Developing a General Chemistry Laboratory Procedure to Construct and Characterize Perovskite Solar Cells

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MADISON AREA TECHNICAL COLLEGE

Objective

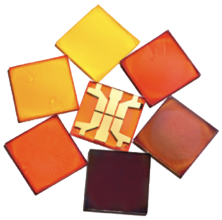


Image Credit: *Scientific American*

Our goal is to develop an affordable lab activity for undergraduate students to fabricate and test the performance of perovskite solar cells.

Perovskite-Based Solar Cells

Structure of a Perovskite

- Chemical formula **ABX_3**
  - A larger metal cation (e.g. Ca^{2+})
  - B smaller metal cation (e.g. Ti^{4+})
  - X typically oxygen
- The most common perovskite light absorber in solar cells is **$CH_3NH_3PbX_3$** with X as I^-, Br^-, or Cl^-.

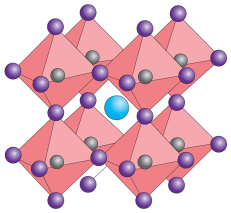


Image Credit: *NPG*

Progress in Research Cell Efficiencies Over Time

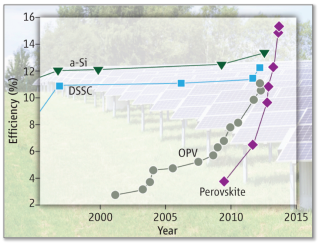


Image Credit: *Science Magazine*

Advantages

- Low production costs
- Simple to manufacture
- High efficiency (17.9% as of 2015)
- Earth abundant materials

Disadvantages

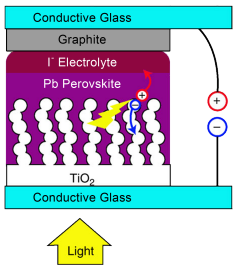
- Degrades in humid environments
- Difficult to make large continuous films
- Contains toxic materials (lead)

Constructing the Cell

The architecture for my current version of the cell is based on that of a dye-sensitized solar cell.

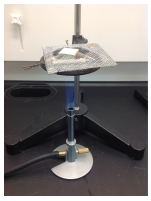
By using a liquid electrolyte instead of a typical hole transport layer, I have eliminated the need for DPS, a hazardous solvent.

Current Cell Structure

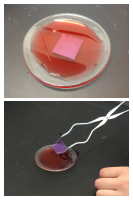


Experimental Work

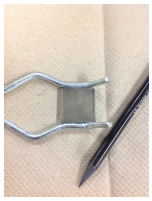
Dye-Sensitized Solar Cell



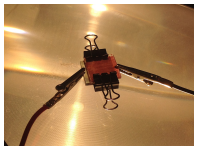
Titanium dioxide suspension coating on conductive glass.



Glass soaking in raspberry juice to bond dye to TiO_2.

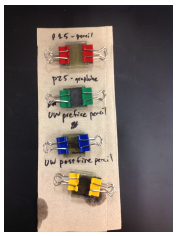


Graphite coating on second piece of conductive glass.

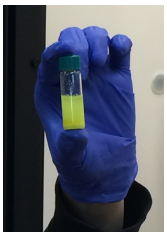


Iodide electrolyte between glass pieces (coated sides together) hooked up to a multimeter.

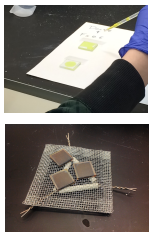
Perovskite Solar Cell



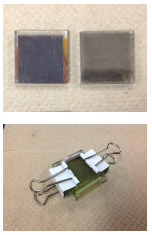
12 different versions of the cell were tested; 3 proved functional; proceeded with trials for most efficient cell design.



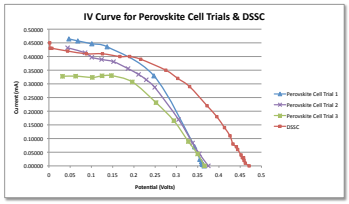
Perovskite solution, $CH_3NH_3PbCl_3$.

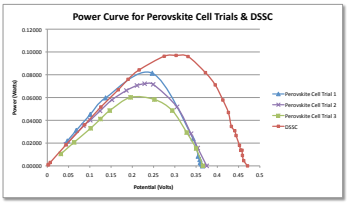


Perovskite layer added to TiO_2-coated conductive glass (top); glass after firing (bottom).



Graphite coated on second piece of glass (top right); fully assembled cell with I⁻ electrolyte (bottom).





Future Work

I. Continue to minimize use of hazardous materials
II. Finalize lab procedure
III. Write lab instructions for student use
IV. Write and submit journal article for publication

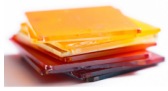


Image Credit: Oxford PV

Acknowledgements

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