CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

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Project Number

36712

Project Title

Enhancing the Efficiency of Self-Assembled Organic Solar Cells with the Addition of a Second Electron Donor and Graphene

Abstract

Objectives/Goals

Solar energy, as the largest energy resource on Earth, is a viable source of renewable power because it is free and easily available. Organic solar cells are a promising low-cost renewable energy technology that offers multiple advantages, including flexibility, semi-transparency, significantly lower manufacturing costs, and possible integration into a variety of products, over their inorganic counterparts. Organic photovoltaics are limited, however, by their low power conversion efficiencies and narrow absorption ranges. The goal of this project was to expand the absorption spectrum and increase efficiency by incorporating two photoactive polymers, Poly(3-hexylthiophene) (P3HT) and Poly[9#-hepta-decanyl-2,7-carbazole-alt-5,5- (4#,7#-di-2-thienyl-2#,1#,3#-benzothiadiazole)] (PCDTBT), and graphene into self-assembled organic solar cells.

Methods/Materials

Absorption spectra of the devices obtained through ultraviolet-visible spectroscopy elucidated the interactions between the photoactive polymers. Transmission electron and atomic force microscopy were used to show the formation of columnar structures within the devices and study the changes in morphology brought about by the additives.

Results

The addition of polystyrene created vertical nanostructures that enlarged the interfacial areas between the donor and acceptor materials. Analysis of AFM images using surface roughness and contact angle values revealed that graphene gathered at the sides of the self-assembled columns and induced the diffusion of both electron donor and acceptor materials, resulting in greater electricity generation. Measurements of short circuit current indicated that P3HT expanded the spectral ranges of the solar cells. Addition of a second electron donor led to a 12.4% increase in solar cell efficiency. A 95.2% increase in efficiency was achieved with the incorporation of graphene.

Conclusions/Discussion

This project is the first time that the effects of a secondary electron donor and graphene on the morphology of a self-assembled active layer have been studied and presents an economical way of increasing device performance. This research advances the development of organic solar cells and increases their potential towards application in clean energy.

Summary Statement

I obtained the highest energy generation efficiency to date of self-assembled organic solar cells through the novel incorporation of multiple electron donors and graphene.

Help Received

My research mentor, Professor Miriam Rafailovich, explained the procedures for making the solar cells and supervised me during experimentation. She operated the AFM and TEM to scan my samples and collected device performance data at Brookhaven National Lab.