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A single polymer can be used to fabricate both thin-film transistors and solar cells

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Polymers are the material of choice for making thin-film transistors and solar cells. They are also potentially suitable for manufacture using economical, high-throughput techniques, such as roll-to-roll and inkjet printing processes. However, transistors and solar cells have traditionally used different kinds of polymers, and this can severely complicate the fabrication process. Zhi-Kuan Chen at the A*STAR Institute of Materials Research and Engineering and co-workers have now developed a versatile polymer that is suitable for both kinds of devices.

Polymers with high-charge mobilities are ideal to use in the manufacture of transistors. However, these materials are susceptible to having large energy bandgaps, which prevent them from absorbing portions of the solar spectrum. Such materials could severely hamper the energy conversion efficiency if made into solar cells.

The researchers focused on a class of polymers called polythiophenes, derivatives of which have been measured to have high hole (or positive charge) mobilities. However, polythiophenes also have a large energy bandgap, which prevents them from absorbing light with red-orange wavelengths longer than 650 nm, thus reducing solar cell performance.

Previous work by other researchers has shown that this bandgap can be lowered by making modifications to the backbone of the polythiophene chain with groups of atoms that are able to accept charge. Even so, the power conversion efficiency of the resulting solar cells was below 2.3%, less than half of the best-performing polymer cells.

Chen and co-workers followed in the steps of their predecessors by modifying a polythiophene polymer. The result was a novel polymer called POD2T-DTBT that was measured to have a relatively low bandgap which resulted in an optical absorption range that extended to red-orange wavelengths of 780 nm, thus taking in more of the solar spectrum. At the same time, the hole mobility of the polymer was measured to be 0.20 cm2 per volt per second, comparable to unmodified polythiophene. This allowed for fabrication of high-performance transistors and solar cells. In particular, by combining POD2T-DTBT with the ester PC71BM, the research team constructed a solar cell with a power conversion efficiency of 6.26%, comparable to the efficiency of the best polymer cells to date.

This strong performance was drawn in part from the morphology of the thin films that resulted from the POD2T-DTBT / PC71BM mixture. Electron microscopy of the films showed that the two components were intimately mixed together: the long white fibers, which are 20–25 nm in width, correspond to the polymer, and the darker domains correspond to the ester (see image). The high-charge mobility of the POD2T-DTBT polymer itself also boosted performance.

More information: Ong, K.-H. et al. A versatile low bandgap polymer for air-stable, high-mobility field-effect transistors and efficient polymer solar cells. *Advanced Materials* 23, 1409–1413 (2011). DOI: 10.1002/adma.201003903

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