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Editors' choice collection on organic photovoltaics: back in the game

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The ever-increasing energy consumption of modern society and the urgency to reduce dependence on fossil fuels, have motivated significant research effort to develop third generation solar cells in recent years. The emergence and stunning rise of hybrid perovskite solar cells has revolutionised the prospects of photovoltaics, but despite maturing at an exceptional rate, their potentially negative environmental impact and relatively low stability are still limiting their infiltration of the market. In parallel, technologies integrating organic materials as the photoactive layers – the development of which was initiated in the early 1990s – have continuously progressed, and today dye-sensitized solar cells and organic photovoltaics (OPVs) reach power conversion efficiencies of up to 14% and 18%, respectively, in leading laboratories. The recent development of semi-transparent, large area devices and the demonstration of their acceptable stability have opened the path to application in building-integrated photovoltaics (BIPV).

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Chemists and materials scientists, through the synthesis of a plethora of novel organic semiconductors, have enabled the development of more efficient and robust organic solar cells, and have contributed to the decrease of their environmental impact and manufacturing costs. Until recently, fullerene-based materials, such as phenyl-C_{61}-butyric acid methyl ester ($PC_{61}BM$) or its C_{70} analogue ($PC_{71}BM$) were ubiquitously employed as electron-accepting semiconductors and played a critical role in the development of bulk-heterojunction solar cells. With fullerenes, the electrical performance of organic photovoltaic devices has progressed continuously over two decades, owing to the development of a large number of electron-donating π-conjugated polymers and small molecules that exhibit improved optical, electronic and transport properties. Despite this impressive progress, the drawbacks of fullerenes led to only a limited market application of organic solar cells. These drawbacks include their low absorption in the visible light range, the poor variability of their optoelectronic properties, rather limited solubility, and the low stability of the blends made up from fullerenes in combination with polymers or small molecules. These and other reasons have led to a stagnation in the improvement of organic solar cell performance and a decrease in interest of their large-scale integration into industrial applications.

In recent years, the field of organic photovoltaics has experienced a renaissance. The emergence of several classes of electron-accepting materials to replace fullerenes – the so-called non-fullerene acceptors (NFAs) – resulted in remarkable improvements in device efficiency over a short period and created new perspectives for the development of this technology at an industrial level. This is exemplified by the discovery of molecules such as ITIC in 2015 and Y6 in 2017 that has led to a rapid increase of the performances of organic solar cells from 10% to more than 18% – thus significantly outperforming the solar cells using fullerene-based materials.

The use of NFAs has widened the possibility to vary the chemical structure of acceptor materials, allowing chemists to more finely control their electronic structure, absorption range and other useful properties – such as solubility – necessary to ease the fabrication of large-area solar cells by printing techniques. The high molar absorption coefficient of

NFAs, and their complementary absorption spectra to that of the polymer donors, are particularly appealing for the development of high-performance photovoltaic devices, or even semi-transparent solar cells with potential applications as multi-functional windows or light-shading systems.

The introduction of ternary blends in bulk-heterojunction solar cells, in which NFAs play a crucial role, is another promising approach to obtain photovoltaic devices with better photocurrent generation, minimized energy losses, and increased power conversion efficiency. Designing NFAs with new molecular structures and exploiting them in ternary or even quaternary blends is probably one of the key strategies to overcome the remaining technological limits of OPVs. In photovoltaics, there will be no room in the market for non-stable solar cells. In the next few years, efforts are still needed to push further the performances of organic solar cells, but more importantly, it is crucial to tackle the challenge of their long-term (in)stability.

Through the selection of the articles gathered in this themed collection we hope to share with the community of chemists, materials scientists, physicists and device engineers some of the latest progress in the exciting OPVs research field. We would like to particularly thank the authors for their excellent contributions, reviewers and the editorial staff for their work. Without their great support, this themed collection would not be possible. We hope this collection will motivate new developments in this fast-moving field of research and bring OPVs one step closer to industrial application (rsc.li/OrganicPhotovoltaics).

