Organic solar cells as an alternative to conventional solar cells

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Credit: Angela Roma from Pexels

Organic solar cells could be an inexpensive and versatile alternative to inorganic solar cells. However, their low efficiencies and limited lifetimes currently render them impractical for commercial use.

As part of an effort to enable performance improvements and bring these solar cells closer to practical adoption, researchers at the Argonne-Northwestern Solar Energy Research Center (ANSER), a collaboration between Northwestern University and the U.S. Department of Energy's (DOE) Argonne National Laboratory, have gotten a better look at how the molecular structures of organic solar cells form.

Using Argonne's Advanced Photon Source (APS), a DOE Office of Science User Facility, researchers analyzed how organic solar cells' crystal structures develop as they are produced under different conditions. With the APS, researchers learned how certain additives affect the microstructures obtained, providing new insights that can improve the cells' efficiency.

The scientists focused on the photoactive layer of the cell, built from thin films that absorb energy from sunlight and then convert that energy into electric current. The researchers produced the films via spin coating, a widely used process for film fabrication in research labs.

In spin coating, the scientists dropped the material, dissolved in a solvent, on a spinning surface. This caused it to spread into a thin, uniform sheet. They mounted the spin-coater at an X-ray beamline at the APS and watched the film's crystal structure evolve in real time.

To view how the crystallites formed in a complete and detailed way, the researchers took advantage of a specific in-situ method, called grazing incidence wide-angle X-ray scattering (GIWAXS), to collect the X-ray diffraction data.

"It was the stability and reproducibility of this specific spin-coating setup that allowed this study to happen," said Northwestern graduate student Eric Manley, first author of the study published Oct. 9 in *Advanced Materials*.

The study's most significant discovery, made possible by the new experimental setup, was how certain additives can significantly affect both the time it takes for the film's structure to stop changing and the intermediate structures the film adopts during evolution. Even after the solvent dissolves, the structures can continue to change for anywhere from seconds to hours, depending on what additives are present. The films produced more slowly with additives generally perform better than the more rapidly formed films.

"Producers of solar cells will often go to the next step in production quickly after spin coating, which has the potential to lock the morphology while the structure is still forming. This can significantly affect the cell's performance, positively and negatively," said Manley. "We discovered that we needed to report the time between fabrication steps to control conditions to reproduce optimized results."

The researchers plan to study more complex structures and examine how different choices can optimize performance. "We hope this will pave the way to making these cells more viable for everyday applications," said Joseph Strzalka, physicist and member of the Time-Resolved Research group within Argonne's X-Ray Sciences division.

More information: Eric F. Manley et al. In Situ GIWAXS Analysis of Solvent and Additive Effects on PTB7 Thin Film Microstructure Evolution during Spin Coating, *Advanced Materials* (2017). DOI: 10.1002/adma.201703933

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