EVALUATION OF OXYGEN PERMEABILITY IN AMORPHOUS POLYMERS BY PHOSPHORESCENT IMIDE COMPOUNDS AT LOW TEMPERATURES

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Abstract

Organic photoluminescent (PL) materials, especially organic phosphors, are particularly effective for detecting environmental changes. Phosphorescence (PH) quenching occurs via several non-radiative (NR) pathways, such as thermal deactivation and oxygen quenching (OQ), where O_2 directly quenches PH due to the matching of spin multiplicity.[1] The efficiency of OQ depends on the collision probability between O_2 and PH phosphors, which is significantly affected by oxygen diffusion in polymer matrices.[2] The objective of this study is to elucidate the oxygen permeability of amorphous polymers under low-temperature conditions as proved by the PH of an imide compound.

A dual-luminescent imide compound (*s*BP, **Fig. 1**) was dispersed in four polymer matrices at 0.2 wt%: poly(methyl methacrylate) (PMMA), polystyrene (PS), polyether sulfone (PSF), cycloolefin copolymer (COC). Variable temperature PL (VT-PL) spectra were measured from 300 to 100 K under vacuum, N_2, or O_2 atmosphere using a homebuilt spectroscopic system.

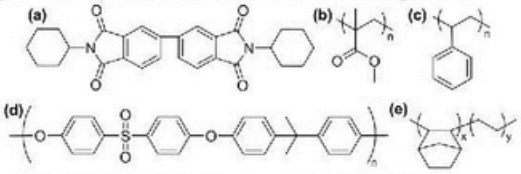

Fig. 1 Chemical structures of (a) *s*BP, (b) PMMA, (c) PS, (d) PSF, and (e) COC.

Fig. 2 shows the temperature dependence of normalized spectral areas of PH estimated from the VT-PL spectra of *s*BP dispersed in polymer matrices. No significant atmospheric dependency was observed in vacuum or N_2, suggesting that N_2 gas does not affect the NR deactivation pathways. The spectra obtained in the presence of O_2 exhibited no PH at around room temperature, while a noticeable increase in PH was observed below 200 K, indicating that the temperature dependence of PH is closely related to the efficiency of OQ. In addition, characteristic temperature ranges of local relaxation (LR) of PMMA,[3] PS,[4] PSF,[5] and COC[6] are drawn by orange, green, and blue lines, corresponding to β-, γ-, and δ-relaxations, respectively. A significant correlation was observed between the γ-relaxation and the increase in PH of *s*BP, which indicates that LR plays a crucial role in oxygen diffusion at low temperatures. Furthermore, by utilizing the relationship between the oxygen diffusion and LR motion, variation of PH of phosphors in the VT-PL spectra can be used as an analytical tool for characterizing the LR phenomena of amorphous polymers under low temperature.

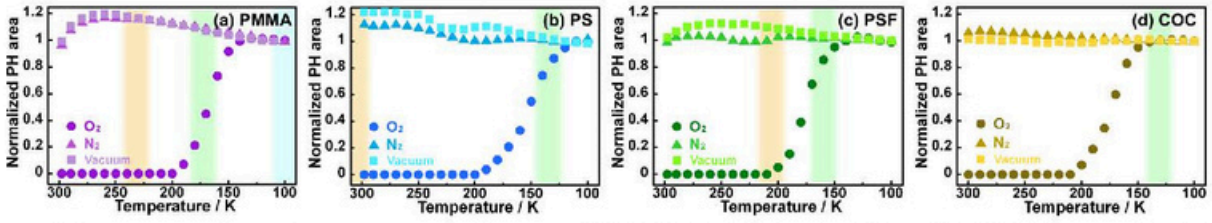

Fig. 2 Temperature-dependent normalized PH area of (a) PMMA, (b) PS, (c) PSF, and (d) COC films under O_2, N_2, and vacuum from 300 to 100 K with the characterisitc β-, γ-, and δ-relaxation temperatures.

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