CAPTURING THE SUN'S POWER WITH PLASTIC SOLAR CELLS

J. M. Hodgkiss Research Group

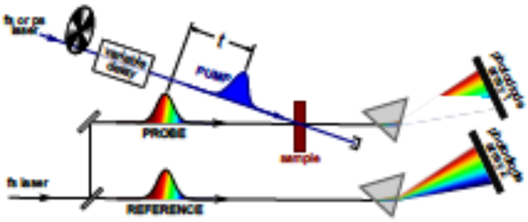
Solar cells made from special types of plastic could hold the key to clean renewable energy. Electronically active plastics can be printed, which is a very practical way of making large area solar cells. Yet, the power conversion efficiency of plastic solar cells must be improved. We use fast laser pulses to understand how solar energy is converted to electricity and guide the design of better plastic solar cells.

Most of the absorbed light does not generate electrical current - so what happens to it?

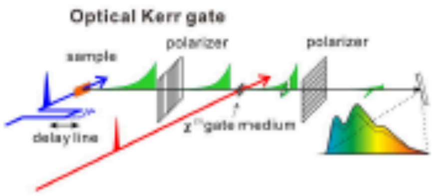
The absorption of light triggers a cascade of electronic processes in conducting polymers. Processes that produce electrical current compete with unwanted processes that waste absorbed energy. Understanding how to turn off the unwanted processes is a scientific challenge because they happen extremely quickly - sometimes as fast as a few femtoseconds. One femtosecond is a *millionth of a billionth* of a second. We have developed tools to see on this time scale.

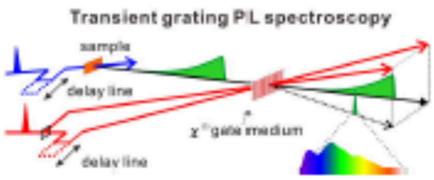
Broadband ultrafast optical techniques

We use ultrashort laser pulses to take snapshots of the evolution of events after the light trigger.



Transient absorption spectroscopy - This is like a strobe camera and provides the electronic spectra of species as a function of time.





Time-resolved photoluminescence spectroscopy - This is a really quick shutter and provides a picture of the relaxation of electronically excited species. Transient grating PL is a state-of-the-art method developed in our lab providing broadband high sensitivity, and the ability to probe over large timescales.

References

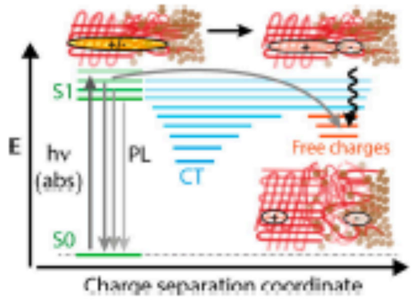
(1) Chen, K.; Barker, A. J.; Reish, M. E.; Gordon, K. C.; Hodgkiss, J. M. J. Am. Chem. Soc. **2013**, 135, 18502–18512.

(2) Chen, K.; Gallaher, J. K.; Barker, A. J.; Hodgkiss, J. M. J. Phys. Chem. Lett. **2014**, 1732–1737.

(3) Barker, A. J.; Chen, K.; Hodgkiss, J. M. J. Am. Chem. Soc. **2014**.

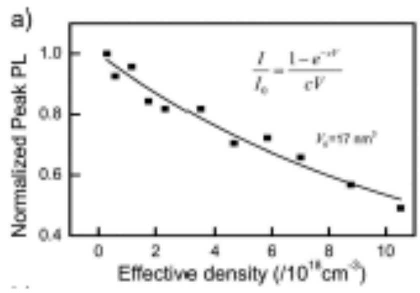
Recent studies suggest the current model of OPV device operation is too simplistic

Upon photoexcitation of a conjugated polymer, an electron-hole pair is formed which is bound by coulombic attraction. In order to generate free charges, this binding energy must be overcome, typically through the use of a donor/acceptor interface. However, this model fails to account for ultrafast charge generation, and how charges can form without a donor/acecptor interface. In order to expalin such results, new models have been proposed.



How do we quantify the initial delocalised state?

We have used our PL techniques to probe the initial volume of an excited state. This was achieved through studying the quenching of initial excitations and determined the large volume could explain the unexpected formation of free charges within a few femtoseconds.



Probing the distance between electron and hole

We are able to investigate the separation between the electron and hole. This is achieved by freezing the charges (at -263 °C) which limits the recombination processes and provides distance dependent coodrinate of charge pairs. Such results are in a good position to test the validity of current (and future) models of free charge generation.