

The Maryanoff Freshman Summer Research Program Chemistry in the College of Arts and Sciences

The **Maryanoff Freshman Summer Research Program** provides support for students for a period of up to ten (10) weeks to do **research in chemistry** at Drexel University. **The stipend is \$4000.** Please note, summer lodging **will be** provided this year. This program is open to all Drexel students who are freshmen in the academic year 2014-2015 and who are enrolled in the following majors: **Biological Sciences, Chemistry, Environmental Science, Environmental Studies, Geosciences, Mathematics, Nutrition Science, Physics, Psychology and Science (undecided).** After the completion of the research, the students are each required to make a 10-minute power point presentation (date to be determined) to the donors, Drs. Bruce and Cynthia Maryanoff.

The items required in the application are as follows:

1. **A short (one page or less) essay** on why you, the applicant, wish to be involved in research. Be sure to include your name, university ID number and major at the top of your word document.
2. **Identification of the *first, second and third* choice of the research project** on which you wish to work, chosen from the following areas of research:

A. Inorganic Chemistry (Dr. A.W. Addison)

B. Materials Chemistry (Dr. Frank Ji)

C. Nanoscience (Dr. Aaron Fafarman)

*****Please see the attachments for complete descriptions of the projects offered*****

3. **Declaration of the time period over which you are available to conduct research.** Typically, the work would start in mid-to-late June and would terminate ten weeks later and prior to the beginning of the 2015 fall term. This is to be considered a full-time position for ten weeks. If only nine weeks are possible for the student, the stipend will be pro-rated.

Applications are due on or before March 31, 2015 for full consideration. Awardees will be notified by the end of April 2015.

Please e-mail your application to:

Dr. Jun Xi, Chemistry Department
jx35@drexel.edu

Proposal for Maryanoff 2015 Summer Research Program.

Prof. A. W. Addison.

Do iridium salts induce the photo/electro-oxidation of water, or just catalyze the decomposition of periodate ?

This is a proposal that seeks to test a finding in the older chemical literature, that some metals' salts catalyze the decomposition of periodate ion (IO_4^-) to iodate (IO_3^-) and oxygen.

The significance of this is that several recent papers utilize iridium compounds as photocatalysts or electrochemical catalysts for the production of oxygen from water - a very active area of current research. The connection with periodate is that several such experiments have used periodate as an oxidant (terminal electron acceptor) with the stated purpose of regenerating the high oxidation state of the iridium catalysts.

The procedure involved will utilize an oxygen-sensing electrode in aqueous media, to study the potential decomposition of periodate by various metal salts.

Copper Chalcogenide Nanocrystal Building-Blocks for Low-Cost Solar Cells

The need for sustainable, scalable approaches to powering our society presents the most pressing technological challenge of our day. In order to drive dramatic reduction in the cost of solar cell manufacturing, we employ semiconducting nanocrystal colloids (i.e. nanocrystals dispersed in a solvent) as building-blocks for the light-absorbing layer. This liquid starting-material can be rapidly and inexpensively processed like an ink to form a solid. Such an approach can be scaled to a tremendous production volume.

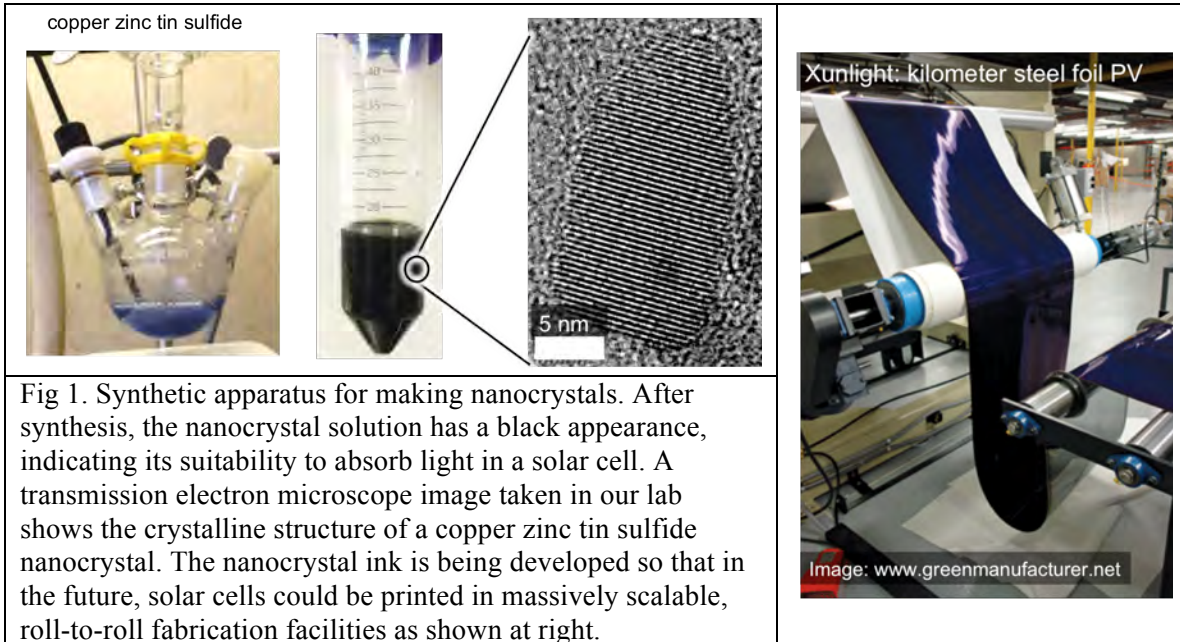


Fig 1. Synthetic apparatus for making nanocrystals. After synthesis, the nanocrystal solution has a black appearance, indicating its suitability to absorb light in a solar cell. A transmission electron microscope image taken in our lab shows the crystalline structure of a copper zinc tin sulfide nanocrystal. The nanocrystal ink is being developed so that in the future, solar cells could be printed in massively scalable, roll-to-roll fabrication facilities as shown at right.

The student selected for this project will synthesize the copper chalcogenide nanocrystals, copper indium selenide and copper zinc tin sulfide (shown in Fig 1), using simple chemistry. In addition to synthetic methods, the student will learn how to perform spectroscopic characterization of the nanocrystals in solution and in the solid state, and electrical characterization techniques to understand the suitability of the materials for device applications.

The presence of high temperatures, flammable chemicals and delicate equipment in the lab necessitate that the candidate be careful, dexterous and mindful of safety. The goal of this project is to produce publishable scientific discoveries while pushing this promising technology closer to realization. Please contact Professor Fafarman directly for more details at fafarman@drexel.edu.



Ultimately we are seeking technological solutions that can scale to meet society's tremendous demands for electrical power at costs that compete with fossil fuels.

Novel Porous Metal Organic Framework (MOF) Materials for CO₂ uptake and other energy applications

Recently, we were funded by Drexel-SARI to develop new porous MOF materials for CO₂ uptake. The project focuses on development of novel porous materials based on metal-organic-frameworks (MOF) for CO₂ uptake and other applications in the energy field, such as CO₂ catalytic reaction to methanol, methanol based fuel cells, etc. We aim to demonstrate a level of control over the unique structure and properties of MOF nanowires using a convenient approach that is unmatched by current methods. The specific aim of the project in the summer is to synthesis and characterization of novel MOF materials. This project falls in the categories of sustainable energy and sustainable chemistry. Successful completion of the project will lead to new families of MOF materials for applications in CO₂ uptake, conversion, fuel cells, etc. The study of these new materials will lead not only to advances of knowledge in this field, but may also their commercialization.

We would like to have an undergraduate student to work on this project in the summer. Experience not needed, but the student should be interested in and dedicated to the research project. The student is not allowed to take any summer classes in the summer. The student will gain knowledge in nanostructure fabrication and characterization, UV, Fluorescence, surface area measurement, thermal analysis, scanning electron microscopy, x-ray crystal diffraction, electron chemistry, and maybe modeling as well.

Background and Scientific Significance:

Carbon dioxide (CO₂) is the primary greenhouse gas emitted through human activities.^{i,ii} In 2011, CO₂ accounted for about 84% of all U.S. greenhouse gas emissions. CO₂ capture and sequestration is a set of technologies that can potentially greatly reduce CO₂ emissions from new and existing coal- and gas-fired power plants, industrial processes, and other stationary sources of CO₂. Current methods for CO₂ removal can actually use up to 30% of the power produced by power plants, a significant penalty. Given the large quantity of CO₂ that must be removed, materials should hold large densities of CO₂ in order to minimize the amount of adsorbent in the system.

Metal-Organic frameworks (MOF),ⁱⁱⁱ 3D network materials with large internal surface areas and tunable properties, offer distinct advantages over other CO₂ adsorbent materials. Despite promise for effective CO₂ uptake, technical challenges facing the industries include: a) the need to improve mechanical stability of the MOF materials for industrial usage. b) lower adsorption capacity under lower-pressure at ambient temperature; The development of lower pressure CO₂ capture applications is crucial given the current engineering of coal burning power plants.^{iv}

We propose two strategies to improve CO₂ uptake and other applications based on the recent work of the PIs (Figure 1). fabrication of 1D MOF nanostructures with larger internal surface areas and growth of MOFs on supporting materials for enhanced mechanical strength. These strategies will be discussed further in the research section. The two strategies will be integrated or culminate in intersection during the collaborative study, which will generate new knowledge and new materials for the ultimate goal of CO₂ uptake, storage, removal, and conversions.

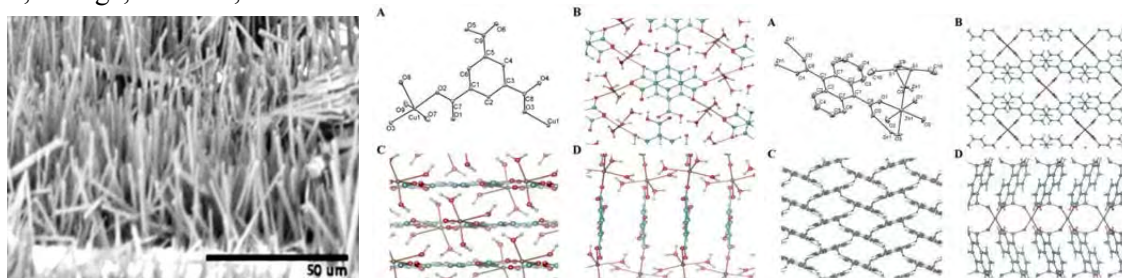


Figure 1. Left: SEM images of Cu(BTC)·3H₂O MOF crystals. Middle: Cu(BTC)·3H₂O crystallographic representations. Right: Zn(ADC)·DMSO crystallographic representations.

Contact:

Hai-Feng (Frank) Ji, Ph. D.
Associate Professor
Department of Chemistry
Drexel University
3141 Chestnut Street, Disque 507
Philadelphia, PA 19104
Phone: 215-895-2562
Fax: 215-895-1265
Email: hj56@drexel.edu

- ⁱ NRC (2010). Advancing the Science of Climate Change. National Research Council. The National Academies Press, Washington, DC, USA.
- ⁱⁱ U.S. Department of State (2007). Fourth Climate Action Report to the UN Framework Convention on Climate Change: Projected Greenhouse Gas Emissions. U.S. Department of State, Washington, DC, USA.
- ⁱⁱⁱ R. J. Kuppler, D. J. Timmons, Q.-R. Fang, J.-R. Li, T. a. Makal, M. D. Young, D. Yuan, D. Zhao, W. Zhuang, and H.-C. Zhou, *Coord. Chem. Rev.* **2009**, 253, 3042.
- ^{iv} H. Takeda, K. Koike, H. Inoue, O. Ishitani, “Development of an efficient photocatalytic system for CO₂ reduction using rhenium(I) complexes based on mechanistic studies.” *J. Am. Chem. Soc.* **2008**, 130, 2023.