# Nanocrystalline Solar Cell: Harnessing Light Energy

**Overview**

In this activity students will learn about solar cells and be able to construct their own nanocrystalline solar cell. They can then test and measure their cell's electrical output. This activity starts with a review of photosynthesis and then discusses bio-mimicry. Engineers use solar cells to mimic photosynthesis. After a short discussion about the different types of solar cells, students are given instructions to create their own nanocrystalline solar cell. This activity is appropriate for high school science classes and requires a teacher who is familiar with chemical safety.

**Objectives**

Students will be able to:

- describe similarities between photosynthesis and the technology used in solar cells.
- define biomimicry as the process of emulating nature in order to solve human problems.

**Oregon State Science Standards 2009**

Interaction and Change
7.2L.2: Explain the processes by which plants and animals obtain energy and materials for growth and metabolism.

Engineering Design
7.4D.3 Explain how new scientific knowledge can be used to develop new technologies and how new technologies can be used to generate new scientific knowledge.

8.4D.3 Explain how creating a new technology requires considering societal goals, costs, priorities, and trade-offs.

**Student Pre-requisite Knowledge**

Students should have some understanding of photosynthesis. Students should also be able to read and follow lab protocol and safety procedures. They need to wear gloves and goggles at all times.

## Materials

Each group needs:

- TiO2 coated conductive glass slide
- Clean conductive glass slide
- Iodine electrolyte solution
- 3 blackberries or raspberries
- Cheesecloth (or other material to strain berries)
- 2 binder clips
- Carbon art pencil
- 2 alligator clips
- Fork (plastic or metal)
- Petri dish (top and bottom)
- Deionized water in wash bottle
- Isopropanol in wash bottle

## Teacher Preparation

It is recommended that the instructor for this lesson have some chemistry background. This is especially important for preparing the $TiO_2$ coated slides. There are two different ways to prepare the $TiO_2$ paste and they can be found with the lesson attachments titled "$TiO_2$ Slide Preparation and Clean-Up" We prefer the 2$^{nd}$ method of paste preparation because it is easier to coat the slides although it does require a more advanced lab with sonification technology. The video demonstrating making the $TiO_2$ paste and coating the slides can be found here, http://www.youtube.com/watch?v=U7QuQYbIw4Y. The video demonstrating the assembly of the solar cell is here, http://www.youtube.com/watch?v=c-0dPlQKwfg.

## Procedure

1. **Anticipatory activity-** Show students a seed and a large plant. Ask the students how the seed grew into this large plant. Start a discussion about how plants are able to obtain light energy and convert it to energy they use to make their own food. This process is known as photosynthesis. You can show students the following simplified formula for photosynthesis:

$$\textbf{Sunlight} + H_2O + CO_2 \rightarrow \textbf{sugar (energy)} + O_2$$

There is a complex process known as the Calvin cycle that this equation does not describe. Just know that in order to create energy the process requires the movement of electrons. Electricity is defined as the movement of electrons. This process of photosynthesis can also be described as the ability for plants to use sunlight to move electrons. Now we must remember that the movement of electrons is electricity. We can now make a connection between photosynthesis and our modern solar panels.

2. Give the PowerPoint presentation titled Formal Solar Cell PowerPoint. There are notes on the power point that help to explain the similarities between the photosynthetic process and that of a solar panel.

One should also use the term biomimicry and explain its meaning. Students should be able to break the word into bio=life and mimic=to copy. Solar panels are examples of the engineering process known as biomimicry. Describe the two types of solar panels: silica (most prevalent) and nanocrystalline (newer technology). Silica solar cells are made of silica in its crystallized form. Silica solar panels are fairly expensive to make, however. The nanocrystalline solar cell, also called a dye sensitized solar cell, uses materials that are much less expensive: dye, titanium dioxide, carbon. Explain that a nanocrystalline solar cell has a pigment (like plants have chlorophyll) that absorbs light energy. Light energy excites electrons in the berry pigment which travel through the titanium dioxide then through the wire to the multi-meter that is then attached to the carbon on the other glass slide. The electrolyte solution is used to replace the lost electrons from the pigment and pick up the extra electrons in the carbon. If the solar cell is missing any of these components the electrons will not travel.

3. Divide the class into pairs. Each pair of students will make one solar cell.

4. Pass out the directions and supplies. Give the students time to read through the directions. Go over directions with students and answer any questions. Show students the supplies on each tray and name them. Show the students the difference between the titanium coated slide and the non-coated slide.

5. Students can begin constructing their solar cell.

   a. First mash up the berries in one of the Petri dishes and strain the berry juice into the other dish. Add a few drops of water to the berry juice.

   b. Place the $TiO_2$ slide coated side down onto the berry juice mixture let dye for 5-10 minutes.

   c. Determine the conductive side of the other glass slide with a multi-meter (set multi-meter to measure ohms and use probes to determine which has the least resistance, 1 being maximum resistance and less that one shows the conductive side)

   d. Using the carbon pencil apply a good amount of carbon to the conductive slide.

   e. Rinse the $TiO_2$ slide with deionized water and then isopropanol and blot dry.

   f. Place the two slides together with the $TiO_2$ and the carbon on the inside. Slides should be placed so that they are offset to create two ends to attach the alligator clips.

   g. Secure the sides with binder clips on the flush sides.

   h. Place a couple drops of the electrolyte solution on one of the offset edges where the two slides meet. Allow the electrolyte solution to seep in between the two slides.

   i. Attach alligator clips the offset edges of the solar cell.

6. After the cell is constructed, attach the alligator clips to the multi-meter and take it outside to test the electrical output of the cell. The best settings to use are 20V and 200mA.

7. **Closure**-Wrap up the activity with by having students input their data into a spreadsheet, or chart on the board. This will allow the class to look at the collective data. Discuss the data variations. Were any groups able to add more electrolytes and improve their readings? Did students notice that their electrical output decreased as the electrolyte dries. Ask students if they can think of ways to improve upon the solar cell design.

8. **Clean Up-** Have students clean up their areas. The Petri dishes will need to be washed. The slides for the solar cell can be reused. See the attachment titled “$TiO_2$ Slide Preparation and Clean-Up” for more information.

## <u>Extensions</u>

Students can attempt to increase the electrical output by connecting the slides in series and/or parallel. Attaching the slides in parallel should increase the voltage, while connecting them in series should increase the current.

## <u>Credits</u>

This activity is based upon the Nanocrystalline kit sold by the Institute of Chemical Education at the University of Wisconsin-Madison. They can be found on the web at http://ice.chem.wisc.edu/. We encourage you to explore their many activities and supplies.