Optoelectronic Measurements of Organic Solar Cell Materials and Devices

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The Organic Semiconductor Centre provides state of the art facilities for advanced measurements on organic semiconductors. Measurements on both materials and devices are made, enabling the key factors determining their operation to be identified and the next generation of organic semiconductors to be developed. An interdisciplinary approach involving physicists and chemists is used, and materials studied include conjugated polymers, dendrimers and quantum dots.

A wide range of measurements are used, and combined to understand the operation of organic solar cells. The photophysical characterization of materials involves techniques such as photoluminescence quantum yield and time-resolved luminescence to study the extent of quenching due to charge separation. Light-induced electron spin resonance is used to study the charge separation process, and exciton diffusion measurements are also made. Charge transport measurements are made by time-of-flight mobility measurements, whilst confocal microscopy is used for photocurrent mapping.

The exciton diffusion length is an important factor in determining the efficiency of charge separation and the feasible device geometries. One way of looking at the limited efficiency of organic solar cells is that it results from the exciton diffusion length being much shorter than the absorption length. We have shown that time-resolved techniques are more robust and give more information about exciton transport than steady state techniques. We have developed two methods for exciton diffusion measurements: one is diffusion to a quencher, and the other is the use of exciton-exciton annihilation.

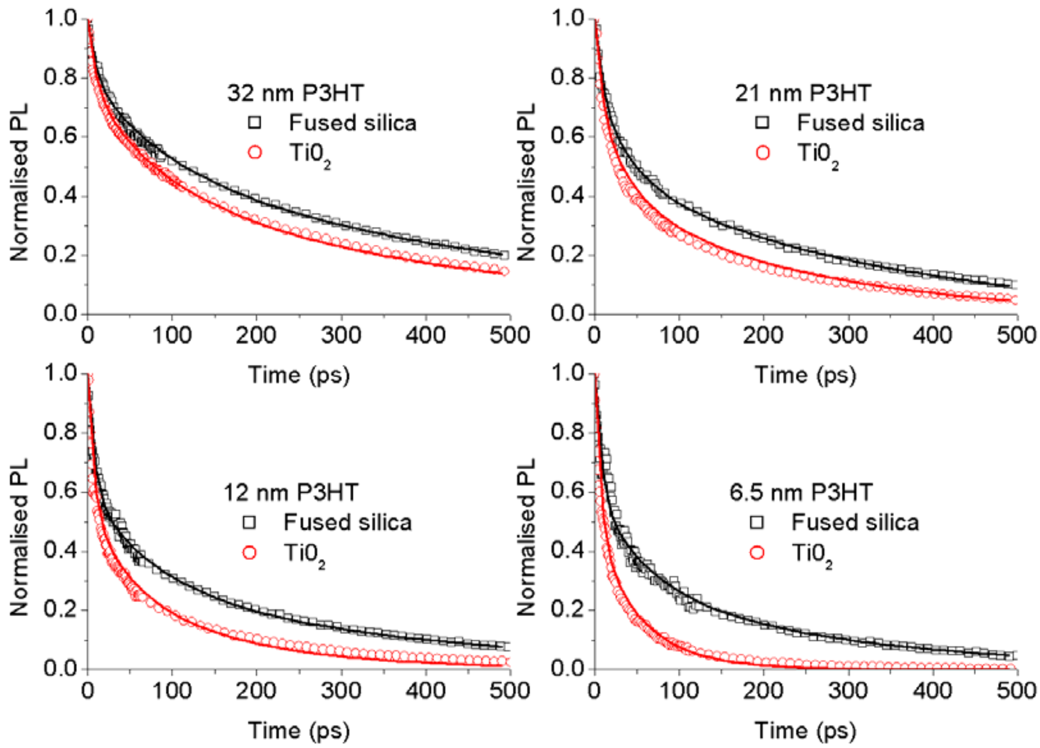

Figure 1: Time-resolved luminescence of P3HT on a quenching (TiO_2) and non-quenching (fused silica) substrate. All four decay curves on TiO_2 are fitted by a one dimensional diffusion model with only one fitting parameter for all the graphs, a diffusion coefficient of $1.8\text{x}10^{-3}$ cm^2s^{-1}, corresponding to a one-dimensional diffusion length of 8.5 nm for a 400 ps exciton lifetime.