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Non-fullerene acceptors inaugurating a new era of organic photovoltaic research and technology

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Organic photovoltaic (OPV) solar cells possess some unique merits, such as the potential to be fabricated at low cost, and the fact that they can be semi-transparent to highly transparent in visible light, flexible and lightweight. These properties are attractive for building integrated solar power generation and for portable devices. The active layer in an OPV cell typically consists of a blend of an electron donor (a low ionization energy material) and an electron acceptor (a high electron affinity material) with a bulk heterojunction structure that helps ensure effective light absorption, charge separation and transport of electrons and holes to their corresponding electrodes. During the last 2 decades, fullerene derivatives have been the most widely used electron acceptors in OPV cells. However, their shortcomings, such as weak light absorption, limited variability of electronic properties and morphology instability, constrain the sustainable development of this field, most specifically limiting the upper achievable device efficiencies. Organic non-fullerene acceptors offer the possibility of overcoming these deficiencies of fullerene acceptors. Historically, the performance of non-fullerene OPV cells has lagged far behind that of fullerene-based devices, and only recently has the development of non-fullerene acceptors become an area of intense research. In particular, thanks to the discovery of the benchmark molecule ITIC in 2015 as well as conception and development of a class of non-fullerene acceptors termed "fused-ring electron acceptors (FREA)", the efficiency of non-fullerene-based OPV devices has rapidly increased from $<7\%$ to $>17\%$, dramatically outperforming the fullerene-based materials. The emergence of high-performance non-fullerene acceptors, particularly the ITIC family, has essentially led to the rebirth of this field, overturned the dominant position of fullerene acceptors, and is inaugurating a new era of OPV research. Now, with the resurgence of activity in OPV research, the prospect of solution processed tandem cells with 20% efficiencies is in sight, whereas only 5 years ago such performance was considered to be an unrealistic dream.

This themed collection consists of 8 Research Articles on the latest advances in this rapidly advancing topic of non-fullerene OPVs. These cutting-edge advances cover a wide variety of research: design of new non-fullerene acceptors, design of new polymer donors to match with non-fullerene acceptors, donor/acceptor paring and multi-length scale morphology.

In summary, we hope the excellent contributions in this themed collection may provide the OPV community a platform to discuss the progress and challenges in this flourishing research field. As noted above, we are now more confident than ever that efficiencies of over 20% could be possible based upon lead-free organic materials, processable at low temperature on flexible substrates. We would like to thank the authors, reviewers and the editorial staff for their great support in making this themed collection possible.

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