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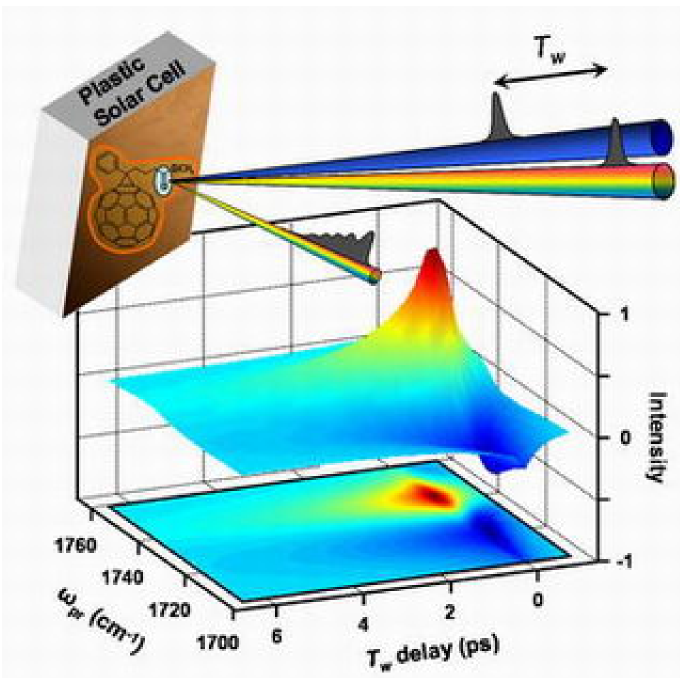
New Technique Studies How Plastic Solar Cells Turn Sunlight into Electricity

December 11 2006



A plot of the wavelength of emitted infrared light vs. the time delay of the light emission provides information about the path of an electron within a plastic solar cell. This information about how the cell makes an electric current from light will lead to improvements in the efficiency and usable lifetime of solar cells. Credit: Penn State

A new analytical technique that uses infrared spectroscopy to study light-sensitive organic materials could lead to the development of cheaper, more efficient solar cells. Using infrared (IR) spectroscopy to study the vibrations of atoms within the material, the technique provides information about the movement of electrons within a film of carbon-based materials.

Obtaining this information is a critical step in the development of a new class of solar cells, which promise significant savings in production costs compared to conventional silicon-based cells. The new analytical technique, published as the cover story in this week's issue of the *Journal of Physical Chemistry B*, was developed by a team led by Penn State University researcher John B. Asbury, assistant professor of chemistry.

Organic photovoltaic devices (OPV) have become important because they are much less expensive to produce than silicon-based solar cells. The material consists of a film made of two different types of chemicals: a polymer that releases an electron when it is struck by a photon of light and a large molecule that accepts the freed electrons, which is based on the soccer-ball-shaped "buckminsterfullerene" carbon molecules popularly known as "buckyballs."

Because the electrical interactions needed to produce an electric current occur at the interfaces of the two components of this polymer blend, materials scientists need to understand the arrangement of molecules in the film. Asbury's new analytical technique provides a closer look at this arrangement than the techniques that traditionally have been used.

Previous studies, using atomic-force microscopy, supply general information about the packing of the molecules, but they provide very limited information about the interfaces where the molecules actually come together. IR spectroscopy, on the other hand, provides a more detailed picture of the interface by tracing the exchange of electrons between two molecules of the film.

"The problems with OPVs today are that they are not efficient enough and they tend to stop working over time," says Asbury. In order to develop a useful electric current, the flow between the two components must be optimized. "To improve performance, we need to understand what happens at the molecular level when light is converted to electrons," Asbury explains.

When the film is exposed to light, each photon excites an electron in the polymer. If an interface between the polymer molecule and the functionalized buckminsterfullerene exists, a current can be produced. However, in the materials developed to date, many of the electrons appear to become sidetracked. Asbury exposes the film to light using ultrashort laser pulses, which causes photons of light to be converted to electrons across the entire surface at the same time. Two-dimensional IR spectroscopy is used to monitor the vibration of the molecules within the film.

"The vibrations of the molecules are strongly affected by the presence or absence of electrons," says Asbury. "We use these vibrations as a probe to track the movement of electrons. By varying the structures of the materials, we expect to identify the side paths that reduce efficiency and ultimately to use that information to guide material design." The ultimate goal is a solar cell that is sufficiently inexpensive and efficient that it can be used on a rooftop to provide the electrical energy needed in a building.

In addition to Asbury, the Penn State research team includes graduate students Larry W. Barbour and Maureen Hegadorn.

Source: Penn State