Solar Energy Harvesting Device – Biomimetic Solar Cell

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Abstract

Exploring sustainable energy resources are becoming important due to the predicted oil depletion and soaring CO₂ levels in the atmosphere. Of available alternatives, solar energy finds special attention due to its vast availability and high power density of 1000 watts per square meter. Various mechanisms have been carefully employed to harvest the solar power including semiconductor silicon based photovoltaic, inorganic/organic dye sensitized or bulk heterojunction solar devices. Some of the latter devices utilize donor-acceptor supramolecular systems designed based on natural photosynthesis. Here, self-assembly of energy donor and acceptor is proved to be an important criterion.

In the present study, we demonstrate an elegant method of self-assembly to modify TiO₂ surface using coordinating ligands followed by immobilization of a variety of photosensitizers and dyads. This method, in addition to testing the photoelectrochemical behavior of simple zinc tetrapyrole also allows us to introduce fairly complex structures involving more than one donor and/or acceptor entities. As will be demonstrated, all of macrocycles studied, a biomimetic zinc porphyrin-ferrocene dyad markedly improves the current-voltage performance of the photoelectrochemical cell due to an electron transfer-hole, migration mechanism. Incident photon-to-current efficiency value up to 37%, highest value reported for this type of devices is obtained for the electrode modified with the dyad. Highlighting the importance of photosets built based on biomimetic principles for efficient harvesting of solar energy.

Available Solar Harvesting Devices

Supramolecular Solar Cells: Surface Modification of Nanocrystalline TiO₂ with Coordinating Ligands To Immobilize Sensitizers and Dyads via Metal-Ligand Coordination for Enhanced Photocurrent Generation

Electrode Preparation

- Inorganic PV devices are efficient but expensive.
- Dye-Sensitized Solar Cells (DSSC) are made up of Titanium dioxide (TiO₂).
- Organic Solar Cells are less efficient.

How does a DSSC Work?

- Dye absorb sunlight and inject electron into TiO₂ resulting in photocurrent.
- Maximum 11% efficiency reported till now.
- Dye should contain acid functional group to adsorb on TiO₂.
- A Dye should absorb visible light (400-800 nm) – Research Target.

Introduction

Are We in need of More Energy?

- Increase in the energy consumption per year necessitates alternate energy source.

Why Should Attempts be Made to Harvest Solar Energy??

- Widely available
- More powerful (1000 W/m²)

Natural Photosynthesis

Photoelectrochemical studies

- Different types of zinc porphyrin modified electrodes (versatility of this method).
- Zn porphyrin-ferrocene (B) showed better photo response than other two compounds.
- Current switching experiment shows that it is reproducible indicating the stability of the supramolecular photoelectrochemical system.

Conclusion

- Self assembly of different types of dye molecules is possible by using axial ligation technique.
- Increased charge separation facilitates better performing solar cell.
- Highest IPCE value of 36% was obtained in current study.
- Efforts to improve the performance using different dyes are under study.

Acknowledgements

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NSF, NSF - EPSCOR, K-TEC, ACS-PRF & WSU