Photovoltaics: Cu_2S Synthesis, Solar Cell Efficiencies, and Applications

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CENTER FOR SUSTAINABLE ENERGY AT NOTRE DAME

Research Proposal

While there are currently many different methods of solar cell production, the need to make them as efficient as possible is the primary goal. In the same manner as energetic efficiency, economic and materialistic efficiency are factors that are playing ever increasing roles in the manufacturing schema of the solar cell. Given the significance manufacturing solar cells using widely available, low cost materials while maximizing efficiencies, the goal of the research was to make solar cells that accomplish all of the aforementioned criteria. Finally, the research concepts will be transitioned into the high school chemistry classroom.

Curricular Application

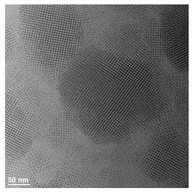
- Awareness to the need for alternative forms of energy is quickly increasing. Because of this, solar cells are becoming much more prevalent. It is important to understand WHY they are being used, HOW they operate, and WHAT is the level of efficiency.
- From here the following concepts can be addressed
  - Why solar cells – significance, potential offerings/benefits
  - How do you make a solar cell (components, roles, connectivity)
  - Materials (preferential selection, balance of “give and take”)
  - Production (measured quantities – I, V, P)
  - Limitations (efficiency – why not 100%, comparing to processing by plants)

Curricular Activity

- Students will be engaged in a unit of study focused on photovoltaics – solar energy. During this unit, a focus will be placed on discussing and gaining an understanding for why solar energy is necessary, the process of turning solar energy into electricity, and how this process is applied using various materials and apparatuses
- Students will construct a dye-sensitized solar cell (DSSC) with the option to choose their light absorber [independent variable]. Upon completion of construction, the solar cells will be tested for voltage, current, and ultimately power and efficiency.

Research Focus

Show Stopper Copper (Cu_2S) – readily available, low cost solar cell component

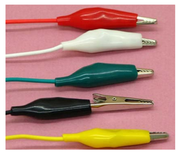


- Optimization of the synthetic procedure for Cu_2S nanocrystals (image at left).
- Determining if synthesized Cu_2S nanocrystals will lead to increased efficiencies when incorporated into the current methodologies of solar cell production

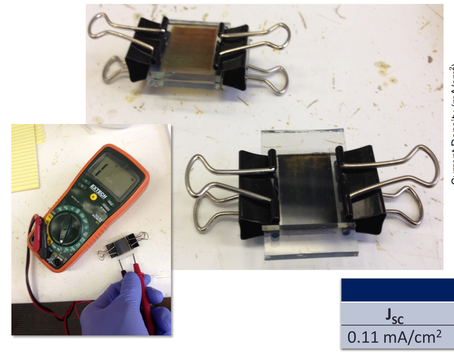
T_2T – Transitioning to Teaching

- Understanding the concepts and methods of solar cell manufacturing and functioning will provide insights for how to share these things in the high school class room
- Solar cell production in the collegiate, university level lab will provide methods to build solar cells In the high school laboratory

Curriculum Process

Mark Connections	Curricular Apply	Active Apply	Report Back
			
Connecting discussion introducing alternative forms of energy – solar cells	Using prior knowledge to apply chemical concepts to the structure and function of solar cells	Take knowledge and connections and construct a working solar cell	Testing the function and outputs of the solar cells Discuss the reasons for the results

Curricular Apparatus

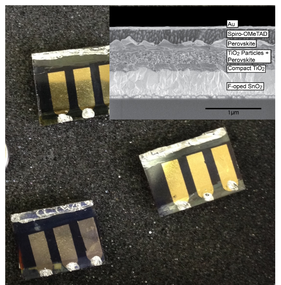


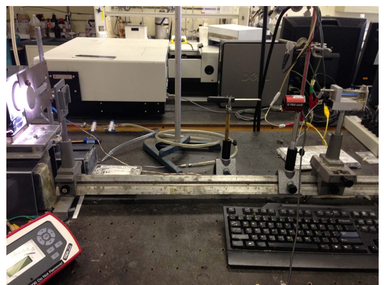
Black Cherry Tea DSSC			
J_{SC}	V_{OC}	Fill Factor	Efficiency
0.11 mA/cm²	0.330 V	0.40	0.015 %

DSSC’s will be constructed by the students with allowance to select various photoabsorbers. Constructed DSSC will be tested using a multimeter to ultimately determine levels of voltage and current.

Assembly & Analysis

Picture of constructed solar cells with scanning electron microscope cross section image of a cell (left). Cells attached to circuit for analysis using a xenon lamp solar simulator





Conclusions

- Fabricated control solar cells [not using Cu_2S nanocrystals] were fully functional, and efficiencies over 7% were obtained.
- Cu_2S nanocrystals were successfully synthesized. The synthetic procedure was modified to improve reproducibility.
- TEM analysis showed Cu_2S particles form a superlattice, a crystalline “particle of particles” with particles acting as atoms.
- Further work is being carried out using SEM to guide the implementation of Cu_2S in solar cells.
- The curriculum procedure has been revised and tested. Initial results have been very promising in that the DSSC’s are fully functional, conductive, and emit low voltages.

Acknowledgements

Prof. Kamat – Thank you for providing me with the opportunity to learn, study, and research with you and the Lab Rats. You are truly a gifted man with an ability to teach, model, and chastise in the same sentence and while making everyone laugh. I admire how you lead, teach, and inspire! May there be a softball championship in your future!

Lab Rats! – Wow! What a family! You all have been so gracious and so supportive. The work never ceases and neither do the laughs and the enjoyment of each other. Thank you for taking me in and even letting me play softball! I hope the smell in 206 goes away. Believe-land!

Jeff – hank ou or ll ou ave one. I annot egin o xpress ow uch I ave earned nd he omfort/onfidence I ave ained n o any reas. Ou ave a pecial ift o each, hare, nd upport, hile ixing n ons f un! I ish ou ll he est nd ope o eep n ouch! ay our eading enter or nts e a uccess!