

Exciton diffusion Length and morphology in TFB/ fullerene blends

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Organic materials present a promising direction for potentially cheaper solar cells and to allow the construction of mechanically flexible cells. Although recent bulk-heterojunction devices have given really encouraging performances, reaching efficiencies around 8% [1], more work is needed in order to be able to understand the energy losses within these devices, and so increase their efficiency.

As many recent studies have outlined, the excited state dynamics and the processes occurring at the donor-acceptor (D/A) interface [2-4] are critical to the performance of solar cells. The efficiency of charge separation at the D/A interface is crucial to the photocurrent generation in organic solar cells, and a complete understanding of this process is essential in order to be able to maximize the power generation efficiency.

In fact in a polymer-based photovoltaic device light absorption by the polymer usually results predominantly in formation of excitons that diffuse through the polymer layer to reach the interface with the electron acceptor, there they can dissociate into an electrostatically bound charge pair. The pair then separates into a positive polaron in the donor and a negative polaron in the acceptor, which are then transported to the respective electrodes. [5,6].

Here we present a recent work performed using a fluorescence up-conversion technique to systematically study the effect of using three different types of acceptors as [6,6]-phenyl-C61 butyric acid methyl ester (mono-PCBM) and its multi-adduct analogues bis-PCBM and tris-PCBM on the emission quenching and morphology in [9,9-dioctylfluorene-co-N-(4-butylphenyl)-diphenylamine] (TFB) blends. All molecular structures are reported in figure 1.

The innovative experimental set up allows us to probe the ultrafast (<1 ps) excited state dynamics of photo-generated species with a high resolution (<200 fs). This means that we are able to follow the formation of the excited state in the polymer and the charge separation process at the interface with the acceptor.

The ultrafast fluorescence quenching for the three different acceptors has been correlated with the different blends morphologies. Moreover a new exciton dynamic model has been developed to reproduce the experimental quenching rates and in order to evaluate their diffusion length, for the first time from the ultrafast fluorescence measurements. We also present independent measurements of diffusion length to support our evaluation.

When coupled with other standard spectroscopic techniques the exciton recombination dynamics of such systems allow quantitative design rules to be formalized which is essential for the continued development of highly efficient organic bulk hetero-junction PV devices.

References

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Figures

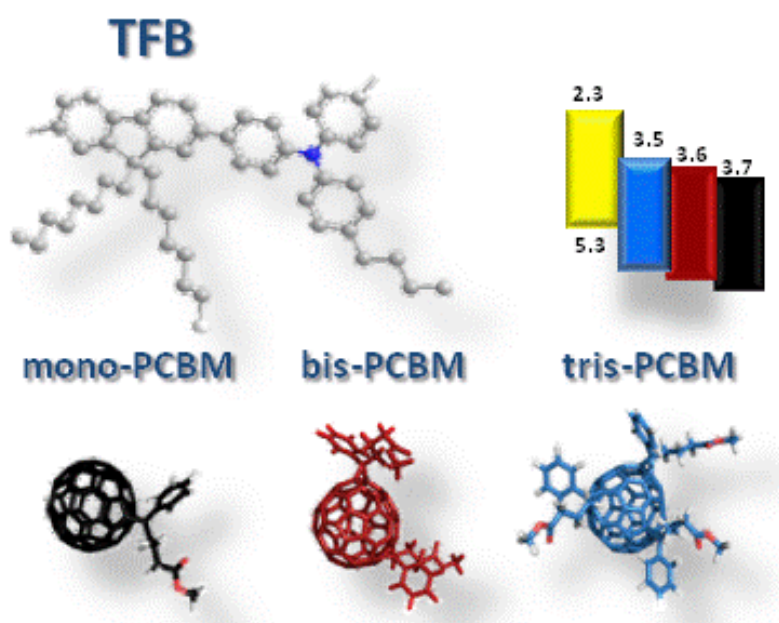


Figure 1:
TFB molecular structure and energy levels are reported in the upper part. MonoPCBM, bisPCBM, and trisPCBM molecular structures are in the lower part.