Titanium Dioxide Raspberry Solar Cell


Using a dye found in raspberries to absorb sunlight, a tin oxide electrode, a graphite electrode, and nanocrystalline titanium dioxide, makes a solar cell that will produce a voltage.

**Procedure**

Wear eye protection

Chemical gloves recommended

Grind about 0.5 gram of nanocrystalline titanium dioxide (TiO$_2$) in a mortar and pestle with a few drops of very dilute acetic acid. Alternate grinding and addition of a few drops of very dilute acetic acid until you obtain a colloidal suspension with a smooth consistency, somewhat like latex paint. (Very dilute acetic acid is prepared by adding 0.1 mL concentrated acetic acid to 50 mL of water.)

Add a few drops of Triton X-100 surfactant or clear dishwashing detergent and mix some more.
Identify the conducting side of a tin oxide-coated piece of glass by using a multimeter to measure resistance. The conducting side will have a resistance of 20-30 ohms.

With the conducting side up, tape the glass on three sides using one thickness of tape. Wipe off any fingerprints or oils using a tissue wet with ethanol.

Add some of the titanium dioxide suspension and quickly spread using a glass rod. The tape serves as a 40-50 micrometer spacer to control the thickness of the titanium dioxide layer. (If the layer dries out, add more water.)

Carefully remove the tape without scratching the TiO$_2$ coating.

Heat the glass on a hotplate in a hood for 10-20 minutes. The surface turns brown as the organic solvent and surfactant dries and burns off to produce a white or green titanium dioxide coating. (Note: this requires a plate that gets quite hot.) Allow the glass to slowly cool by turning off the hotplate.
Immerse the coating in a source of anthocyanins, such as raspberry juice. The raspberry juice may be obtained most easily from frozen raspberries. (Blackberries, pomegranate seeds, and Bing cherries can also be used.) The white TiO$_2$ will change color as the dye is absorbed and complexed to the Ti(IV).

Rinse gently with water and then with ethanol. (The ethanol serves to remove water from the porous TiO$_2$.)

Pass a second piece of tin oxide glass, conducting side down, through a candle flame to coat the conducting side with carbon (soot). For best results, pass the glass piece quickly and repeatedly through the middle part of the flame.

Wipe off the carbon along the perimeter of three sides of the carbon-coated glass plate using a cotton swab.
Assemble the two glass plates with coated sides together, but offset so that uncoated glass extends beyond the sandwich. Do not rub or slide the plates. Clamp the plates together.

Add a few drops of a triiodide solution to the edge of the plate. Capillary action will cause the KI$_3$ solution to travel between the two plates. (The KI$_3$ electrolyte solution consists of 0.5 M KI and 0.05 M I$_2$ in anhydrous ethylene glycol.)

**Properties**

Connect a multimeter using an alligator clip to each plate (the negative electrode is the TiO$_2$ coated glass and the positive electrode is the carbon coated glass).

Test the current and voltage produced by solar illumination, or...

test the current and voltage produced by illumination from an overhead projector.
Materials

A kit that contains the supplies (conductive glass, nanocrystalline TiO$_2$, binder clips, KI$_3$ electrolyte, manual, etc.) to create five titanium dioxide raspberry solar cells can be ordered from the Institute for Chemical Education.

Additional supplies

- Frozen raspberries
- Mortar and pestle
- Dishwashing detergent
- Multimeter
- Transparent tape
- Glass stirring rod
- Watch glass
- Water wash bottle
- Candle and a way to light it
- Clamp or tongs to hold glass while smoking
- Cotton swabs
- Hotplate
- Strong light source (projector or sun)