West Side Science Club – Event #15– “Dye-Sensitized Solar Cells”

Original Presentation

Date: 29 June 2013
Time: 10 am to 12 pm
Site: West Side Science Club

Big Questions

- These questions are meant to frame the day’s event and might be written on the chalkboard

(1) What is solar energy?

(2) Why is using solar power a good idea?

Concepts

- Concepts to cover from the “Work of CCI Solar” Mind Map: Devices- design, cost-effectiveness; Reactions- redox, photochemistry; Social Aspects- climate change, green house gases, CO2, global energy demand, fossil fuels, renewable energy; Energy- batteries, fuels, conversions; Electricity- current, voltage, charge, electrons, V=IR, series/parallel; Light- absorption, transmission, wavelength, spectrum, energy

Lesson Plan

Student Objectives

- Introduce the students to solar cells and solar devices
- Connect the chemistry of past lessons to the earlier concepts of light and energy
- Learn new vocabulary (DSSC, solar power, semiconductor, dye, etc)

Schedule/Agenda

- Review: Event # 14– “Chemistry of Pranks and Gags ” (10 min.)
- Activity: DSSC (1h 40 min.)
- Wrap-up (10 min.)

Materials

Activity: DSSC

- 2 FTO glass electrodes (2.5cm x 2.5cm)
- TiO2 paste
- Blackberries
- Pencil
- I3-/I- electrolyte
- Binder clips
- Isopropanol
- Water
- Wash beaker
- Multimeter
- 2 alligator clips
- Strong light source
- Hot plate

Safety

- Goggles and gloves should be worn for the experiment to practice good lab hygiene

Activity: DSSC

Procedure

Part 1

1. Take one piece of conductive glass and ensure that the conductive side is facing up; do this by using the multimeter probes to measure resistance across two points on the glass surface. Ensure that the multimeter is set to resistance mode (Ω) on any setting. (*Carefully handle the sides of the glass electrodes and avoid touching the faces of the electrodes.*) If no resistance is measured turn the electrode over and measure again. Typical resistances should be around 10 – 30 ohms.

2. Tape the electrode down to a clean, sturdy surface so that the tape masks off ~1.5 cm (bigger is better) down along the length of the electrode (Figure 1a). This will create a masked off area on the electrode where the TiO_2 paste will be spread.

3. Using a pipette, drip a few drops of the TiO_2 solution in the center of the plate and immediately squeegee the solution down and up once with the side of the pipette. Aim for an even coating of the paste. If a TiO_2 film does not coat the entire exposed surface, quickly drip a few more drops of TiO_2 on the exposed areas and re-squeegee the entire film. Allow the electrodes to dry, undisturbed, for a few minutes.

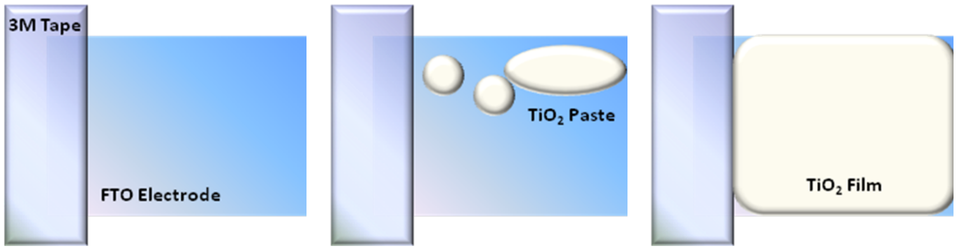


Figure 1. *Steps for depositing TiO_2 paste.*

4. Remove the Scotch tape from the dried TiO_2 electrode.

5. *A teacher will take the electrode to anneal (dry) on a hotplate.*

Part 2

1. Prepare the dye by thoroughly (but gently) crushing 1 blackberry in a plastic bag by squeezing the outside of the bag.

2. Take the TiO_2 coated glass electrode and place it into the blackberry juice in the bag for ~5 minutes. (*Use tweezers or tongs to handle the electrode.*) Be sure that the electrode is completely covered. The white TiO_2 paste should turn completely purple so there is no white left.

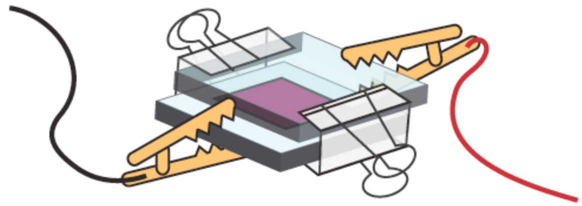
3. Rinse the blackberry pieces off the electrode with water and then isopropanol, catching the drippings in a glass beaker. Allow it to dry for 10 min.

4. While you wait, take your other piece of conductive glass—this will be the *counter electrode*. Use a multimeter to find the conductive side (see step 1). Use a pencil to coat the entire surface with graphite (pencil lead).

5. Assemble the dyed TiO_2 electrode with the counter electrode using 2 binder clips to form a sandwich. Make sure the graphite-coated electrode covers the purple dyed TiO_2 surface and avoid overlapping the bare glass electrodes (the part you covered with tape). The graphite-coated electrode should line up with the TiO_2 line but is offset so that an alligator clip can be attached to each individual electrode. The binder clips go on the edges that are not offset. (see picture below)

6. Carefully add the iodide/triiodide (I^-/I_3^-) electrolyte solution with a pipette to the seam of the two electrodes. Capillary action will pull the solution in and the space between the glass electrodes should turn slightly yellow and be entirely wetted by the solution.

7. To test your solar cell, clip the positive terminus (red) of the multimeter probe to the graphite electrode and negative terminus (black) to the TiO_2 electrode using alligator clips.



Facilitation Questions and Concepts

- What happens to the current and/or voltage when you cover the cell and block the light?
- Why does the cell work better outside in the sun or by the strong lamp?
- How powerful is your cell compared to the lemon batteries you made? Is that what you expected?

Check for Understanding

- How does your DSSC work?
- What are some ways you could think of improving it?

Wrap Up: End of the year!

- Goodbye to Caltech mentors until the fall

References

(1) : "Juice from Juice"
http://www.thesolararmy.org/jfromj