Materials Research Science and Engineering Center

University of Minnesota

Driven to Discover℠

Summer Undergraduate Research Expo

August 7, 2014

McNamara Alumni Center

Memorial Hall

4:00-6:00pm

Undergraduate Poster Presentations
Listed Alphabetically by Presenting Author

1	**Katharine Anton** *Development of Titanium Based Catalysis for CN Bond Formation* **Advisor:** Ian Tonks **Department or Sponsoring Program:** UMN Chemistry- Heisig Gleysteen **Home Institution:** UMN **Abstract:** Transition metal catalysts are used to synthesize a variety of organic products. The aim of this research project is to develop titanium-based catalysis for the synthesis of pyrroles and diamination of alkynes. Current work focuses on the development of a pyridine phenolate (NO) ligand, substrates, and titanium imido and hydrazido starting materials. Future work will focus on metalation of the NO ligand onto the titanium catalyst precursors and exploring the catalytic properties of synthesized species.

2	**Xiang Ao** *The study of a new prophosphatrane* **Advisor:** Connie Lu **Department or Sponsoring Program:** UMN Chemistry- Heisig Gleysteen **Home Institution:** University of Minnesota--twin cities **Abstract:** The study of prophosphatrane can be dated back to last century. It can be used for the catalysis in organic chemical reactions and also as a scaffold to bind transition metal. Lately, a new molecule belongs to the prophosphatrane family with the pridine ring as the R group was successfully sythesized by Lu group. The properties of the molecule was studied, and a Cu complex was sythesized with this molecule as the ligand.

3	**Maya Audi** *Optimized Synthesis of Stereo-Electronically Different Triazolylidenes for the Nickel-Catalyzed Dehydrogenation of Ammonia-Borane* **Advisor:** Marites Guino-o **Department or Sponsoring Program:** University of St Thomas- Chemistry **Home Institution:** University of St. Thomas **Abstract:** Hydrogen gas has the potential for use as a renewable fuel. It can be stored in a chemical hydride, i.e. ammonia-borane, and its release can be controlled via a catalyst. Baker found in 2007 that Enders' carbene, a triazolylidene, was the most effective ligand for a nickel catalyst. To understand why it is most effective, we need to investigate how the ligand stereo-electronically affects the nickel center. Herein, we report the optimized synthesis of triazolylidenes with different steric bulk and electronic properties. Our colleague, Meghan Talbot, will report on the results of the nickel-based dehydrogenation catalysis of ammonia-borane utilizing these ligands.

4	**Chad Auginash** *Effective removal of poly(methyl methacrylate) residue from chemical vapor deposited graphene* **Advisor:** Steven Koester **Department or Sponsoring Program:** MRSEC **Home Institution:** University of Minnesota Duluth **Abstract:** Graphene, which is a one atom thick material made of carbon, has been found to have extraordinary physical properties. For instance, graphene has been found to have very high electron mobility and thermal conductivity. Graphene has been produced using methods such as chemical vapor deposition (CVD), mechanical exfoliation, and chemical synthesis. The removal of poly(methyl methacrylate) (PMMA) film from CVD graphene has been a critical step in the process of producing quality graphene. The sole purpose of PMMA is to provide a rigid surface as the graphene is transferred to a substrate such as SiO2/Si. Once the PMMA has served its purpose it will need to be removed. PMMA residue has been found to be substantially responsible for p-type doping in CVD graphene. Therefore, the effective removal is of great importance. The process used to remove the PMMA film will include a glacial acetic acid treatment, thermal annealing in an Ar/H2 gas mixture, and exposure to UV light at a wavelength of 253.7nm. The samples will then undergo atomic force microscope characterization to determine the optimal amount of time the samples need to undergo thermal annealing, glacial acetic acid treatment, and UV light exposure to effectively remove the PMMA residue.

5	**Marissa Beam** *Synthesis and Characterization of Molecular Bottlebrushes in Block Copolymers* **Advisor:** Marc Hillmyer **Department or Sponsoring Program:** MRSEC **Home Institution:** Tulane University **Abstract:** Molecular bottlebrushes consist of a polymeric backbone with densely grafted side chains, giving it the physical appearance of a bottlebrush. Block copolymers exist when two chemically distinct, but not necessarily dissimilar, polymers are "stitched" together. The two polymers will repel each other and, in turn, these copolymers will self-assemble into well-defined structures (called microphase separation). My research will explore the synthesis of block copolymers with the bottlebrush architecture using polystyrene (PS) and atactic polypropylene-norbornene (aPP-NB). I will synthesize diblocks of varying total molecular weights and volume fractions of the two polymers. Reversible Addition-Fragmentation Chain Transfer (RAFT) polymerizations and Ring Opening Metathesis Polymerization (ROMP) will be used to form the copolymers, and various analytical techniques such as nuclear magnetic resonance (NMR) spectroscopy, size exclusion chromatography (SEC) and differential scanning calorimetry (DSC) will be employed to characterize the polymers' physical properties such as molecular weight, glass transition temperature, and chemical composition. These will then be further characterized to determine the microphase separation present which will be used to help determine the effect of the bottlebrush architecture in block copolymers on microphase separation.

6	**Emily Bermel** *Planar Biaxial Extension of Porcine Cervical Facet Capsular Ligaments (FCLs) for Insight into Shear Loading and Localized Stress Concentrations* **Advisor:** Victor Barocas **Department or Sponsoring Program:** MRSEC **Home Institution:** Montana State University **Abstract:** Facet joints are located on the posterior side of the spine and multiple FCLs span from the cervical to lumbar regions. Facet joints include rigid bone and flexible connective tissue, and the different tissues work together to transfer loads across the joint and stabilize the vertebrae. The FCL is the flexible connective tissue that connects adjacent articulating vertebrae and exhibits viscoelastic properties. The FCL is composed of nerve fibers embedded within the aligned collagen fibers that send proprioceptive (position) and nociceptive (pain) signals to the brain. Investigations of this ligament have led to a deeper understanding of its significant role in back pain and whiplash. During this project FCLs will be subjected to planar extension tests with an Instron® bi-axial tester. We aim to determine how porcine cervical FCLs respond to varying loading configurations and rates of loading by analyzing load data and calculating global and local strains.

7	**Alexandra Boldin** *Analysis of Spin Polarization in Half Metallic Heusler Alloys* **Advisor:** Paul Crowell **Department or Sponsoring Program:** Physics REU **Home Institution:** Macalester College **Abstract:** Half metals are of great interest in the field of spintronics because of their high spin polarization leading to a much larger spin signal. In this project, we examined four ferromagnetic Heusler alloys that are expected to be half metallic. We studied both the Anisotropic Magnetoresistance (AMR) effect and the Anomalous Hall Effect (AHE) to characterize the samples. Both effects are expected to exhibit a sign dependence on spin polarization, thus providing an easy method of identification of half metals.

8	**Faith Bradley** *Carbon Composite Shell for a Hydraulically Powered Ankle-Foot Orthosis* **Advisor:** William Durfee **Department or Sponsoring Program:** CCEFP **Home Institution:** University of Illinois at Urbana-Champaign **Abstract:** Ankle-foot impairments are considered one of the most immobilizing conditions to treat, and there is a need for improvements in clinical rehabilitation, diagnostics, and treatment methods. Orthoses can be used to address this need. Orthoses have certain design requirements. First, they should be light-weight; it has been shown that merely 2 kg placed around each foot of a healthy adult can increase oxygen consumption by 30% [1]. Second, they should be comfortable; the orthosis should not bruise nor abrade the user's skin. The Human/Machine Design Lab at the University of Minnesota- Twin Cities is developing a Hydraulic Ankle-Foot Orthosis (HAFO) that has the capability of producing up to 90 Nm of torque about the ankle joint to assist in plantar flexion. The previous model of the HAFO weighs over 2 kg, and lacks comfort when worn by users of many shapes and sizes. The objective of this project was to reduce the weight of the HAFO by designing and fabricating a lower-weight shell that can withstand high forces from the device, yet is still comfortable to the researchers in the lab for the future development of the HAFO. To meet the design requirements, a composite shell was fabricated using twill-weave carbon-fiber and epoxy in a design inspired by metal double-upright ankle-foot orthoses. To achieve a precise geometry, the composite was formed around a thin 3D-printed shell made of PLA-filament. Given the design of the shell, it can be secured to the HAFO without embedding the machined parts into the composite. This design allows for easy disassembly, and, consequently, easy modifications for future development of the HAFO. Future goals include testing to ensure that the shell can withstand clinically-relevant forces over multiple cycles and that prolonged use of the shell will not cause discomfort to the wearer. [1] Waters, Robert L., and Sara Mulroy. "The energy expenditure of normal and pathologic gait." Gait & posture 9.3 (1999): 207-231.

9	**Julia Brekke** *A Novel Method to Improve the Efficacy of Cardiopulmonary Resuscitation* **Advisor:** Afshin Divani **Department or Sponsoring Program:** UROP **Home Institution:** University of Minnesota, College of Science and Engineering **Abstract:** Reduced left ventricular performance and sudden cardiac arrest are leading causes of morbidity and mortality. During cardiac arrest, urgent reestablishment of cardiac function is required to prevent irreversible damage to viable organs, particularly the brain. Cardiopulmonary resuscitation (CPR), whereby serial compression is applied to the external or closed chest combined with airway support, serves to reestablish circulation of oxygenated blood for vital perfusion in an emergent setting. One drawback of this technique is that the applied force and resulting pressure is not fully absorbed by the heart due to the dead space in the chest cavity between the spine and anterior rib cage. In fact, the slight increase in cardiac output during CPR is generally attributed to the creation of negative pressure in the thorax with subsequent increase in venous return during chest compressions. To improve the cardiac output and effective distal perfusion during CPR, it was proposed to place a non-compliant esophageal dilation balloon-catheter to provide relatively rigid support against the posterior wall of the left ventricle, so that the external chest compressions may translate to a more efficient compression of the heart during CPR. It was found that the coronary perfusion pressure increased by approximately 50% when the balloon was deployed in the esophagus.

10

Stephanie Breunig
Rational Design of APOBEC3 Inhibitors Based on High-Throughput Screening Hits
Advisor: Daniel Harki
Department or Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota, Twin Cities
Abstract: The APOBEC3 (A3) family of enzymes consists of seven single-stranded DNA cytosine-to-uracil deaminases, which function in the innate immune response. A3-catalyzed deamination in the template DNA strand results in insertion of adenine across the uracil nucleobase during replication, resulting in an overall guanine-to-adenine mutation. An accumulation of A3-promoted pro-mutagenic events leads to hypermutation within the A3-targeted, foreign DNA genome, thereby providing protection to the host cell. However, misregulation of A3 enzymes can lead to the initiation and propagation of certain diseases by contributing to the genetic variation observed in human immunodeficiency virus (HIV-1) and breast cancer. Sub-lethal A3-catalyzed mutation in HIV-1 can allow the virus to evade the host immune system and antiviral therapies, while overexpression of A3 in cancer cells can lead to chemotherapeutic resistance.
High-throughput screening (HTS) performed by the Harki and Harris labs have identified structurally unique small molecule inhibitors of A3 enzymes as lead compounds for future HIV-1 and cancer therapeutics. Two classes of inhibitors were indentified through this effort: non-covalent inhibitors of A3A, A3B, and A3G; and covalent inhibitors that specifically engage A3G. This poster will present our progress towards the rational design, synthesis and preliminary biochemical evaluation of next-generation A3 inhibitors with enhanced potency, selectivity, and water solubility.

11

Nicholas Brinza
Liquid Extraction of Bacteria Produced Lactones and Indoles
Advisor: Anthony Borgerding
Department or Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: In this work, liquid extraction is used to trap and analyze VOCs produced by bacteria directly from the culture while the bacteria are growing. An organic solvent (hexanol or dodecane) is mixed with a bacterial culture of e. coli to collect VOCs produced by the bacteria. Once the two layers separate, the organic layer is manually extracted and then placed in a vial for injection into a GC FID. GC retention times and peak areas are used to determine the types of VOCs made by bacteria as well as calculate the quantity of VOCs produced. To verify the quantitative aspects of these experiments, indole, gamma-nonanoic lactone, and toluene standards prepared in growth media without bacteria have been extracted into the solvents. These experiments were used to study equilibrium effects and the time required for extraction. These analytes were observed with signal to noise ratios of at least five to one for concentrations as low as 0.001M, and further experiments to see whether concentration of the analyte can be increased by evaporation of solvent were performed.

12

Jordan Buhle
Substituent and Solvent Effects: Examining Acidity Via Infrared Spectroscopy
Advisor: Steven Kass
Department or Sponsoring Program: UMN Chemistry- Lando
Home Institution: Ripon College
Abstract: There is a large collection of substituent constant data measured in polar protic and polar aprotic solvents, but a lack of information on substituent effects in nonpolar aprotic solvents. In this study, substituent effects on the acidities of phenol derivatives were examined in CCl_4 using infrared (IR) spectroscopy. The IR peak of the free phenolic -OH appears at approximately 3600 cm^{-1} which is redshifted in the presence of a hydrogen bond acceptor. The magnitude of the splitting between the free and the hydrogen-bonded -OH peak is related to the acidity of the protic hydrogen. Deuterated acetonitrile was used as the hydrogen-bond acceptor to probe the relative acidities of 21 phenol derivatives in CCl_4. While most phenol derivatives exhibited similar acidity trends in CCl_4 as in DMSO, several demonstrated a reduction in acidity which indicates a solvent dependence on substituent effects. This study offers a facile method to examine substituent effects on the acidity of alcohols and has identified several solvent-dependent substituents.

13

Emiliana Cofell
Cerium Doped TIG for Magneto-Optical Applications
Advisor: Beth Stadler
Department or Sponsoring Program: NNIN
Home Institution: Scripps College
Abstract: Cerium doped Terbium Iron Garnet is a material with magneto-optical properties that make it useful in devices such as optical isolators, which are used to improve silicon photonics devices by restricting light to pass through photonic circuits in only one direction. The principle behind such non-reciprocal devices is called Faraday Rotation. This is the rotation of the polarization of light when passing through a magneto-optic material under an applied magnetic field. Iron Garnet materials produce this effect and therefore are useful in silicon photonics. The particular material that I investigated is known as Terbium Iron Garnet (Tb3Fe5O12). My research involved introducing various percentages of Cerium into the TIG compound (CeXTb3-xFe5O12), which was done using the sputtering technique onto quartz and silicon substrates. I then annealed these samples at various temperatures using the Rapid Thermal Annealer (RTA). Using X-Ray Diffraction (XRD), I discovered that crystallization was achieved at annealing temperature of 800 and 900 Celsius with zero to around 15 percent Cerium. I then measured the magnetic properties of my samples using the Vibrating Sample Magnetometer (VSM), and also measured the Faraday Rotation of the materials using an optics bench setup with an IR laser, discovering a correlation between increasing Cerium content and greater Faraday Rotation of the laser.

14

Monique Cook
Microstructure and Mechanical Properties of Block Copolymer Modified Epoxy Resins
Advisor: Frank Bates
Department or Sponsoring Program: MRSEC
Home Institution: Florida Agricultural and Mechanical University
Abstract: From hardwood floor finishing to food packaging, epoxy coatings are widely used today to extend the life of materials that would, otherwise, be susceptible to deterioration (i.e. corrosion). This investigation takes a closer look into toughening epoxy coatings by the inclusion of block polymers at low weight percentages (2 – 5 wt %) with the hopes of creating a more durable coating. The epoxy resin being studied contains a commercially available epoxy monomer (DGEBA) and a curing agent (Jeffamine T-403). When added to the resin, poly(ethylene-alt-propylene)-b-poly(ethylene oxide) (PEP–PEO), the block polymer, will self-assemble into various structures which will toughen the coating by preventing the propagation of cracks. By varying the morphology of PEP-PEO in the resin, tougher coatings can be prepared. Mechanical properties, which are dependent on the thickness of the coating and the morphology of the block polymer, will be determined by various techniques. It has been hypothesized that a worm-like structure would be the most beneficial while still maintaining the integrity of the original resin; that is to say, that the modulus and glass transition temperature will not be sacrificed.

15

Katie Cornille
Metabolic Incorporation of Alkyne-Modified Isoprenoid Analogs in Human Cells
Advisor: Mark Distefano
Department or Sponsoring Program: Other
Home Institution: Allegheny College
Abstract: Protein prenylation is a post-translational modification that occurs when an isoprenoid is covalently attached to a protein. Here, metabolic labeling of multiple isoprenoid analogs modified with an alkyne group was used to observe prenylation in human cells. Cells were treated with combinations of lovastatin and one of seven probes. After labeling in cell culture, cells were lysed and subjected to a copper-catalyzed, bio-orthogonal reaction using a TAMRA-azide-based reagent to fluorescently tag labeled proteins. These proteins were fractioned and visualized via 1-dimentional gel electrophoresis, and the extent of labeling was quantified by densitometry analysis. The effects of probe concentration on prenylation were studied by performing labeling in concentrations from 5 to 50 μM. Labeling specificity of prenylated proteins was demonstrated by increased prenylation in the presence of lovastatin and decreased prenylation when in competition with the natural substrates. These results help clarify critical structural features that provide optimal metabolic labeling in prenylated proteins. Studies such as this are important for identifying which proteins become prenylated in mammalian cells and how the levels of such proteins affect human diseases.

16

Laura Crepeau
Synthesis of Isoprenoid Diphosphate Substrates for PFTase
Advisor: James Wollack
Department or Sponsoring Program: St. Catherine University- Chemistry
Home Institution: St. Catherine University
Abstract: Protein Farnesyltransferase (PFTase) is an enzyme that incorporates farnesyl groups into proteins and peptides that end in a certain amino acid sequence. Previously, non-natural substrates have also been transferred by PFTase. These substrates could subsequently undergo bioconjugation reactions via copper catalyzed click chemistry. Because of copper's cytotoxicity, these substrates are not compatible with in vivo applications.
Presented here are two bioorthogonal substrates that do not require the use of a copper catalyst for subsequent bioconjugation reactions. The first contains a norborene ring to initiate a tetrazine ligation reaction and the second contains a vinyloxybenzene for a photoreaction on a diaryl tetrazole. Both substrates are predicted to be PFTase substrates that will allow for the eventual incorporation of new properties such as fluorescence on targeted proteins.

17

Christopher Davidson
Development of Diamond-Like Carbon Deposition Processes and Microfabrication of Thin-Film Ag/AgCl Reference Electrodes
Advisor: Stephen Campbell
Department or Sponsoring Program: NNIN
Home Institution: University of Nebraska - Lincoln
Abstract: The ability to track neurotransmitters at a cellular level could greatly expand our understanding of the brain. To do this, however, we need to make safe, implantable devices that can sense activity at this level. Two aspects of this project were focused on in this research: a) the use of diamond-like carbon as a biocompatible coating for these devices, and b) the fabrication of thin-film Ag/AgCl electrodes to measure concentration of neurotransmitters. Due to its favorable properties, diamond-like carbon could reduce glial scarring and improve durability of these sensors. It was deposited using different gas mixtures of CH4 with N2, He, or Ar by an rf-plasma enhanced chemical vapor deposition (PECVD) system. The deposition rates for each gas mixture was found and the films were then characterized by Raman spectroscopy. Unfortunately, it was found that only amorphous carbon was formed during this process. However, annealing said samples at 600°C for 30 minutes in a sealed ampoule was shown to make DLC. After this was done, microfabrication of a Ti/Pd/Ag/AgCl/KCl-gel solid-state electrode was completed. This electrode can be used to measure concentration of different neurotransmitters in the brain through cyclic voltammetry.

18

Rong Deng
Synthesis and Characterization of Strontium Titanate
Advisor: Chris Leighton
Department or Sponsoring Program: UROP
Home Institution: University of Minnesota
Abstract: As a semi-conducting perovskite oxide, Strontium Titanate (SrTiO3) has many remarkable electronic properties that make it a widely investigated material both in bulk and thin film forms. The focus of the project is to grow highly-stoichiometric thin films of SrTiO3 using high pressure oxygen sputtering over various substrates with the aim of studying spin transport in these films. Powder processing and sintering processes are used to make targets for sputtering. Undoped SrTiO3 and various doping concentrations of Nb- or La- doped SrTiO3 were synthesized as sputtering targets. During sputtering, atoms ejected from the sputtering target are collected on the surface of substrates placed in the chamber to get the thin film of the desired material – in this case, Strontium Titanate. X-Ray Diffraction was used to study the structure of synthesized films with respect to various deposition parameters and film thicknesses. The experimental results illustrate that high pressure oxygen sputtering leads to stoichiometric SrTiO3 film under certain deposition conditions. The poster will discuss our recent results on strain relaxation in both stoichiometric and non-stoichiometric films of SrTiO3 grown on LaAlO3(001) substrates. Both structural and electronic properties will be discussed to develop a full picture of strain relaxation in these films.

19	**Sam Dennert** *Effects of Mass Spectrometer Parameters on Protein Spectra* **Advisor:** Anthony Borgerding **Department or Sponsoring Program:** University of St Thomas- Chemistry **Home Institution:** University of St. Thomas **Abstract:** Protein analysis is important to a number of different fields, especially biomedical and food science. Because of the integral part proteins play in human health analysis is extremely important. As such, knowing the best parameters by which to analyze proteins is also important. Analysis of 7 different proteins was conducted on a Q-TOF mass spectrometer using electrospray ionization (ESI). The parameters of the mass spectrometer, including cone voltage, and ESI voltage, were changed to determine the impact of charge state and other parameters on the generated spectra. This was done both in an attempt to determine the best parameters for the testing of proteins in general as well as to give information on the consistency of spectra taken under different conditions. The results of this research will aid in the future analysis of proteins so as to ensure accuracy whether it be the diagnosis of illness or determining the nutritional value of various foods.

20	**Jaya Dhami** *Structures and Reactivity of Some Nitrogenous Organic Solids* **Advisor:** William Ojala **Department or Sponsoring Program:** University of St Thomas- Chemistry **Home Institution:** University of St. Thomas **Abstract:** Our work is focused on the relationship between molecular structure and crystal structure in organic compounds and its implications for solid-state reactivity. As part of that work, we have been examining two families of nitrogen-containing organic compounds, the benzylideneanilines (R-CH=N-R', R = aryl) and the benzonitrile oxides (R-C≡N+-O-, R = aryl). We define bridge-flipped isomeric benzylideneanilines as those pairs that differ only in the reversal of the orientation of the imino linkage: R-CH=N-R' vs. R-N=CH-R'. The relatively small size of the bridge hydrogen atom and the common occurrence of end-for-end disorder of the molecules in benzylideneaniline crystal structures suggest to us that isomorphism (identical solid-state molecular packing arrangements) should be possible for bridge-flipped isomeric benzylideneanilines. We are examining benzylideneanilines substituted with both halogen atoms and nitrile groups to determine whether similar intermolecular X-R-C≡N:…X-R-C≡N: Lewis acid-base interactions occurring in both members of a bridge-flipped pair can encourage their isomorphism. We are also preparing bis-benzylideneanilines capable of assuming centrosymmetric molecular conformations to determine whether or not the tendency of centrosymmetric molecules to occupy crystallographic centers of symmetry can encourage isomorphism. Our studies of crystalline benzonitrile oxides concern the solid-state reactivity of these compounds as a function of their ring substitution pattern. Which of three possible solid-state dimers may form and how readily they form are questions being explored. As part of that study, we have begun monitoring the solid-state reactivity of 3-bromobenzonitrile oxide and 4-nitrobenzonitrile oxide by infrared spectroscopy and are pursuing an X-ray crystal structure determination of one of the possible 3-bromobenzonitrile oxide dimers, the bis-(3-bromophenyl)furoxan.

21

Christina Dinh
Viral Gene Silencing Using Peptide Targeted Stealth Liposomes
Advisor: Efie Kokkoli
Department or Sponsoring Program: UROP
Home Institution: University of Minnesota
Abstract: siRNA has shown potential as a powerful gene therapy tool, however its application is limited by the lack of effective delivery methods. The major challenges to effective delivery of siRNA include avoiding siRNA degradation prior to reaching target cells, release of siRNA from the vehicle upon entering the cell and targeted delivery to diseased cells. In order to address these challenges, peptide targeted liposome-encapsulated siRNA was developed, characterized and the efficacy of the system to silence a target gene was assessed. In the developed system, siRNA is first condensed into particles with the cationic polymer polyethylenimine (PEI) in different PEI:siRNA ratios before being encapsulated by peptide targeted stealth liposomes.Size and charge of the condensed siRNA particles and the liposomes as well as encapsulation yield of siRNA within the liposomes was measured. In order to determine the best liposome formulation for effective targeting, liposomes with varying peptide composition were delivered to cancer cells and the binding and internalization of the liposomes was measured. Finally, peptide targeted liposomes containing an siRNA sequence found to degrade the E7 Human Papillomavirus (HPV) gene were delivered to HPV infected cells, and silencing of the target gene was determined using RT-PCR. For all PEI:siRNA ratios, peptide targeted stealth liposomes showed higher silencing than siRNA particles, and the liposomes containing siRNA particles condensed at a PEI:siRNA ratio of 6:1 achieved the highest silencing. Understanding how different characteristics of the developed peptide targeted liposome - encapsulated siRNA system affects HPV silencing has moved siRNA therapy closer to successful application in vivo.

22

Erin Duffy
Monitoring the Labeling Effects of Chromeo P503 on Amino Acids using High Speed Capillary Electrophoresis
Advisor: Michael Bowser
Department or Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota, Twin Cities
Abstract: Several labeling reagents have been studied for use in high speed microdialysis-capillary electrophoresis (MD-CE) assays for amino acids. The method of microdialysis has found widespread significance, and this assay focuses on applications to areas of neuroscience that monitor chemical changes in the brain. In particular, these labeling strategies look to overcome limitations related to reaction efficiency, reaction times and potential formation of precipitates. This study focuses on the implementation of Chromeo P503 for an online labeling protocol of branched chain amino acids. Comparisons between the existing protocol using NBD-F (4-Fluoro-7-nitro-2,1,3,-benzoxadiaxole) have been drawn in an effort to overcome the current limitations.

23

Danielle Francis
Platelet Response to Opioid Agonists
Advisor: Christy Haynes
Department or Sponsoring Program: UMN Chemistry- Lando
Home Institution: Mississippi State University
Abstract: Platelets, 2.5 mm disk-shaped cell-like bodies, help maintain hemostasis and play a role in the primary immune response. Upon mechanical or chemical stimulation, platelets undergo morphological changes to form tendril-like extensions and release coagulation proteins and communication factors, housed in specific secretion vesicles called granules, through the highly conserved process of exocytosis. The three distinct types of granules in platelets are dense-body granules, which contain small molecules including serotonin, alpha granules, which contain molecules for clotting, and lysosomes. The granule release and adhesion properties can be quantitatively measured after exocytosis through electrochemical methods, ELISA and aggregation assays, and adhesion microfluidic devices. By measuring a variety of platelet functions, platelet response to their environment can be better understood, particularly when they are subjected to drugs such as legal or illegal opioids. In the past few years, the use of opioids such as morphine has increased, but the connections between prolonged use of these drugs and the effects on biological systems are not fully understood. Our results show that mouse platelets contain opioid receptors, and we have elucidated effects of opioid interactions with platelets by measuring serotonin, PF4, B-HEX, and adherence. Our results show that both the opioid receptors and the agonists affect platelet function.

24

Joseph Gauthier
Determining Interfacial Rheological Properties of Thin Pulmonary Surfactant Films
Advisor: Chris Macosko
Department or Sponsoring Program: MRSEC
Home Institution: Ohio State University
Abstract: Neonatal respiratory distress syndrome (NRDS) is a condition in which the lung surfactant of infants is not produced in adequate quantities. Further, acute respiratory distress syndrome (ARDS), a condition in which lung surfactant becomes deactivated giving way to rapid respiratory failure, has a mortality rate of 30-40% and affects over 100,000 people in the U.S. per year. This surfactant consists primarily of the phospholipid Dipalmitoylphosphatidylcholine (DPPC), which consists of two long hydrocarbon chains attached to a hydrophilic head. The pulmonary surfactant, and thus DPPC, exists in the lungs as thin films coating the alveoli, and so characteristics of DPPC as a thin film is significant in the performance of the lung surfactant. It is known that cholesterol and fatty acid has a significant effect on the surface characteristics of DPPC even in very small concentrations. Previous attempts to characterize the surface interfacial rheology of DPPC have failed due to the high surface viscosities exhibited by the surfactant at high surface pressures and low concentrations of cholesterol. The goal of this research is to utilize a new technique to measure interfacial rheology, called the double wall ring. By determining how the interfacial rheology of DPPC is affected by surface pressure, cholesterol concentrations, and fatty acid concentrations, it is hoped that conditions such as ARDS and NRDS may be able to be better treated by adjusting surface rheology in the replacement surfactant via cholesterol and fatty acid concentration.

25

Benjamin Gelinas
A Mechanistic Study of the Final Ring Closure of BN-Pyrene
Advisor: Eric Fort
Department or Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of Saint Thomas
Abstract: A 2007 study by Piers et al. reported that BN-Pyrene could be synthesized through a platinum catalyzed ring closure of 1-chloro-2-(trimethylsilyl)boracyclohexa-2,5-diene and 2,6-diethynylpyridine; however, in a 2014 study by Fort et al. reported a microwave assisted synthesis that did not require the platinum catalyst. The mechanism of the initial ring closure was reported to be electrocyclic by Piers; however, the final ring closure mechanism is unknown to date. This study investigates three possible mechanisms for this non-catalyzed ring closure of BN-Pyrene using Deuterated 2,6-diethynylpridine. In addition, we report one of the first microwave assisted deuterated desilylation reactions, in which we were able to achieve deuterium incorporation as high as 98%.

26

Tyler Goddard
Mechanism Studies for the Pentadehydro-Diels-Alder Reaction
Advisor: Thomas Hoye
Department or Sponsoring Program: UMN Chemistry- Lando
Home Institution: Baylor University
Abstract: Recently, Hoye and coworkers have developed a novel reaction which they have named the pentadehydro-Diels-Alder (PDDA) reaction. They have proposed that it occurs through an allene intermediate. Several different substrates were synthesized for use in mechanism studies to test this theory, and two of the monoyne substrates were reacted with various bases under different conditions. These reactions were monitored by gas chromatography, and a change in retention time for both of these compounds was observed when they were reacted with sodium hydroxide, suggesting that allene formation may have occurred. This observation was successfully confirmed by NMR for one of these compounds. Similar results have not yet been observed with organic bases, but allene formation in other related substrates is currently being investigated under more mild reaction conditions like those used in the PDDA reaction.

27

Philip Grossweiler
From Nanoparticles to Solar Panels
Advisor: Uwe Kortshagen
Department or Sponsoring Program: MRSEC
Home Institution: University of Texas- Pan American
Abstract: A nanoparticle is defined as a particle that is at least one dimension less than 100 nm. Different elements can be used to make different nanoparticles that are appropriate for the certain applications of the project or experiment; the main elements being used in this project will be silicon and germanium. This project focuses on the use of a spray gun to apply these nanoparticles to a substrate, with the expected future application of being able to easily create solar panels by simply spraying a coating of nanoparticles on a large substrate. Both silicon and germanium are being spotlighted by this project because they both have properties that indicate that they will attract and hold sunlight, while also being safe and non-toxic. My purpose in this project is to automate the spray gun being used. This will allow for the conditions of each test to be effortlessly duplicated which in turn will make it easier for the results to be analyzed and compared to one another.

28

Alek Gust
Modeling the Check Valve
Advisor: Jim Van de Ven
Department or Sponsoring Program: CCEFP
Home Institution: St John's University
Abstract: Hydraulic fluid power systems have very high power and force output advantages over other technologies but it comes at the cost of being inefficient. The introduction of switch-mode hydraulics (which is analogous to digital electronics) holds great promise for these systems to become more efficient. Unfortunately, several challenges arise regarding switch-mode hydraulics that are not present in digital electronics. Electrons, being of very low mass and thus low inertia can be forced to change directions very easily. Whereas fluids, being much more massive, are very difficult to change direction. Switch mode hydraulics systems require a high speed valve that can route flow quickly between the load and tank. A major component in a high speed valve is a one way check valve. At high frequencies, check valves in hydraulic systems have the tendency to allow leakage flow back to tank which results in wasted energy and decreases efficiency. My summer 2014 REU research program is to investigate and measure the behavior of a check valve under different conditions to better understand the root causes of this leakage.

29

Stephanie Hart
Vibrational Coherences Driving Singlet Fission in Tetracene
Advisor: Renee Frontiera
Department or Sponsoring Program: URS
Home Institution: University of Minnesota
Abstract: The efficiency of current photovoltaic cells is restricted by the Shockley-Queisser limit making the theoretical maximum efficiency of a single p-n junction system 32% (Smith & Michl, 2013). In recent years singlet fission in organic thin films has gained interest as it has the potential to increase this theoretical maximum efficiency. The goal of this project is to determine what vibrational coherences drive singlet fission in tetracene using Femtosecond Stimulated Raman Spectroscopy (FSRS), an innovative technique using three laser pulses to achieve high spatial and temporal resolution. The tetracene crystals were grown by evaporation and physical vapor transport, and we took ground state Raman spectra, time resolved Raman spectra, and transient absorption data. The crystals were too thick to acquire the appropriate time resolved data to track the dynamics of singlet fission, so further improvements can be made in producing tetracene samples with a low optical density.

30

Helen Heinks
Luminescent Lanthanide Probes for Transition Metal Ions
Advisor: Valarie Pierre
Department or Sponsoring Program: UROP
Home Institution: University of Minnesota
Abstract: The transition metal ions copper and zinc have interrelated roles in brain function. Their localization is known to be affected by and related to aging, stroke, and neurodegenerative diseases. However, little is known about how the location and concentration of these metal ions change throughout the process. Currently, there is no probe that can accurately measure the concentration of these metal ions at the same time, so their interrelated roles cannot be accurately studied. A luminescent lanthanide probe can fulfill this need because each lanthanide has a unique emission spectra that does not overlap with the others or participate in förster energy transfer. By simultaneously using probes with different lanthanides, the metal ions can be monitored in concert, making lanthanide probes ideal for studying several metal ions at once. Probes have been designed that contain one, two, or three phenanthridine antennas in such a way that the lanthanide responds to a specific analyte of interest. Herein, the sensitivity and selectivity of the probes Tb monophen, Tb diphen, and Tb triphen are presented.

31

Daniel Hickox-Young
Spin Hall Effect Based Magnetic Tunnel Junction Logic Devices
Advisor: Jian-Ping Wang
Department or Sponsoring Program: MRSEC
Home Institution: St. Olaf College
Abstract: As the use of MTJ based devices becomes more widespread, one of the limitations of modern magnet-based computing is the necessity of an external magnetic field for clocking purposes. This limits scalability and energy reduction. However, we can overcome both of these limitations by using logic devices with three innovations: magnetoresistive elements for read-out, spin transfer torque for writing of information, and the spin Hall effect for clocking. Working primarily in the Minnesota Nano Center, we used photolithography, electron beam lithography, and ion milling to fabricate multiple MTJ pillars on top of a tantalum Hall bar. The MTJ pillars have perpendicular anisotropy and a TbFeCo/Mgo/TbFeCo structure. We then used electron beam evaporation to deposit Ti/Au contacts. By measuring the magnetoresistance across the circuit while varying an external magnetic field, we observed each MTJ pillar switch from anti-parallel to parallel individually. Our results demonstrate the feasibility of using these different states to represent the logic values of 0 and 1 in a majority logic function.

32

Joshua Hiltbrand
Properties of Amorphous Silicon Thin Films Embedded with Nanocrystals for Application in Particle Detectors
Advisor: Jim Kakalios
Department or Sponsoring Program: Physics REU
Home Institution: University of Minnesota Duluth
Abstract: The next generation of particle detectors must be able to withstand an incredible amount of harsh radiation and one possible material for withstanding this intense radiation is a/nc-Si:H. For this project, conductivity as a function of temperature and the Staebler-Wronski effect were measured in a series of amorphous silicon thin films embedded with silicon nanocrystals. Each film's conductivity was measured from 305 K to 470 K with 50 V applied across the film. In addition, the Staebler-Wronski effect was induced on the films by shining a light, whose spectrum resembles the sun, on the films. Conductivity tests were run before and after this "lightsoaking," to get a measure of how severe the Staebler-Wronski effect is for the films. In the continuation of this project, the films will be irradiated by a high flux proton beam. The films will then be given the same conductivity tests as before in order to measure the effect of the radiation damage, how the damage compares to the Staebler-Wronski effect and how well the radiation damage can be annealed away. Based on the conductivity tests of the pre-irradiated films, a high concentration of large nanocrystals seems to show a lowering of the overall conductivity compared with films of lower concentration and those with smaller nanocrystals.

33

Bradley Hogan
Free Piston Engine Hydraulic Pump
Advisor: Sun Zongxuan
Department or Sponsoring Program: CCEFP
Home Institution: University of Wisconsin - Madison
Abstract: In today's common internal combustion engine exist a limiting crankshaft associated with mechanical losses. These disadvantages are eliminated in the free piston engine hydraulic pump due to the creation of a virtual crankshaft. The opposed piston pairs and hydraulics work together to supply fluid power in an efficient and compact manner; the virtual crankshaft is created and controlled from the hydraulic power accumulated by the free piston engine. This allows for variable combustion ratios and higher I.C.E. efficiencies. Due to the pistons and hydraulics direct connections, the pistons act as linear hydraulic pumps, also increasing pump efficiency. This promising engine-pump pair is developed on the test bed of a hydraulic hybrid passenger vehicle. Recently the project has developed new heat release calculations along with a high pressure direct injection system and will be taking on the optimization of combustion. If control of the piston motion and combustion elements is mastered, the free piston engine hydraulic pump could take both on and off road vehicle efficiencies to new heights.

34

Anna Huff
Microwave Characterization of Xe-SO3
Advisor: Ken Leopold
Department or Sponsoring Program: UMN Chemistry- Lando
Home Institution: Gustavus Adolphus College
Abstract: Intermolecular interactions are at the core of chemical processes, making their detailed characterization widely applicable to the fundamental understanding of various chemical systems. Microwave spectroscopy is a sensitive technique for gaining structural information which gives insight to the interactions in weakly bound clusters. This microwave study of Xe-SO3 continues from a series of noble gas (Ng=Ar, Kr) complexes that involve a strong Lewis acid, SO3, which plays a prominent role in the formation of atmospheric sulfuric acid. By utilizing both the broadband chirped-pulse and high resolution cavity components of a Fourier-transform microwave spectrometer, spectra were easily located and resolved for nine Xe-SO3 isotopologues resulting in fitted rotational constants B, DJ, and DJK for each complex. The nuclear quadrupole coupling constant, which depends on the electric field gradient at the Xe nucleus, was also determined for 131Xe which has a nuclear spin of 3/2 and consequently exhibits hyperfine structure. As expected, the calculated Xe-S bond length is the largest of the Ng-SO3 series as is the Xe-S stretching force constant. While this observation, along with a large electric field gradient at the Xe nucleus compared to Kr, might initially indicate more significant polarization of the Xe nucleus, prior work with Kr revealed electrostatic and charge transfer terms also contribute to the electric field gradient which prevents a direct relationship to polarization.

35

Kadir Hussein
Toxicity of Silver Nanoparticles in the Environment: Natural Organic Matter Effects on Silver Nanoparticle Toxicity to Bacteria
Advisor: Christy Haynes
Department or Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota Twin Cities
Abstract: Silver Nanoparticles (AgNPs) are one of the most commonly utilized nanomaterials in biomedical, electronic, and consumer products due to, e.g., their unique antibacterial, electrical and optical properties. The increasing prevalence of silver nanoparticles in these products will inevitably lead to their release into aquatic environments, as a result of product use and/or degradation. Therefore, it is important to investigate the toxicity and behavior of AgNPs under environmentally relevant conditions to prevent potential negative impacts on aquatic environments. Our previous studies have shown that natural organic matter, a ubiquitous component of natural aquatic environments, can form complexes with Ag^+, the species released during oxidative dissolution of AgNPs which is the primary source of AgNP toxicity to microorganisms. In this work, we evaluated the hypothesis that complexation of Ag^+ by NOM alters its toxicity to microorganisms. To do this, we evaluated the impact of Ag^+ on bacterial cell membrane integrity as a function of NOM concentration and chemical composition. Our results suggest that NOM which is rich in sites with high affinity for Ag^+ will have the greatest mitigating impact on AgNP toxicity to microorganisms.

36

Nezhueyotl Izquierdo

Aerosol-jet printed electrolyte-gated transistor using co-block polymers for application in printed electronics

Advisor: C. Daniel Frisbie

Department or Sponsoring Program: MRSEC

Home Institution: The University of Texas Pan-American

Abstract: Electrolyte gated transistors (EGT) fabricated by aerosol jet printing offers exciting insight into a viable method for high-volume and low-cost manufacturing of transistors for potential application in printed electronics and bio-chemical sensors. Aerosol-jet printing technique will be used to deposit thin films of poly (3-hexylthiophene) (P3HT) p-type semiconductor layer onto a SiO2 substrate prepatterned with Au electrodes achieved by photolithography. Three co-block polymers will be investigated for the ion gel that will be used in the EGT device; Poly(styrene-b-ethylene oxide-b-styrene) (SOS,) Poly(styrene-b-methyl methacrylate-b-styrene) (SMS), and Poly(styrene-b-ethyl methacrylate-b-styrene) (SES). The ion gel is composed of a co-block polymer and ((1-ethyl-3-methylimidazolium bis(trifluoromethyl sufonyl)amide) [EMIM][TFSA] ionic liquid which functions as a high capacitance dielectric layer. Finally, electrical probe techniques (transfer curve and displacement current measurements) will be utilized to determine the effect of the mid-block chemistry on the device performance including capacitance and ion mobility.

37

Kathryn Jacobson

Biological Cell Damage due to Ionizing Radiation

Advisor: John Broadhurst

Department or Sponsoring Program: Physics REU

Home Institution: College of Saint Benedict/ Saint John's University

Abstract: Radiation therapy is used to treat many different types of cancer. Ionizing radiation occurs at very high frequencies and can cause reparable or permanent damage to biological cells, both healthy and cancerous. Cancerous tumors are typically located behind layers of healthy tissue and when radiated, both the healthy and cancerous cells are damaged. Unfortunately, this damage is not uniform, most of the radiation is absorbed within the first few layers of cells. Previous experiments have only used one piece of meat to look at the biological damage caused by ionizing radiation. My research looks at the damage of nonliving biological cells at different depths of beef after it is radiated. To measure this, pieces of beef are stacked up with aluminum foil between each to act as capacitors so the dielectric constant of the meat can be determined before and after doses of radiation are given. Using the results, a depth versus dose profile can be created and compared to the expected damage, which is given by the radiation machine used. Future work would be to repeat this experiment, but with living biological cells to see how cell damage changes when the cells are able to repair.

38

Joe Jaye

A Combined Computational and Experimental Study of the Ring Closure Mechanism of BN-Pyrene

Advisor: Eric Fort

Department or Sponsoring Program: MRSEC

Home Institution: University of Saint Thomas

Abstract: Azaborine containing molecules are those with a boron-nitrogen bond in place of a carbon-carbon bond. These molecules are currently being researched for potential use in biomedical and materials chemistry. The substituted boron-nitrogen bond gives the molecule a dipole moment, which changes the chemical and physical properties of the molecule. Our work this summer has been on the microwave-assisted synthesis of BN-Pyrene. When reacted in a microwave, the second ring closure of BN-Pyrene occurs faster and without the use of catalyst seen in previous literature. There are three different proposed mechanisms for the second ring closure, which may occur through an electrocyclic or carbene route. Our work investigates these mechanisms computationally and experimentally in an effort to design a closure mechanism that can aid in the synthesis of other azaborine containing molecules.

39	**Emily Jewell** *Examination of Dynamic Equilibrium in the Outdoor Stream Lab* **Advisor:** Jessica Kozarek **Department or Sponsoring Program:** St. Anthony Falls Lab **Home Institution:** University of Wisconsin- Madison **Abstract:** Mass balance analysis provides an assessment of the long term scour impacts of Outdoor Stream Lab experiments. During early Summer 2014, the stream was flooded leading to excessive scour at the middle meander. Through Bank Full Flows and an increase of sediment input, equilibrium was attempted to be restored. Bed sediment levels were examined to determine equilibrium by mass balance analysis of the dynamic system and point gage cross-sections during Bank Full Flows. Ultimately, the meander achieved a new lower equilibrium level than that of pre-floods. Subsequently the meander was raked flat to a uniform depth for the next lab experiment, and Bank Full Flow was resumed leading to the original higher equilibrium level from 2014 being approximately restored. No further flooding and deep scouring will occur within the stream for the next few months as the bed will continue to be raked flat and scoured to equilibrium weekly. This will allow for analysis for consistency in determining the stream's equilibrium state through both cross-sections and topographic cart scans of the middle meander and mass balance calculations. Additionally, the dynamic equilibrium state in Summer 2014 will be compared to previous summer levels to understand long term changes to the streams equilibrium. Due to the lab and somewhat artificial environment of the stream, equilibrium was more easily restored and maintained compared to natural streams that experience increased lateral erosion and downcutting with time. Therefore this equilibrium analysis will answer whether these erosive processes can be fully prevented in an experimental environment; and if not, what the ideal approach is to maintain relative equilibrium depths across the middle meander when at dynamic equilibrium.

40	**Hannah Johlas** *Pressure-Controlled Hydro-Mechanical Transmission for Mid-Sized Wind Turbines* **Advisor:** Kim Stelson **Department or Sponsoring Program:** CCEFP **Home Institution:** Macalester College **Abstract:** A new pressure-controlled hydro-mechanical transmission (PCHMT) has the potential to improve the performance of wind turbine transmissions. The PCHMT combines the reliability and control of a hydraulic system with the efficiency of a mechanical system, offering a better transmission for a variety of applications. The step-up PCHMT in this study consists of a variable displacement hydraulic pump and a pressure-controlled transmission (PCT). The PCT combines both pumping and motoring functions, acting as a simplified hydrostatic transmission (HST). The pressure at the PCT control port, fed by the variable pump, dictates the transmission ratio. In this study, system-level simulations of a step-up PCHMT in a mid-size wind turbine determined the optimal configuration, sizing, and control system of the PCHMT for this application.

41	**Evan Johnson** *Validation of Peripheral Pulse Wave Analysis Techniques to Detect Aortic Valve State in Continuous-Flow LVADs* **Advisor:** Peter Eckman **Department or Sponsoring Program:** UROP **Home Institution:** University of Minnesota **Abstract:** Continuous-flow ventricular assist devices (CF-VADs) have become the standard of care for patients with end-stage heart failure. Currently available CF-VADs are unable to automatically adjust output based on the hemodynamic needs of the patient. We hypothesize that with the aid of peripheral arterial tonometry (PAT) measurements obtained from finger tips of subjects, in conjunction with digital signal processing techniques to calculate the power spectrum (PS) of normalized PAT signal, the frequency of aortic valve (AV) opening and closing can be detected. This method can be further expanded to automatically optimize CF-VADs. We found that the PS of PAT signals is not only affected by changes in pump output, but is also correlated with the state of AV. These findings demonstrate that PAT signals possess inherent signatures, which can be extracted from patients with CF-VADs.

42

Adam Juelfs
Functionalization and Modification of Mesoporous Silica Nanoparticles
Advisor: Christy Haynes
Department or Sponsoring Program: UROP
Home Institution: University of Minnesota
Abstract: Since its discovery by Mobil researchers in 1991, mesoporous silica (MS) has found use in a variety of fields, including biomedicine, waste water cleanup, catalysis, and spectroscopy. In the nanoparticle form, MS's broad applicability is due to the facile functionalization, controlled syntheses, and colloidal stability of these nanoparticles. The research presented herein focuses on MS nanoparticle modifications to study solvent dynamics, create a fluorine-based dual MRI contrast agent and oxygen sensor, and shorten transverse relaxivity in iron oxide core MS. An array of analytical & characterization methods were used to study the synthesized materials such as dynamic light scattering, nitrogen physisorption, transmission electron microscopy, fluorine NMR, two-dimensional infrared spectroscopy, and relaxometry.

43

Kara Kassekert
Benzylideneanilines and Benzonitrile Oxides: Solid-State Structure and Reactivity Studies
Advisor: William Ojala
Department or Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: We are using single-crystal X-ray diffraction to examine how molecular structure influences crystal structure and solid-state reactivity. Our focus is on two families of nitrogenous organic compounds: the benzylideneanilines (R-CH=N-R', R = aryl) and the benzonitrile oxides (R-C≡N+-O-, R = aryl). Among the benzylideneanilines we have identified pairs of molecules we have designated bridge-flipped isomers, molecules that differ only in the orientation of a bridge of atoms connecting two major parts of the molecule (R-CH=N-R' vs. R-N=CH-R'). Bridge-flipped isomeric benzylideneanilines that are isomorphous (that assume identical molecular packing arrangements in the solid state) should be capable of solid solution formation over a wide range of component ratios; those that are not isomorphous may be capable of serving as seed crystals that could initiate the growth of a new polymorph of each isomeric compound in the pair. We have been investigating the role of the nitrile (C≡N) group in defining molecular packing patterns in crystals; its versatility in participating in a range of commonly occurring intermolecular interactions such as halogen-nitrile contacts and C-H…:N≡C contacts lends it significance in crystal engineering. We have thus prepared and determined the crystal structures of two nitrile-bearing benzylideneanilines: 4'-cyanobenzylidene-2-methylaniline and 2'-cyanobenzylidene-4-cyanoaniline. Although we have not yet obtained crystals of the bridge-flipped isomer of the methyl compound, our previous determination of the crystal structure of the bridge-flipped isomer of the dicyano compound shows that these two are not isomorphous. In contrast, the methyl compound is isomorphous with the corresponding iodo compound but not with the corresponding bromo and chloro compounds. In a parallel investigation, we are investigating the relationship between ring substitution and solid-state reactivity in benzonitrile oxides. To that end, we have prepared 4-bromobenzonitrile oxide and 3-nitrobenzonitrile oxide and have been investigating their potential solid-state dimerization to one of three possible dimers.

44

Lucas Keehr

Solid-Phase Extraction of Aquatic Samples Containing Pesticides From Banana Plantation Runoff

Advisor: Anthony Borgerding

Department or Sponsoring Program: University of St Thomas- Chemistry

Home Institution: University of St Thomas

Abstract: Pesticide usage on banana plantations is exceeding environmental standards and beginning to endanger nearby aquatic ecosystems. Gas chromatography-mass spectrometry was used to measure various pesticides to determine their mass/charge ratio and retention times, which will be used to identify each specific pesticide. A mix of 11 pesticides and fungicides were separated in approximately 30 minutes by using a slow temperature ramp after reaching 220°C. Solid phase extraction was performed to concentrate the various pesticides in each mixture. This allows a lower concentration of analyte in a sample able to be measured by GC-MS. Methods in literature report detection limits of about 1 µg/L. Without concentration we can detect 100 µg/L, which means we will need to concentrate by a factor of 100:1. Three different sorbents, octadecyl, octyl, and cyano, were used to determine which type was most effective in trapping the pesticides. Breakthrough volume for each sorbent will help determine the amount of analyte able to be concentrated. The results from this research will hopefully improve on previous methods of pesticide measurements and help determine their effects on nearby aquatic ecosystems.

45

Liberty Kirkeide

Designing and Testing a Perfusion Bioreactor for Cellular Viability Measurements

Advisor: Michael Garwood

Department or Sponsoring Program: UROP

Home Institution: University of Minnesota- Twin Cities

Abstract: Pancreatic islet transplantation is a promising new treatment for type 1 diabetes. Oxygen consumption rate (OCR) is a measure of cell viability and is frequently used in the field of islet transplantation. A stirred micro-chamber system has been shown to accurately measure the OCR of small representative samples; however there is a need for a device to measure the OCR of larger samples. Perfusion bioreactors are capable of determining the OCR of larger samples by the measuring the partial pressure of oxygen (pO2) in perfused medium before and after it passes through the sample chamber. A perfusion bioreactor was designed, constructed, and tested with the aim of measuring OCR while providing a supportive environment for the sample. A perfusion bioreactor for OCR measurement was constructed, and although filter clogging interfered with oxygen measurement, the system was successfully calibrated, the flow rate was controlled, and the temperature was maintained in an incubator. Future designs will aim to prevent filter clogging to enable large scale OCR measurement.

46

Nathan Klein

Heat-Mediated Drug Release from Inorganic Nanoparticles

Advisor: Christy Haynes

Department or Sponsoring Program: Independent Research

Home Institution: University of Minnesota - Twin Cities

Abstract: In recent years, iron oxide nanoparticles (IONPs) have been investigated for use as a theranostic device in cancer treatment. Because of their magnetic response, IONPs could provide image contrast through MRI and induce hyperthermia in a tumor upon the application of an alternating magnetic field. Mesoporous silica can be synthesized around these IONPs to create stable and biocompatibile core-shell structured nanoparticles (msIONPs). These msIONPs are of interest for loading anti-cancer drugs or immunologic adjuvants into the pores to be released as a combination treatment with hyperthermia. While loading has been investigated in mesoporous silica particles, there has been limited study of release in hyperthermia conditions. In this research, the effect of heat on the release of biologically relevant molecules from msIONPs has been studied. Loading and release methodologies have been developed for these cargoes and used to obtain heat-mediated release profiles from msIONPs.

47

Daniel Kremer, Ana deBettencourt-Dias

Speciation Studies Involving a Pincer Ligand with Lanthanum (III) Salts for Lanthanide (III) Luminescence

Advisor: Marites Guino-o

Department or Sponsoring Program: University of St Thomas- Chemistry

Home Institution: University of St.Thomas

Abstract: Trivalent lanthanides are naturally occurring metals that possess unique optical properties resulting from 4f shielding by filled 5s2 5p6 subshells. When excited, the lanthanide ion's buried f-f transitions produce line-like emission bands in the visible and near infrared regions that are less susceptible to matrix effects. For this reason, trivalent lanthanides are desired in theranostics, protein tagging, and anti-counterfeiting applications. However, lanthanide f-f transitions are parity forbidden, allowing for long lived excited states at the cost of low absorption coefficients, limiting their practical use. To circumvent this, organic ligands are implemented sensitize the lanthanide by transferring excited electrons from ligand to metal and shielding the metal reducing routes to non-radiative transitions. Herein, we report our preliminary speciation studies of the pincer ligand with lanthanum(III) salt.

48

Mitchell Lancaster

Spectroscopic Binding Constant Determination of the Trifluoroacetophenone-Carbonate Complex for the Study of Fluorous Ionophores in Carbonate Ion-Selective Electrodes

Advisor: Philippe Buhlmann

Department or Sponsoring Program: UMN Chemistry- Heisig Gleysteen

Home Institution: University of Minnesota

Abstract: Trifluoroacetophenone derivatives have been known to selectively bind to carbonate through covalent bond formation and are commonly used as ionophores in carbonate ion selective electrodes. Heptadecafluoroctyl phenyl ketone was previously synthesized as a new ionophore designed to selectively bind to carbonate. Synthesizing a carbonate compound lipophilic enough to determine the affinity of carbonate for this new ionophore by way of an NMR titration experiment, however, was unsuccessful. Instead, the use of a commercially available, hydrophilic carbonate salt, potassium carbonate, was tested to determine its suitability for determining carbonate binding with fluorophilic ionophores. Spectroscopic methods were used to study the interaction between carbonate and a widely-available, fluorophilic analog to heptadecafluoroctyl phenyl ketone, trifluoroacetophenone. NMR dilutions and titrations coupled with original Mathematica programs specifically designed to simultaneously fit data from multiple experiments provided binding (equilibrium) constants for the formation of both 1:1 and 2:1 trifluoroacetophenone-carbonate complexes as well as chemical shift values for each complex formed. In addition, for the NMR dilution experiments, the binding constant results made it possible to prepare speciation plots describing the concentrations of free ionophore and each complex formed throughout the course of each dilution experiment. For the dilution experiments, results indicate weak binding between trifluoroacetophenone and carbonate with 1:1 and 2:1 log scale binding constant estimates of 1.70 ± 0.15 and 1.59 ± 0.35, respectively. From these results, using a Mathematica file to concurrently fit multiple NMR experiments produced reliable binding constants for the trifluoroacetophenone-carbonate complex, confirming both 1:1 and 2:1 ionophore-carbonate complex formation.

49	**Jasmine Lane** *Terthiophene Fluorescence Quenching Studies with Carboxylate and Thiol Capped Zinc Oxide Nanocrystals* **Advisor:** Wayne Gladfelter **Department or Sponsoring Program:** UROP **Home Institution:** University of Minnesota- Twin Cities **Abstract:** Dye-sensitized solar cells, an alternative to silicon based cells, use a light-absorbing molecule attached to the surface of semiconducting nanocrystalline films. The goal of this project was to alter the surface chemistry of ZnO nanocrystals by exchanging the original surface-bound acetate ligands with long chain carboxylate or thiol groups. A terthiophene-based dye was used throughout this study to probe the substitution process. When the terthiophene dye is bound to the ZnO nanocrystal, its fluorescence is quenched; a process that is monitored using fluorescence spectroscopy. The hydrocarbon chain length on the ligands varied from 4 to 8 to 12 and 18 carbons.The ligand exchanges were verified by IR and Uv-Visible spectroscopy. Finally, Stern-Volmer experiments were performed in methylene chloride with the synthesized ZnO nanocrystals to quantify the quenching behavior. The impact of chain length and binding group on the quenching behavior will be described.

50	**Trevor Lee** *Printed Electrolyte Gated Transistors Using N-type Semiconductors* **Advisor:** Dan Frisbie **Department or Sponsoring Program:** MRSEC **Home Institution:** Utah Valley University **Abstract:** Electrolyte gated transistors (EGT) that can be printed using an aerosol-jet printer have potential applications in large area electronics, biosensors, and flexible electronics. Creating EGTs with P-type and N-type semiconductors are important for the creation of complementary circuits. We are using ZnO as a N-type semiconductor in the construction of our EGTs. In addition we are using some ion gels which consist of an ionic conducting liquid suspended within a polymer. There are different ion gels that are tested in the EGTs and we wish observe how it performs along with the ZnO. All the materials will be printed in layers on a SiO substrate and tested with electrical probes in a variety of conditions to assess performance and stability.

51	**William Lindemann** *VLab - a virtual repository of computed, thermodynamic properties of minerals* **Advisor:** Renata Wentzcovitch **Department or Sponsoring Program:** MRSEC **Home Institution:** Iowa State University **Abstract:** Understanding the physical properties of materials at high temperatures and pressures is essential to the field of geophysics. Today, computational methods provide the most accurate approach for interpreting seismic data and modeling mineral behavior under extreme conditions of temperature and pressure. The Virtual Laboratory for Earth and Planetary Materials (VLab), located at http://www.vlab.msi.umn.edu, is a Science Gateway designed to allow distributed, high-throughput computation of materials properties at high temperatures and pressures. Hosted by the Minnesota Supercomputing Institute (MSI), VLab leverages the computational power of grid systems to perform computations using density functional perturbation theory (DFPT). This technique is employed to calculate the vibrational density of states (VDOS) for a mineral. From the VDOS, VLab can extrapolate a variety of thermodynamic quantities by applying the quasi-harmonic approximation (QHA). These include the isochoric and isobaric specific heat (CV and CP), the isothermal and adiabatic bulk modulus (KT and KS), the thermal Grüneisen parameter (γ) and the coefficient of thermal expansivity, (α) as functions of pressure and temperature. VLab also allows direct calculation of thermodynamically relevant quantities such as entropy (S), enthalpy (H) and Helmholtz free energy (F). Users may control the range of temperatures and pressures and may choose the equation of state according to which values are calculated. Resultant data can then be tabulated, plotted or downloaded from the VLab website.

52

Devin Mahon
Improving Cosmic-Ray Filtering for NOvA Data Analysis
Advisor: Marvin Marshak
Department or Sponsoring Program: Physics REU
Home Institution: Rice University
Abstract: I examined a preliminary cosmic ray filtering algorithm used for the NOvA experiment to eliminate signal from cosmic rays while removing as few actual neutrino events as possible in a non-CPU-intensive way. In order to study the mysterious phenomenon of neutrino oscillations, NOvA detects energy deposited by charged particles in the form of light. While some neutrino interactions, rare as they may be, produce charged particles that can be detected, these are not the only charged particles that may pass through the detector. Secondary cosmic rays, primarily muons, created by interactions from primary cosmic rays from space and molecules in the Earth's atmosphere, rain down on the Earth and can actually reach and penetrate the Earth's surface. These charged particle are subsequently detected in the NOvA detector even though they are of no interest to the study of neutrinos. The NOvA collaboration has developed a preliminary algorithm known as Cosmic Veto, which serves as a quick, non-time-consuming way to filter out many of these muons from the data so that effort can be focused on examining possible neutrino events; however, the filtering methods used by Cosmic Veto are flawed in that they make inefficient cuts on cosmic rays while also filtering out some useful neutrino events. By examining problems with the current veto, I was able to make more systematic cuts on the data and filter more cosmic rays while filtering fewer actual neutrino events. And by studying other problems with the cosmic tracking software, which reconstructs the particle's path through the detector, I was able to prevent Cosmic Veto from filtering out some specific neutrino events of particular interest to NOvA data analysis.

53

Maggie Malone-Povolny
Obtaining Accurate Spectra from an LCTF Microfluorometer
Advisor: Gary Mabbott
Department or Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of Saint Thomas
Abstract: The primary objective of this research was to develop a method of obtaining accurate spectra from a liquid crystal tunable filter (LCTF) microfluorometer. Like with any instrument, the various components of this instrument can display non-ideal behavior. By comparing the raw spectra from the instrument to one from a conventional instrument, a set of proportionality constants was generated that served to correct all future spectra taken by the microfluorometer. By overcoming artifacts in the light source, filter, and camera, the spectra from this microfluorometer were found to be in agreement with spectra obtained by conventional instruments. This research utilizes this instrument's ability to study the fluorescence of micro-volumes in order to determine varying fluorescence between microenvironments. The instrument was able to distinguish between these microenvironments by displaying the shift in emission peaks associated with varying pH, solvent, and sample preparation. Current efforts are aimed at the generation of a calibration curve to measure the concentration in micro-volumes of fluorescent species.

54

Grant McCormick
The Functionalization of BN-Pyrene
Advisor: Dr. Eric Fort
Department or Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: BN-pyrene (10b-aza-10c-borapyrene) belongs to a class of molecules called azaborines. An azaborine is a molecule that contains at least one boron-nitrogen bond. These molecules are of interest because they maintain the same number of valence electrons as a carbon-carbon bond; however, due to the difference in electronegativity, a dipole moment is formed. This can cause many unique optical and electronic properties. BN-pyrene fluoresces at a different wavelength than the fluorophore pyrene. We hope this difference can be utilized in multicolor labeling experiments. BN-pyrene is shown computationally to react regioselectivly in the 6 and 8 position of the molecule for electrophilic aromatic substitution. Due to these studies we believe we will be able to funtionalize BN-pyrene in a selective manner using well-established chemical reactions.

55

Catherine Meis
Polymerization of diblock copolymers containing a zwitterionic arginine moiety
Advisor: Theresa Reineke
Department or Sponsoring Program: MRSEC
Home Institution: Iowa State University
Abstract: Some cationic polymers used as nucleic acid delivery vehicles can exhibit high cellular toxicity (such as JetPEI). Recent literature shows that polymers containing zwitterionic moieties or blocks can be less toxic alternatives for DNA delivery applications, while showing high efficiency in uptake. We employ multiple methods to synthesize and purify a methacrylate-based zwitterionic monomer and polymerize it using reversible addition- fragmentation chain transfer (RAFT) polymerization. The chosen monomer is a derivative of the amino acid arginine, which is synthetically modified to be compatible for RAFT polymerization. RAFT polymerization conditions are determined to reliably produce diblock copolymers of zwitterionic arginine monomer and polyethylene glycol (PEG). Nuclear magnetic resonance (NMR) spectrometry was used to analyze synthesized products and determine purity. Size exclusion chromatography (SEC) was used to determine the molecular weight (Mw) and dispersity (_) for the synthesized polymers.

56

Kayla Mitt
Investigation of the mechanical properties of collagen-HA gels
Advisor: Victor Barocas
Department or Sponsoring Program: MRSEC
Home Institution: Dillard University
Abstract: Collagen is a unique triple helix protein that serves as a medium for cell attachment and macromolecule anchoring. There are several types of collagen (types I-IV) abundant in tissues as long fibrils to provide and maintain tissue structure. Collagen does not swell or shrivel when put into saline solutions or distilled water, unlike hyaluronic acid. Hyaluronic acid is a carbohydrate that shrivels in saline solutions and swells in distilled water. A collagen-HA gel can be made for tissue modeling and the purpose was to obtain the basic mechanical properties of this gel. Specifically, the aim was to observe Young's modulus to characterize the elasticity of collagen-HA gels. This was achieved by swelling the collagen-HA gels in various gradients of a phosphate buffer saline solution then performing a micro-pipette aspiration. In a micro pipette aspiration, the swollen collagen-HA gel is subjected to applied pressures caused by the micropipette's suction; due to this pressure, the gel will deform and be aspirated into the pipette. The extent of deformation is measured and interpreted to reveal Young's modulus of collagen-HA gels.

57

Abbie Mozzetti
CZTS nanoparticle growth kinetics and mechanisms synthesized utilizing microwave heating
Advisor: Lee Penn
Department or Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota - Twin Cities
Abstract: With ever-increasing energy consumption and an unsustainable supply of fossil fuels, advances are needed in the renewable energy field to make more cost sensitive, efficient, green, and sustainable energy systems. The research performed was based on the synthesis of Cu2ZnSnS4 (CZTS). CZTS is a p-type absorbing material that has a promising outlook in the solar energy field, as it has the potential to be an economical, efficient, and benign solar cell material. In creating photovoltaic systems, the composition, crystallite size, and crystal structure is critical; therefore the growth kinetics and mechanism involved in creating phase-pure CZTS nanocrystals was studied. The nanoparticles were synthesized and grown at varied temperatures and time periods. It was found that the CZTS grew larger at higher temperatures and longer time periods, but at each temperature, the growth was controlled by the dissolution kinetics at the particle-solvent interface.

58

Erik Navarro
Quantifying Encapsulated Objects In Artificial Cells Using Fluorescent Microscopy
Advisor: Vincent Noireaux
Department or Sponsoring Program: Physics REU
Home Institution: California State University, Chico
Abstract: The ultimate goal of our research is the bottom up construction of an artificial cell. A method of artificial cell synthesis that shows a lot of promise is encapsulating a transcription-translation system inside of a synthetic liposome and programming the liposome to develop cell functions. An important step in this process is to be able to quantify encapsulated objects such as transcription-translation machinery, DNA, and synthesized proteins. Our research this summer involved figuring out how fluorescent microscopy can be used to quantify the amount of such objects inside of artificial cells.

59

Luke Ness
Sharper Optical Responses for Biosensing with Smaller Nanohole Arrays
Advisor: Sang-Hyun Oh
Department or Sponsoring Program: NNIN
Home Institution: Bethel University
Abstract: Nanohole arrays can be used for surface plasmon biosensing. Smaller nanoholes have sharper optical responses, making a better sensor. At the same time, smaller nanoholes have larger intensity drop off. Template-stripped Ag nanohole arrays of varying diameters were used in a combination with an ultra bright white light source to look at the difference in the optical response of nanoholes with a diameter of 80 nanometers in comparison to nanoholes with diameters of 100 nanometers and 120 nanometers. To achieve the resolutions needed for the nanohole arrays, electron beam lithography was used to pattern them. The use of electron beam lithography limited the size of the devices so they could not be tested in real biosensing applications.

60

Molly Newbold
Investigation of In-Vivo like Neutrophil Transendothelial Migration Based on a Microfluidic Platform
Advisor: Christy Haynes
Department or Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota- Twin Cities
Abstract: Neutrophils account for 60%-80% of white blood cells in the human body and play an important role in many diseases. Neutrophil transendothelial migration (TEM), a critical component in neutrophil physiological responses, was studied using a microfluidic platform. Compared to the traditional assays, microfluidic platform is capable of operating chemical gradients for neutrophil migration over physiological time frames and providing *in-vivo* like microenvironments for mimic the vascular functions. Using controllable competing chemical gradients, a hierarchy of neutrophil chemoattractants was measured and established. In addition, synergistic effects between any two chemoattractants were explored so that detailed mechanisms about neutrophil TEM process were developed.

61

Lyle Nyberg, Hilena Frew, Lyle Nyberg, Ian Gunsolus, Sam Lohse
Nanotoxicity of surface-functionalized Au nanoparticles on Bacillus subtilis
Advisor: Vivian Feng
Department or Sponsoring Program: Augsburg - Chemistry
Home Institution: Augsburg College
Abstract: The wide use of nanomaterials in our society has brought increasing environmental concerns because the ecological impacts of these materials are not fully assessed. In our study, engineered and well characterized gold nanoparticles (AuNPs) with different surface stabilizers are investigated with a model bacterium, *Bacillus subtilis*, an environmentally beneficial soil bacterium. We employ respirometry, flow cytometry, florescence microscopy, and Transmission Electron Microscopy (TEM) to assess the activity, viability of the bacteria, and the interactions between cells and nanoparticles. We have observed that the growth inhibition of *Bacillus* is dependent on the surface ligands used to stabilize the AuNPs, in particular positively charged ones. In addition, AuNPs agglomerate on bacterial surfaces, as observed in TEM images. We attribute these observations to the strong electrostatic interactions between the negative bacterial surfaces and the positive AuNP surfaces.

62

Theresa Oehmke
Analysis of Rates of Entrainment in a Debris Flow using High Speed Video Technology
Advisor: Kimberly Hill
Department or Sponsoring Program: Civil Engineering
Home Institution: Massachusetts Institute of Technology
Abstract: Debris flows are a naturally occurring phenomenon that has gained attention in the past few decades. The combination of flowing sediment and water down an elevated channel is dangerous for the people and infrastructures that reside where the flow deposits. This research simulates debris flows in a laboratory using 2mm zirconium silicate beads in a small elevated channel. The structure of the channel allows for various amounts of water and beads to be added to the flow supply. High speed video analysis will be used to find velocity profiles during the debris flow and to calculate instantaneous rates of entrainment. Identifying how the dynamics of the flow change with varying initial conditions will be helpful to models of full scale debris flows that are used for hazard assessment analysis. Preliminary results show that as the water content of the supply flow increases, erosional effects become more defined and entrainment penetrates deeper into the bed. Pore pressure results have yet to be analyzed, but are expected to play a significant role in the total net erosion or deposition of the flow.

63

Wilfredo Ortiz
Reduction of Oxygen Impurities in ZnS for Thin Film Solar Cells
Advisor: Eray Aydil
Department or Sponsoring Program: MRSEC
Home Institution: University of Puerto Rico - Mayaguez
Abstract: Solar cells are environmentally friendly devices that convert solar energy into electricity. This work will focus on n-type semiconductors for thin film solar cells. Currently, CdS is the most commonly used n-type material. Unfortunately, CdS has a poor blue spectral response due to its narrow band gap, and there is a concern with the toxicity of Cd. We aim to replace CdS with ZnS, a non-toxic alternative, with a wider band gap (3.8 eV) compared to the band gap of CdS (2.4 eV). Additionally, ZnS can form an ideal conduction band offset with larger band gap absorbers like copper indium gallium aluminum diselenide (CIAGS). However, ZnS has high oxygen impurities that may increase the electron affinity of the resulting film and can create a non-ideal band alignment with p-type absorbers. ZnS will be synthesized using chemical bath deposition. The goal will be to reduce the oxygen content in ZnS films by adjusting the reagent concentration, pH and temperature of the deposition. Auger electron spectroscopy (AES) will be used to determine the oxygen content and x-ray diffraction will be implemented to evaluate the film crystallinity.

64

Mark Allen Pagkaliwangan
Linearization of DNA in Nanochannels and Applications in Optical Mapping
Advisor: Kevin Dorfman
Department or Sponsoring Program: NNIN
Home Institution: University of Massachusetts Amherst
Abstract: Conventional DNA sequencing has yielded relatively accurate maps of how base pairs are ordered in various genomes. However, the process encounters difficulties in sequencing large gaps in genomic information, as well as genomic variations. Optical mapping of DNA has emerged as a viable technology to help with these deficiencies in genomic sequencing. Rather than using a large population of short sequence reads to derive a final sequence, optical mapping uses fluorescent imaging of large (~10 kbp-1 Mbp), linearly arranged, individual DNA strands to view large scale patterns that would be lost with traditional sequencing. The difficulty with optical mapping is that a strand of DNA is very unlikely to be in a linear state, unless it is confined to it. The goal of this lab is to study how a strand of DNA behaves while confined by a nanochannel, specifically how it extends in response to the variation of width of the channel. We intend to use nanochannel devices etched in fused silica substrate by e-beam lithography to explore this subject. Because individual DNA strands are difficult to confine, slight pressure, along with etched microchannels, will feed the DNA into the nanochannels. We expect that channels with the same depth and width will exhibit more precise lengthening properties.

65

Mitch Patzer
Anomalous UV Polarization and its Implications on Grain Alignment
Advisor: Terry Jones
Department or Sponsoring Program: Physics REU
Home Institution: University of Minnesota - Morris
Abstract: The Hubble Space Telescope (HST) using the Faint Object Spectrograph (FOS) along with the Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE) provided many valuable ultraviolet spectropolarimetric observations of stars. These observations include the polarization of radiation by the intervening interstellar medium dust grains. Two out of 32 observed stars, HD 197770 and HD 147933-4, had a conspicuous polarization feature at λ = .2175μm. The enhanced polarization could be explained by White Dwarfs that are, by chance, along these two lines of sight. White Dwarfs can contribute to the polarization through aligning smaller interstellar dust grains due to a White Dwarf's radiance of hard UV. HD 197770 and HD 147933-4 exhibit an 11% and 50% polarization enhancement respectively. I calculated the amount of alignment of dust grains necessary to explain the UV polarimetry for these two stars. I also estimated the number of White Dwarfs necessary to reproduce the enhancement. I conclusively show approximately forty White Dwarfs are needed along a line of sight to effectively reproduce the 11% enhancement, by comparing with polarimetry data from other normal lines of sight. The current accepted space density of White Dwarfs would need to be over one hundred times greater in order for UV radiation from White Dwarfs to be the source of the polarization enhancement. I show that the presence of White Dwarfs along these two lines of sight cannot be invoked to generate the enhanced polarization.

66

Shannon Petersen
Modeling micelle-polymer chain complex formation
Advisor: Tim Lodge
Department or Sponsoring Program: MRSEC
Home Institution: Allegheny College
Abstract: Polymer-micelle complexes are currently under heavy investigation due to their potential applications in gene therapy and targeted drug delivery, yet the dynamics of the complex formation are still relatively unstudied. Our aim was to model this complexation process using poly(dimethylaminoethyl methacrylate)-b-poly(styrene) micelles and poly(styrene sulfonate) chains. By varying the amine to sulfonate charge ratios, pH, ionic strength, and polymer chain length and measuring the hydrodynamic radius, distribution of sizes, and relative charge of the particles with dynamic light scattering and zeta potential measurements we have created an introductory model for how different parameters affect the complexation process and the complexes themselves.

67

Neil Peterson
Weighted Voronoi Diagrams for Data Visualization of Information Spaces
Advisor: John Carlsson
Department or Sponsoring Program: UROP
Home Institution: University of Minnesota-College of Science and Engineering
Abstract: My research focused on a contemporary application of weighted Voronoi diagrams for visualizing data. Using algorithms developed by Professor John Gunnar Carlsson of the Industrial and Systems and Engineering department and his research team, I explored several intriguing datasets to determine which weighting method most effectively communicates the type of data to be visualized. Through careful analysis, surveys given to the public, and the construction of numerous diagrams, I was able to draw important conclusions on how best to fashion a weighted Voronoi diagram to display relevant data in an easily digestible manner.

68

Sonia Pollock
Aziridine Crosslinked Polylactide Vitrimers
Advisor: Marc Hillmyer
Department or Sponsoring Program: Center for Sustainable Polymers
Home Institution: Macalester College
Abstract: Vitrimers are a class of crosslinked polymers in which catalysts facilitate exchange reactions, allowing for changes in the network topology upon addition of heat and stress. These materials are tough and insoluble like typical crosslinked polymers, yet they can be remolded or healed without losing their strength. It is interesting to explore the properties of vitrimers synthesized from polylactide, a sustainable polymer currently produced from corn sugars. Polylactide is an important polymer due to its low environmental impact – it is sustainably sourced, biodegradable, and is comparable to conventional plastics such as polystyrene or polyethylene terephthalate. Carboxylic acid terminated polylactide is readily crosslinked at room temperature by polyaziridine. The properties of carboxylic acid terminated star-shaped (±)-polylactide (CATSPLA) crosslinked with aziridine and varying catalysts were investigated to determine conditions for varying the network topology of the material.

69

Chase Quinney
Flocculation of Bentonite solutions using cationic poly-acrylamide
Advisor: Cari Dutcher
Department or Sponsoring Program: MRSEC
Home Institution: College of Menominee Nation
Abstract: Flocculation is a prevalent process in all forms of water treatment to aid in separation. Polyelectrolytes, or water-soluble polymers with ionizable groups, are useful because of their increased efficiency over mineral coagulants. However, due to the complex nature of flocculation, treatment plants have to use more polymer than needed, resulting in higher costs. We are using the commercially available FLOPAM cationic poly-acrylamide from SNF INC. Bentonite, an inorganic clay, is used to simulate source water. We are studying the effect of pH, ionic strength, and the presence of natural organic matter (NOM) on flocculation efficiency using standard jar test procedures. This information will be used to further characterize the aggregates (flocs) that are formed using a Taylor-Couette cell. Our goal is to optimize the treatment of water through flocculation to reduce costs.

70

Lucero Ramirez
Multifunctional peptide-amphiphile hydrogels
Advisor: Efie Kokkoli
Department or Sponsoring Program: MRSEC
Home Institution: University of Texas-Pan American
Abstract: Nanofiber hydrogels are emerging as important class of tissue engineering scaffolds to mimic natural extracellular matrix (ECM) found in tissues. These scaffolds can be designed to match both the physical as well as biochemical characteristics of the ECM. Peptide ligands that mimic ECM components such as collagen, fibronectin, or growth factors can be synthesized and used to create the building blocks necessary for the formation of nanofibers. We propose the design, synthesis and characterization of peptide-amphiphiles that mimic the above ECM components. Further, these peptide-amphiphiles will be used to form nanofibers in aqueous/physiological conditions and the resulting hydrogels will be evaluated as scaffolds for adhesion and proliferation of cells in-vitro.

71	**Jamal Russell** *Permeability of Collagen Gels & Fibroblast-Seeded Gels* **Advisor:** Victor Barocas **Department or Sponsoring Program:** MRSEC **Home Institution:** Grambling State University **Abstract:** The CDC has reported, "One in 10 American adults, more than 20 million, has some level of CKD (Chronic Kidney Disease)." Kidney disease is recorded to be United States ninth leading cause of death. The kidneys are used to regulate the excess fluid or waste throughout the body giving you and I better blood. It helps to maintain the balance with our salt intake. There are five different types of kidney failure. They can be caused by a multitude of things such as direct trauma to kidneys or insufficient blood flow. Some kidney diseases can cause changes in permeability. Using a certain apparatus called the manometer can help you calculate the permeability of such things as collagen gels, filter papers, or capillaries. The tubing of the manometer provides gravitational pressure, which carries a dense fluid, either water or saline measuring the hydraulic resistance between the entry point of the substance and the exiting point. With this, we are designing a 3D structure of how the kidney receives flow up through the glomerulus where the mesangial cells are. Now we are testing Fibroblast gels in order to see if the mesangial cells will work for future experimentation. The collagen gels we are using represent the spaces between the mesangial cells, better known as the mesangium matrix. In my efforts this summer, I hope to better my knowledge of the kidney to a more in-depth understanding so I apply this knowledge in my advancement to seeking a higher education.

72	**Seungyeon Seo** *Nanoindentation Tests of Engineering Materials to Study Indentation Size Effect* **Advisor:** Andre Mkhoyan **Department or Sponsoring Program:** MRSEC **Home Institution:** Northwestern University **Abstract:** Indentation size effect (ISE) is a nanoscale materials phenomenon that results in an increase in hardness with a decrease in volume under strain of a material specimen. ISE has been observed experimentally in certain materials, and this scale-dependent behavior is due to microstructural constraints and complexities in the deformation mechanism. Further studies of ISE are vital as advancements in nanotechnology will require a better understanding of nanoscale materials properties. Utilizing nanoindentation experiments, we determined how hardness of materials changes with indenter depth of penetration, which correlates to volume under strain. Commonly used engineering materials Nitronic 50 stainless steel, silicon, iron-3wt% silicon, and magnesium oxide were examined. Analysis of experimental data shows that all materials investigated in this study exhibit ISE.

73	**Lidia Swanson** *Synthesis and Polymerization of Acetylated Methacrylic Isosorbide* **Advisor:** Marc Hillmyer **Department or Sponsoring Program:** Center for Sustainable Polymers **Home Institution:** University of MN **Abstract:** Seeking to source polymers for plastics from a renewable, bio-sourced feedstock. Pricing becomes more cost competitive as the prices of traditional plastics continues to rise. Synthesis of the target polymer, acetylated methacrylic isosorbide, is accomplished through the use of a starch-based monomer, isosorbide. Isosorbide is a non-toxic, rigid molecule with a high glass transition temperature ideal for use in monomer synthesis for polymerization.

74

Anthony Tabet
Modeling Extinction Energy in P3HT Films
Advisor: Aaron Massari
Department or Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota
Abstract: Organic polymers have wide and vital applications to the fields of photovoltaics and transistors. Organic solar cells remain one of the most potentially cost-efficient and widely used devices. The crux of the device, charge separation, occurs at the interface of the electron donor and acceptor. Field effect transistors deploy a polymer layer as the semiconductor between the source and drain, and as has been shown, the electrical current predominantly resides at or near the polymer interface. In both applications, understanding the physical properties of the polymer bulk and interface is crucial to creating more efficient devices. In this work we explore the variable spectra of ultrathin films of regioregular and regiorandom Poly (3-hexylthiophene) via spectroscopic and microscopic methods. The issues of predominant interest are the distinct extinction spectra of the interface and bulk, and the role the interface-to-bulk ratio plays on a film's absorption spectrum. We define a center of mass wavelength λ^* as a means of characterizing the data and propose a model to quantify the nonlinear relationship between thickness and λ^*. The model's industrial applications include more systematically engineered devices with wavelength-tunable components.

75

Meghan Talbot
Electronic Effects of Triazolylidene Ligands in the Nickel Catalyzed Dehydrogenation of Ammonia-Borane
Advisor: Marites Guino-o
Department or Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: The dehydrogenation of ammonia-borane is an effective way to produce hydrogen fuel. In order to maximize the efficiency of this reaction, different triazole-based ligands with unique electronic properties were synthesized. These ligands, when complexed with nickel, serve as a catalyst in the dehydrogenation reaction. The amount of hydrogen gas produced in each reaction is compared back to the electronic properties of the specific ligand. This correlation can produce a trend that can then be used to predict the effectiveness of new ligands based solely on their electronic properties.

76

Samantha Thrush
Fact Checking LIGO's Radiometer Code with Simulated LIGO Frames
Advisor: Vuk Mandic
Department or Sponsoring Program: Physics REU
Home Institution: Ohio University
Abstract: Stochastic gravitational waves are the result of many gravitational waves interfering with each other to create a background of seemingly random gravitational wave signals. The original gravitational waves are most often from astrophysical objects, such as pulsars with surface defects. A key set of instruments that are used for the detection of gravitational waves are the LIGO detectors. As it can be difficult to differentiate stochastic gravitational waves from background noise, frame data from two detectors must be cross-correlated with a radiometer code in order to see if the original sources of the gravitational waves can be resolved. In order to test the effectiveness of the radiometer code's ability to find point sources from stochastic data, fake frame data of multiple pulsar signals, simulated with LIGO's MakeFakeData code, was injected into real data to see how well the radiometer code can recover the original simulated gravitational wave sources. To validate the findings, three other trials were run: fake frames only, real frames only and fake frames input as real frames. Results are currently pending.

77

Richard Tiah
ALD Infilling Study To Achieve Efficient Film Density
Advisor: Uwe Kortshagen
Department or Sponsoring Program: MRSEC
Home Institution: UTPA
Abstract: Semiconductor Nano crystals have attracted considerable interest because of their many possible applications with respect to light emitting devices and displays, solar cells, Nano electronics and luminescent markers. For these semiconductors Nano crystals to be functional in devices, they need to be coated onto a film. Currently, there are very few methods that make high efficiency films. For energy to be conducted through the crystals, they need to be as close together as possible. However when dealing with Nano particles, it is difficult to coat the films in such a way that these Nano crystals are already close together. The Atomic layer deposition (ALD) infilling process seeks to alleviate that problem by filling the gaps between the semiconductor Nano crystals with another conductive substance to allow electrons to move freely from particle to particle. The study will be focused on improving the film density by altering the recipes used in the ALD when infilling our Nano crystal films to get the best film density to allow for the most efficient transfer of electrons. The recipes in the ALD have a number of parameters that we will be alter in working toward improving the film density, mainly the number of cycles of substrate we need to the best infill onto the Nano film. We will work with Zinc oxide as our infilling substrate and we will use Silicon and germanium based Nano particles in our tests with the ALD and at the end we will compare the results of both combinations. By finding the appropriate number of cycles of Zinc Oxide being deposited, we should see the best possible film density for conduction across both Nano films.

78

Javier Topete
Targeted Drug Delivery Using DNA Aptamer-Amphihiles
Advisor: Efie Kokkoli
Department or Sponsoring Program: MRSEC
Home Institution: University of Texas Pan-American
Abstract: A common problem with cancer chemotherapy is the off-target toxicity levels that most treatments cause. Off-target toxicity occurs when the drug that is delivered affects both healthy cells and diseased cells, which results in a number of side effects including nausea and hair loss. A new way to deliver drugs that promises to be more effective in treating or combating cancer is to use nanoparticles to carry drug to the diseased cells. A particular type of nanoparticle used to deliver drugs are micelles, created by the self-assembly of amphiphilic molecules. We plan to synthesize single stranded DNA aptamer-amphiphiles that will self-assemble into spherical micelles to help deliver drugs to the cancer cells. The spherical micelles will hold the chemotherapeutic drug inside while the DNA aptamer will be present on the outside of the micelles and will help guide the drug towards the cancer cells, thus reducing the amount of off-target toxicity while increasing the amount of drug delivered to the diseased cells.

79

Yenchi Tran
Structural Dynamics Studies of FABP-4 by Solution NMR Spectroscopy
Advisor: Kim Ha
Department or Sponsoring Program: St. Catherine University-Chemistry
Home Institution: St. Catherine University
Abstract: Adipocyte fatty acid binding protein (FABP-4, A-FABP) is the best characterized isoform among the FABP family but its correlation to diabetes is unknown. Interestingly, FABP-4 knockout mice do not develop diabetes. Analyzing the structure and dynamics of FABP-4 bound with its ligands will help in understanding the details of its connection to diabetes. In this research, 13C and 15N isotopically labeled FABP-4 was produced in E.coli, and nuclear magnetic resonance (NMR) will be used to interpret the changes in the structure and interactions between FABP-4 and its ligands. So far, FABP-4 have been successfully produced by E.coli in both unlabeled and labeled media and characterized using optical density and protein electrophoresis.

80	**Joel Updyke** *Sustainable Block Copolymers with Tunable Mechanical Properties* **Advisor:** Frank Bates **Department or Sponsoring Program:** Center for Sustainable Polymers **Home Institution:** University of Minnesota **Abstract:** Polylactid acid (PLA) based polymers are considered sustainable polymers because they have a renewable feedstock, plant sugars, and they degrade into bio-compatible components, carbon dioxide and water. The further improvement of PLA plastics are of chief importance to the Center for Sustainable Polymers' mission to discover and develop polymeric products that outperform the current suite of non-sustainable polymers from performance, environmental, and cost perspectives. A focus on improving the brittle nature of PLA plastics utilizes the self assembly of block copolymers into tunable morphologies in order to integrate the rubbery properties of thermoplastic elastomers with PLA's hard, glassy properties. Past Center for Sustainable Polymers research has demonstrated that *multiblock copolymers* of polylactic acid and polybutadiene have displayed enhanced mechanical properties in tensile testing. (up to 1000% strain capacity) However, polybutadiene is not a sustainable polymer because it is oil-based and is not biodegradable. Our strategy is to replace polybutadiene in the aforementioned multiblock copolymer apparatus with poly(β-methyl-δ-valerolactone), a sustainable polymer that past Center for Sustainable Polymers research has demonstrated to be capable of forming the *triblock copolymer* precursor to the *multiblock copolymer* apparatus.

81	**John Valentin** *Detecting Spin at a Ferromagnet Semiconductor Interface* **Advisor:** Paul Crowell **Department or Sponsoring Program:** MRSEC **Home Institution:** University of Puerto Rico, Mayaguez Campus **Abstract:** It is believed that by understanding the nature of spin transport and spin detection we will be able to achieve new functionality while decreasing the size of future electronic devices. The main idea of the research is to understand and improve spin detection in epitaxial heterostructures of ferromagnetic metals grown on gallium arsenide. One of our goals is to try to make our devices smaller while preserving their spin transport properties, which we hope to achieve using electron beam lithography. To test our devices, a cryostat is used and spin injected into the semiconductor from iron is detected using the spin valve effect. What we expect to see is an increase in spin polarization or spin accumulation, which is recorded as a change in voltage. Imaging with the scanning electron microscope (SEM) will be used to obtain valuable information, particularly about the integrity of the electrical contacts and the topography of the devices.

82

Brianna Vickerman

Solid-State Structures and Reactivity of Some Nitrogen-Containing Organic Compounds

Advisor: William Ojala

Department or Sponsoring Program: University of St Thomas- Chemistry

Home Institution: University of St. Thomas

Abstract: We are investigating the solid-state structures and reactivity of two families of nitrogenous organic compounds: the benzylideneanilines (R-CH=N-R', R = aryl) and the benzonitrile oxides (R-C≡N+-O-, R = aryl). The benzylideneanilines provide examples of pairs of molecules we have designated bridge-flipped isomers, molecules differing only in the orientation of a bridge of atoms connecting two major parts of the molecule (R-CH=N-R' vs. R-N=CH-R'). Bridge-flipped isomers that are isomorphous (possessing identical solid-state molecular packing arrangements) should be capable of forming solid solutions over a wide range of component ratios; bridge-flipped isomers that are not isomorphous may be capable of serving as seed crystals for solutions of the isomeric compound and facilitating its crystallization into a new packing arrangement identical to that of the seed. We have been preparing benzylideneanilines bearing both a halogen substituent and a nitrile substituent to determine whether or not similar Lewis acid-base contacts of the type X-R-C≡N:…X-R-C≡N: occurring in both isomers could encourage their isomorphism. To that end, we have prepared 3'-chlorobenzylidene-2-cyanoaniline and are determining its crystal structure by X-ray diffraction. Although we have not yet obtained the crystal structure of its bridge-flipped isomer, we are pursuing that compound and can already compare our current structure with the previously determined bromo analogues. In a parallel investigation, the benzonitrile oxides provide the opportunity to examine the influence of molecular structure on solid-state reactivity. We are determining which of three possible dimers might form in the solid-state dimerization of these compounds and are examining 4-fluorobenzonitrile oxide as part of that study. An additional property of sterically hindered nitrile oxides is their potential rearrangement to isocyanates, so we have prepared the nitrile oxide derivative of piperonal to determine which route, dimerization or rearrangement, might be followed in a solid-state reaction occurring in this case.

83

Elena Werst

Synthesis of a-factor precursor analogs for testing recognition with the endoprotease and methyltransferase of the protein prenylation pathway

Advisor: Mark Distefano

Department or Sponsoring Program: UMN Chemistry- Heisig Gleysteen

Home Institution: University of Minnesota, Twin Cities

Abstract: Protein prenylation is a common post-translational modification that involves the addition of a hydrocarbon chain at the cysteine residue at the C-terminus of a peptide. The modification occurs in an approximated 2% of mammalian proteins and nearly all signal transduction pathways involve prenylated proteins. Prenylated proteins are implicated in cancer and other diseases, making this an area of interest for many researchers. This project involved synthesizing peptides with non-natural hydrocarbon compounds at the C-terminal cysteine. These peptides will be tested by our collaborators at Purdue University, to see if they may be recognized by the endoprotease and methyltransferase enzymes that act on naturally prenylated proteins. These analogs could be used for protein labeling applications or to examine different enzymatic reactions in detail.

84

Kiera Wilhelm
Why Is There Order in the Purple Membrane?: A Biological Application of Super-resolved Raman Imaging
Advisor: Renee Frontiera
Department or Sponsoring Program: UMN Chemistry- Lando
Home Institution: Carleton College
Abstract: The Frontiera Lab is developing a super-resolution Raman microscopy to allow label-free visualization of a single transmembrane protein and its local environment (1-10 nm) at the femtosecond timescale, at which chemical bonds break and form. I am studying the transmembrane protein bacteriorhodopsin, a light-activated proton pump found in the highly ordered purple membrane of halobacteria, to investigate the scope of this new technique. Thus far I have cultured the halobacterium, H. salinarum, isolated the purple membrane, and acquired continuous wave Raman spectra to confirm the presence of bacteriorhodopsin. I am now imaging purple membrane patches, which are approximately 1 micron in diameter, and quantifying the sharpness of changes in Raman signal to determine the system's spatial resolution. Once the system is optimized, we will use femtosecond stimulated Raman spectroscopy to investigate how activation of one protein affects its local environment in order to explain the crystalline structure of the purple membrane.

85

Joshua Wolanyk
Effects of Electric Field on Superfluid Helium
Advisor: William Zimmermann
Department or Sponsoring Program: Physics REU
Home Institution: Gustavus Adolphus College
Abstract: The effect of an Electric Field on the Lambda Point of Liquid Helium-4 is studied using sound resonance to determine the temperature of Liquid Helium. The resonance is measured in a 1.27 cm cell with the ends covered in 1 μm Nuclepore membrane. One membrane is used as a transducer and the other one is a receiver. The Electric field is applied across the membrane by coating it in aluminum using vacuum evaporation. The temperature is then measured at three different voltages that create Electric Fields up to 107 V/m. Initial results show that there is a change in temperature caused by the Electric Field.

86

James Wondra
Microfabricated Cell Array Device for Screening of Metastatic Potential
Advisor: Patrick Alford
Department or Sponsoring Program: NNIN
Home Institution: California State University Channel Islands
Abstract: Metastasis is a complex cell migration process where a cancer cell leaves its primary tumor site to establish a secondary tumor site, causing greater than 90% of cancer related deaths. One way to quantify the cell migration process has been to track single cells plated on a dish. However, this method is low-throughput and requires costly live microscopy chambers. Here we develop a high-throughput cell migration assay by employing microfabrication techniques to develop a method to capture single cells and place them in an organized array. We will quantify cell migratory behavior by quantifying the disorder of the initial organized array. It is well known that the migration of cancerous cells is dependent upon the interactions between the cells and their micro environments. Thus we will validate our device by characterizing the migration of cells on substrates of varying stiffness, corresponding to how a metastatic cell detaches from the dense tissue of a tumor, and invades the spongy tissues surrounding the tumor. Upon completion of this project, the device will be usable as a diagnostic tool for rapid high-throughput analysis of metastatic potential of biopsied tumor cells.

87

Alison Yang
Optimizing the Synthesis of BN-Pyrene
Advisor: Eric Fort
Department or Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: BN-Pyrene is an organic molecule that may someday be used in various organic semiconducting products such as organic light emitting diodes (OLED) and organic photovoltaic cells (OPVC). The synthesis of BN-Pyrene is inefficient and can be further improved. Several methods of reducing the intermediate dibutyltindichloride were explored, as well as avoiding the reactive cyclic borane intermediate. Our goal is to form a Boron-Nitrogen intermediate that can be mixed to the tin precursor and synthesize BN-Pyrene directly. Optimizing the synthesis of BN-Pyrene may lead to other discoveries in azaborine compounds and in organic chemistry.

88

Haini Zhang
Effect of Counterion on Carbonate Binding to Perfluoroalkyl Phenyl Ketones
Advisor: Philippe Buhlmann
Department or Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota
Abstract: Ion Selective Electrodes (ISEs) are widely used to determine the concentration of a specific ion dissolved in aqueous solution. The goal of this project is to design a carbonate ISE in which a perfluoroalkyl ketone serves as the ionophore in a fluorous liquid phase membrane. Perfluoroakyl ketones are potential ionophores for the doping of the membranes of ion selective electrodes due to the proposed superiority of binding with carbonate ions. NMR dilution and titration experiments were used to estimate the binding constant between an analogous ionophore and carbonate. Potassium carbonate was used as the carbonate source and trifluoroacetophenone (TFAP) was used as a suitable replacement for the limited quantity of perfluoroalkyl ketone ionophore in the lab. Cryptand-2,2,2 was applied in this host-guest system because of its good selectivity to potassium cations to promote an increase in the amount of free carbonate. In the NMR dilution experiment, a series of NMR samples of TFAP, K2CO3 and cryptand in deuterated methanol were diluted with the TFAP:carbonate ratio of 1:2, 1:1 or 2:1. In the NMR titration experiment, a series of samples with various TFAP concentrations in a constant total carbonate concentration was also performed. The non-linear regression methods for data fitting were carried out using Mathematica 9.0. From the NMR dilution experiment, the logarithm of the binding constant for a 1:1 guest to host ratio was calculated to be 2.77 ± 0.03 while for a 2:1 complex, the binding constant was 1.9 ± 0.2. So far, from the data of the dilution NMR experiment, we can conclude that binding of the potassium ion with cryptand-2, 2, 2 increases the stability of the complexes between carbonate and the perfluoroalkyl ketone ionophore.

89

Runchen Zhao
Liquid Drop Impact on a Granular Surface
Advisor: Xiang Cheng
Department or Sponsoring Program: CEMS
Home Institution: Chemical Engineering and Materials Science
Abstract: In this research we quantitatively measured the morphology of the impact craters from impinging liquid drop and derived the same power law as that from asteroid impact cratering. From the dynamic observation we proposed a developed liquid marble theory with imbibition effect, and hence successfully explained and predicted the inner residue in the center of the crater.

Poster Presentations for RET Participants

Listed Alphabetically by Presenting Author

90	**Cassandra Knutson** *Increasing the Accessibility of High School Laboratory Investigations by Utilizing Familiar and Common Technologies* **Advisor:** Lee Penn **Department or Sponsoring Program:** MRSEC **Home Institution:** White Bear Lake High School **Abstract:** Optical measurement experiments are common in advanced high school chemistry courses. These experiments generally require expensive spectrophotometers and colorimeters making them inaccessible to some classrooms. Even if schools have access to such equipment, they may be less effective for student learning due to the "black box" nature of the equipment. A kinetics experiment that utilizes smartphones or tablet devices and studies the fading of crystal violet by reaction with sodium hydroxide was developed. This use of smartphone or tablet devices was extended to an experiment that studies the concentration of gold nanoparticles in a mesogold mineral supplement. Advanced Placement Chemistry students from White Bear Lake High School participated in the development of the kinetics experiment and a field trip experience in which they applied their knowledge from the kinetics experimentation to the nanoparticle experimentation. The use of familiar technologies increased student engagement, participation, and learning during the laboratory investigations.

91	**Debra Mixon** *Research Experience for High School: Cloud in a Bottle* **Advisor:** Chris Hogan **Department or Sponsoring Program:** MRSEC **Home Institution:** Breck School **Abstract:** Cloud condensation nuclei are small particles in the atmosphere necessary for the formation of water droplets that make up clouds. Sulfuric acid (H2SO4) is known to be an important molecule in the formation of cloud condensation nuclei. Sulfuric acid is produced in the atmosphere when sulfur dioxide emissions from the burning of fossil fuels react with water vapor in the air. Dimethylamine (DMA) is a molecule emitted into the atmosphere by anthropogenic sources such as cattle farming and waste treatment. When DMA and H2SO4 interact, they may enhance the formation of cloud condensation nuclei and subsequent growth of particles from water uptake in a humid environment. This investigation aims to shed light on the formation of cloud condensation nuclei in the nanoscale (~2- 6 nm) in order to better understand how these aerosols contribute to cloud condensation nuclei, cloud formation, and climate. To incorporate aspects of this investigation into my chemistry classroom, I have developed a project combining authentic laboratory research with the study of the effects of aerosols on cloud formation. Students will research, design and construct a cloud chamber made from inexpensive materials that are readily available. They will collaborate across disciplines to design and build the cloud chamber, and then work with sixth grade students to design a procedure that will be used to test the effects of different aerosols on cloud properties.

92	**Angela Osuji** *Food Grade Oil Dispersant Effectiveness Testing* **Advisor:** Alon McCormick **Department or Sponsoring Program:** MRSEC **Home Institution:** Minneapolis Public Schools **Abstract:** Effectively managing oil spills in an open sea environment presents mounting challenges to scientists and engineers both in government agencies and in oil companies. When used appropriately, chemical dispersants can be one of the tools available for oil spill response teams to use. The decision to use chemical dispersants requires an interdisciplinary cost-benefit assessment of the net ecological and environmental impact. Dispersants formulation and action, however, still remain underdeveloped. Moreover, understanding dispersants is also important in industries related to food, agricultural, and pharmaceutical products.In this research on dispersant effectiveness, we examine the influence of dispersant composition on dispersion effectiveness. The experiments are done with a view to modifying it for replication by middle school STEM students.