

## *Berry Solar Cell- Nanocrystalline TiO<sub>2</sub>*

### Overview:

Students create a dye sensitized solar cell that can generate a small current using nanocrystalline TiO<sub>2</sub> and berry juice.

### Essential Question:

How can we make a device which captures solar energy to produce electricity?

### Background:

This dye-sensitized solar cell, also known as a Grätzel cell, uses a thin film of titanium dioxide which has been ground to a fine powder (nanocrystalline) to increase its reactive surface area. The TiO<sub>2</sub> is sandwiched between two glass slides that are coated with conductive and transparent indium tin oxide (ITO). The TiO<sub>2</sub> is impregnated with some kind of colored dye, in this case anthocyanin from raspberry juice, which is the chemical which first traps the solar energy and passes the charge to the TiO<sub>2</sub>. Finally, the space between the slides is filled with a liquid electrolyte solution of potassium iodide which serves to transport charge (by way of a redox reaction) from the bottom electrode to the dye to complete the circuit.

### Research Connection:

Researchers are seeking new materials that can be used for solar cells that are cheaper to manufacture than conventional silicon. The Grätzel cell has been the focus of years of research but has failed to become a commercial success.

### NGSS Standards:

Standard Number	Standard text
HS-PS3-3	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

## Materials:

Titanium oxide ( $\text{TiO}_2$ ) coated FTO slides

Mortar and pestle

Berries

Distilled water

Petri Dish

Tweezers

Ethanol or isopropanol

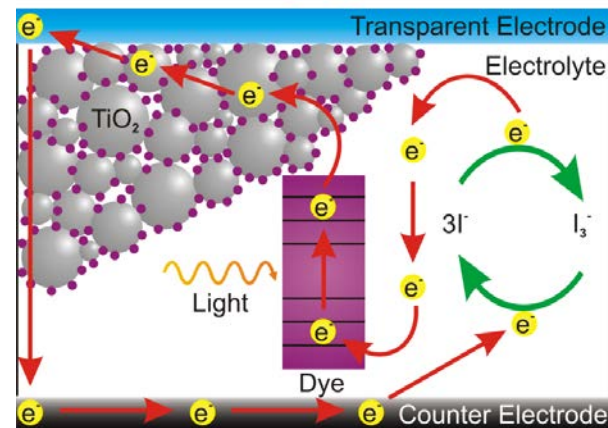
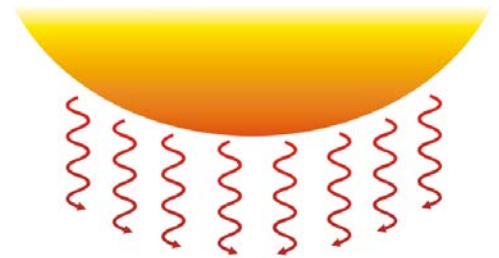
Conductive glass slide

Graphite pencil

Iodide electrolyte solution

Binder clips

Multimeter with alligator clip leads



## Procedure:

### Part 1: Staining the $\text{TiO}_2$ with Anthocyanin Dye

1. Use a mortar and pestle to crush 3-4 berries. Transfer to a Petri dish.
2. Add about a tablespoon (15mL) of distilled water to the crushed berries and stir with a clean glass rod
3. Take the  $\text{TiO}_2$  coated slide and place it  $\text{TiO}_2$ -side down into the berry mixture
4. Let the slide soak for 10 minutes in the berry juice. The film should be stained bright purple/pink. If any white  $\text{TiO}_2$  remains, return the slide back to the juice for another 10 minutes. (You can go onto Part 2 while you wait for the slide to stain)
5. Lift the slide out of the juice using tweezers. Rinse the slide first with distilled water, then rinse with ethanol. Blot the slide dry with a tissue.

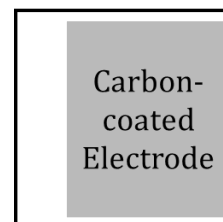
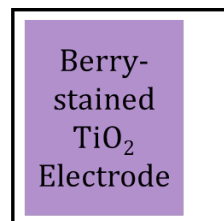
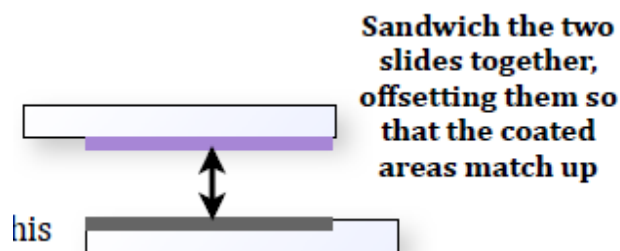
### Part 2: Carbon Coating the Counter Electrode

1. Determine the conductive side of a FTO coated glass slide using a multimeter. Set the meter to measure Ohms and put both leads on one side of the slide, if the resistance measured is near zero, that is the conductive side.
2. Place a piece of tape over one edge, covering about 4mm of the slide
3. Use a graphite pencil to cover the conductive side with a thin layer of graphite (conductive carbon) and remove the tape.
4. The carbon coating is fragile and can be easily rubbed off. Be careful not to touch it.

This carbon acts as a **catalyst** for converting triiodide to iodide. A catalyst is a substance that increases the rate of reaction without being consumed.

### Part 3: Assembling the Solar Cell

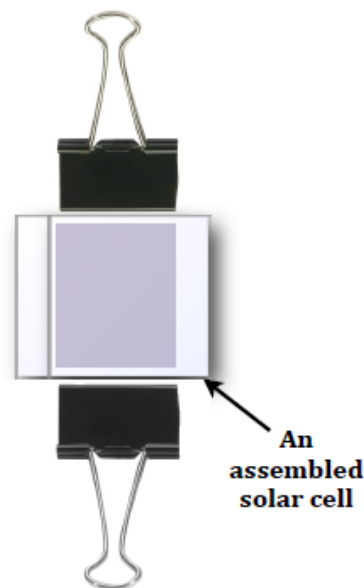
1. The berry-stained  $\text{TiO}_2$  slide and the carbon-coated slide will be sandwiched together to make the solar cell.
2. Identify the clean 4mm strip on each slide. These strips will be connected to alligator clips to test your cell. Orient the strips so that are on opposite sides as shown.
3. Place the carbon-coated slide on the table face up. Place the berry-stained slide on top of it so that the coated areas match up and are touching with a 4 mm strip on each side, shown below.



4. Pick up the slides in this orientation, careful not to let them move. Clip the edges (the two without the 4mm strips) with binder clips to hold the cell together.
5. Remove one binder clip and place 1 or 2 drops of iodine electrolyte solution at the edge of the slides. Re-clip the slides together.
6. Alternately open and close each side of the solar cell by releasing and returning the binder clips. Make sure that all the stained area is wetted with this solution. Make sure the binder clips are just on the edge of the cell not covering the coated area.
7. Wipe off excess electrolyte solution with a small amount of ethanol on a tissue. Make sure there is no electrolyte solution on the 4mm strips where the alligator clips will attach.

### Part 4: Testing Your Solar Cell

1. Use a multimeter and attach the alligator clips to your cell: one clip on each side.
2. Turn the multimeter to measure current (A). Note the current before placing your cell under the lamp.
3. Place your device under the lamp and write down the current measured.
4. Turn the multimeter to measure voltage (V) and note this value with and without the light.



***If the numbers changed you successfully made a working solar cell!***

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### Extensions:

Try other types of berries, synthetic dyes or food colorings. See if thickness of the coating makes a difference.

### Resources

<https://www.youtube.com/watch?v=tnK3z6s21j4>

<https://www.youtube.com/watch?v=Qbsl1NP5uZI&t=13s>

### Alternative Device Instructions

[Wisconsin MRSEC TiO<sub>2</sub> Example](#)

[Office of Energy Efficiency and Renewable Energy \(EERE\) lesson plans](#)

[Exploratorium version](#)

[Solideas version](#)

### Source

[Institute for Chemical Education - Nanocrystalline Solar Cell Kit](#)