Catching some rays: Organic solar cells make a leap forward

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Improvements in the efficiencies of organic solar cells will eventually make them competitive with traditional silicon-based solar cells and, hopefully, ultimately with fossil fuels.

(Phys.org) -- Drawn together by the force of nature, but pulled apart by the force of man – it sounds like the setting for a love story, but it is also a basic description of how scientists have begun to make more efficient organic solar cells.

At the atomic level, organic solar cells function like the feuding families in Romeo and Juliet. There's a strong natural attraction between the positive and negative charges that a photon generates after it strikes the cell, but in order to capture the energy, these charges need to be kept separate.

When these charges are still bound together, they are known to scientists as an exciton. “The real question that this work tries to answer is how to design a material that will make splitting the exciton require less energy,” said senior chemist Lin Chen of the U.S. Department of Energy’s (DOE) Argonne National Laboratory.

Excitons can be thought of as a sort of “quasiparticle,” Chen said, because they exhibit certain unique behaviors. When the two charged regions of the exciton – the electron and a region known as a “hole” – are close together, they are difficult to pry apart.

“The closer the hole and the electron regions are inside an exciton, the more likely they are to recombine without generating electricity,” Chen said.

When energy is added to the system, however, the charges begin to separate, rendering the electrons and holes completely free and eventually allowing for the possibility of generating current and extracting electricity

“The closer the hole and the electron regions are inside an exciton, the more likely they are to recombine without generating electricity,” Chen said. “But if they are already ‘pre-separated,’ or polarized, the more likely they are to escape from this potential trap and become effective charge carriers.”

In the new experiment, Chen and her colleagues examined how four different molecules in the polymer layer in the middle of a solar cell generated different exciton dynamics. They discovered that more heavily polarized excitons yielded more efficient polymer-based solar cells.

“If the conventional exciton, right after it is generated, contains the hole and electron in almost the same location, these new materials are generating an exciton that is much more polarized at the beginning," Chen said. Currently, the collaborative team is exploring new materials for high-efficiency organic solar cells based on these findings.

Organic solar cells still have a ways to go to get close to the efficiency of their inorganic, silicon-based competitors, but they remain much more attractive from a cost perspective. Further research into the electronic dynamics of organic photovoltaics is essential to improving their efficiency and thus making solar power cost-competitive with conventional energy sources, Chen said.

The work has been recently published in the Journal of the American Chemical Society.

Chen's work on organic solar cells represents one of several avenues of solar energy research currently underway as part of the Argonne-Northwestern Solar Energy Research Center (ANSER), a collaborative enterprise between Argonne and Northwestern University that seeks to investigate a number of possible improvements to the current generation of photovoltaic devices. ANSER is one of 46 Energy Frontier Research Centers established in 2009 by DOE's Office of Science at universities, national laboratories, and other institutions across the nation to advance basic research on energy.

Provided by Argonne National Laboratory

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