# A non-fullerene electron acceptor modified by thiophene-2-carbonitrile for solution-processed organic solar cells

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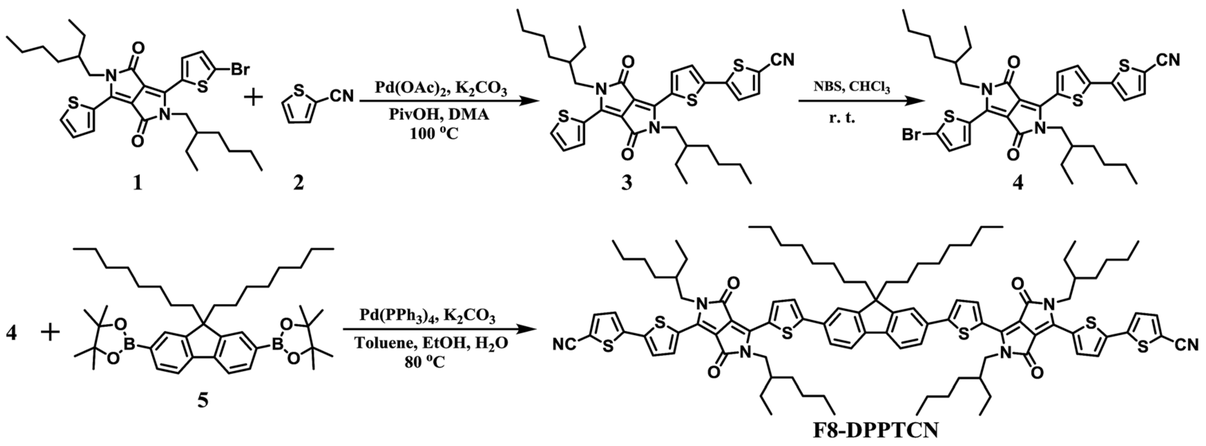
## Introduction

Effective electron acceptor materials usually have a deep lowest unoccupied molecular orbital (LUMO) energy level that can split excitons and generate current. A non-fullerene electron acceptor (F8-DPPTCN) was developed, using fluorene as the core with arms of diketopyrrolopyrrole (DPP) having thiophene-2-carbonitrile as the terminal units. The new molecule had a LUMO of -3.65 eV and a narrow bandgap ($E_g$) of 1.66 eV, owing to the electronegativity of the thiophene-2-carbonitrile group and its conjugation with DPP units. Organic solar cells (OSCs) with F8-DPPTCN as the acceptor and poly(3-hexylthiophene) (P3HT) as the donor were fabricated. A power conversion efficiency (PCE) of 2.37% was obtained with an open-circuit voltage ($V_{oc}$) of 0.97 V, a short-circuit current ($J_{sc}$) of 6.25 mA cm$^{-2}$, and a fill fator (FF) of 0.39.

## Results and discussion




**Scheme 1** Synthetic route of F8-DPPTCN.

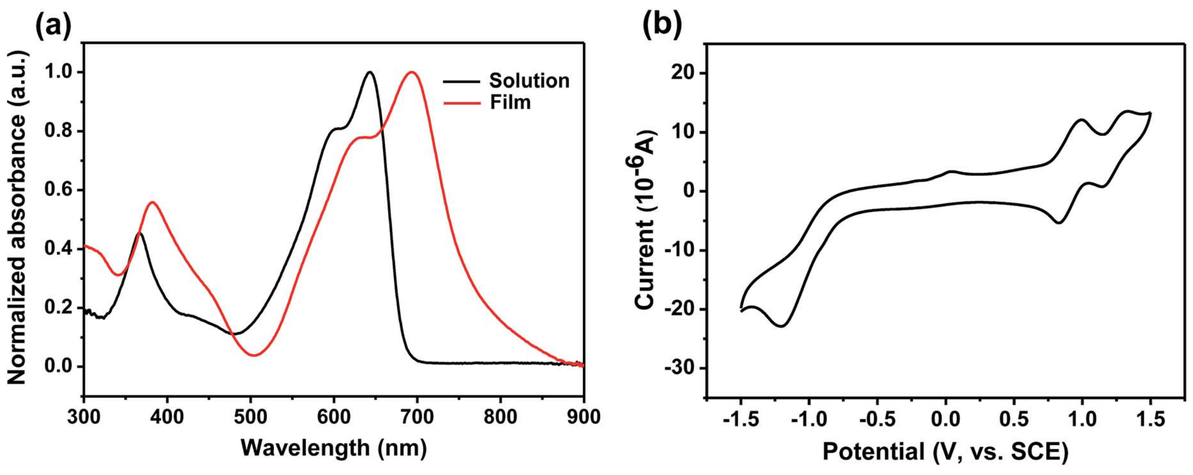



**Fig. 1** (a) UV-vis absorption spectra of F8-DPPTCN in $CHCl_3$ solution and films; (b) cyclic voltammogram of F8-DPPTCN in $CH_2Cl_2$ solution.

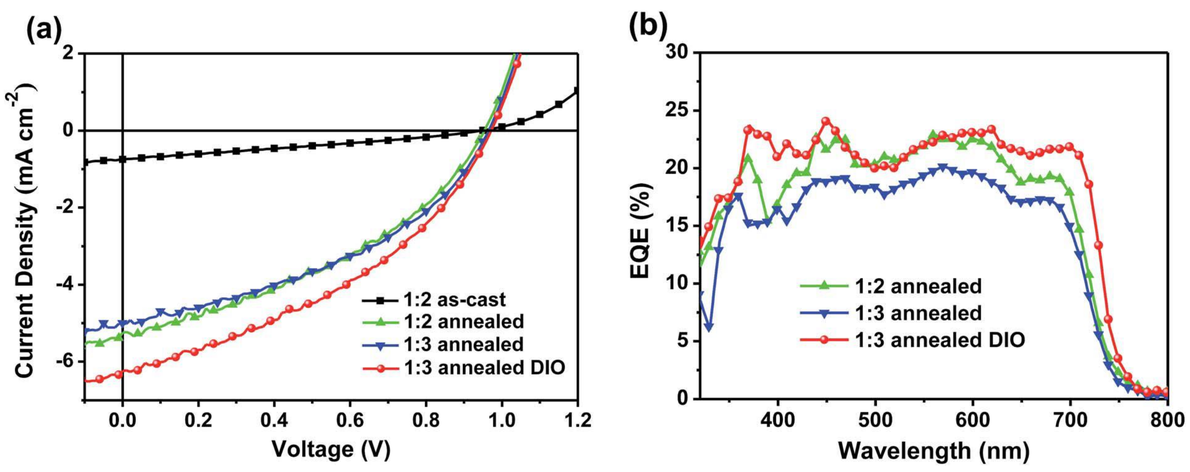



**Fig. 2** (a) *J-V* curves and (b) EQE spectra of P3HT:F8-DPPTCN based OSCs.

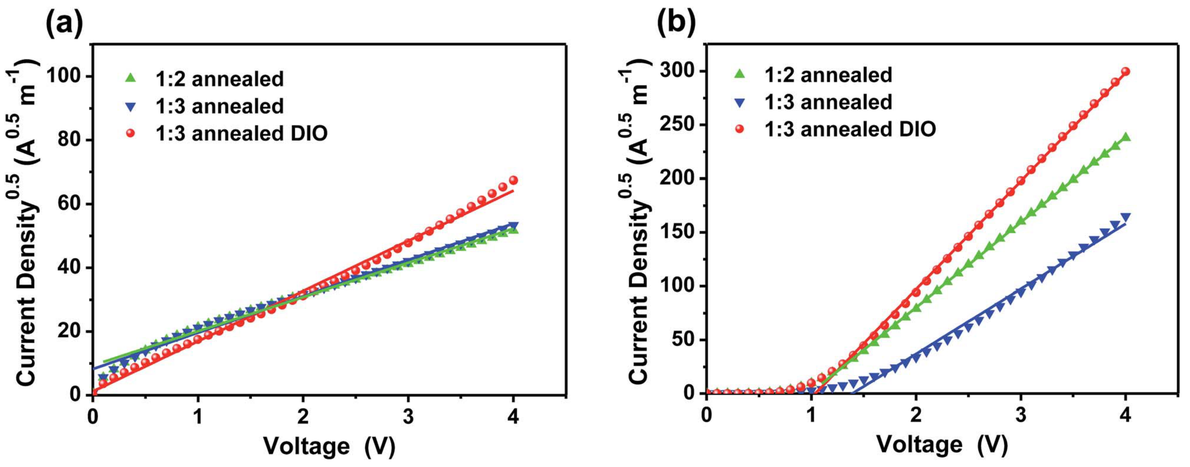



**Fig. 3** (a) $J^{0.5}$-$V$ curves of (a) the hole-only and (b) electron-only devices based on P3HT:F8-DPPTCN blends.

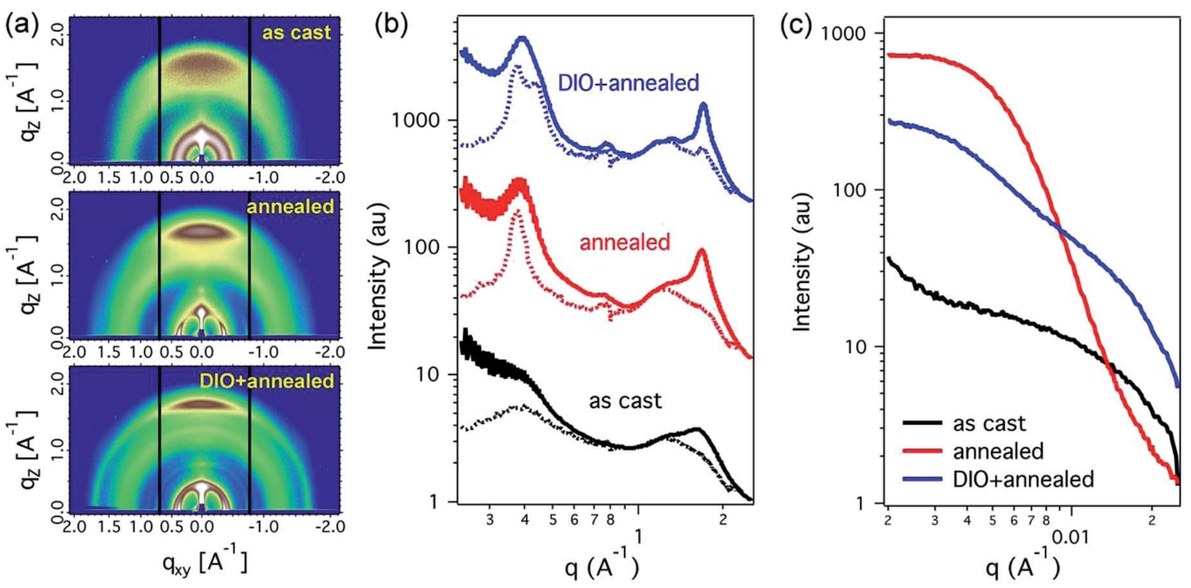



**Fig. 4** (a) The 2D GIXD images of P3HT:F8-DPPTCN (1:3, by wt) blend films; (b) 1D out-of-plane (solid lines) and in-plane (dot lines) X-ray profiles extracted from GIXD; (c) RSoXS profiles of P3HT:F8-DPPTCN (1:3, by wt) blend films.

## Conclusions

We have designed and synthesized an electron acceptor (F8-DPPTCN) with a fluorene core having DPP arms that are end-capped with thiophene-2-carbonitrile. The resulting material exhibits extended absorption to the near infrared region (up to 757 nm). F8-DPPTCN molecules exhibit good electron mobility (up to $10^{-3}$ cm$^2$V$^{-1}$s$^{-1}$) in bulk heterojunction blends. The best performing solar cells are obtained by using an additive processing method, and the active layer shows multi-length scale morphology. In device, a PCE of 2.37%, and $V_{oc}$ of 0.97 V, $J_{sc}$ of 6.25 mA cm$^{-2}$, FF of 0.39 are obtained.

## Notes and references

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