Enhancing Solar Cell Performance with Silver Nanoparticles

Kilian Anderson, Sam Carani, Justin Cathey, Nate Engstrom, Sean Keane, Daniel Loya
Outline

Introduction

Background Information

Hypothesis

Specific objectives/Conceptual approaches

Experimental procedures

Results and discussion/observation

http://www.nickjr.co.uk/_/grownups/sites/default/files/article-images/science-experiments.jpg
Introduction

Our group wanted to answer the question: What method of applying silver nanoparticles to poly(4-vinyl pyridine) (PVP) will produce the most energy output in a dye sensitized solar cell (DSSC)?
Dye Sensitized Solar Cell

- DSSC uses titanium dioxide (TiO$_2$) coated with a photoactive dye on top of a tin coated glass slide to generate electricity.
How a Dye Sensitized Solar Cell Works
Background Information

We designed and conduct an experiment using poly(4-vinylpyridine) (PVP) to attach silver nanoparticles to a DSSC.

The silver nanoparticles exhibit plasmon resonance.

This process causes light waves to bounce around in the semiconductor layer.
Hypothesis

The solid nanoparticles mixed with 1% PVP solution will produce the maximum energy output in a dye sensitized solar cell (DSSC).
Hypothesis Justification

The PVP contains Nitrogen and Oxygen, which bind to Ag particles. The solid nanoparticles are more readily available to bind with the PVP. The water in the colloidal nanoparticles will cause the PVP to aggregate. This happens because PVP does not significantly disperse in water.
Specific Objectives

To achieve the highest energy output by determining which method of coating nanoparticles in a DSSC is the best.
Conceptual approach

The PVP is an adhesive that can bind silver particles to a DSSC.

We wanted to form a thin layer on the DSSC.

The silver nanoparticles are light amplifiers for certain wavelengths.

This can increase the energy output of the DSSC.
Conceptual approach (continued)

The PVP was layered on the solar cell with silver nanoparticles on top. (Picture on the left).

The silver nanoparticles were either in a colloidal or solid state with PVP coating. The PVP coated silver then bonded to the titanium and dye surface. (Picture on the right).

Y shape is PVP viewed on axis
Experimental Procedure 1

1% PVP mixed with colloidal silver nanoparticles

Sonicate

Centrifuge and decant

Re Diluted with 200 proof ethanol and sonicate

Soak anode of DSSC with solution.
Experimental Procedures 2

Centrifuge/decant colloidal nanoparticles to create solid nanoparticles

Mix with 1% PVP

Sonicate

Centrifuge/decant again

Re dilute with 200 proof ethanol and sonicate

Soak anode of DSSC
Experimental Procedures 3

Take 1% PVP and soak the anode of the DSSC

Wash and anneal

Soak anode in colloidal silver

Wash with DI water

Test
Results and discussion

The Ag/PVP/ethanol solution had excess PVP dispersed.

We tried to resolve this through centrifuging the silver nanoparticles out.

The solid nanoparticles that appeared became clear when they were put into the ethanol.
We concluded we could not make a solution concentrated enough.
Results and discussion (continued)

Not enough PVP coated Ag nanoparticles, the excess stuck to the solar cell.

Excess PVP, without Ag coating, on the solar cell hinders the energy output.

A thick coating of PVP was left on the glass slide because the ethanol had evaporated overnight. (Top Picture).

Sonication helped PVP coat the silver.
Results and discussion (continued)

Dye-Sensitized Solar Cell Energy Output

<table>
<thead>
<tr>
<th>Type of Solar Cell</th>
<th>Ambient (V)</th>
<th>Test Light (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control DSSC</td>
<td>0.20</td>
<td>0.34</td>
</tr>
<tr>
<td>Silver Nanoparticle DSSC #1</td>
<td>0.17</td>
<td>0.22</td>
</tr>
<tr>
<td>Silver Nanoparticle DSSC #2</td>
<td>0.18</td>
<td>0.26</td>
</tr>
</tbody>
</table>
Conclusion and future work

The DSSC with layered PVP and silver nanoparticles had a lower energy output than the control DSSC. A few reasons might be…

- Glass slides were not plasma cleaned.
- PVP was insulating.
- The test light’s wavelength might have been past the silver nanoparticles peak absorbance.
- We need to conduct more tests
Conclusion and future work (continued)

Use different substances in the place of silver to see the effect it has on the solar cell.
Such substances include:
- Quantum Dots
- Gold Nanoparticles
- Other Noble Metals
Also, PVP coated nanoparticles should be more concentrated so they bind to the DSSC.
Acknowledgements

Thank you Dr. Korampally for all of your guidance and teaching us about nanotechnology for two weeks.

A special thanks to National Science Foundation for funding this research opportunity.

Thank you Dr. Hayman, Dr. Tahernezhadi, Tracy, Liz, Corey, Mohammed, and the rest of the PROMISE staff for all of their hard work in putting this together.

https://www.youtube.com/watch?v=3KHJSOgzew


http://gcell.com/dye-sensitized-solar-cell


Questions?