Dye Sensitised Nanocrystalline Solar Cell - Fabrication and Performance Measurement

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Experiment Overview

Photovoltaic energy is a renewable energy source of major significance. Current technologies are based on silicon. Silicon solar cells are relatively expensive, difficult to manufacture and do not provide the highest levels of biocompatibility. To date, no solar cell technology has produced an efficient, reliable and cost effective solar module that can be widely used to replace fossil fuel energy sources. A promising alternative technology is the Dye Sensitised Nanocrystalline Solar Cell also known as the Grätzel Cell[1]. This is a photoelectrochemical device that is significantly cheaper and easier to manufacture, and offers improved biocompatibility and reduced payback with respect to silicon cells.

[1] Professor Grätzel of EPFL, first developed the cell in the early 1990's by and it promises great potential as a cheap and efficient device. Mesoporous titanium dioxide is the bulk material, sensitised to the solar spectrum by absorbed dye. With such solar cells, white light conversion efficiency of over 10% has been realised.
(http://www.bath.ac.uk/chemistry/electrochemistry/gratzel.html)

Aims and Objectives

In this experiment students fabricate a photovoltaic cell based on nanocrystalline titanium dioxide as the semiconductor. An organic dye is used to sensitise the semiconductor by complexing with the titanium dioxide and adsorb the light required to power the cell. An electrolyte solution is used to complete the circuit by replacing the electrons lost by the dye via light absorption. The completed cell consists of a sandwich of titanium dioxide, dye, electrolyte and catalyst between two conducting transparent electrodes.

Finally, students determine the current-voltage and power output characteristics of the assembled photoelectrochemical cell.

Level of Experiment

This experiment is aimed at students in their second year physical chemistry laboratory course.

Keyword Descriptions of the Experiment

Domain
physical chemistry

Specific Descriptors
photovoltaic solar cells

Course Context and Prerequisite Knowledge and Skills

This experiment was developed to illustrate the significance of photovoltaic cells as an energy source. A prior knowledge of the structure and operation of silicon solar cells is helpful. Some knowledge of electrochemical cells is also helpful.

Time Required to Complete

Prior to Lab: 1 h
In Laboratory: 3 h (for fabrication of the cell) plus 3 h (for testing, measuring performance characteristics, and data analysis)
After Laboratory: 2-3 h (report writing)

Experiment History

The experiment is based on the article in the *Journal of Chemical Education* by Smestad and Grätzel (1998).

Comments

The experiment is open ended. There is much potential for further student experimentation to gain further knowledge on the subject. For example, students could repeat the experiment using different chelating agents to compare the maximum power achieved. They could also use titanium dioxide of different grain sizes and use different thicknesses to coat the conductive plates. The performance of the cell can be compared at various light intensities.

References

Smestad, G. P. & Grätzel, M. (1998). Demonstrating electron transfer and nanotechnology: A natural dye-sensitised nanocrystalline energy converter. *Journal of Chemical Education,* **75,** 752-756.

Another source of information is a Solar Cell Kit produced by the Institute for Chemical Education, Department of Chemistry, University of Wisconsin-Madison, 1101 University Avenue, Madison, WI 53706-1399.

O'Reagan, B. & Grätzel, M. (1991). A low-cost, high efficiency solar dell based on dye-sensitive colloidal TiO_2 films. *Nature,* **353,** 737-740.