Solution-Processed Bulk Heterojunction Solar Cells with Novel Acceptor Molecules

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Organic Photovoltaics

Solar energy is a highly abundant, clean energy source. In 1.5 hours, enough solar energy hits the surface of the Earth to provide 100% of our global energy needs for an entire year (15 Tw × 1 year).

Why organic photovoltaics?

- Using a 1.1V cell as a top cell in a tandem device with a CIGS cell could boost efficiency from 15% to 21%, cutting overall cost by ~ 30%
- Energy payback time for organic solar cells is only 2-3 months, compared to 2-3 years for other technologies
- Roll-to-roll processing techniques are potentially very low cost

How do organic solar cells work?

- How current is generated
  - 1) Photon absorption and exciton generation
  - 2) Charge transfer / exciton splitting
  - 3) Charge carrier collection

Acceptor Materials in OPV

Fullerene Derivatives (Up to 9.9% efficiency)

- PC60BM
- PC70BM
- ICBA

How do fullerenes work so well?

Polymer-Fullerene Miscibility

Energetic Offsets from Mixed Phase

X-Ray Diffraction shows no Miscibility

- X-ray diffraction scans show evidence of crystalline HPI-BT phase with only 15 wt.% HPI-BT (miscibility limit of HPI-BT in P3HT < 15 wt%)

Summary

- New small molecule electron acceptors fill some gaps left by fullerene derivatives
  - Open-circuit voltages as high as 1.11 V targeting top cells in tandem devices
  - Increased photocurrent from absorption in acceptor phase
  - Potentially lower cost synthesis
- No energetic offsets caused by two-phase morphology (low miscibility of HPI-BT in donor polymers) results in lower charge collection efficiency
- Design rules for better non-fullerene acceptors
  - Appropriate energy levels
  - Good electron mobility (both local and device-level)
  - Mixing between donor polymer and small molecule acceptor
  - Good electron transport through mixed phase

Future Directions

- Investigate effect of local vs. device-level mobility in improving charge separation efficiency
- Synthesis of new acceptor architectures to control promote donor-acceptor mixing