

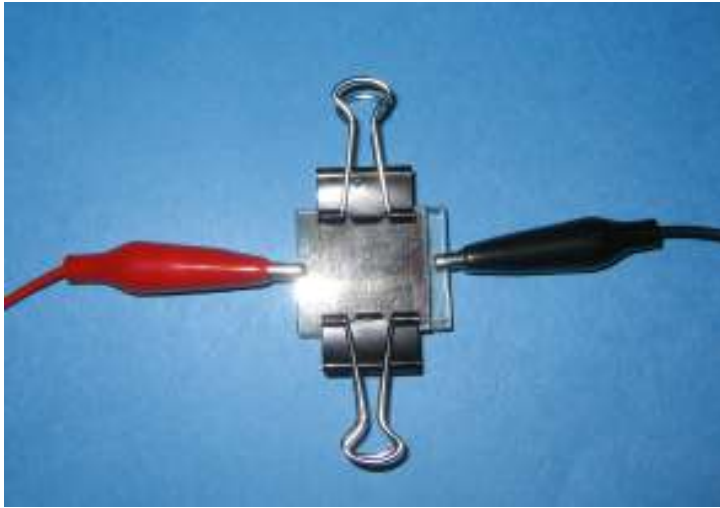
Nanocrystalline Solar Cell

Introduction

In this activity we will explore photogeneration of electricity using dye-sensitized nanocrystalline titanium dioxide.

Material

Nanocrystalline Titanium Dioxide Powder
Two glass microscope slides
Distilled white vinegar
Dish washing detergent
Small paint brush
Broiler
Blackberries
Distilled water
Small shallow dish
Tweezers
Sand Paper
Pencil
Two binder clips
Iodide electrolyte solution
Eye dropper
Two alligator clip leads
Digital multimeter



To Do and Notice

The TiO_2 coated slides and the Iodide electrolyte solution can be prepared ahead of time.

Nano Titanium Dioxide

To make the nano titanium dioxide suspension, add 9 mL vinegar to 6 g titanium dioxide and mix until smooth. Add one drop of dishwashing detergent and let sit for 15 minutes.

Using a small paintbrush distribute a thin layer of the TiO_2 solution across the surface of one microscope slide. Allow the slide to dry for a few minutes. Place the TiO_2 coated slide film side up in the broiler for 30 minutes to an hour. You will notice the slides turn yellow and then white again. Turn off the broiler once the slides have turned white again and let them cool to room temperature slowly.

Iodide Electrolyte Solution

To mix your own Iodide electrolyte solution, dissolve 0.127 g Iodine (I_2) in 10 mL of ethylene glycol. Next add 0.83 g Potassium Iodide (KI), stir and store in a dark container.

Preparing the Electrodes

Blend or crush fresh or frozen blackberries in a blender or by hand periodically adding distilled water until the mixture is mostly liquid. You should add about a tablespoon of water for every 10 blackberries. Coat the bottom of a shallow clean dish with about 2 mm of blackberry juice. Place the TiO_2 coated slide face down in the blackberry juice for 5 to 10 minutes. While the TiO_2 coated slide is soaking a carbon catalyst layer must be added to the second slide. Scuff up one side of the clean slide using sand paper. Use a soft pencil to coat the scuffed up side of a microscope slide. Make sure the entire surface is coated.

After about 10 minutes the TiO_2 coated slide soaking in the blackberry juice should be stained dark purple. At this point remove the slide and rinse with distilled water. Use a tissue or paper towel to gently dry the slide.

Assembling the Solar Cell

Place the graphite coated slide face down on top of the dry blackberry juice soaked TiO_2 coated side of the second slide. The slides should be placed slightly off set to allow enough room on the end to place an alligator clip. Use two binder clips to hold the two slides together.

Now with an eyedropper add one to two drops of liquid iodide/iodine electrolyte solution to the crease between the two slides. The solution will be drawn into the cell by capillary action and will stain the entire inside of the slides.

Attach the alligator clips to the two overhanging edges of the slides and attach the clip leads to your multimeter with the negative terminal attached to the TiO_2 coated slide, and the positive terminal attached to the graphite coated slide. Measure both the current and the voltage of the cell in direct sunlight and indoors. The maximum voltage in direct sunlight should be about 0.3 to 0.5 Volts.

What's Going On?

TiO_2 is a wide band gap semiconductor. In semiconductors there is an energy gap between the electrons that are tightly bound to the atom, unavailable for conduction, and the electrons that are farther from the atom and free to move and conduct. The blackberry dye is adsorbed on the TiO_2 ; energy from the sun excites electrons in the blackberry dye, which are then transferred to the conduction band in the TiO_2 and through the outer circuit. The blackberry dye is oxidized, so the electrons are replaced by the iodine electrolyte, which in turn obtains electrons from the graphite-coated

electrode thereby completing the circuit. The TiO_2 acts as an electron acceptor, the Iodide/iodine electrolyte solution is an electron donor, and the blackberry dye acts as a photochemical pump to promote the movement of electrons.

Where to Purchase Materials

Nanocrystalline TiO_2 can be purchased from Degussa USA. The product is called Aeroxide TiO_2 P25. www.aerosil.com Phone: 1-330-668-2235

This activity is based on a journal article from Smestad, G.P.: Gratzel, M. *J. Chem. Educ.* **1998**, 75, 752-756.