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Photovoltaics

Semiconductor sandwich solution for solar cells

Improved chemical process offers simpler route to promising organic photovoltaics

An improved technique for making flexible organic solar cells with higher efficiencies, using a sandwiched configuration that is more cost-effective to manufacture, could help to boost their application, according to research from Japan's NAIST.

Organic photovoltaic (OPV) devices, which rely on carbon-based molecules to harvest light, are lightweight and perform well in relatively dim conditions, but currently have lower efficiencies than conventional solar cells. "Owing to these characteristics, OPVs are likely to find applications first as indoor or portable devices, rather than in large-scale power plants," says NAIST's Mitsuharu Suzuki.

He and his colleagues have developed a way to make OPVs that contain three layers of semiconducting molecules. One of the outer layers is an n-type semiconductor, which has a surfeit of electrons; the other is p-type, which has a deficit of electrons. The filling inside this semiconductor sandwich is an 'inter layer' made from a mixture of p- and n-type materials. When light hits these cells, it frees electrical charge from the inter layer so that electrons — and the holes they leave behind — can flow to the outer layers, thereby generating a current.

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A technique for fabricating flexible solar cells with three layers of semiconductor molecules offers more efficient organic photovoltaics.

> **"Our proof-of-concept system will be further elaborated in the very near future, so that much higher efficiencies can be achieved."**

Building these cells can be troublesome and expensive, not least because the crucial organic molecules often dissolve into neighbouring layers during production. Suzuki's team solved this problem by forming some of the layers from precursor molecules containing chemical groups called ketones.

When the researchers exposed these precursors to a bright light, it triggered a reaction that stripped away the ketones and generated an insoluble semiconductor layer. After testing a range of different semiconductor combinations, the team made a cell with an efficiency of 2.89 per cent — among the highest recorded for this category of device[1].

Using this approach meant that the researchers could build their cells using solutions of the semiconductor molecules, a process that is more cost-effective than alternative vacuum evaporation. The strategy avoids extensive heat treatments, so that the semiconductors can be coated directly onto thin plastic films. And tailoring the layers in this way also allowed the researchers to use materials that have ideal properties for each different layer of the cell.

Suzuki notes that access to high-quality instruments and well-trained operational staff at NAIST's facilities in Ikoma, Japan, was also crucial to the success of their research.

His team of researchers are now tweaking their molecules to absorb a greater quantity of light, and to carry current more effectively. "Our proof-of-concept system will be further elaborated in the very near future, so that much higher efficiencies can be achieved," says Suzuki.

Reference

1. Yamaguchi, Y., Suzuki, M., Motoyama, T., Sugii, S., Katagiri, C. *et al.* Photoprecursor approach as an effective means for preparing multilayer organic semiconducting thin films by solution processes. *Scientific Reports* **4**, 7151 (2014).

More information about the group's research can be found at the Laboratory for Photofunctional Organic Chemistry webpage:
http://mswebs.naist.jp/LABs/env_photo_greenmat/en/Yamada_Group/HOME.html