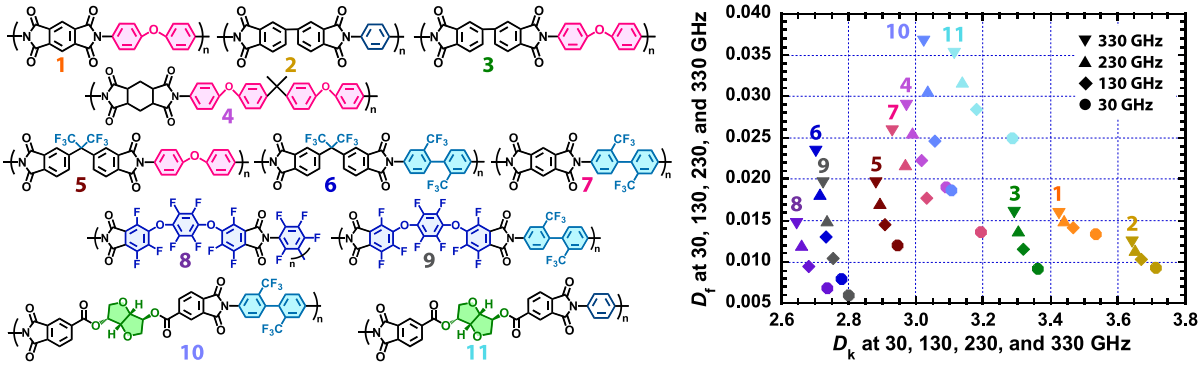

Figure 1. Structures and dielectric properties (D_k and D_f) of PIs in the 25–330 GHz range.

Reference: [1] S. Ando, T. Matsuura, and S. Sasaki, *Macromolecules* **1992**, *25*, 5858–5860.