INFORMATION SHEET
RENEWABLE DEVELOPMENT FUND

Investing in Renewable Energy

LOW BAND GAP MATERIALS FOR ORGANIC PHOTOVOLTAICS

Executive Summary

Most photovoltaic (PV) devices are fabricated on silicon wafers that have high production costs associated with obtaining pure wafers. The production process results in the generation of toxic wastes during manufacturing. To reduce the cost of PV manufacturing National Renewable Energy Laboratory (NREL) researched the latest generation of technology organic photovoltaics (OPV). OPV is a chemical processing method that does not require high temperature or high vacuum conditions. Energy conversion efficiencies of OPV devices have reached 5.9 percent but it is believed efficiencies of eight percent to 10 percent are needed for commercialization.

Project Description

OPV is a solution that can be applied to a variety of substrates by printing or spraying and has the potential to drastically reduce manufacturing costs. Band gaps are an energy range in a solid where no electron states can exist and is a major factor determining the electrical conductivity of a solid. Substances with large band gaps are generally insulators while conductors either have very small band gaps or none.

Methodology

NREL designed, synthesized and characterized OPV materials with low band gaps. Based on theoretical performance, NREL first generated computational designs of OPV dendrimers and polymers at the molecular structure. Designs that demonstrated good theoretical performance were expanded to model PV devices. The best low band gap polymers were chemically synthesized and tested to determine the actual conversion of light to electrical generation capacity and physical properties of the PV devices produced.

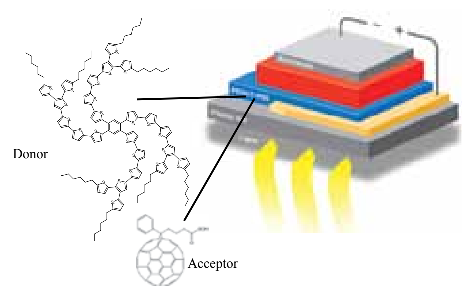
Lessons Learned

- Feedback from transport and structural measurements has been used to guide optimization of OPV device structures
- Easier dendrimer synthesize process that demonstrate good molecular ordering and, as a consequence, expected to have good charge transport properties
- Block copolymers are a little more difficult to synthesize; however they have the ability to form self-organized structures that allow for tuning the domain size in the donor-acceptor blend, which is a critical factor in determining PV device performance

Outcomes

NREL advanced the theoretical understanding of the molecular structure for OPV materials and how the structure determines the performance of OPV devices.

- Developed a completely new OPV dendrimer with a power conversion efficiency exceeding one percent
- Produced a newly synthesized polymer with an optimal band gap of 1.52 electronvolt



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- New versatile monomers were synthesized as building blocks for low band gap copolymers
- Published six papers in peer-reviewed scientific journals
- 20 presentations at national and international conferences

Project Benefits

Limitations to increase OPV device efficiency are not well understood, mainly, the band on the light spectrum for absorption of energy is too high to take advantage of solar photons.

This pioneering research of the next generation of solar technology has increased the knowledge base for OPV materials.

- Understanding the physical mechanisms underlying the design and properties of OPV has identified a optimal molecular arrangement for improved absorption
- Collaboration with the Department of Chemical Engineering and Materials Science of the University of Minnesota on synthesizing block copolymers and low band gap polymers has increased the scientific knowledge base of Minnesota's PV research community.

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