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Organic Solar Cells are Flexing their Efficiency

Editorial submission by Jonas N. Søndergaard @thefairjournal

Original title
Single-Junction Organic Solar Cell with over 15% Efficiency Using Fused-Ring Acceptor with Electron-Deficient Core.[1]

Introduction
A solar cell is a device that takes energy from the sun and converts it into electricity that can be used to power any kind of modern electronic device. You may have seen the principle before if you have ever had a small pocket calculator.

There are in general two types of solar cells: inorganic and organic solar cells. The solar cell that is currently commercially produced is of the inorganic type and is nowadays mainly produced using silicon. These are large flat devices, which are usually attached to the roof of a house or are free-standing in solar cell farms. Because of their large flat and heavy structure, they require a well-defined surface area limiting where they can be placed. In contrast to this, organic solar cells are flexible, lightweight, non-toxic, and large organic solar cells panels can be produced at low cost. They can also be produced in many different colors and can even be semi-transparent so that they blend into the environment and you might not even notice them. This has led to a great interest in using organic solar cells in the microelectronic industry for mobile and biomedical devices, as well as in the building industry to cover whole surface of buildings, cars, busses etc. Due to their semi-transparency they can even be used to cover windows.

Unfortunately, we are not ready to use organic solar cells everywhere yet, mainly due to organic solar cells having a much lower energy-conversion efficiency than silicon-based solar cells. In 2018 the best inorganic solar cells had an efficiency of 26.1%, while the best organic solar cell only had an efficiency of 12.3%.[2]

The part of an organic solar cell that can collect the energy from the sun – the photosensitive layer – is made of two types of organic materials (electron donor and electron acceptor materials). For a long time, the highest efficiency in organic solar cells was achieved by using an acceptor molecule called fullerene. Although different versions of the fullerene acceptor were designed and produced, the fixed ring structure did not allow too much fine-tuning of its properties. But then came the non-fullerene acceptor called ITIC with easier tunability of its photoelectric properties and a longer lifespan than fullerene-acceptors. Although the efficiency was still lagging behind the fullerene acceptors, ITIC has been the superstar of organic solar cell acceptor molecules since 2015. But things may soon change.

Findings
The authors of "Single-Junction Organic Solar Cell with over 15% Efficiency Using Fused-Ring Acceptor with Electron-Deficient Core"[1] designed and synthesized a new type of acceptor molecule. The molecule named Y6 worked very well and broke the efficiency record of organic solar cells by giving a max efficiency of 15.7%. In contrast to its predecessors, the Y6 acceptor has an electron-deficient-core structure, which fits a commercial donor polymer PM6 for complementary absorption in the solar spectrum. Because of the acceptor and the donor mixes extremely well, Y6-based devices

can achieve a low energy loss and a high photocurrent at the same time, resulting in this record-breaking result.

Conclusions

Although the power conversion efficiencies of Y6-based organic solar cells are still inferior to their inorganic counterparts, it has improved several fundamental shortcomings in the field of organic photovoltaics. Since scientists discovered that molecules other than fullerene could work efficiently in organic solar cells, much of the focus has been placed on modifying the structures of the molecule that broke the fullerene paradigm. The discovery of Y6 is special as it has broken the paradigm again and has demonstrated that a wider range of molecules can be used in organic solar cells. These results may thus pave the way for organic solar cells that would be efficient enough to use in everyday life. It will however still take a while before organic solar cells will become as efficient as silicon-based solar cells, but this work is at least a step in the right direction. Since the publication in 2019 the community behind the Y6 molecule have further tweaked the system, and has recently achieved another record breaking efficiency of 17.4%[3], demonstrating that we are quickly getting closer to an efficiency able to compete with inorganic solar cells.

Article info

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References

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3. Green, M. A. *et al.* Solar cell efficiency tables (Version 55). *Prog. Photovoltaics Res. Appl.* **28**, 3–15 (2020).