Dye-Sensitized Solar Cell Engineering Lab (Student Handout)
UCLA Nanotech Program - CNSI

Instructions: **Use these slides to answer the pre-lab questions 1-5**

PRE-LAB

1. What is a Dye Sensitized Solar Cell (DSSS)?

2. For each component of the DSSC, describe its purpose.

Component	Purpose in the solar cell
Titanium dioxide nanoparticles	
Dye (raspberry juice)	
Iodide electrolyte	

Using the virtual notebook and the slides provided answer the following:

3. According to the Next Generation Science (NGSS) cross-cutting concepts (ideas across science), what is the "cause" and what is the "effect" of this lab?
4. According to the "Patterns" segment of the NGSS cross-cutting concepts, what is the relationship between the dye and current (electrons flowing)?
5. According to the "Stability and change" segment of the NGSS cross-cutting concepts, what are two limitations to a dye-sensitized solar cell?

Lab Procedures:

Cleaning the Glass Plates

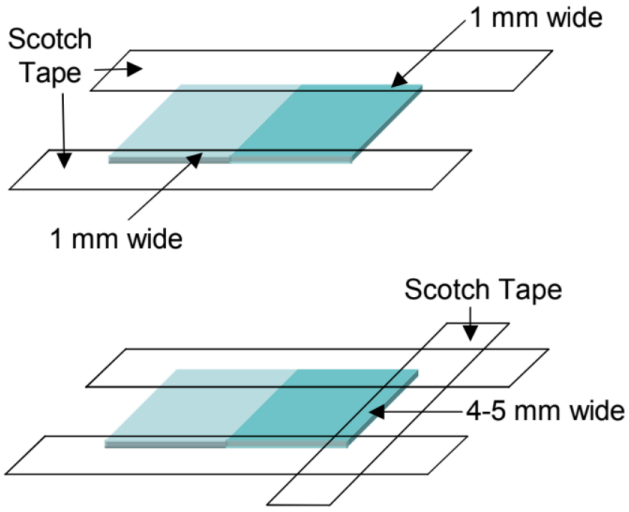
1. Obtain 2 glass plates and clean with ethanol. Do not touch the faces of the plates once they are cleaned!

Preparing the Glass Plates

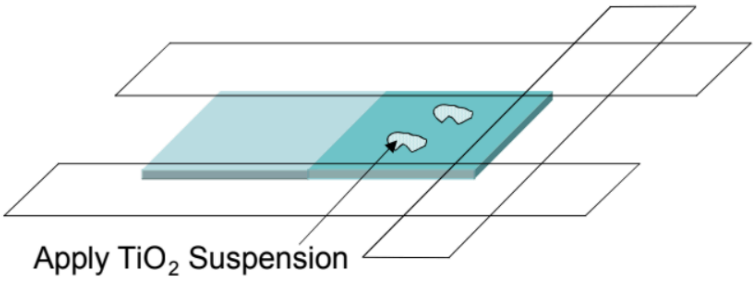
2. Determine which side of each glass plate is conducting with a multimeter. Turn the dial to 200 Ω, if you measure a "1" or no number at all and it means that side of the glass is nonconductive. If it measures something much higher, it means it's conductive.



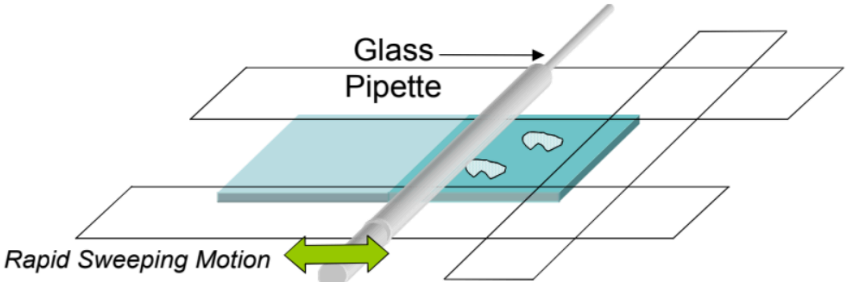
3. Put the glass plates side by side with one conducting side down (Plate B) and another conducting side up (Plate A)
4. Cover **1 mm** of each long edge of the plates with Scotch tape.
5. Cover **4-5 mm** of the short edge of Plate A with Scotch tape.



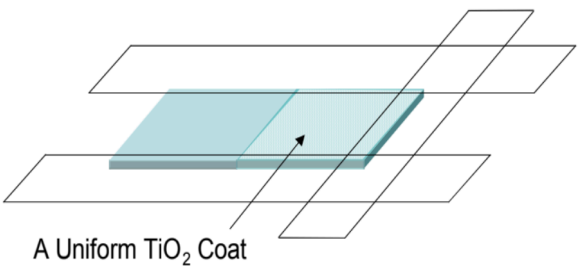
6. Add 4 drops of the white TiO_2 solution on Plate A close to the short edge of the Plate A near the tape.



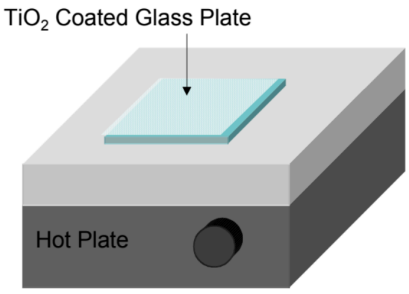
7. Place a glass pipette onto TiO_2 drops and spread the drops along the short length of Plate A by sliding the pipette back and forth as shown in the image below.



8. Slide (DO NOT ROLL) the pipette across Plate A with a thin film of TiO_2. See figure below. If it is not smooth and continuous across Plate A, wash the plates with ethanol and try again.



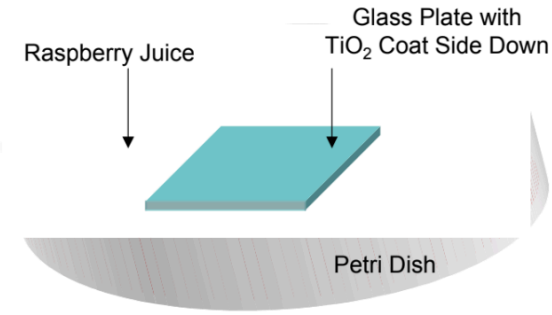
9. Remove the tape and place the TiO_2- coated glass on the hot plate, keeping track of where your plate is. Bake on the hot plate for ~ 20 minutes The other plate, Plate B, needs to be cleaned with ethanol, for now, it was just used as support for Plate A.



10. After 20 minutes, turn off the hot plate and allow Plate A to cool. While you are waiting, ensure there is quality in the pre-lab you wrote. Re-read the purpose of each component of the DSSC found in the pre-lab or you may also start on the post lab.

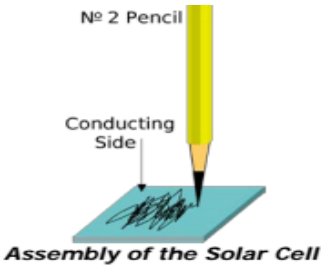
Staining of the TiO_2- Coated Glass with Raspberry Juice

1. Get your cooled TiO_2-coated glass plate from the hot plate where you left it.



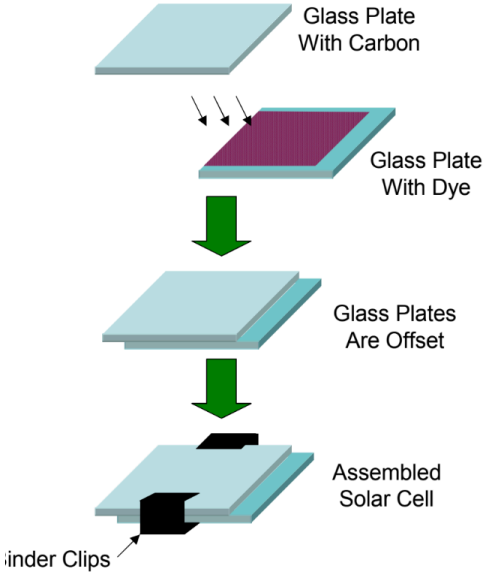
2. Place Plate A in a petri dish containing raspberry juice. Make sure the TiO_2 is fully submerged in the juice for 10 min.

3. Get Plate B that you cleaned with ethanol and use the multimeter to figure out which side is conducting. (See step 2 at the very beginning of the procedures)



Preparing the Carbon-Coated Glass Plate

4. Use a № 2 pencil to apply a thin carbon coating on the conductive side of Plate B. Don't miss any spots. **Complete steps 1 to 4 in less than 2 minutes.**



5. Remove the Plate A from the raspberry juice (after 10 minutes) and rinse it with deionized water, then with ethanol.

6. Gently blot dry with a wipe without removing any TiO_2

7. Place the carbon-coated glass plate face down on the TiO_2-coated glass plate (see figure on the right).

8. The two glass plates must be slightly offset (5 mm).

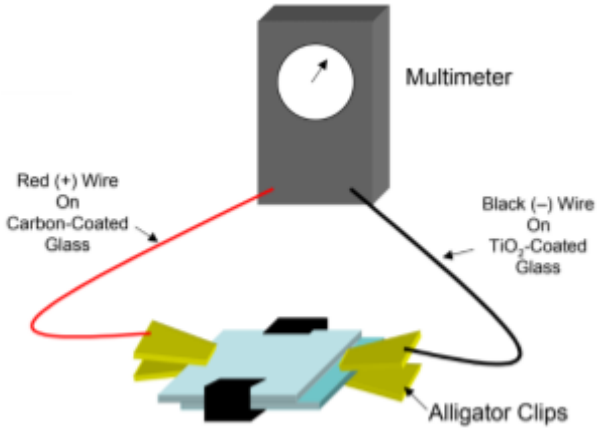
9. Hold the plates with binder clips on each side of the longer edges.

10. Add 2 drops of the iodide solution on an offset side and allow it to soak through.

11. Alternately open and close each side of the solar cell by releasing and returning the binder clips.

12. Make sure that all of the stained area is in contact with the iodide solution.

13. Wipe off excess iodide solution on the exposed area with wipes or tissue paper. This is important for making your solar cell work!



Measuring the Electrical Output

1. Fasten alligator clips to the two exposed sides of the solar cell to make an electrical contact (see figure on the left).

2. Attach the black (-) wire of the multimeter to the TiO_2-coated glass plate. This is the negative electrode.

3. Attach the red (+) wire of the multimeter to the carbon-coated glass plate. This is the positive electrode.

4. Place the solar cell on a light source.

5. Measure the voltage using DCV (direct current voltage) in millivolts (mV). Try "2000m"
6. Measure the time it takes for the current to dissipate over time. This would represent the reaction rate.

DATA COLLECTION

LIGHT SOURCE	**Maximum VOLTAGE (mV)**	**Reaction Rate (time)**
Inside Classroom/Building		
Direct Sun		
Shade		

- **The data collection table will depend on what variable(s) you chose to explore. The table should reflect those parameters meaning that the table above may need to be modified.**

CREATE A BAR GRAPH on Google Sheets

You get to choose what to include in this bar graph using the data above; if data doesn't make sense for some, you can omit - look for PATTERNS! Use the guide here on how to create a graph using spreadsheets. **Insert a graph of YOUR data below:**

Post-lab Discussion Questions

1. Predict what would happen if the titanium dioxide was spotty and uneven on the conductive side of the plate. See Pre-lab to help you.
2. Predict what would happen at the molecular level if the iodide dried up. Use the pre-lab table to help you! We've focused on structure and function a lot in this course! You can do this!
3. What were some VALID sources of error? (We didn't measure correctly is not a valid reason).
4. What is ONE limitation you can think of regarding the design of this experiment?
5. How might you be able to redesign this experiment to make it most efficient?
6. If the voltage fluctuates too much, what does that say about your titanium dioxide?

Extended Research CER

Prompt

Our climate is getting hotter and hotter over the years as a result of too much greenhouse gas emissions. Research how solar cells may help mitigate this global challenge. A claim has been provided.

Here are some points to consider:

1. Problem = meeting the global energetic demands of a growing world population while not contributing to higher global temperatures.
2. Goal = reducing GHGs and not harming a fragile economy is a challenge among countries (especially developing countries).

3. Things to consider: safety, affordability, and effectiveness.

Claim: Renewable energies such as **solar cells** can solve our climate change crisis when we consider safety, reliability, cost, and acceptance from developed and developing countries around the world.

Evidence #1 (Quantitative data aka numbers from lab)

Evidence #2 (research solar energy benefits on the internet. You may review evidence-based articles from World101 as your SECOND evidence)

Evidence #3 (Include another pro or benefit to solar panels/cells from the internet, be sure to cite your source)

Reasoning (3-5 sentences, ensure reasoning addresses the "why it matters" AND ensure everything ties to the prompt - think about tradeoffs, cost, effectiveness, cleanliness, or our daily lives…)