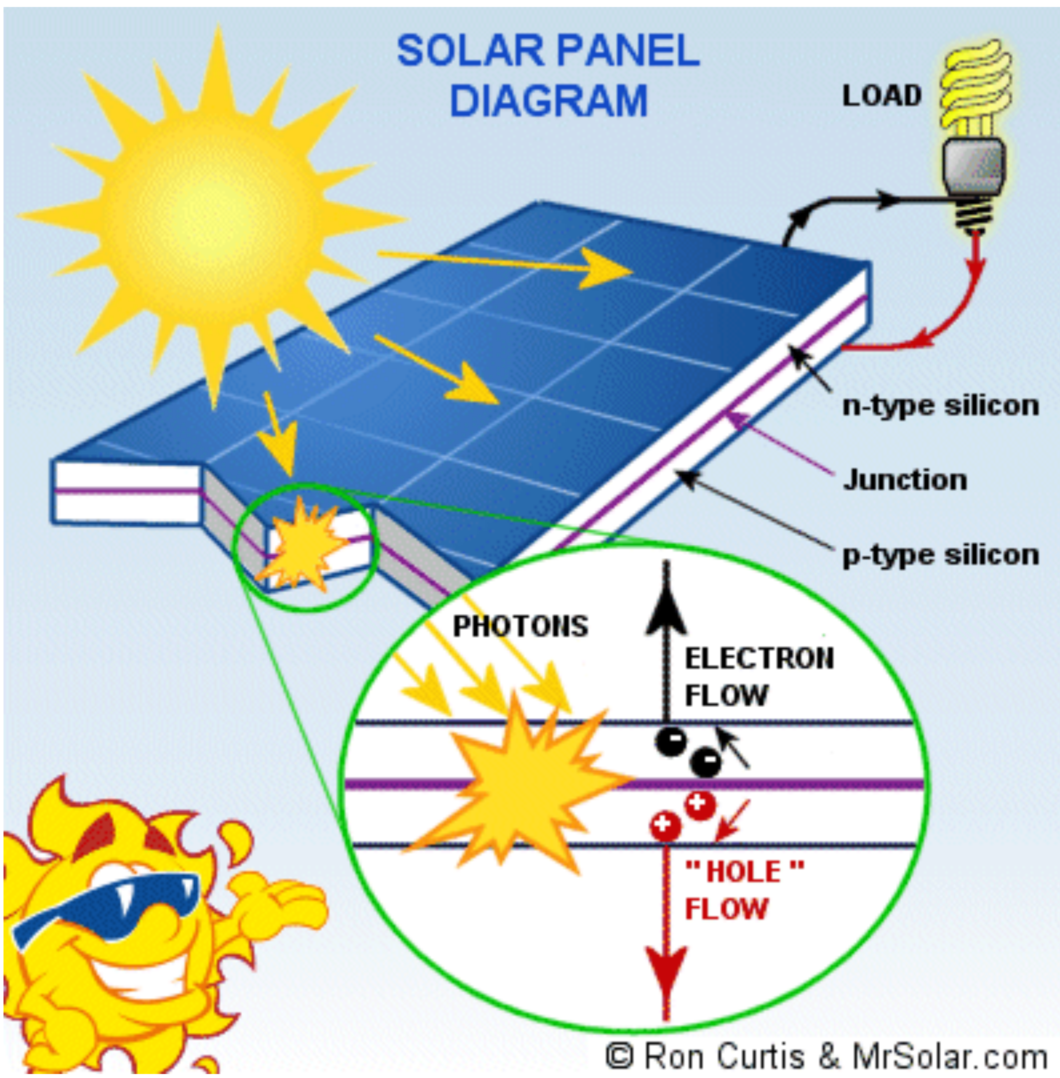
1. Raspberry Solar Cell

1.1. Photovoltaic devices

Photovoltaic cells, also called solar cells, are devices that create electricity directly from light. These devices work by exciting electrons in a material by the absorption of light. The electrons are then driven through an external circuit and brought back into the material at the original lower energy state. This allows for the output of current and voltage. The most common type is made from silicon in a process similar to the way computer chips are made and requires large expensive factories. One possible alternative to silicon cells is dye-sensitized cells, which are less efficient, but are far less expensive to manufacture. The dye absorbs light and transfers the excited electrons to the titanium dioxide. The titanium dioxide semiconductor material separates the charge. The I^-/I_3^- redox couple completes the circuit. In this lab, we will use raspberry juice to construct a simple dye-sensitized solar cell and measure the electricity the cell produces.



1.2. Raspberry Dye-sensitized solar cell

Objective:

- Construct a dye-sensitized solar cell from raspberries
- Gain an understanding of the components that make up a photovoltaic device and methods of device characterization

Material:

- Frozen raspberries
- TiOx powder
- ITO glass slides
- Glass slides
- Solar simulator
- Eye protection
- Binder clips
- Multimeter

Procedure:

Figure 12. Raspberries

1. Identify the conducting side of a tin oxide-coated piece of glass by using a multimeter to measure resistance. The conducting side will have a resistance of 20-30 ohms.
2. With the conducting side up, tape the glass on three sides to the center of a spill tray using one thickness of tape. Wipe off any fingerprints or oils using a tissue wet with ethanol.
3. Opposite sides of tape will serve as a spacer (see below) so the tape should be flat and not wrinkled. The third side of tape gives an uncoated portion where an aligator clip will be connected.
4. Add a small amount of titanium dioxide paste and quickly spread by pushing down and across with a microscope slide before the paste dries. The tape serves as a 40-50 micrometer spacer to control the thickness of the titanium dioxide layer if you push down.
5. Carefully remove the tape without scratching the TiO_2 coating. Leave the removed tape in a spill tray for disposal.
6. Heat the glass on a hotplate in a hood for 10-20 minutes. The surface turns brown as the organic solvent and surfactant dries and burns off to produce a white or green sintered titanium dioxide coating. (Note: this requires a plate that gets quite hot.) Allow the glass to slowly cool by turning off the hotplate. The sample will look quite similar before and after heating; you only know it is done if you have observed the darkening stage along the way.
7. Immerse the coating in a source of anthocyanins, such as raspberry juice. The raspberry juice may be obtained from frozen raspberries. (Blackberries, pomegranate

seeds, and Bing cherries can also be used.) The white TiO_2 will change color as the dye is absorbed and complexed to the Ti(IV).

8. Rinse gently with water to remove any berry solids and then with ethanol to remove water from the porous TiO_2. The ethanol should have evaporated before the cell is assembled.
9. Pass a second piece of tin oxide glass, conducting side down, through a candle flame to coat the conducting side with carbon (soot). For best results, pass the glass piece quickly and repeatedly through the middle part of the flame.
10. Wipe off the carbon along the perimeter of three sides of the carbon-coated glass plate using a dry cotton swab.
11. Assemble the two glass plates with coated sides together, but offset so that *uncoated glass extends beyond the sandwich*. Do not rub or slide the plates. Clamp the plates together with binder clips.
12. Add a drop of a triiodide solution to opposite edges of the plate. Capillary action will cause the KI_3 solution to travel between the two plates. (The KI_3 electrolyte solution consists of 0.5 M KI and 0.05 M I_2 in anhydrous ethylene glycol.) The solution can corrode the aligator clips in the next step so wipe off any excess.
13. Connect a multimeter using an alligator clip to each plate (the negative electrode is the TiO_2 coated glass and the positive electrode is the carbon coated glass).
14. Test the current and voltage produced by solar illumination

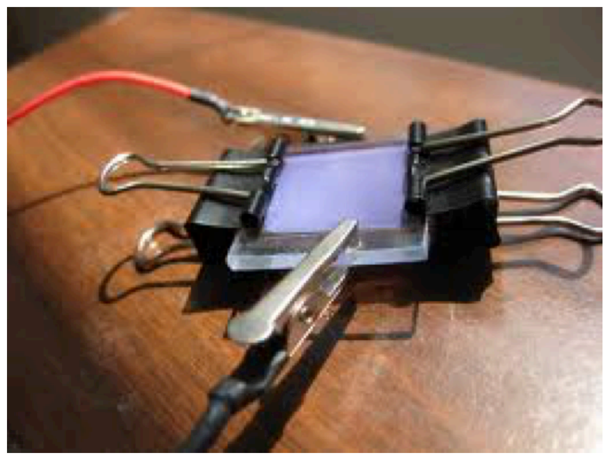


Figure 13. Example raspberry solar cell

Questions

- Did your solar cell work? Include the current and voltage (with units) produced by your solar cell in your conclusions. How much power is produced? (energy/time = volts x amps = watts)
- What area of solar cell would be needed to produce 1 watt? (Assume the voltage produced is constant and that the current would be proportional to the area of the solar cell.)
- Gather together all the cells you and your classmates made. How would you assemble them together to produce a maximum voltage? What about a maximum current? What voltage and current did you get for each assemblage? Which gives the most power?
- What is the function of each part of the solar cell you built? One way to answer this question is to follow the path of an electron through the complete circuit.
- How could you improve the efficiency of your solar cell?