SPECTROSCOPIC DETECTION OF CHARGE CARRIERS AND EXCITONS IN ORGANICS, GARRY RUMBLES

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I will report on studies of photo-induced electron transfer between conjugated polymers blended with fullerenes, as well as some new studies of donor-acceptor bi-layer systems of vapor-deposited molecular thin films, and solution-deposited conjugated polymers on colloidal quantum dot arrays. Using flash photolysis, transient microwave conductivity (fp-TRMC) studies of exciton transfer and dissociation at the interfaces formed between in these systems will be reported. The technique is proving to be an invaluable tool, providing us with the ability to probe the yield and kinetics of the formation of mobile carriers created in nanoscale donor-acceptor networks.

Our recent work on the investigation of blends of fullerenes in conjugated polymers, demonstrates that we are able to detect the formation of fullerene clusters through the presence of a microwave absorption signal that is a signature for mobile electrons and that is distinct from the mobile holes in the donor polymer. A result from one of our modeling efforts is shown in Figure 1 for a 50:50 blend of a fullerene (PCBM) in poly(3-hexylthiophene). This study has enabled us to understand the kinetics of the excitons and charge carriers in bulk heterojunctions, which is the foundation of the prototypical solar cell created from these blends. We can now demonstrate that the ability to detect fullerene clusters of this type provides us with an invaluable method for probing nanoscale morphologies in these complex blends. This effect will be reported through the studies of a range of new conjugated polymers and substituted fullerenes.

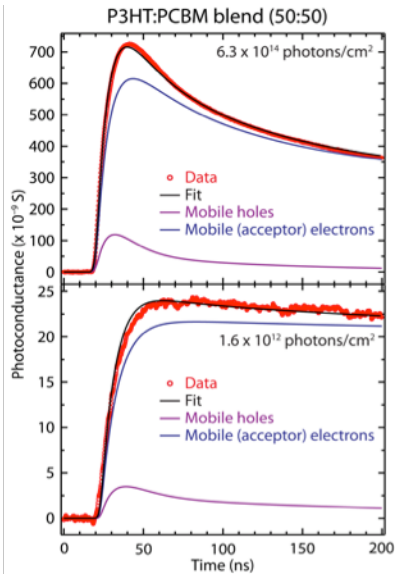

Figure 1 – TRMC transients at low and high laser fluences on a 50:50 blend of PCBM in P3HT. The modeling shows that the absorption signal is dominated by electrons in PCBM clusters.

The complex morphologies exhibited by the blends, although of technological value, make the fundamental investigation of the photophysics that occurs at the interface a difficult one to study. To overcome this issue we are constructing planar heterojunctions using vapor-deposited molecules, such as phthalocyanines and perylenes, onto C_{60}, and not its soluble derivative, PCBM, often used in blends. Such systems, studied by fp-TRMC, enable us to understand the role of both exciton dissociation, and the transfer of the exciton energy to the fullerene, followed by back transfer the hole. By attaching electrodes to the multi-layer constructs, we are able to extract the photo-generated carriers, and compare the yields with those measured by microwave absorption.

While the presentation will focus on the use of fp-TRMC, I will introduce a variety of other complementary approaches to detecting charge carriers, such as transient absorption and teraherz spectroscopies.