

Single Molecule/Particle Spectroscopic Studies of Donor-Acceptor Systems for Organic Photovoltaics

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As of 2008, Si-based photovoltaics held 91% of the solar energy market.¹ Solar energy has yet to achieve an appreciable amount of use, due primarily to the high costs associated with the production of these Si-based photovoltaic devices. Consequently, photovoltaic devices made from organic materials (OPV's) have been investigated as a possible alternative due to the comparatively low cost of organic materials and the ease with which these cells can be fabricated. Free charge carriers are generated in organic solar cells at the interface of an electron-donating (D) and an electron-accepting (A) material due to high interfacial electric fields and differences in chemical potential.

Since there is a large number of factors that affect the performance of an OPV device, the optimization of one device parameter at a time is a rather daunting task if using overall efficiency as a metric. Resultantly, various analytical techniques have been employed to evaluate the potential of a system before attempting to fabricate and optimize a real device. Here, we present single molecule/particle spectroscopic (SMS/SPS) studies of CdSe/ZnS core/shell quantum dots and poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene] (MEH-PPV) molecules on TiO₂, which both represent actual OPV systems of interest.

Both CdSe/ZnS core/shell QDs and single MEH-PPV molecules exhibited typical fluorescence "blinking" behavior which sensitive to the substrate used; on TiO₂ both fluorophores exhibited shifts to shorter "on" state durations and longer "off" state durations. These distributions were found to exhibit power law behavior, where the probability density, $P(t)$, obeys $P(t) \propto t^{-m}$. Comparison of these obtained m factors reinforce these observations in a more quantitative manner. It is our hypothesis that the substrate sensitivity is due to the effects of electron transfer from the excited states of the individual fluorophores to the conduction band (CB) or surface defect states of TiO₂.