Undergraduate Research Symposium May 18, 2018 Mary Gates Hall

Online Proceedings

POSTER SESSION 1

MGH 241, Easel 124

11:00 AM to 1:00 PM

Investigation of an InP/CoP Core Shell System for Photocatalytic Hydrogen Evolution

Nathan Legaspi Lai, Senior, Chemical Engineering
Mary Gates Scholar, UW Honors Program
Mentor: Brandi Cossairt, Chemistry
Mentor: Marja (Beth) Mundy, Chemistry

Current global population growth has led to higher demands for food production, increasing our reliance on synthetic fertilizers. These are formed via the Haber Process, where nitrogen from air and hydrogen (currently obtained from natural gas combustion) is used to produce the needed ammonia. More sustainable ways of generating hydrogen gas that don't involve burning fossil fuels are necessary. One possible replacement is nanoscale cobalt phosphide, a known, effective electrocatalyst for the hydrogen evolution reaction (HER), defined as transforming two protons and two electrons into hydrogen gas. However, this electrocatalytic system requires energy input to achieve the transformation. This project investigates the design of a synthesis to produce an indium phosphide/cobalt phosphide (InP/CoP) core/shell structure that can generate H_2 photocatalytically. The InP quantum dot will be used to generate a photoexcited electron using visible light, and then this photoexcited electron will be transferred to the CoP catalyst to perform the desired proton reduction step. Regeneration of the quantum dot ground state will be mediated through the use of a sacrificial electron donor. Here we present our findings evaluating several approaches to the colloidal synthesis of the desired core-shell heterostructure using an aminophosphine precursor and the corresponding metal halides. Success of the various syntheses was determined by examining data from multiple characterization techniques including UV-Vis spectroscopy, X-ray diffraction, electron microscopy, and elemental analysis. We expect these methods to be generalizable to a suite of electrocatalytically active transition metal phosphide shell materials. This work will ultimately contribute new methods to the sustainable production of hydrogen for industrial scale applications.

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MGH 241, Easel 125

11:00 AM to 1:00 PM

Photocatalytic Lignin Degradation Using Nanorod Heterostructures

Harrison Sarsito, Senior, Chemical Engineering
Mary Gates Scholar
Mentor: Brandi Cossairt, Chemistry
Mentor: Michael Enright, Chemistry

Increasing world energy consumption is accompanied by rising concerns over non-renewable fossil fuel usage and its detrimental environmental impacts. Even if we were to try to meet future energy demands exclusively with fossil fuels, we would fall woefully short of our projected global needs. Consequently, there are compelling economic and environmental reasons that support a dramatic shift in future energy utilization to renewable technologies. The development of solar-driven technologies to generate renewable, transportable, and storable fuel sources is desirable since these energy-dense fuels can be used in the future regardless of the time of day, season, or geographic location. My research explores the utilization of nanomaterials for solar energy-catalyzed biomass decomposition into fuels and valuable, small molecules with diverse industrial applications. Specifically, this work shows the potential of using nanomaterials of a variety of structures to convert lignin (which composes 20-30% of biomass) into more useful small molecule components. To do this, we strive to understand how to make a nanomaterial that both efficiently absorbs light and subsequently uses that absorbed energy to power lignin degradation. The ability of a nanomaterial to absorb light and catalyze this reaction depends on its electronic properties, which is dependent on both its elemental composition and morphology. Our work explores the various catalytic efficiencies of nanomaterial systems of different shapes and sizes.

POSTER SESSION 1

MGH 241, Easel 123

11:00 AM to 1:00 PM

Synthesizing Ni2P Nanoparticles with Surface Ligated Proton Relays

Noushyar (Noush) Panahpour Eslami, Senior, Chemistry (ACS Certified)
Mary Gates Scholar
Mentor: Brandi Cossairt, Chemistry
Mentor: David Ung, Solar Energy Technologies Office

Energy efficiency of important industrial chemical reactions is a motivation behind scientific research across a wide range of disciplines as a response to the growing energy crisis. Electrocatalysts play a crucial role in improving energy efficiency in the interconversion of electrical and chemical energy, and are essential components in any sustainable solar fuels conversion scheme. An issue in the widespread use of renewable energy sources is the fluctuation between energy demand and energy supply. This issue can be solved by using the renewable energy source to generate chemical fuels, storing the energy from the sun or wind in energy-dense chemical bonds to be released on-demand. One such fuel is molecular hydrogen, H2. Molecular [Ni(PNP)2]2+ catalysts are highly active catalysts for the hydrogen evolution reaction (HER) that employ pendant amines—an end group that assists with hydrogen production by allowing for efficient proton transfer. However, as molecular species, these catalysts suffer from low stability and low potential for scalability. The primary focus of this research is to develop an efficient nano-scale Ni2P synthesis based off prior syntheses in the literature, that incorporates cooperative ligands for HER on the surface. Our end goal is to determine the best method to synthesize Ni2P nanoparticles with enhanced activity due to the cooperative effects of pendant amine functionalities to create a nanomaterial catalyst with properties that meet and surpass the molecular [Ni(PNP)2]2+ catalysts for HER.