Understanding Photo-Oxidation in Ternary Organic Solar Cells

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Abstract

In recent years, organic solar cells (OSCs) have made significant progress achieving power conversion efficiencies close to 20% thanks to novel organic semiconductors [1]. However, beyond achieving high energy conversion efficiency, device stability remains a critical challenge for the large-scale commercialization of OSCs. In this context, a better understanding of the role of organic photovoltaic materials is essential, particularly for novel non-fullerene acceptors (NFAs) and their blends. These materials which constitute today the photoactive layer of OSCs play a crucial role in light absorption, charges generation, charges transport and overall device stability [2]. In this study, we focus on the photo-oxidation of the ternary blend PTQ10:Y12:$PC_{71}BM$, identified as one of the most promising candidates for industrial application [3]. The polymeric donor (PTQ10), the two acceptors (Y12, $PC_{71}BM$) and blends (PTQ10:Y12, PTQ10:$PC_{71}BM$, PTQ10:Y12:$PC_{71}BM$), deposited as thin films were analysed by UV-vis absorption spectroscopy. These films were then exposed for 100 hours in a solar chamber in ambient air (1 sun, 50°C), with spectral absorption measurements acquired periodically. Figure 1 shows the main absorption spectra obtained. The initial photo-oxidation results revealed unexpected behaviour. All three mixtures degraded faster than both individual materials. It was also observed that the addition of a small amount of fullerene slowed down the degradation of the mixture, acting as a radical trap. In addition, the initial ageing tests on the OSCs showed a 40% reduction in performance for the binary mixtures, compared to only 24% for the ternary active layer. Using complementary analysis with infrared spectroscopy measurements, this communication will elucidate the photochemical degradation pathways of electron acceptor and donor materials and help establish a correlation with the degradation of solar cells.

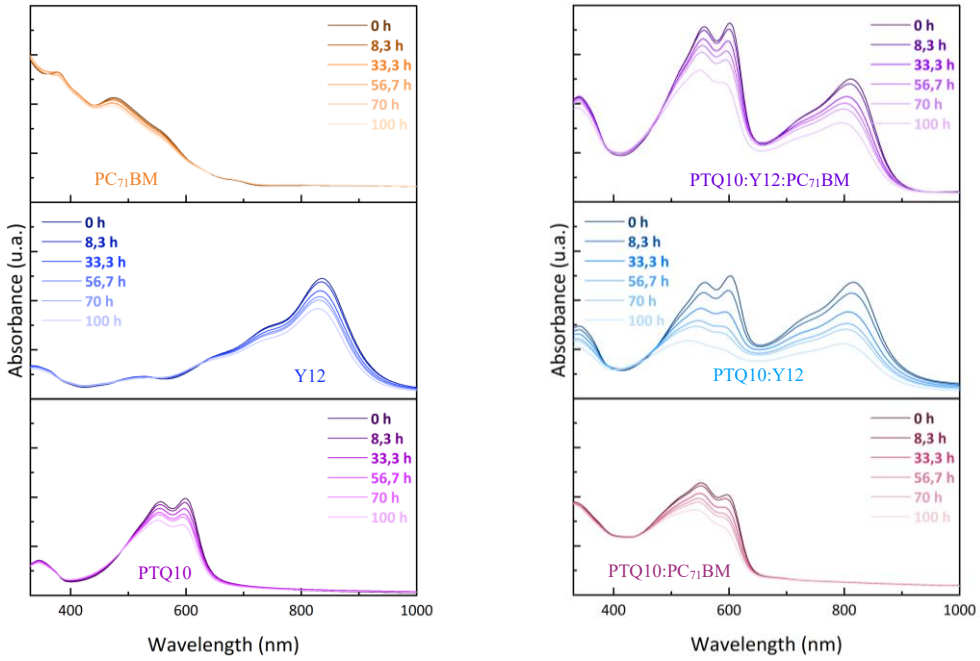

Fig. 1 – UV-vis spectra of photo-oxidized PTQ10, Y12, $PC_{71}BM$ and blends films at different exposure times in a 1-sun chamber at 50°C in ambient air.

References

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