Advanced Materials and Devices for Low Cost and High Performance Organic Photovoltaic Cells

Investigators
Zhenan Bao, Associate Professor, Chemical Engineering; Mike McGehee, Assistant Professor, Material Sciences and Engineering; Yang Yang, Professor, Material Sciences and Engineering (UCLA, subcontract pending); Toshihiro Okamoto, Melissa Summers, Postdoc Researchers; Ming Lee Tang, Quan Yuan, Ajay Virkar, Graduate Researchers

Introduction

A significant fraction of the carbon released into the atmosphere is a result of burning coal and natural gas to produce electricity. It is therefore highly desirable to find ways to generate electricity without releasing carbon. The development of affordable photovoltaic (solar) cells is one of the most promising long-term solutions to keeping the CO_2 concentration in the atmosphere at safe levels.

Currently, almost all photovoltaic (PV) cells being manufactured are made of crystalline silicon. The average cost of the electricity that is generated in a sunny location using these cells is about two-four times more than the typical cost of electricity from the grid. Our goal is to develop technology that can reduce the cost per Watt of generation capability by at least a factor of five and hopefully even more. Our approach is to use organic semiconductors because they can be deposited onto flexible substrates in roll-to-roll coating machines, similar to those used to make photographic film and newspapers. In this project, we plan to work on three directions: (i) having significant exciton harvesting and preventing geminate recombination by using phosphorescent semiconductors, (ii) new device designs and materials required for double or triple the efficiency, and (iii) new materials design concepts to improve the absorption of low energy photons by using new low band gap semiconductors that have sufficient charge carrier mobilities for charge extraction.

Background

Many research groups have made organic PV cells, however, they have mostly used materials that were designed for light-emitting diodes or field effect transistors. Yang Yang's group in UCLA recently reported efficiency of 4.4 % for a regioregular poly(3-hexylthiophene)/C60 based solar cell.[1] Recently Yang Yang's group reported an organic solar cell based on harvesting of triplet excitons. The efficiency of such a cell using a Pt complex of porphyrin as the triplet generating molecule is still relatively low, about 2 %.[2]

Results

We have designed and synthesized new molecules that may potentially generate triplet excitons more efficiently. These molecules have been synthesized and purified. We are currently investigating their efficiencies in generating triplet states and performance of devices using these new molecules.

Progress

This work will open up new design rules for efficient solar cell materials. A simple multilayer device architecture utilizing triplet excitons in combination with a low bandgap absorbing layer (polymer or other small organic molecule) has the potential to produce an organic device with high photocurrent and world-record efficiency.

Future Plans

We plan to continue the synthesis and evaluation of triplet exciton generating molecules. We will prepare solar cells based on these materials together with matching acceptor materials.

We will also start the synthesis of low band-gap high charge carrier mobility polymers based on our proposed new material designs. Their photophysical and device performance will be evaluated.

Publications

None.

References

1. Li, G., Shrotriya, V., Huang, J.S., Yao, Y., Moriarty, T., Emery, K., Yang, Y., *Nature Materials* **2006**, 4, 864-868.
2. Shao, Y., Yang, Y., *Advanced Materials* **2005**, 17, 2841-2843.

Contacts

zbao@stanford.edu
mmcgehee@stanford.edu
yangy@ucla.edu