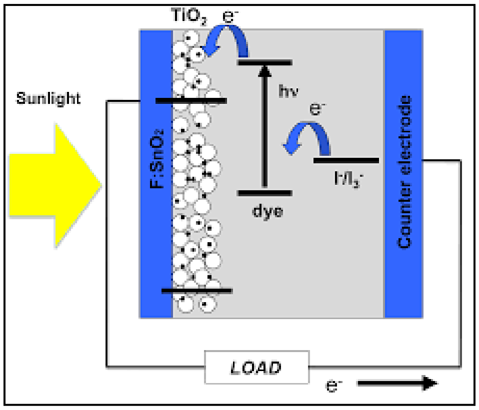
# Titanium Dioxide Raspberry Solar Cells

Overview:

In this lab, you will be constructing a layered organic photovoltaic cell (OPVC) using titanium dioxide bound to naturally occurring anthocyanins in raspberry juice. The solar cells will be layered on FTO-coated glass, while potassium tri-iodide and a carbon soot layer will complete the solar cell circuit. This solar cell functions well under sunlight, but has a limited lifespan based on the organic anthocyanins found in the raspberries.




The transportation of electrons is complex in this cell. The fluorine tin oxide (FTO) layer of the glass slide provides a means of electrical conductivity along a transparent surface. The students will layer the conductive side with Titanium dioxide, which helps capture light in the cell and serves as a binder for the anthocyanins. The anthocyanin will transport electrons when hit with light photons, allowing electrons to flow into the FTO conductive layer. A second FTO-coated cell is layered with carbon soot from a candle, acting as the counter electrode in the solar cell. Finally, the electrons are cycled back to the anthocyanins via a potassium tri-iodide electrolyte solution.

Materials per student group:

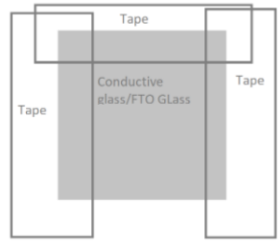
- 2 FTO (TEC15) 1” x 1” coated glass slides
- 0.2 grams titanium dioxide
- A few drops of dilute acetic acid
- Scotch tape
- Hot plate or electric burner
- Anthocyanin-containing berries (raspberry, blackberry, blueberry, pomegranate)
- Small bowl or weigh boat for crushing berries
- Tea candle
- Cotton swab or pad
- A few drops of potassium tri-iodide solution
- 2 Small binder clips
- Multimeter
- 2 Alligator clips

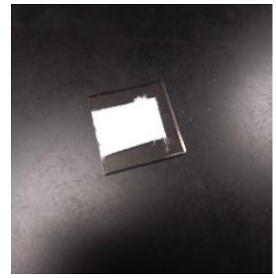
Procedure:

**Preparing the Titanium Dioxide paste**

1. Crush the titanium dioxide with the mortar and pestle, until you have a fine powder.
2. Add a few drops of the dilute acetic acid and mix it into the powder. Alternate adding drops and mixing until you have a paste somewhat of the consistency of latex paint.
3. *Optional*–store paste in a syringe, wrapping the end of the syringe in saran wrap to preserve moisture.

**Coating the FTO glass (Titanium Dioxide)**



1. Using a multimeter set to measure resistance, test the resistance of each side of the FTO glass. The coated side should have about 20-30Ω of resistance.
2. Using the scotch tape, tape three sides of the FTO glass plate about 0.5 cm from the outer edge. Make sure the tape is completely flat, as you can use this to measure thickness.
3. Take the $TiO_2$ paste you made and spread it in the square between the tapes, using the tape on opposite sides to keep the paste at a consistent thickness. It will dry, so be fairly quick.
4. Remove the tape carefully, making sure to leave the titanium dioxide intact.
5. Heat the glass (titanium dioxide side face up) on a hotplate for about 20 minutes. You'll need it set as hot as possible, as you are burning the acetic acid off, and evaporating whatever water is left. It will turn brown before returning back to white or green in this process, so you'll only know it happened if you saw the transition.
6. Leave the glass to cool slowly on the plate to prevent it from shattering.

**Coating the FTO glass (soot/carbon)**

1. Light the candle.
2. Grip the other FTO glass with the tweezers, holding it conductive side face down (refer to Step 1 in "Coating the FTO glass (Titanium Dioxide)" to measure which side is conductive). Grab on one of the edges to make sure you cover the entire middle.
3. Pass it quickly through the middle of the candle flame, and repeat until it is coated in carbon.
4. Douse the candle.
5. Using a cotton swab, gently remove a 0.5 cm strip of soot from three of the edges, similar to the shape of the titanium dioxide layer.

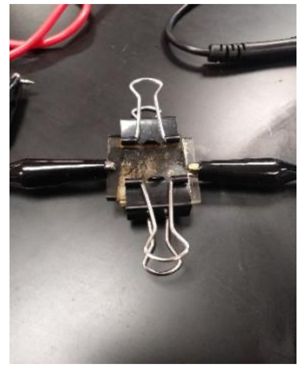
**Raspberries…?**

1. Take the raspberries (or other berries), and crush them until they secrete their juices, then remove as much solid material as possible.
2. Immerse the titanium dioxide coated glass in the juice. Remove it once the coating is stained red/purple.
3. Gently rinse with distilled water to remove whatever solids are left.
4. Rinse with ethanol to dissolve the water, then allow it to evaporate.

**Assembling the Cell**

1. Take the two glass squares, and place them against each other such that the middle uncoated edge sticks out from each end. Do not rub them together.
2. Clamp the plates with binder clips.
3. Add a drop of $KI_3$ to each side. The solution will enter between the plates through a process called "capillary action".
4. Wipe off the excess, as it is corrosive to the alligator clips.

**Testing your solar cell**



1. Connect your multimeter to the cell using alligator clips (the carbon glass is positive). Set it to either voltage or amperage.
2. Measure the voltage and current of the cell under multiple conditions as directed by your teacher:
   - Under ambient indoor classroom lighting
   - Under enhanced indoor lights such as clamp on lamps or halogen workshop lights
   - Outdoors in full sun
   - Outdoors in the shade

**Measuring amperage:**

1. Plug the positive (red) end of the multimeter lead into the positive terminal or socket labeled "mA"
2. Plug the negative (black) end of the multimeter lead into the negative terminal or socket labeled "COM"
3. Set the multimeter dial to measure microamps (μA)

**Measuring voltage:**

1. Plug the positive (red) end of the multimeter lead into the positive terminal or socket labeled "V"
2. Plug the negative (black) end of the multimeter lead into the negative terminal or socket labeled "COM"
3. Set the multimeter dial to measure volts DC (VDC or 10V)

Name(s):___________________________

Date: ______________

Period:________

Titanium Dioxide Raspberry Solar Cell Data Sheet

| Condition | Voltage | Amperage |
|---|---|---|
| Indoor Ambient Light | | |
| Indoor Enhanced Light<br>Wattage: | | |
| Indoor Enhanced Light<br>Wattage: | | |
| Outdoors (shade) | | |
| Outdoors (partial sun) | | |
| Outdoors (full sun) | | |