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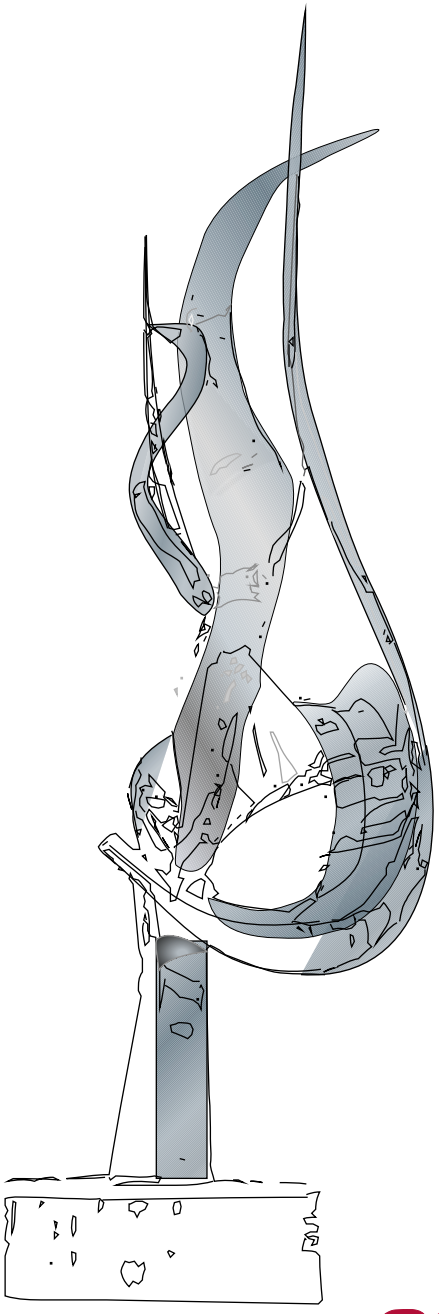
Rose-Hulman Institute of Technology



10th Annual IRC Undergraduate Research Symposium

Friday
October 25, 2013

Sponsored by

Edwards Lifesciences

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Welcome to the

10th Annual IRC Undergraduate Research Symposium

Sponsored by

Edwards Lifesciences

Friday, October 25, 2013

We are honored to welcome you to the 10th Annual IRC Undergraduate Research Symposium and we sincerely appreciate your participation. The symposium is coordinated by the Interdisciplinary Research Collaborative (IRC), which is supported by funding from Edwards Lifesciences, the Lilly/Guidant Applied Life Sciences Research Center, and Rose-Hulman Institute of Technology. The IRC would like to express its great appreciation for the Symposium sponsorship of Edwards Lifesciences and the Wabash Valley Local Section of the American Chemical Society.

The IRC was created to encourage scientific research by undergraduate students and to help them better understand the exciting educational and research opportunities that exist in science and engineering. An appreciation for laboratory research is central to a working understanding of experimental sciences. By participating in research, students add to current knowledge and, furthermore, they enhance their education and broaden their understanding of the scientific method and its application.

Interdisciplinary research is gaining prominence in both academia and industry, as new techniques from one discipline are applied to problems in other disciplines. By acquiring experience in interdisciplinary research, students become more attractive to potential post-graduate programs and employers. The IRC program specifically fosters such interdisciplinary work, and we are pleased to highlight the research of our students, as well as the research of some of our colleagues in Indiana.

We are delighted to welcome you to this tenth in the annual event series. Our intention in hosting this event is to offer students an opportunity to share their research interests and progress with their colleagues in a nurturing and supportive environment, and to encourage celebration of the undergraduate research experience. We hope you enjoy the dynamic program of speakers.

Mark Brandt
IRC Program Coordinator

Peter Coppinger
IRC Program Coordinator

ROSE-HULMAN
INSTITUTE OF TECHNOLOGY

Symposium Schedule

Morning Session I (8:30 – 9:45 AM)

Development and Validation of a Finite Element Model of a Total Hip Replacement

Nathanael Moore, Scott Small, and Renee Rogge*
Departments of Computer Science & Software Engineering and Applied Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803 and Joint Replacement Surgeons of Indiana Research Foundation Mooresville, IN 46158

Statistical Analysis and Empirical Modeling of Physical Properties of Alcohols and Related Solvents

Giuliana Watson, Yosi Shibberu, and Mark E. Brandt*
Departments of Mathematics, and Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803

The Effects of Stem Length on Strain in the Proximal Femur Following Total Hip Arthroplasty

Sarah Hensley, Paige Cook, Rebecca Stevens, Audrey Niverson, James Conwell, Scott Small, and Renee Rogge*
Joint Replacement Surgeons of Indiana, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

High index of refraction polycarbonates synthesized from triphosgene and indicators

Mike Yuan Xue and Bruce Allison*
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803

Synthesis and Analysis of Permanently Charged Tamoxifen Derivatives in ERα Positive Breast Cancer Cells

Matthew Conrad and Ross V. Weatherman*
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Morning Session II (10:00 AM – 10:45 AM)

Numerical Simulation of Delay Differential Equations via PSM
Dustin Lehmkuhl and Vincenzo Isaia*
Department of Mathematics, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Detection of Oxidative DNA Damage Using Micellar Electrokinetic Capillary Electrophoresis
Patricia Beddow and Daniel Morris*
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Mapping The Discrete Lambert
Krishan Kumar and Joshua Holden*
Department of Mathematics, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Keynote Presentation: 11:00 AM – 12:00 PM

From mind to machine – using imagined motor movement to control devices
Alan Chiu Ph.D.
Department of Applied Biology & Biomedical Engineering
Rose-Hulman Institute of Technology

Lunch Break 12:00 PM – 1:00 PM

Poster Session (1:00 PM – 2:00 PM)

Diatom History of Dock Lake, Indiana

Sabrina R. Brown and Jeffery R. Stone*
Department of Earth & Environmental Systems, Indiana State University, Terre Haute, Indiana, USA 47809

Assessing Visual Perception Using Behavior Conditioning in the Rat Model

Patricia Bacala and Jameel Ahmed*
Department of Applied Biology and Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Metal Isocyanides for the Undergraduate Laboratory – Without the Smell

Daniel J. Burkett and Laurence Rosenhein*
Department of Chemistry and Physics, Indiana State University, Terre Haute, IN 47809

Investigation of the Responsiveness of the Optical Qualities of Treated and Untreated Silicon Nanoparticle Films to Changing Humidity

Ross Chongson, Adam Nolte, and Marij Syed*
Department of Chemical Engineering and Department of Physics & Optical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN

Spin-Coated, Photo-Polymerized Temperature and Humidity Sensitive Polymer Thin Films

*Zhengyuan (Jung) Fang**
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Ablation and Desorption of Cryogenic Deposits of Water Ice

Jessica Gregory[1], Thomas Canty[2], and Pat Reardon[3]*
[1]Department of Physics & Optical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN, [2]Optical Sciences Corporation, [3]University of Alabama in Huntsville

DNA Condensation of Individual Plasmids Using Fluorescence Microscopy

David Harvey[1], Daniel Pack[2], Chris Richards[3], and Jason DeRouchey[3]*
[1]Department of Chemical Engineering, Rose-Hulman Institute of Technology, [2]Department of Chemical and Materials Engineering, University of Kentucky, [3]Department of Chemistry, University of Kentucky

Simulating the Dimerization Process of the Estrogen Receptor Protein

Jacob Hiance, Yosi Shibberu, and Mark E. Brandt*
Department of Mathematics, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Differential Metabolomics Using Multiplex Stable Isotope Labeling

Brent Hukill[b], Xue Shi[a], Sebastien Laulhe[a], Michael Nantz[a], Xiang Zhang[a]*
[a]Department of Chemistry, University of Louisville, Louisville, KY 40292, and [b]Department of Chemical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Constructing a Unique Platform for Interspecies-Dependence (CUPID): The Evolution of Multicellular Machines

Dax Earl, Bianca Maled, Adam Nighswander, Tanner Reeb*, Ted Samore, Mary Schultz, and Ayla Walters*

Department of Applied Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Method Development for the Identification and Quantification of Plastic Additives

Leah Markowitz and Jared A. Tatum*

Department of Chemical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803 and Ampacet Corporation R&D Center, Terre Haute, IN 47804

Synthesis and Analysis of Tamoxifen Derivatives through Linker Modification

Casey Mihal and Ross Weatherman*

Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Molecular Analysis of Phytoplasmic Infection in *Trillium grandiflorum*

Nathan Wheeler and J. Peter Coppinger*

Department of Applied Biology and Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Humidity swelling/deswelling study of constructing polyelectrolyte multilayer films with poly(allylamine hydrochloride) and poly(acrylic acid) at different pH values

Ziyang Yin and Adam J. Nolte*

Department of Chemical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803

Afternoon Session I (2:00 – 3:00 PM)

Characterization of Polyethylene Glycol (PEG) Hydrogels with Multi-Scale Porosity for Islet Transplantation to Treat Type I Diabetes

*Lonnie Shea[1], Peter D. Rios[1], and Victor Aguilar[2]**

[1]Department of Chemical & Biological Engineering, Northwestern University, Evanston, IL 60208, and [2]Department of Applied Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Modeling the Liquid Crystalline Properties of Type-I Collagen

Alexander Thomas and Luanne Tilstra*

Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803

Identifying Novel Signaling Molecules in the Maintenance of Quiescence of Muscle Satellite Stem Cells

Katherine Moravec, Susan Eliazer, and Andrew Brack*

Department of Chemical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803, Massachusetts General Hospital, and the Harvard Stem Cell Institute

Tumor-specific Toxicity of Pro-oxidant X loaded LDL Nanoparticles on Hepatocellular Carcinoma

Esther Kim[1], Lacy Reynolds[2], Tim Van Treuren[2], Rohit Mulik[2], Xiaodong Wen[2], and Ian Corbin[2]*

[1]Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute IN 47803 and [2]Advanced Imaging Research Center, UT Southwestern Medical Center, Dallas TX

Afternoon Session II (3:30 PM – 4:45 PM)

A Comparison of Amidation Methods of Arylacetic Acids

Daniel J. Burkett, Mopelola Akinlaja,* Anna Walls, Veronica Rodriguez, and Richard W. Fitch*
Department of Chemistry and Physics, Indiana State University, Terre Haute, IN 47809.

Nuclear Data Evaluation of Beta Delayed Particle Decay in Light Nuclei, A=3-20

Jillian Shuman, John Kelley, and Chih-Wan Sheu*
Department of Physics, Rose-Hulman Institute of Technology, Terre Haute, IN 47803 and Triangle University Nuclear Laboratory, Duke University, Durham, NC, 27708

Epoxidation in Ether? Cycloalkene Oxides from *in-situ* Generated Trifluoroperoxyacetic Acid

Hunter Lavoine and Richard W. Fitch*
Department of Chemistry and Physics, Indiana State University, Terre Haute, IN 47809.

Comparative Examination of Carbon Cryogel as a Solid Phase Extraction Media

Gregory Horne and Justin Shearer*
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Analysis and Simulation of Biopixel Arrays

Doo Young (Paul) Park, Omar S. Betouni*, and Dave M. Goulet*
Departments of Mathematics, Electrical Engineering, and Applied Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803

Development and Validation of a Finite Element Model of a Total Hip Replacement

Nathanael Moore*, Scott Small, and Renee Rogge
Departments of Computer Science & Software Engineering and Applied Biology & Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803 and Joint Replacement Surgeons of Indiana Research Foundation
Mooresville, IN 46158

More than 300,000 total hip replacements are performed each year in the United States. Despite the relative success of these procedures, researchers continue to investigate ways to improve implant design, minimize the trauma of the implantation procedure, and enhance the long-term efficacy of the implants. One approach to accomplishing these research goals more efficiently is through the development of computational models. This research project examined the development and validation of a computational model of a human femur to predict implant performance. Finite element models were developed from CT images of composite femurs that had each undergone a simulated hip replacement. Femoral implants (developed by Biomet Orthopedics) were installed in each femur by an orthopedic surgeon with extensive experience performing hip replacement surgery. The CT images taken of these femurs were then refined using the Mimics and 3-Matics software suites (Materialize, Michigan). Mimics was used to generate an initial computer model of each femur containing accurate density and material properties information. 3-Matics was then used to convert this initial rendering into a finite element model. Next, the models were imported into the ANSYS software suite, which allowed for analysis of the finite element model. Virtual strain data was collected by simulating physiologically appropriate forces on these models. The virtual strains were compared to in vitro strain data collected from experimental testing of composite femurs using a materials testing system to simulate physiologic loading conditions. The virtual and experimental data were compared to determine the validity of the computer modeling approach to strain prediction. Preliminary qualitative comparisons between the finite element model and the in vitro results were promising, but a quantitative analysis indicated that additional refinement of the finite element model is required in order to more accurately simulate the *in vitro* testing results.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC.

Statistical Analysis and Empirical Modeling of Physical Properties of Alcohols and Related Solvents

Giuliana Watson*, Yosi Shibberu, and Mark E. Brandt
Departments of Mathematics, and Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803

Alcohols are oxygen containing organic molecules, in which the oxygen is bonded to a single hydrogen and to the carbon backbone of the molecule. Ethanol, the active ingredient in alcoholic beverages, is the second simplest member of this important family of molecules.

While the molecules are relatively simple, the aggregate properties are understood only empirically. Most alcohols with fewer than about seven carbons are liquids at room temperature. However, the boiling and melting points of these compounds vary significantly, and there is little theoretical understanding of the underlying source of these variations.

We have experimental evidence for an interaction of alcohols and the estrogen receptor protein. The magnitude of the observed effect on the estrogen receptor appears to correlate with the boiling point of the pure alcohol. However, while boiling point is readily measurable experimentally, we need to construct an empirical model that relates the experimental data to parameters obtained from first principle quantum mechanical calculations.

I have developed a program which graphs all of the possible combinations of 23 empirical properties of alcohols up to seven carbons, and selects for both extremely correlated and uncorrelated trends defined by our threshold. We were then able to determine the significance of each of these select trends. I then developed a program which clusters alcohols in 23-dimentional space by their experimentally measurable or quantum mechanical properties and construct empirical models and hierarchical correlations based on these clusters. I then used statistical analysis to evaluate the predictive capabilities of the models.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC.

The Effects of Stem Length on Strain in the Proximal Femur Following Total Hip Arthroplasty

Sarah Hensley*, Paige Cook, Rebecca Stevens, Audrey Niverson, James Conwell, Scott Small, and Renee Rogge
Joint Replacement Surgeons of Indiana, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

One factor that affects the stability and long term success of total hip arthroplasty (THA) is the femoral implant's stem length. In some cases of THA, stress shielding has resulted in bone remodeling, causing loosening of the implanted femoral stem with its surrounding cortical bone. One method of testing the effects of using different stem lengths is to measure and compare strain distributions of unimplanted femurs with femurs after implantation. The goal of this study was to analyze the strain response to loading of the proximal femur in order to quantify the effect of stem length on cortical strain distribution. Strain responses of implanted femurs with short, medium, and long stem lengths were analyzed and compared with the strain of intact femurs. Under axial loading, the short stem measurements were closest to the unimplanted measurements, and under torsional loading, the short stem was 23-48% more stable than the longer stems. Micro-motion was also recorded, measuring the movement between the femoral implant and the surrounding bone. No significant differences were found between stem lengths for micro-motion under axial loading.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC.

High index of refraction polycarbonates synthesized from triphosgene and indicators

Mike Yuan Xue* and Bruce Allison
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN, 47803

Now polycarbonates are widely used in different areas which range from sunglasses to optical equipment because of their special optical properties. Also, they have other fascinating properties such as high glass transition temperature and high refractive index. In order to explore new materials, this research was concentrated on synthesizing and testing novel polycarbonates. Using a variety of synthetic methods, we obtained the polycarbonates by cautiously heating mixed solution of indicators and triphosgene (or phosgene). After cooling the samples, the solvent, chloroform, was distilled away. Then, attempts were made to cast films. The tests included optical analysis (IR spectra) and other chemical and mechanical property measurements.

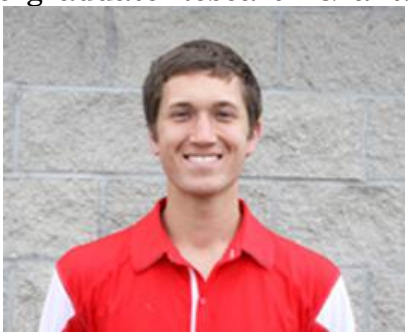
This research was funded in part by Edwards Lifesciences under the auspices of the IRC

Synthesis and Analysis of Permanently Charged Tamoxifen Derivatives in ERα Positive Breast Cancer Cells

Matthew Conrad* and Ross V. Weatherman
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Breast cancer is currently the second leading cause of cancer deaths for women in the United States. There are multiple known mechanisms and types of breast cancer that can occur. One notable case is known as estrogen receptor alpha (ERα) positive breast cancer, meaning that the ERα is believed to be partly responsible for the development and growth of the tumors. ERα is a nuclear hormone receptor found in several tissues in the body including breast tissue. Mechanistically, ERα contains a ligand binding domain (LBD) in which natural estrogens (*e.g.*, estradiol) bind and set off a chain of events in the nucleus that eventually results in the production of new cells. Compounds that bind to the ERα and prevent DNA transcription from occurring are known as antiestrogens. In ERα positive breast cancer, this process occurs without regulation and a tumor can develop. A class of compounds named selective estrogen receptor modulators (SERM's) have been synthesized and shown to bind to the LBD and inhibit the ERα from further genetic activity in breast tissue cells; as a result, the cancer cells cannot grow and are essentially stopped. Tamoxifen, a synthetic antiestrogen, is presently the most common endocrine therapy for ERα positive breast cancer. However, there are several limitations to its long-term use (more than 5 years). Cell mutations can occur that give rise to cancer cells with resistance to tamoxifen, which can nullify its effectiveness. Also, tamoxifen displays estrogenic activity in uterine cells and thus can cause proliferation in uterine tissue. As a result, it becomes necessary to look for new cancer drugs that do not display these limitations. The goal of our research is to investigate the genomic action of permanently charged tamoxifen derivatives (quaternary ammonium salts of tamoxifen coupled to an organic substrate). To do so, the target compound must first be synthesized and purified. *In vitro* ERα binding assays are used to determine the binding affinity to the LBD using fluorescent polarization. Finally, *in vivo* MCF-7 assays are conducted to test the effectiveness using a luminescence assay. IC_{50} values are calculated for both the *in vitro* and *in vivo* assays.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC and by an Eli Lilly Undergraduate Research Grant.



Numerical Simulation of Delay Differential Equations via PSM

Dustin Lehmkuhl* and Vincenzo Isaia
Department of Mathematics, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

The Modified Picard method (PSM) for approximating IVPs (in a non-standard numerical fashion) involving ODEs or PDEs has been established as a viable option (see Sochacki and Parker *et al*.). The form of the approximating method allows itself to be used without much labor on delay differential equations (where the vector field at the current time relies on the state of the system at some earlier time as well as the current time). The properties of the solutions to the DDEs can be different depending on how the delay shows up, hence there are a myriad of subclasses (see Baker, Paul and Wille) and as a consequence, their numerical simulation can be delicate. This jump to DDEs via PSM appears to be possible without worrying about which subclass is involved.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC and by the NSF Mathematics REU grant.

Detection of Oxidative DNA Damage Using Micellar Electrokinetic Capillary Electrophoresis

Patricia Beddow* and Daniel Morris
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Oxidative DNA damage is linked to many diseases and conditions such as Parkinson's, Alzheimer's, and several forms of cancer. This type of damage is identified by the presence of the oxidative damage marker 8-hydroxy-2'-deoxyguanosine (8-OH-dG). This damage occurs as a result of reactive oxygen species (ROS), and the identification of this marker is a useful diagnostic tool. Previous work has shown that separation and identification of 8-OH-dG in a complex sample matrix is possible using high performance liquid chromatography (HPLC) with an electrochemical detector. However, the separations take approximately 24 minutes per sample and require relatively large (50 μL) injection volumes. Micellar electrokinetic capillary electrophoresis (MEKC) exhibits several advantages over traditional HPLC as a separation technique. MEKC separations require shorter separation times (6 – 8 minutes, as opposed to 24 minutes) and smaller injection volumes (sub-μL). Performing separations using MEKC also serves as a transition step to doing analysis using microfluidic devices, which have even smaller sample volume requirements, and smaller equipment that allows easier mobility. This presentation focuses primarily on using cholate micelles as a MEKC run buffer. The results of this study show that a buffer using sodium cholate and sodium borate yields better separations. This is especially useful in detecting the 8-OH-dG marker, which often presents itself as a small peak because of such small concentrations present.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC.

Mapping The Discrete Lambert

Krishan Kumar* and Joshua Holden
Department of Mathematics, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Given a number x, we consider the dynamic system $x \to x\, g^x \bmod\left(p^n\right)$ also known as The Discrete Lambert. In this equation, all variables are known other than x. The Discrete Lambert has puzzled mathematicians around the world for decades. The reason x is so difficult to solve for is that the variable p, which is a prime number, may be hundreds of digits long, meaning that even with the assistance of computer technology, it may take over a hundred years to solve. In the context of this research, smaller examples were used so that proofs could then be drawn on a much larger scale. To visualize this cycle an accompanying map, which illustrates each number and what number it results in when plugged into the original equation, and matrix may be illustrated. In this research an algorithm is extracted which is able to allow any such map to be drawn with accuracy without having to plug in every number x into the generator g until a pattern is distinguished. When the map is actually drawn out, certain numbers (x) will form sets and each element of that set will only go to another element of that set when plugged into the function $f(x) = x\, g^x \bmod(p)$. By noticing a pattern in the arrangement of numbers in these groups and using the properties of logs, proofs were deciphered and an algorithm was distinguished. The Discrete Lambert problem relates to other functions such as The Discrete Logarithm and encryptions known as digital signatures. They are used to verify the authenticity of legal documents, financial transactions, and other important communications. For these reasons and more it is evident that these encryptions are a key element to our society and can impact major domestic and even international transactions. This research may have further implications in related fields such as those just described and also provides insight into the ultimate goal of mapping The Discrete Lambert.

Diatom History of Dock Lake, Indiana

Sabrina R. Brown* and Jeffery R. Stone
Department of Earth & Environmental Systems, Indiana State University, Terre Haute, Indiana, USA 47809

Dock Lake is a small, 7-meter deep lake located in Chain-'O'-Lakes State Park in Albion, IN. It is the third lake in a chain of eight kettle lakes connected by Forker Creek, nestled amongst a mix of active and reclaimed farmland. This lake and river system has been preserved as a state park since the initial land purchase in 1945. In recent years, the park managers have experienced increasing and persistently recurring seasonal cyanobacteria blooms, which are interfering with park operations. Within the park system, upstream of the lake systems, the Chain-'O'-Lakes Correctional Facility and an associated sewage treatment plant have been reportedly contributing to the elevated nutrient levels. Increased nutrient loading is particularly troubling because recreational facilities and beaches along the shore of Sandy Lake, located within the park, now must periodically be restricted for public safety.

In the spring of 2012, we collected a 77 cm sediment core from Dock Lake, to see if the eutrophication of the Chain-'O'-Lakes system has had an observable change in the diatom assemblages. Dock Lake was chosen because of the depth and accessibility, which includes a boat ramp to allow us to easily collect the sediment with a rod-driven piston corer (Griffith corer). The core was sampled at 5mm intervals for diatom analysis throughout the length of the core.

Preliminary diatom analysis has revealed an increase in the relative abundance of species that tend to thrive in higher phosphorus environments, such as *Stephanodiscus hantzchii*. We are now refining the diatom analysis to include more samples to increase our sample resolution and extend our reconstruction of Dock Lake to include detailed changes in diatom productivity and diversity over the length of the core to provide the park managers with more specific information about the nature of human impact on the park.

Assessing Visual Perception Using Behavior Conditioning in the Rat Model

Patricia Bacala* and Jameel Ahmed
Department of Applied Biology and Biomedical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

Behavioral conditioning is a practice of psychology that can be used to assess cognitive function in animals. The conditioning method of autoshaping falls within the realm of classical conditioning and has demonstrated success in measuring the visual perception of pigeons. It is unclear, however, if this conditioning method can be used to measure visual perception in an animal subject whose visual system function degrades over time. An experimental protocol is being developed for the assessment of visual stimulus perception in normal-visioned Long-Evans rats. These rats are being autoshaped to respond to a visual stimulus with the pressing of a lever. The protocol aims to examine the threshold values of the visual system in both stimulus type and intensity. Phase I of the training protocol has been successful in autoshaping rats to press a lever independent of a visual stimulus with an average R^2 of the test subjects >0.90 for a linear fit of pressing frequency over successive trials. Phase II of training aims to pair lever pressing with light stimulus. Autoshaping for this phase has been unsuccessful, thus operant conditioning, another method of behavioral conditioning, is being pursued and preliminary results have been mixed to date.

This research was funded in part by a Joseph B. and Reba A. Weaver Undergraduate Research Award and in part by Edwards Lifesciences under the auspices of the IRC.

Metal Isocyanides for the Undergraduate Laboratory – Without the Smell

Daniel J. Burkett* and Laurence Rosenhein
Department of Chemistry and Physics, Indiana State University, Terre Haute, IN 47809

Metal carbonyl compounds form the basis of much of the field of organometallic chemistry. They are often used as starting materials for other compounds. Isocyanides, with the general formula C≡NR, are isoelectronic with carbonyls and form many of the same metal complexes, but the presence of the substituent enables more characterization methods and allows a series of related ligands to be studied. For this reason, they would be a logical choice for experiments in an undergraduate inorganic synthesis laboratory course. However, this is seldom done because of the notoriously vile odor of isocyanides themselves. A recent report of an easily-synthesized, odor-free class of isocyanides prompted us to test their ability to form metal compounds. We describe several that can conveniently be made, most of which can be seen as extensions of commonly-adopted inorganic experiments.

Investigation of the Responsiveness of the Optical Qualities of Treated and Untreated Silicon Nanoparticle Films to Changing Humidity

Ross Chongson*, Adam Nolte, and Marij Syed
Department of Chemical Engineering and Department of Physics & Optical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN

It has been found that aggregated SiO_2 nanoparticle have strong antireflective (AR) properties. However, these coatings are highly responsive to changes in ambient humidity, with their refractive index, a parameter important to AR design, decreasing substantially in more humid environments. In order to investigate ways to reduce the sensitivity of deposited films to changing environmental conditions, coatings were treated with a silanization reaction to test whether increasing the hydrophobicity of the SiO_2 nanoparticle layer would decrease its sensitivity to changes in humidity.

In order to better analyze the observed changes in optical properties, and to expedite the use of an ellipsometer in taking measurements, the SiO_2 nanoparticle layer was modeled as a two-component EMA layer with Cauchy layer behavior composed of SiO_2 and void or air. The presence of the void space between nanoparticles decreases the reflectivity of the films. However, it was also theorized that, as humidity increased, water would gradually accumulate in the void spaces, reducing the available void and decreasing antireflectivity. Further, it was hypothesized that a hydrophobic layer could effectively 'block' the accumulation of water within the void spaces.

To test the hypothesis, experiments were conducted by exposing treated and untreated nanoparticle layers on silicon substrate to an environment with a particular humidity controlled by use of an equilibrium salt solution. It was found that, by treating the films with a silanization reaction in toluene, one could drastically reduce the responsiveness and variance of the film's optical properties due to changes in humidity. Further experimentation is still necessary to determine the limits of these coatings, as well as to develop methods of processing films for deposited on polymer substrates.

Spin-Coated, Photo-Polymerized Temperature and Humidity Sensitive Polymer Thin Films

Zhengyuan (Jung) Fang*
Department of Chemistry & Biochemistry, Rose-Hulman Institute of Technology, Terre Haute, IN 47803

We demonstrate a framework for constructing thin, humidity and temperature-responsive films containing poly (N-isopropylacrylamide) (PNIPAAm) using Layer-by-Layer (LbL) assembly and via photo-polymerizing. Humidity hysteresis is a difference in degree of swelling by a polymer in response to increasing and decreasing the relative humidity of the ambient environment. The hydrogen bonded multilayer films exhibit significant swelling-deswelling hysteresis, swelling substantially less from a dry state (relative humidity ≈ 0%) than from a hydrated state (relative humidity ≈ 95%) as measured by in-situ reflectometry. Our results indicate that shorter ultraviolet curing time during the photo-polymerization leads to smaller maximum swelling ratios and films exhibit less hysteresis at higher temperatures than that at room temperature due to the collapse of a portion of film networks leading to an increase in rigidity.

Ablation and Desorption of Cryogenic Deposits of Water Ice

Jessica Gregory*[1], Thomas Canty[2], and Pat Reardon[3]
[1]Department of Physics & Optical Engineering, Rose-Hulman Institute of Technology, Terre Haute, IN, [2]Optical Sciences Corporation, [3]University of Alabama in Huntsville

The U.S. Air force sought proposals for monitoring and removing cryogenic deposits of H_2O ice in their high vacuum optical system. The cryogenic deposits would reduce or completely negate the transmission of the mirrors in the system especially in the mid wave infrared regions. In order to measure this reduction, we measured the transmission spectrums with a Fourier Transform Infrared Spectrometer and compared them over time and recorded the variations in pressure of the chamber and its temperature. We acquired an Erbium YAG pulsed laser whose wavelength matched that of the dip in the FTIR transmission spectrums of the cryodeposits so that it could be used to ablate the material without damaging the integrity of the mirror or scattering it onto a different portion of the optical system.

This research was funded through a Small Business Technology Transfer from the US Air force research lab, and The National Aeronautics and Space Administration; Marshal Space Flight Center awarded to Optical Sciences Corporation, and The University of Alabama in Huntsville.

DNA Condensation of Individual Plasmids Using Fluorescence Microscopy

David Harvey*[1], Daniel Pack[2], Chris Richards[3], and Jason DeRouchey[3]
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Condensation and decondensation are crucial steps in the delivery of DNA for use in gene therapy. Little is known about the kinetics of this process. This study has created a novel method for the study of condensation and decondensation of plasmids at the single molecule level. Isolation of single plasmids on a substrate has been achieved using a biotin label to bind to avidin coated slides. Fluorescence was examined using an intercalator dye, YOYO-1. This approach will allow for the study of condensation/ decondensation dynamics of hundreds of individual plasmids simultaneously through the self-quenching of fluorescence that is characteristic of YOYO-1.

Simulating the Dimerization Process of the Estrogen Receptor Protein

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It is known that the Estrogen Receptor Protein (ERP) plays an important role in breast cancer. I simulated the dimerization process of the ERP using molecular dynamics and the program NAMD. An initial 10 nanosecond simulation in water reveals that the two monomers form a stable dimer.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC.

Differential Metabolomics Using Multiplex Stable Isotope Labeling

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Metabolomics is the study of low molecular weight molecules (i.e., metabolites) found within cells and biological systems. It has emerged as the latest of the "omics" disciplines for deciphering the complex time-related concentration, activity and flux of metabolites in biological samples. A significant limitation of the current GC-MS based metabolomics is that only one sample is analyzed on a mass spectrometer in an experiment. It usually takes several weeks to accomplish a large scale biomarker discovery project. Such an extended instrument analysis time not only affects throughput, but also significantly increases experimental costs. In this study, we developed a table isotope labeling-based sample multiplexing method to analyze metabolite with free amine groups, by analyzing up to three samples simultaneously on GCxGC-TOF MS. In this method, three samples are labeled using isotopic labeling reagent [N-Hydroxysuccinimide derivative 32, 33, and 34 (or NHS-32, NHS-33, NHS-34)], respectively. The corresponding products from this reaction are chemically identical—with the exception of substituting different numbers of ^{12}C with ^{13}C atoms in the labeling reagent NHS —and will thus elute together in the GCxGC-TOFMS. The acquired spectral data shows the slight distinction between equivalent compounds that were present in different samples such that the m/z values increase corresponding to the NHS variant that was used (*e.g.*, M, M+1, M+2, where M is the m/z value of the compound reacted with NHS-32) [†]. Once the method and its parameters are optimized to give clean, replicable data, it can be used by researchers and professionals for clinical diagnoses and future research discoveries.

Constructing a Unique Platform for Interspecies-Dependence (CUPID): The Evolution of Multicellular Machines

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CUPID aims for stable obligate symbiosis for the model prokaryote *Escherichia coli* (bacteria) and the model eukaryote *Saccharomyces cerevisiae* (yeast). We address this goal by constructing a unique platform for interspecies-dependence based on inducible expression of a required histidine biosynthetic gene (HIS) in each species. Expression of the bacterial HIS gene is induced by lactic acid produced by constitutive expression of a lactate dehydrogenase gene in the eukaryote. Expression of the yeast HIS gene is induced by the binding of its mating factor receptor to mating factor expressed constitutively on the surface of the prokaryote. Histidine deprivation necessitates physical contact and symbiosis for survival. Such pressure may facilitate evolution of a stable exosymbiotic form of the two species. Study of isolates and further manipulation could provide insight into the use of obligate symbiosis in synthetic biology and yield a chassis for the synthesis of novel multicellular machines.

Method Development for the Identification and Quantification of Plastic Additives

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Being able to detect and quantify common additives in plastics resins is very important in industry because the properties of plastic resins rely on the amount of additive present. Therefore, it is crucial to have a system with these abilities, so we developed a method to detect common additives that would be present in plastic resins. Methods were developed for a system consisting of high performance liquid chromatography (HPLC) and evaporative light scattering detection (ELSD).
A Waters Alliance 2695 HPLC device with Empower3 software were used with a Waters C_{18}, 2.5 μm column. Two detectors were used in series for this work. The first was a Waters 2998 Photodiode array (PDA) followed by an ELSD. The ELSD that was used was a Waters 2424 ELS detector which used nitrogen as the nebulizing gas. Several different methods were developed to test the effects of different mobile phases, mobile phase compositions, mobile phase modifiers, gradients, and flow rates. From the data collected using additive mixtures that had not been added to a plastic resin, the methods were analyzed and compared to determine which method parameters resulted in the best resolution and separation of peaks. The method that was developed can detect glycerol monostearate (GMS), glycerol monooleate (GMO), sorbitan monostearate (SMS), amides, and ethoxylated amines while in the presence of both Anti-Oxidants and UV absorbers which are all common polymer additives used in industry. From this method, these plastic additives can be detected using HPLC which broadens the type of instrumentation that can be used to detect these common plastic additives.

This research was funded in part by Ampacet Corporation under the auspices of the IRC.

Synthesis and Analysis of Tamoxifen Derivatives through Linker Modification

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Breast Cancer is currently one of the leading causes of death in women. One type of breast cancer commonly seen among women is Estrogen Receptor (ER) positive breast cancer. There are two different types of estrogen receptors, ER-α and ER-β. ER positive breast cancer is caused excess ER-α. ER-α interacts with estradiol, which is a known proliferative factor. When estradiol binds to the ligand binding domain of ER-α, it activates the proliferation. Estradiol is an agonist with ER-α, meaning it promotes proliferation. Weatherman lab aims to develop Selective ER modulators (SERMs) to block the action of estradiol with ER-α. SERMs act as antagonists with ER-α in breast tissue. Tamoxifen is a known SERM that is currently used as a hormone therapy to ER positive breast cancer. However, the drug has a few setbacks. The problem of interest for Weatherman lab is that after a prolonged use of Tamoxifen as a treatment for ER positive breast cancer, Tamoxifen will change from being treated as an antagonist in the body to being treated as an agonist, thereby promoting proliferation. Weatherman lab's goal is to synthesize new Tamoxifen derivatives in order to study the estrogen-like activity of Tamoxifen over time. The goal of this project was to develop and analyze 4-hydroxytamoxifen derivatives through linker modification. This was done by first synthesizing, purifying, and characterizing the drugs of interest. The drugs were then put through an *in vitro* ER-α fluorescence polarization binding assay to determine binding ability to the ER. The drugs were then put through an *in vivo* assay in MCF-7 cells to determine binding ability to the ER while in the cells. IC-50 values of both assays were reported.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC.

Molecular Analysis of Phytoplasmic Infection in *Trillium grandiflorum*

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A small population of *Trillium grandiflorum* in southeast Michigan exhibit symptoms typical of infection by a plant pathogen belonging to the genus Phytoplasma; the typical white flowers are either entirely or partially variegated. Phytoplasmic infections are usually confined to phloem tissue, and often result in the transformation of floral parts to leafy green structures, potentially leading to sterility of the plant. The research focus of this summer was to troubleshoot the inconsistent steps in the PCR protocol such as the thermo-cycler protocol and the PCR solution components. Obtaining reliable PCR results is vital to the success of this project. We recently developed a protocol that successfully amplifies E. coli DNA. We now need to apply the protocol to successfully amplify phytoplasma DNA.

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Humidity swelling/deswelling study of constructing polyelectrolyte multilayer films with poly(allylamine hydrochloride) and poly(acrylic acid) at different pH values

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The goal of this research is to investigate the influence of degree of crosslinking by using spin-assisted layer-by-layer assembly of poly(allylamine hydrochloride) (PAH) and poly(acrylic acid) (PAA) to construct polyelectrolyte multilayer film(PEM) systems. A series of bilayer films are constructed using PAH and PAA with pH values ranging from (PAH7.0/PAA3.0) to conditions where both of the polymer solutions are at a neutral pH (PAH7.0/PAA7.0). The hypothesis states that lower PAA pH values will result in more free PAA binding groups (PAH 7.0/PAA3.0) and higher incremental film thickness growth to a highly crosslinked structure with little free PAA binding groups (PAH7.0/PAA7.0) and a small incremental film thickness growth. Afterwards, films are tested for their swelling/deswelling hysteresis in the humid air environment. Post- assembly film measurements are carried out using reflectometer, as well as for the swelling/deswelling hysteresis. According to the previous research, (PAH 7.5/ PAA $3.5)_{20.5}$ demonstrates a maximum swelling of approximately 40% under humid air environment. Similar results are obtained using different pH values indicated above. Furthermore, methylene blue tests are used to examine the free PAA availability for the films. Our results indicate that spin-deposition leads to substantially different film morphologies than dip coating, and that swelling hysteresis is not significantly affected by the pH of PAA during deposition.

Characterization of Polyethylene Glycol (PEG) Hydrogels with Multi-Scale Porosity for Islet Transplantation to Treat Type I Diabetes

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Successful pancreatic islet transplantation can be effective in treating Type 1 diabetes (T1D), eliminating the need for exogenous insulin and immunosuppressive therapy. Biomaterial- based immunoencapsulation may improve engraftment in islet transplantation and reduce islet destruction via the host immune response. In this study, we propose the use of multi-scale porous hydrogels, generated by polymer crosslinking of 4-arm polyethylene glycol-vinyl sulfone (PEG- VS), as an encapsulation platform to protect islets. Multi-scale porosity is achieved via features on polydimethyl siloxane molds (formed through UV-induced photolithography). Ultimately, we generate two degrees of porosity: a ~5 nm mesh size intended to block macrophages and immunoglobulins, and ~300 μm macropores used to facilitate graft vascularization needed for diffusion of nutrients, oxygen, and insulin. Swelling studies indicated the mesh size for 10% and 20% PEG-VS gels are 8.064 ± 0.606 nm and 7.903 ± 0.616 nm, respectively. Diffusion studies with fluorescently-tagged dextran molecules have been suggested to confirm these numbers. These studies demonstrate that multi-scale porous hydrogels may serve as an immunoencapsulation platform while enabling outflow of insulin. Further modifications to the hydrogel design being considered, such as inclusion of the adhesion peptide CRGDS, will enable hydrogels to achieve long-term functionality *in vivo*, making islet transplantation a viable cure for T1D.

Modeling the Liquid Crystalline Properties of Type-I Collagen

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Currently, the self-assembly of type-I collagen triple helices during the formation of microfibrils is not fully understood. Moreover, full understanding of this process could lead to advancements in synthetic collagen macrostructures. This model approximates the triple helices as rigid spherocylinders with a constant length to diameter ratio of 250. Therefore, the location and direction of the triple helices can be described by a midpoint and two angles each. Initially, rods are randomly generated and checked to ensure that excluded volume is taken into account. This project then uses simulating annealing techniques to find the global minimum Helmholtz free energy of solution. This is a function of the rod orientation that incorporates the liquid crystalline properties of type-I collagen. Specifically, the Helmholtz free energy is calculated using the orientation probability distribution assumed by Onsager. Furthermore, the basis for the liquid crystalline properties is the quadrapolar tensor order parameter calculated from the same probability distribution. The most stable conformation of rods indicates a shift from the random orientation but does not mimic the structure of a microfibril. Thus, without the incorporation of Coulombic forces, the liquid crystalline properties of type-I collagen do not resolve the structure of the microfibril.

Identifying Novel Signaling Molecules in the Maintenance of Quiescence of Muscle Satellite Stem Cells

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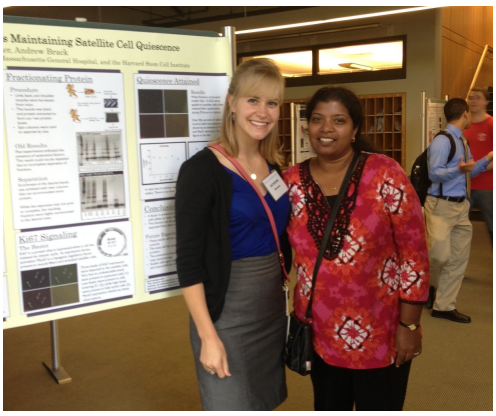
Satellite cells are maintained in muscle fiber niches and are regulated by many growth factors which can restrict or encourage their proliferation. Some proteins, such as Notch ligands, retain the cell's quiescence, while FGF, HGF, and IGF among other growth factors, often interact with satellite cells and cause them to lose quiescence. While these factors are known and have been studied, scientists are still unable to grow satellite cells in culture while maintaining quiescence. A screen of all proteins would help to find new factors on the cell's activity. My project uses protein filtration to discover and characterize a new quiescence factor that will allow *in vitro* culture of satellite cells.

Muscle stem cells, known as satellite cells, are located sporadically on skeletal muscle fibers which form their niche. These cells upon injury proliferate and fuse together to form multinucleated fibers and self renew to form new satellite cells which reside on the new muscle fibers, repairing the muscle. This regeneration is important in not only healing after a hard workout, but also in maintenance of muscles on a day-to-day basis. In both aging and degenerative diseases, stem cell therapies could potentially be used to treat muscle ailments. To further study these diseases and therapies, the mechanisms by which stem cells are maintained must be better understood. Unfortunately, culturing these cells *in vitro* causes them to lose their quiescence. We desire to produce an *in vitro* niche in which to grow and maintain satellite cells in their quiescent state. This niche could be compared to aged fiber's niche, which cannot retain satellite cell quiescence, to produce therapies restoring regenerative properties to degenerative cells.

The activation of satellite cells involves a few known signaling pathways such at Notch, FGF, IGF, and HGF signaling, but the mechanism of maintenance of the cells in quiescence remains unknown. Notch signaling plays an important role in quiescence and their exact mechanism is not known. We suspect that there are other quiescence factors present in the niche and identifying these factors will enable *in vitro* culturing of quiescent cells.

To identify a novel factor that regulates quiescence in satellite cells *in vitro*, I will optimize the fractionation of different proteins from whole muscle using spin columns and apply these fractions to satellite cells to determine and isolate the effective protein.



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Tumor-specific Toxicity of Pro-oxidant X loaded LDL Nanoparticles on Hepatocellular Carcinoma

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Nanoparticles have recently been highlighted for their potential as a drug delivery device in the fields of biotechnology and pharmaceutical research. Low density lipoprotein (LDL), a naturally existing biological nanoparticle, has been recognized by researchers as one of the promising drug delivery vehicle. Over the last three years, the Corbin lab has developed a novel approach for delivering Pro-oxidant X (Pro-X), an effective anti-tumor agent, to cancer cells using plasma LDL. These modified nanoparticles provide a simple yet highly effective means of delivering Pro-X to cancer cells. Previous studies on the compound suggest that Pro-X is likely an inducer of oxidative stress. The present study was designed to investigate the effects of LDL-ProX on the redox status of cancer cells. DHE fluorescence readings and metabolic measurements of intracellular glutathione and NADPH levels were measured in cells and in animal models of hepatocellular carcinoma (HCC) after LDL-ProX treatment. Collectively, our results showed that LDL-ProX selectively increases reactive oxygen species and reduces the GSH/GSSG and NADPH/NADP ratios in HCC cells and tumors. These findings suggest that LDL-ProX can induce oxidative stress in cancer cells beyond their homeostatic threshold, ultimately leading to irreversible damage and cell death.

A Comparison of Amidation Methods of Arylacetic Acids

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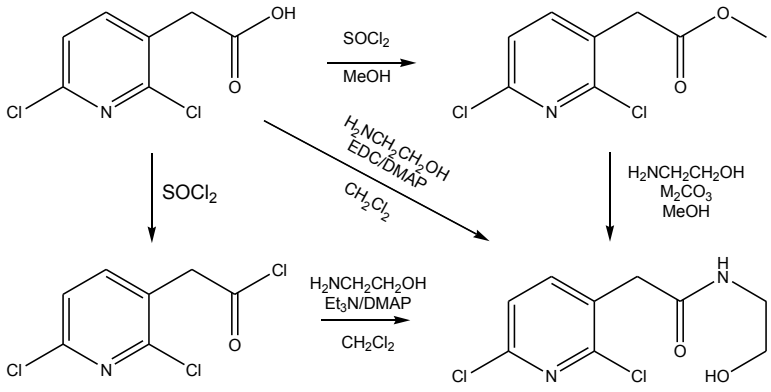
In pursuit of a viable stereoselective synthesis of alkaloids related to phantasmidine, we had need of a convenient method for coupling aminoalcohols to dichlorohomonicotinic acid. First attempts at carbodiimide coupling were not particularly successful and we sought a more convenient route. Conversion to the acid chloride via $SOCl_2$ were more successful and higher yielding but required reflux in the highly corrosive and water reactive reagent. In searching the literature for a milder method, we encountered a transamidation of methyl esters catalyzed by an *N*-heterocyclic carbene catalyst, but on closer examination, the cost of the catalyst would be prohibitive. However, we found that using a simple alkalai metal carbonate in methanol or *tert*-butanol worked quite well. A comparison of catalysts and conditions is presented.



Daniel Burkett is a junior ISU Chemistry major from Terre Haute, IN, and will graduate in May 2015

Mopelola Akinlaja is a sophomore ISU Chemistry major from Nigeria, and will graduate in May 2016

Nuclear Data Evaluation of Beta Delayed Particle Decay in Light Nuclei, A=3-20

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Nuclear data evaluation is the process by which experiments pertaining to the nuclear structure and decay information of over 3000 nuclides are evaluated. Nuclear data evaluation provides a centralized database such that people of all fields can use the same accepted values for the half life, the probability of emission, and other important values related to the energy levels. This summer I performed data evaluations for the following beta decays and beta delayed particle decays: ^{20}C (β^-n), ^{20}N (β^-), ^{20}N (β^-n), ^{19}N (β^-), ^{19}N (β^- n), ^{20}Na (β^+ α), ^{17}Ne (β^+), ^{17}Ne (β^+ p), ^{17}Ne (β^+ α). For each decay I determined the half-life, the probability of neutron emission (if applicable), and the energy levels in the daughter and granddaughter using the energy of gamma decays and the energy of particle decays paired with mass excess calculations. I also obtained the log(*ft*) value which is helpful in determining the spin and parity of each level. These evaluations were produced for the national nuclear data center at Brookhaven National Labs.

Epoxidation in Ether? Cycloalkene Oxides from *in-situ* Generated Trifluoroperoxyacetic Acid

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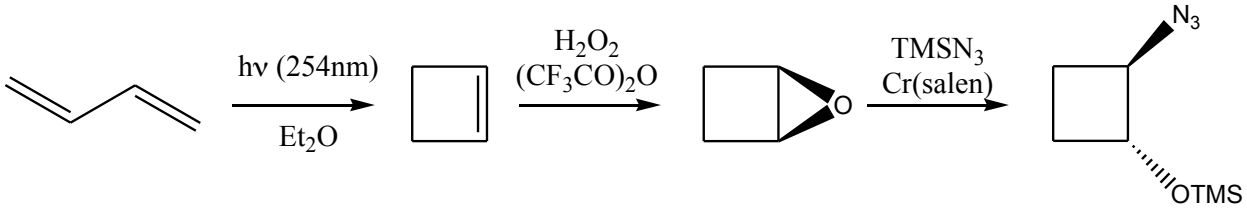
In pursuit of a viable stereoselective synthesis of alkaloids related to phantasmidine, we had need of a convenient method for producing enantiomeric trans-2-aminocyclobutanol on gram scale. Our approach involved photochemical ring closure of 1,3-butadiene to cyclobutene and conversion to the epoxide for ring-opening by azide under Jacobsen conditions. Photolysis proceeds in dilute (1% w/v) solution to produce the cycloalkane albeit slowly (7 days) and with some degree of polymerization. We had intended to carry the crude alkene through the sequence in ether solvent without isolation of intermediates as the Jacobsen ring opening is also conducted in ether. However, epoxidation presents a problem in ether solvent because of concerns of peroxide formation, which is both hazardous and fouls the catalyst for subsequent ring opening. We have investigated a variety of reagents for this transformation and for a variety of reasons, hydrogen peroxide and peroxytrifluoroacetic acid are preferred. We will discuss here our optimization of this process and methods for removing residual peroxide, water and peracid.



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Comparative Examination of Carbon Cryogel as a Solid Phase Extraction Media

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The concerning pollutants of the modern world tend to be the waste of exotic organic materials used in medicine, pest or weed removal. EPA method 525.1 describes a solid-phase extraction (SPE) preconcentration of contaminants in water followed by analysis using gas chromatography with mass spectrometric detection. SPE is an excellent candidate for removing these pollutants as it does not expose the water to organic solvents and works at trace concentrations. Carbon cryogels exhibit similar recoveries of trace amounts of 12 pesticides described in EPA method 525.1 when compared to the recoveries of four commercially available octadecylsilane (ODS or C18) cartridges. The extractions can also be accomplished using less mass per extraction with carbon versus standard columns.

This research was funded in part by Edwards Lifesciences under the auspices of the IRC.

Analysis and Simulation of Biopixel Arrays

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Biopixel arrays are a series of compartmentalized bacterial colonies, usually consisting of modified E. coli, designed to fluoresce in synchrony in response to heavy metal exposure. The synchronization across the arrays is achieved through a combination of short range and long range diffusive transport of redox signaling molecules such as hydrogen peroxide (H_2O_2). The main application of this technology is to provide an inexpensive heavy metal detector for use in testing drinking water in developing regions around the world. While it is a promising technology, biopixel arrays still exhibit some insufficiently explained oscillatory phenomena in respect to space and speed. A mathematical model for quorum sensing has been constructed and numerically analyzed by others. Our team proposes to build simplifications and generalizations of this model and would like to ultimately design a model that better represents the processes of the colonies.

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