Online Proceedings

POSTER SESSION 2

Balcony, Easel 123

12:45 PM to 2:15 PM

Modeling the Reduction of Zinc Oxide Nanoparticles

Ashley Nicole Celevante (Ashley) Soria, Senior, Chemistry
Mentor: Carolyn Valdez, Chemistry
Mentor: James Mayer, Chemistry

Colloidal zinc oxide nanocrystals (NCs) become charged with electrons upon reduction with decamethylcobaltocene. Understanding this redox chemistry can further develop research on quantum dot sensitized solar cells and other various applications of NCs. The goal of my project is to determine whether this electron transfer can be characterized by an equilibrium constant K_eq, and if so, to see which variables in the reaction affect the K_eq. Two models were tested: (1) in which the concentration of NCs would affect the K_eq, and another (2) in which it would not. Using data from optical titrations, I found that the K_eq is affected by NC concentration and is therefore better described by model (1). Similarly, other variables are currently being tested in order to refine a working model that can accurately describe the reaction of NCs with reductants. The contribution of a simple model for these charge transfer processes can be applied to various areas.

SESSION 2D

CURRENT TOPICS IN BIOENGINEERING

Session Moderator: Elain Fu, Bioengineering

231 MGH

3:45 PM to 5:15 PM

* Note: Titles in order of presentation.

The Distribution and Influence on Properties of Small Levels of Organic Materials in Glass Sponges

John Jinwoo (John) Park, Senior, Materials Science & Engineering
Mentor: George Mayer, Materials Science & Engineering

Glass sponge spicules (elements of the skeleton) have been shown to exhibit unique energy dissipating characteristics which may be extendable to applications such as earthquake protection, deep-sea fiber optics, and ceramic implants. Previous studies have revealed that a small volume (less than a few percent) of viscoelastic organic constituent is present throughout the spicule and acts as a key component in controlling the spicule's mechanical behavior. However, the spatial distribution of the organic component within the biomineralized glass material has yet to be identified. This information may be critical to understanding the spicule's energy dispersive behavior and, by extension, influence the design of new glass- or ceramic-based composites. Through the use of high resolution microscopy and other microscopic analysis techniques this study investigates the presence of organic material within the glass phase of these structures as a precursor for developing spicule-inspired synthetic composites.

SESSION 2G

MICRO- AND NANO-MATERIALS IN ACTION

Session Moderator: John Berg, Chemical Engineering

242 MGH

3:45 PM to 5:15 PM

* Note: Titles in order of presentation.

Characterizing the Reducing Potential and Two Proton - Two Electron Transfer Reactions of Titanium Dioxide Nanoparticles

Benjamin Guthrie (Ben) Horst, Senior, Chemistry (ACS Certified), Biochemistry
Levinson Emerging Scholar, Mary Gates Scholar, Undergraduate Research Conference Travel Awardee, Washington Research Foundation Fellow
Mentor: James Mayer, Chemistry

Titanium dioxide (TiO_2) displays a variety of interesting properties and has been intensely investigated for applications in environmental cleanup, photocatalysis, dye-sensitized solar cells, and semiconductor fabrication among others. However, the underlying mechanisms which govern TiO_2 chemistry are not well understood. Here, the tendency for reduced TiO_2 nanoparticles to donate stored electrons to other reagents is being characterized. The reduced ("charged") nanoparticles are made by UV irradiation which excites an electron from the valence band to the higher energy conduc-

tion band of the TiO_2 nanoparticles. In the absence of oxygen and other oxidants, the charged TiO_2 nanoparticles are stable and can be easily monitored by their absorption of visible light and blue color. We are exploring the chemical reactions of the charged particles. If the optical spectrum changes after the addition of other reagents, that is an indication that the nanoparticles are reducing the reagents. Removal of the electrons from the nanoparticles has been previously accomplished using aqueous Cu^2+, but not Zn^2+ or Mn^2+. I am repeating this result and extending it to other metal ions such as Cr^3+ in order to estimate the standard reduction potential of the charged particles. In addition, I am studying optically and via NMR whether dimethyl sulfoxide (DMSO) is reduced to dimethyl sulfide by charged TiO_2 nanoparticles. Because one-electron reduction of DMSO results in extremely unfavorable intermediates we are probing whether the reaction by charged TiO_2 occurs by the direct transfer of two electrons from the TiO_2 nanoparticles to the DMSO. These studies will provide valuable insight into the electronic chemistry of TiO_2 and will aid in the application of TiO_2 to other systems which require the transfer of multiple electrons.

Poster Session 3

Commons East, Easel 66

2:30 PM to 4:00 PM

Ocean of Plastic: A Look at the Growing Problem of Marine Waste Sites

Salla Tuuli (Salla) Northup, Sophomore, Pre Engineering
Mentor: George Mayer, Materials Science & Engineering

Every year an estimated 6.4 million tons of plastic waste manifests itself in the world's oceans through a number of avenues. Due to the fact that this plastic waste accumulates and covers large, mobile swatches known as "garbage patches," tracking and studying them is a time and labor intensive process. This project focuses on examining the size and extent of the garbage patches in the oceans and considers the pros and cons of various solutions for "end of life" plastic processing for the plastic debris present in the patches. Sampling efforts have been concentrated in the North Pacific using a trawl system for collection. Analysis of these plastics reveals several types present, including polyethylene and polyvinyl chloride. Plastics are not able to fully degrade into the marine environment; they break up into smaller pieces until they become microplastics. There the plastic can mistakenly become a food source and potentially enter the marine life food chain, leading to digestive issues that commonly result in starvation. Plastic could potentially be reused upon collection by converting it into forms that could be used for fuel. There are companies that can take a variety of "end of life" plastic and have it undergo the process of pyrolysis, where the plastic experiences an extremely high temperature in a closed system. This process essentially mimics the Earth's natural process of creating fossil fuels. The resulting product can be used as fuel or processed further for other uses. Another way to recycle plastic aims to create new, usable plastic for manufacture by heating the old plastic and adding "virgin polymers" that will strengthen new plastic and form resin beads which can be used to manufacture new products. Another process that is common to dispose of waste like plastic is by incineration. However, like all of these possible solutions, more research needs to be done about the potentially harmful by-products that could be released through these processes.

Poster Session 3

Commons East, Easel 67

2:30 PM to 4:00 PM

Solid Waste and Landfills: Current Issues and Potential Solutions

Heather Nalini (Heather) Mc Pherson, Sophomore, Pre Engineering
Mentor: George Mayer, Materials Science & Engineering

As consumers - especially as consumers in the industrialized United States - we go through a considerable amount of material goods and create copious quantities of solid waste on a regular basis. Generally, after we dispose of waste (items no longer of value to us), the discarded materials are out of sight and out of mind. However, the effects of our solid waste are not negligible by any means. The materials that we put in the trash, recycling, or elsewhere, can have undesirable effects on human health, human society, the natural environment, and even the climate. The materials chosen to produce various goods can have substantial impacts that far outlive the lifespan of the consumer products. Waste materials break down - or in some cases, do not break down – and the components have the potential to go through phase changes leading to a risk of harming groundwater and air quality. On Earth, we have an ever-growing human population; a constant stream of mass-produced consumer goods; and a finite amount of land and raw material resources. Actively examining and modifying how we manage our waste – at various stages within the materials' life cycles – is critical when regarding the future of human and environmental well-being. This research, by means of searching through various media resources and conducting interviews, investigates waste and management techniques with a materials-conscious lens. This presentation will delve into some of the main issues in landfills, such as the most problematic materials that don't decompose well; the pros and cons of current waste management methods; and potential alternatives and solutions – often involving a materials focus - that fit into various parts of the product-to-waste life cycle.

POSTER SESSION 3

Commons East, Easel 65

2:30 PM to 4:00 PM

Radioactive Waste Management and the Hanford Story
Arun Madav (Arun) Somasundaram, Sophomore, Pre Engineering
Mentor: George Mayer, Materials Science & Engineering

The Hanford Site in south-central Washington State has played a pivotal role in the history of the United States, and the world. The weapons grade Plutonium produced at the site from 1943 to 1987 became a critical component of the tens of thousands of nuclear warheads in the US arsenal. While this is a noteworthy legacy for any place to leave behind, there is another story to Hanford that will have implications for decades, centuries and millennia to come. Hanford is the most contaminated nuclear site in the United States, and is currently in the midst of the largest and most expensive cleanup effort in the world. This project explored the issues pertaining to the Hanford Site from the standpoint of radioactive waste management, complete with an overview of the nuclear fuel cycle and the complications that arose with managing the two million cubic meters of liquid radioactive waste. A plethora of miscalculations over the course of decades resulted in the ecological catastrophe that is Hanford, whether it's the lack of foresight on the limitations of the waste tanks, extended delay of the $12 billion waste processing facility or an overall disregard of the waste itself. While this project explores key critical mistakes from a technical standpoint, it also focuses on the lessons learned, and the implications they will have on future cleanup efforts, and nuclear energy as a whole. The key question this project sought to resolve is how the inherent hazardous nature of nuclear fuel itself can be distinguished from unprecedented level of mismanagement, and how both of those factors will make or break the future of nuclear energy.

POSTER SESSION 3

MGH 241, Easel 133

2:30 PM to 4:00 PM

Reversibility of Compound I Formation in the Reduction of Hydrogen Peroxide by Horseradish Peroxidase
Margaux Marie (Margaux) Pinney, Junior, Biochemistry
Mentor: James Mayer, Chemistry
Mentor: Caroline Saouma, Chemistry
Mentor: Michael Coggins, Chemistry

Horseradish peroxidase (HRP) is part of a family of heme-containing metalloenzymes that reduce the O-O bond of peroxides while oxidizing a wide variety of substrates; in the case of HRP, hydrogen peroxide is reduced to water. In the presence of an oxidant and the absence of a substrate to oxidize, hydrogen peroxide coordinates to the iron cofactor of HRP, forming a ferric-hydroperoxide intermediate known as Compound 0, and subsequent O-O bond cleavage releases water and a very oxidizing ferryl-oxo porphyrin radical cation intermediate, known as Compound I. The goal of this project is to probe the potential reversibility of Compound I formation, a step traditionally thought to be irreversible. A key experiment will react HRP with unlabeled H_2O_2 in ^{1}8O-labeled water, and determine whether mixed-labeled H_2O_2 is formed. The presence of mixed-labeled H_2O_2 indicates that there is reversibility of the O-O bond cleavage that forms Compound I and its existence will be determined by addition of a water soluble phosphine that is too bulky to fit into the active site of HRP. In this case, the phosphine cannot be oxidized by Compound I, but can readily react with free hydrogen peroxide in solution to give the corresponding phosphine oxide. ^{3}1P-NMR will be used to determine whether the phosphine oxide is labeled because the NMR shifts of ^{1}6OPR3 and ^{1}8OPR3 are distinct. If this reaction proves to be reversible, this knowledge could then be used to describe other enzymes that catalyze oxidations with similar intermediates. This would not only be important to enzymatic systems, but possibly catalytic chemical processes.

POSTER SESSION 3

MGH 241, Easel 169

2:30 PM to 4:00 PM

Visualizing Mobility Data
Kelly Ann Ridge, Fifth Year, Nursing
Mentor: Hilaire Thompson, Biobehavioral Nursing and Health Informatics
Mentor: George Demiris, Biobehavioral Nursing and Health Systems

Mobility is a sensitive indicator of overall health in older adults. Objective mobility data can provide insight into patterns of function including sleep, behavior, and activity, which is valuable information for both individuals and their healthcare providers. By visualizing objective mobility data, providers can assess for trends that could indicate a shift in overall health in order to intervene earlier, whereas older individuals with mobility goals may benefit from feedback in order to better meet goals or sustain behavior change. The purpose of this project is to perform a secondary data analysis and determine methods for visualizing objective mobility data for both individual users and healthcare providers. Participants of the original study were older adults with a recent history of mild traumatic brain injury. Data was collected with an active sensor system requiring participants to wear a sensor device during waking hours. Working through an interface designed by the University of Washington Ubicomp Lab I aim to create a composite profile of a single participants mobility and movement within their life-space. I am using Excel to sort and create visual representations of data. Key factors to include in visualizing these data are total amounts of active versus passive time spent per participant and the participant's mobility within his or her life-space. Data analysis is in process and prototypes for visualization are under development. With any visualization effort, it is important to address the different stakeholders' needs and expectations. Visualizing mobility data for individuals to better understand their own activity levels requires an approach that may be different from visualization targeting clinicians to support clinical decision making. Differences include preferences for granularity of data, level of abstraction, and annotation of context specific details that complement the visualization data. This study demonstrates that visualization can maximize the utility of health monitoring data.