Materials Research Science and Engineering Center

University of Minnesota
Driven to Discover℠

Summer Undergraduate Research Expo

August 9, 2018
McNamara Alumni Center
Memorial Hall
4:00-6:00pm

Undergraduate Poster Presentations
Listed Alphabetically by Presenting Author

Presenters should be at their posters at the following times:
4:00 - 5:00 even numbered posters
5:00 - 6:00 odd numbered posters

1. **Fatima Abdihoosh**
Ion Selective Electrodes Detecting Potassium
Advisor: Philippe Buhlmann
Sponsoring Program: Project SEED
Home Institution: Washington Technology Magnet School, St Paul Public Schools
Abstract: Ion selective electrodes are sensors that are used to detect samples. This ion selective electrode will detect potassium in any aqueous solution. This electrode was constructed using a redox buffer that contained ferrocyanide and ferricyanide in an agar membrane which is hydrophilic, FK13-PK-130 cation exchange membrane, and potassium chloride solution. The electrode was put in a solution of 1 molar potassium chloride with a reference electrode. Reference electrode have a known stable potential and will aid the potassium detecting electrode to be calibrated. This will show a calibration curve that will determine if the electrode is detecting potassium and this is measured by if the slope of the calibration curve is less than or equal to 50 millivolts.

2. **Asma Ahmed**
Hydraulic Pump-Motor Employing Partial Stroke Piston Pressurization
Advisor: Thomas Chase
Sponsoring Program: CCEFP
Home Institution: University of Minnesota
Abstract: The focus of this project is to maximize the efficiency of hydraulic pump-motors by employing a technology called 'partial stroke piston pressurization' (PSPP). This technique addresses issues with commercialized pump-motors by decreasing leakage losses and substituting complex electrical valve controls with a hydromechanical fluid control system. The control system consists of a pilot spool valve with a helical construct that allows for selective communication with multiple main stage valves. Consequently, the main stage valves operate as the drivers of the system by increasing or decreasing the net power based on the position of the pilot spool valve. Each main stage valve goes between cycles of power and returns strokes. Conventionally, high pressure is utilized throughout the power stroke making power input greater and thereby increasing overall cost as well as the leakage losses in the system. In a PSPP pump-motor, high pressure is only turned on halfway into the power stroke minimizing both cost and losses.

3. **Samir Ahmed**
Synthesis of Novel Bio-Derived Polyesters Through the Development of New Electron Deficient Palladium Catalyst
Advisor: Ian Tonks
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota - Twin Cities
Abstract: Carbonylation reactions of alkenes constitute the most important industrial processes in homogeneous catalysis. Despite the tremendous progress in this transformation, the development of advanced catalyst systems to improve their activity and widen the range of feedstocks continues to be essential for new practical applications. PPh3-based state-of-the-art ligands such as (tBu)2P2(CH2)2Ph, (dtbx), as well as species reported by Mecking et al. and Beller et al. display the use of various phosphine electron rich bulky ligands in applications ranging from hydroesterifications to carbonylation polymerizations to a potential methyl methacrylate production. The role of ligand electronics in hydroesterification chemistry is still not fully understood, and thus research in this area is of interest of both from a fundamental and practical perspective.

4. **Brian Almaraz**
Oil Dispersion—Understanding Effective Dispersion through Phase Equilibria and Nanostructure
Advisor: Lee Penn
Sponsoring Program: Project SEED
Home Institution: Washington Technology Magnet School, St Paul Public Schools
Abstract: Recently, a marine oil dispersant has been formulated that is composed of the food-grade surfactants lecithin and Tween80 that is expected to be more environmentally friendly than current commercial formulations (e.g. Corexit). While lab-scale testing has shown that lecithin-Tween80 (LT) dispersants exhibit comparable dispersant effectiveness to Corexit-based formulations, little is understood about the interfacial phenomena that make this surfactant mixture an effective dispersant. LT blends do not exhibit characteristics that would be expected of effective dispersants and because of this it is expected that other phenomena have a role in explaining effective dispersion. Thus, we hypothesize that thermodynamic phase equilibria and nanostructure formation at the oil-water interface can be used as an indicator for effective dispersant formulations and help explain dispersant efficacy. This work focuses on understanding the correlation between ternary phase equilibria and dispersion efficacy as well as characterizing the nanostructures of LT blends at the oil-water interface with the use of polarized light microscopy, dynamic light scattering, and X-ray diffraction. This work is expected to help elucidate the effectiveness and synergy of LT dispersants, both of which will provide information on how the current LT system works and how to optimize this dispersant for future commercial use.

5. **Frank Andujar Lugo**
Inverted Liquid Piston Compressor: Experimental data acquisition
Advisor: James Van de Ven
Sponsoring Program: CCEFP
Home Institution: Carnegie Mellon University
Abstract: With the broader goal of improving the efficiency of air compressors, we investigated the liquid-air stability, how well the liquid kept itself from mixing with the gas during the cycle, in a reverse liquid piston air compressor that aimed to make air compression quasi-isothermal. Our main task was to validate a model of the liquid surface interface. That would allow us to optimize the shape and spacing of the heat sinks inside the air compressor, finding a balance between heat dissipation and liquid-air stability. My main role was to design and run an experimental set up, where we could acquire data with similar variable control as that of the model. During the course of the REU program, we worked on improving our experimental understanding of the liquid surface. Additionally, we optimized the way experimental data for the project was captured, filtered, and analyzed.

6. **Elizabeth Ankrah**
Multi–population clustering: Comparison of scVMDC algorithm to K-means
Advisor: Rui Kuang
Sponsoring Program: Computer Science
Home Institution: George Mason University
Abstract: Single cell RNA sequencing (scRNA-seq) is a growing methodology that allows for new understanding and the characterization of many cells through the analysis of gene expressions. There has been an increase in the availability in scRNA-seq data, and as a result, new methods for the analysis of such data has become an integral part of computational biology and bioinformatics. Currently, there are many algorithms for the analysis of scRNA-seq data, yet these methodologies are limited as they are derived from algorithms meant to analyze bulk RNA-seq. As a result, these algorithms cannot always account for scRNA-seq specific properties especially, when analyzing multi-population datasets. Variance Driven multi-task Clustering (scVDMC) is one of the first algorithms built specifically for the analysis of scRNA– seq containing multi-populations. The goal of this experiment is to demonstrate the accuracy, and efficiency of the scVDMC algorithm, against the k means algorithm that it was derived from.

7. **Jonathan Ayala**
Phase Behavior of Salt Doped, Homopolymer-rich A/B/A-B Ternary Blends
Advisor: Timothy Lodge
Sponsoring Program: MRSEC
Home Institution: University of Texas Rio Grande Valley
Abstract: Conductive polymeric materials with a robust, high modulus, and high ionic conductivity have been of particular interest as of late due to their potential direct applications in Lithium Ion Batteries (LIB's). Their potential as a replacement for the separator and the highly flammable liquid electrolyte is an interesting and exciting possibility. It is broadly accepted that a co-continuous structure leads to these interesting properties. Thus, understanding the thermodynamics of mixing and the corresponding phase behavior is an important first step. A/B/A-B ternary polymer blends which consist of two homopolymers (A and B) and the corresponding diblock copolymer (AB) have been analyzed and studied thoroughly over the last couple of decades. An equilibrium bicontinuous microemulsion (BμE) structure can be obtained when the components are suitably designed. Here, we will explore the addition of a salt (LiTFSI) and its effects on the structure of an A/B/A-B ternary polymer blend of poly(ethylene oxide) (PEO), polystyrene (PS), and poly(ethylene oxide)-block-polystyrene (PS-b-PEO) diblock copolymer. We will first focus on blends with small PS-b-PEO compositions and explore the potential macroscopic phase separation by cloud point measurement. The ion concentration dependence will also be investigated. After that, an experimental phase diagram will be constructed and fit with a thermodynamic model. The result will guide design of ion-containing polymer mixtures with multiple components.

8. **Jeremy Barakos**
Solid-State Structures of Benzonitrile Oxides and their Dimers: Crystal Structure of an Unexpected Heterocyclic Compound
Advisor: William Ojala
Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: Benzonitrile oxides (Ar-C≡N$^+$-O$^-$, where Ar = aryl) dimerize in solution to form three different products: a furoxan or 1,2,5-oxadiazole-*N*-oxide, a dioxadiazine, or a 1,2,4-oxadiazole-*N*-oxide, depending on the reaction conditions. We are conducting a study of the solid-state chemistry of benzonitrile oxides, using single-crystal X-ray diffraction to determine whether the crystal structure of the parent benzonitrile oxide determines the identity of the solid-state dimerization product. We have recently determined the crystal structure of the compound resulting from an attempted solution-phase dimerization of 2,4-dichlorobenzonitrile oxide. Instead of one of the anticipated benzonitrile oxide dimers, we obtained the corresponding 1,2,4-oxadiazole, a heterocyclic compound not bearing the expected exocyclic oxygen atom, and we describe its crystal structure here. Previous work by other investigators has demonstrated that this compound can form by reaction of the corresponding 1,2,4-oxadiazole-*N*-oxide with additional benzonitrile oxide. Because the heteropentacycle structure is also consistent with reaction between the benzonitrile oxide and the corresponding nitrile, we are currently investigating the occurrence of an absorbance in the nitrile region of the infrared spectrum at an unexpectedly early step of our benzonitrile oxide synthesis, an absorbance that gradually disappears on standing, to determine how and why this unexpected product is formed.

9. **Nancy Bautista**
Extensional Rheology in Polyelectrolytes
Advisor: Cari Dutcher
Sponsoring Program: MRSEC
Home Institution: University of Texas Rio Grande Valley
Abstract: Extensional Rheology for Ionic Polymer Solutions
Extensional rheology is a powerful technique applied to understand and control the behavior of non-Newtonian fluids encountered in numerous applications such as spraying, printing, potable water production, and food processing. The viscoelastic capillary thinning of fluids is an essential dynamic process used to determine the extensional flow properties of polymeric materials. For complex fluids, capillary thinning can be affected by inertia, viscosity, and other external forces that distort the shape of the macrostructure. Capillary Breakup Extensional Rheometry (CaBER) is an experimental procedure that describes the behavior of complex fluids by applying time-dependent extensional stresses. The elongational break-up of high molecular weight polyelectrolytes was studied here to calculate their extensional relaxation time using constitutive models. The extensional viscosity for these ionic polymers was also analyzed. As the extensional relaxation time of polymer increases, the extensional viscosity also increases. The correlation between both extensional parameters was studied, which can inform commercial applications.

10. **Onri Jay Benally**
Patterning Perpendicular Magnetic Tunneling Junctions
Advisor: Jian-Ping Wang
Sponsoring Program: MRSEC
Home Institution: University of Minnesota
Abstract: In the scope of this project, we focus on an area of spintronics known as perpendicular anisotropic Magnetic Tunnel Junctions (MTJs). Inside MTJs, a basic stack consists of a tunnel barrier and 2 ferromagnetic electrode layers. In a tunneling process, the Tunneling Magneto Resistive (TMR) effect, a quantum mechanical phenomenon, is determined by the tunneling conductance which can change based on the whether the magnetizations of the 2 electrodes are parallel or anti-parallel. Recently, it's been shown that spin-orbit interactions in magnetic conducting layers can produce strong Spin Transfer Torques (STTs) on a proximal magnetic layer and without disturbing the tunneling barrier (typically MgO). When requiring different anisotropy strengths, TMR curves in relation to PMTJ structures is considered. On a final note, prediction of the spin-Hall effect allows for the generation of substantial amounts of dissipation-less quantum spin current in semiconductors and ferromagnetic materials by (spin) injection. Since spintronic devices aren't set back by the velocity limit of electric charge (≈1-2*107 cm/s) and have ultra-low power consumption, they are a great candidate for future three-dimensional chips in computation and high-density, non-volatile storage systems such as Spin-Transfer Torque Magnetoresistive Random Access Memory (STT-MRAM).

11. **Samuel Bennyhoff,** Jesse McCaffrey, David Thomas
Aggregation State of SERCA as Affected by Inhibitors
Advisor: David Thomas
Sponsoring Program: Physics REU
Home Institution: Augsburg University
Abstract: We have performed saturation transfer electron paramagnetic resonance (ST-EPR) on the sarcoplasmic reticulum calcium ATPase (SERCA) in the presence of known SERCA inhibitors thapsigargin (Tg) and cyclopiazonic acid (CPA) to determine their effect on SERCA's aggregation state. Previous studies have observed SERCA aggregation upon addition of Tg [7]. ST-EPR is uniquely sensitive to the microsecond rotational motion expected for aggregates of SERCA, providing resolution between different aggregate sizes of SERCA. SERCA was purified from rabbit skeletal muscle by ReactiveRed affinity chromatography, and reconstituted into physiological lipid vesicles by detergent mediation for subsequent EPR measurements. Plans to investigate other SERCA inhibitors such as 2, 5-Di-t-butyl-1,4-benzohydroquinone (BHQ) and activators using ST-EPR are in place following the preliminary results from Tg and CPA.

12. **Adugna Berkessa**
Foraging Swarm Robotics Optimization of Cache Location
Advisor: Maria Gini
Sponsoring Program: Northstar STEM Alliance
Home Institution: University of Minnesota
Abstract: Foraging Swarm Robotics is a rapidly emerging technology of a large number of robots to transport heavy objects and for exploration purposes. Other applications are search and rescue and environmental cleanup in disaster zones, exploration, surveying and remote construction in mines and space. A group of robot collects and transport material from different sources to the intermediate storage location. In swarm robotics the intermediate location is called "cache". It is possible to put the cache in any location in the given arena, but there should be easy to reach and safe. In order to optimize the location of the cache we extended the Particle Swarm Optimization Algorithm by adapting it to a 2D environment.

13. **Bryan Bogin**
Developing chemical tools to investigate penicillin-binding proteins
Advisor: Erin Carlson
Sponsoring Program: UMN Chemistry- Lando
Home Institution: The College of New Jersey
Abstract: The rise of antibiotic resistance has created a huge challenge in combating infectious diseases. The most startling trends suggest resistance to current drugs are increasing faster than new drugs can be developed. The gaps in our basic knowledge about the antibacterial targets and mechanisms of acquiring resistance need to be filled in order to develop more robust strategies. Penicillin-binding proteins (PBPs), discovered as the targets of β-lactam antibiotics such as penicillin, are enzymes which catalyze the formation of peptidoglycan, long polymers of sugars interconnected with peptide chains, which makes up the main part of cell wall in prokaryotes. Peptidoglycan layer provides the cell with strength, rigidity, and resistance to osmotic pressure. In this study, small molecule probes are utilized to selectively target PBPs. These probes label only active PBPs and either carry reporter groups or have bioorthogonal (non-natural) handles enabling subsequent conjugation with fluorophores and detection via SDS-PAGE or live fluorescent imaging of whole cells. In addition, PBP2x, an essential PBP in S. pneumoniae is produced using recombinant protein expression and purified using affinity chromatography. Future crystallography work as well as computational collaborations studying PBP2x co-crystals with the aforementioned probes will elucidate key interactions which will be integrated into the next generation of PBP probes.

14. **Wei Xi Boo**
Computation of Dispersions Curves for Optical Phenomena in Layered Structures
Advisor: Matthias Maier
Sponsoring Program: UROP
Home Institution: University of Minnesota
Abstract: As technology progresses, new forms of materials emerge and allow us to explore unknown natural phenomena. Layered structures consisting of novel materials such as hexagonal boron nitride and graphene exhibit unusual optical phenomena, such as no refraction and negative refraction. These carefully engineered materials are called metamaterials. To understand how electromagnetic waves travel in metamaterials, we need to understand the dispersion relation. Dispersion is a phenomena that occurs when electromagnetic waves travel in material that does not have a constant refractive index. In this condition, the group velocity will have a different value than the phase velocity, this is the speed which a peak of the wave travels. More precisely, the dispersion relation is the relationship of frequency and wavenumber. The research I am doing is computing the dispersion curves for different conditions in metamaterials. By modeling metamaterials with dispersion curves, we can study and improve the performance of metamaterials.

15. **Avi Brach-Neufeld**
Anti-neutrino energy estimation
Advisor: Greg Pawloski
Sponsoring Program: Physics REU
Home Institution: Bates College
Abstract: I will present about projects to find more accurate and robust ways of calculating anti-neutrino energy including focusing on Quasi-Elastic events and creating a self correcting estimator which can automatically correct systematic errors.

16. **Abby Bratton**
Polyester-Polyolefin Multiblock Copolymers as Compatibilizers for Recycling Multicomponent Film Products
Advisor: Christopher Ellison
Sponsoring Program: Center for Sustainable Polymers
Home Institution: Murray State University
Abstract: Poly(ethylene terephthalate) (PET) and Poly(ethylene) (PE) are among the most common plastics produced today. Together, they are often used as multilayer film for food wrappers and other gas/water vapor barrier products. Unfortunately, these multicomponent systems are also not recycled due to the difficulty in separating the layer components. In this research, multiblock copolymers (MBCPs) were synthesized to serve as blend compatibilizers for use in recycling PET/PE films as blend products. As proof of principle, PET-poly(ethylene/ethylethylene) (PE/E_E) MBCPs were produced and observed to reduce the volume average diameter of PET/PE immiscible blend minority domains from 4.4 μm to 0.53 μm. While this is a demonstration of effective blend compatibilization, the ideal MBCP should contain a pure PE block component such that it can more easily locate at the interface between the blend components. Towards this end, dihydroxy end-functionalized PE (HO-PE-OH) was synthesized by ring-opening metathesis polymerization (ROMP) of *cis*-cyclooctene. Several different molecular weights of HO-PE-OH were produced, and they are currently being substituted for PE/E_E in the PET-PE/E_E MBCPs to provide new PET/PE MBCPs.

17. **Margaret Braunreuther**
3D Bioprinting to Support Macrophages
Advisor: Paolo Provenzano
Sponsoring Program: PSOC
Home Institution: University of Michigan
Abstract: Immune cell migration plays an important role in both normal immune response and disease progression. There has been little investigation of immune cell function and behavior in 3D, and less within the context of bioprinting. Bioprinting offers multilevel spatial control of cell placement and organization, as well as heterogeneous construct of varying cells and bioinks. This work aims to establish a protocol for printing immune cells in a tunable 3D environment. Control of scaffold stiffness and extracellular matrix (ECM) composition can be employed to investigate immune cell behavior in response to environmental conditions. We began this project with a well-characterized macrophage immortalized cell line, RAW 264.7, to develop and optimize the printing process. Macrophage behavior can be either immunostimulatory or immunosuppressive, but the factors that influence this behavior and the switch between the two states are not well characterized. Clinical data has demonstrated the presence of macrophages in tumor tissue is correlated to poor prognosis in cases of breast cancer, prostate cancer, and melanoma. Using this protocol as a basis, we seek to characterize the parameters for printing and culturing macrophages in 3D to establish a reproducible system to study immune cell function and behavior in response to environmental factors.

18. **Jillian Brooks,** Lisa Coles, Elizabeth Seaquist, Anjali Kumar, Lynn Eberly, Amir Moheet
Intranasal Naloxone Pharmacokinetics and Tolerability in Patients with Type-1 Diabetes (T1D) during Recurrent Exercise
Advisor: Lisa Coles
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota
Abstract: Patients with T1D are at risk to develop impaired awareness of hypoglycemia (IAH), a condition where the blood glucose level that elicit the autonomic response is lowered. Exercise induced autonomic failure is one mechanism that contributes to the development of IAH. Administration of intravenous naloxone has been shown to preserve the autonomic response to hypoglycemia (Caprio, 1991). Our research group is conducting a clinical study to evaluate intranasal (IN) naloxone's effect on the autonomic response in individuals undergoing recurrent exercise followed by a period of hypoglycemia. The objective of this work was to characterize the pharmacokinetics of IN-naloxone and compare exposures with those resulting from intravenous administrations. This was a randomized, blinded, crossover study, which consisted of two study visits (naloxone or placebo), with a two-day protocol on each visit. Blood glucose was clamped at 95 mg/dL for 90 minutes during exercise in the morning and afternoon of day 1. 4mg IN-naloxone was administered at the start of exercise and 45 minutes into exercise. Blood samples were collected every 15 minutes. Plasma was analyzed for naloxone concentrations using HPLC-MS/MS. Five subjects with T1D have completed the study with no adverse events experienced. The naloxone concentrations were best fit using a two-compartment pharmacokinetic model with central compartment volumes of distribution of 1.5-5 L and clearances of 50-80 L/hr. Naloxone concentrations were similar to what would have been achieved using intravenous dosing suggesting that IN-naloxone may be promising as a therapy for the treatment of exercise induced autonomic failure.

19. **Jenna Brown**
Particle- Induced Instabilities on a Fluid Interface
Advisor: Sungyon Lee
Sponsoring Program: MRSEC
Home Institution: Fort Lewis College
Abstract: Flows of fluids with particles are relevant in both nature and industry. In nature, an example is the transport of sediment by rivers and tides and in industry, the flow of proppant in hydraulic fracturing. These are just a couple of examples in which suspensions of particles in a fluid are encountered. It is well-known that when a less viscous fluid is driven into a more viscous fluid inside a porous media, this causes an instability known as viscous fingering. This instability has been extensively studied. In this work, we are interested in what happens to the fluid-fluid interface with the addition of a suspension of non-colloidal particles within the Hele-Shaw cell. Specifically, we investigate cases in which a layer of suspension beneath a layer of air is drained from the cell. We vary the suspension concentration, gap width, particle size and flow rate to determine each variable's effect on the observed instability. It has been observed that for thin gaps, slightly larger than the particle diameter, the particles move slower than the bulk fluid flow causing them to accumulate on the interface. This leads to an interfacial instability in which the particles stretch from the interface and create long filaments, due to the viscous drag between the particles and the walls of the cell. From experimental results we see that for the particles to move slower than the bulk fluid the suspension concentration, the gap width of the Hele-Shaw cell and particle diameter all influence this instability.

20. **Caroline Brown**
Protein Prenylation and Implications in Alzheimer's Disease
Advisor: Mark Distefano
Sponsoring Program: UMN Chemistry- Lando
Home Institution: University of North Georgia
Abstract: Protein prenylation is an enzymatic post-translational modification made to proteins containing a "CAAX" motif in which an isoprenoid unit of either 15 or 20 carbons is attached to the protein's C-terminus. Protein prenylation has been implicated in a variety of medical conditions including cancer, infection diseases, and neurodegenerative diseases. This project seeks to understand the prenylation patterns of three types of brain cells: neurons, microglia, and astrocytes and the implications these patterns have for Alzheimer's disease. A metabolic labeling approach was employed to map the prenylation patterns of the cell lines using a biorthogonal isoprenoid analog as a probe. A copper-catalyzed azide-alkyne cycloaddition reaction was performed to functionalize the probe with either a TAMRA fluorophore or a biotin handle for fluorescence and proteomics studies respectively. The fluorescence study showed differences between prenylation levels or the cell lines' ability to incorporate the probe. The proteomics study will offer conclusive evidence about specific proteins that are prenylated in each cell type as well as give quantitative data about prenylation levels.

21. **Siri Bruhn**
Retro-Acylation of Dihydroxybenzophenone
Advisor: Chris Douglas
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Grinnell College
Abstract: Research in the Douglas group has recently focused on activating inert bonds in cross-coupling reactions to avoid starting material pre-functionalization requirements and the production of environmentally harmful halogenated waste. During the examination of the acylation reaction that forms benzophenones from phenyl salicylate, successful ketone-to-ester transformation under slightly modified reaction conditions was discovered, prompting investigation of C—C bond activation. This summer, I conducted experiments to determine optimal reaction conditions for the metal-catalyzed transformation of 2,2'-dihydroxybenzophenone to phenyl salicylate. Optimized conditions for this retro-acylation reaction are presented here, as well as preliminary efforts to examine the substrate scope. Additional work towards the characterization of reaction byproducts via prep-TLC suggests formation of the para-acylated hydroxyketone. Future work on this project will include further characterization of byproducts, examination of the substrate scope, and increasing the scale of the reaction to determine isolated yields.

22. **Colin Bunner,** Mona S. Minkara
Gibbs Ensemble Simulations Probing the Miscibility Gap in Hydrogen-Water Mixtures at Extreme Temperature and Pressure
Advisor: Ilja Siepmann
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota
Abstract: To explore fluid-fluid immiscibility in the binary system H_2O/H_2 at extreme conditions, *NPT*-Gibbs ensemble Monte Carlo simulations of an equimolar mixture are carried out at temperatures from 650 to 875 K and pressures of 1.8 and 2.6 GPa, in the supercritical region of neat water. The simulations, using molecular mechanics force fields that treat both molecules as rigid and nonpolarizable but quantitatively reproduce the critical points of the neat compounds, support the presence of a miscibility gap under these conditions, in agreement with a recent experimental study that found two distinct immiscible phases in olivine inclusions. Analysis of the atom-atom radial distribution functions for H_2O in the H_2-rich phase highlights the microheterogeneous structure, with significant H_2O aggregation. The cluster size distribution of these H_2O aggregates shows the predominance of smaller clusters at lower temperature (and lower H_2O concentration) and that a cluster percolating in space is formed as the upper critical solution temperature is approached. The distribution of H-bond energies and geometries for H_2O molecules in both phases reveals the weakening of the H-bond network in these mixtures under extreme conditions. Our simulations also highlight the importance of many-body dipole correlations in stabilizing H_2O clusters.

23. **Maxwell Buss**
The Search for Lightly Ionizing Particles with CDMS Data
Advisor: Vuk Mandic
Sponsoring Program: Physics REU
Home Institution: University of Minnesota, Twin Cities
Abstract: Lightly ionizing particles, or LIPs, are hypothetical particles with charge smaller than the electron charge that, unlike quarks, are not bound into heavier particles. Data obtained from a germanium crystal high voltage particle detector in the Physics and Nanotechnology building at the University of Minnesota's Twin Cities campus was used to place new upper limits on the flux of these hypothetical LIPs through the detector. These limits were placed for LIPs with charges e/55 to e/110.
Two different upper limit curves were obtained, based upon two different energy deposition models for LIPs incident on the detector. The limits were initially placed on the order of 10-4 counts/(cm2 s sr) over the range of charges mentioned above using a crude model for energy deposition by LIPs in the detector based upon the Bethe-Bloch equation. The model was then refined based on work done by Dr. Kunj Prasad in his PhD thesis, which modeled the interactions of LIPs with the detector based upon more detailed quantum electrodynamics models. This model tended to yield slightly weaker limits over the range of charges discussed above, though still on the order of 10-4 counts/(cm2 s sr). Future work will focus on extending the analysis to lower fractional charges.

24. **Maria Buss**
Are Advanced LIGO's Black Holes Dark Matter?
Advisor: Vuk Mandic, Andrew Matas
Sponsoring Program: UROP
Home Institution: University of Minnesota
Abstract: Over a century after Einstein's prediction, the first gravitational waves were detected by LIGO in 2015. These gravitational waves were formed from the collision of two black holes weighing approximately 30 solar masses. These discoveries have opened up a new observational window into the Universe, enabling studies of binary black hole mergers, which is exciting due to the fact that little was known about these events before the detection of the first gravitational waves. The ongoing objective of this research is to understand where the black holes seen by Advanced LIGO come from. They could have come from the collapse of stars or have a primordial origin, meaning they formed in the very early universe, before the formation of the first stars. In addition, confirming that the Advanced LIGO's mergers observed were from primordial black holes, rather than from stellar evolution ones, could provide information about dark matter, whose origin is one of the most pressing unsolved mysteries in astrophysics today. I have approached these questions by implementing the model developed Sasaki et al in Matlab and comparing the results to the ones in their article. Once the software is written, I can use this model in analyzing data from Advanced LIGO.

25. **Peter Buttery**
Identification of Novel Farnesyltransferase Substrates through the Use of Peptide Libraries
Advisor: Mark Distefano
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota
Abstract: Protein prenylation is a post-translational modification essential for a variety of biological functions in humans and other eukaryotes. In this process, an isoprenoid group is covalently attached to a cysteine residue near the C terminus of a substrate protein by the enzymes farnesyltransferase (FTase) or geranylgeranyltransferase type 1 or 2 (GGTase-1 and GGTase-2). It has long been thought that FTase and GGTase-1 recognize a tetrapeptide sequence motif referred to as a "CaaX box", where C is a cysteine residue, a is an aliphatic amino acid, and X is an amino acid that helps determine substrate specificity. However, recent findings have shown that FTase is capable of modifying sequences longer than the canonical CaaX sequence. To date, a handful of substrates containing an extended "C(x3)X" recognition motif have been identified to be prenylated by both yeast and mammalian FTase. In this project, a peptide library approach is being implemented to scan peptides containing C(x3)X sequences in order to identify novel FTase substrates. Solid-phase peptide synthesis is being employed to prepare libraries of peptides, which are then subjected to farnesylation conditions and analyzed using MALDI-TOF MS to determine which peptides undergo a mass shift representative of the addition of a C15 farnesyl group. Identifying novel FTase substrates can help improve our understanding of this essential biological process, as well as having potential therapeutic and biotechnical applications.

26. **Thomas Calascione,** Mike V. Patton, Andrew H. Morgenstern, Nathan A. Fischer
Controlling Magnetic Properties in Fused Deposition Modeling Parts via Shape, Infill Orientation, and Infill Percentage
Advisor: Brittany Nelson-Cheeseman
Sponsoring Program: UROP
Home Institution: University of St.Thomas
Abstract: A fused deposition modeling process (FDM) is a type of 3D printer that deposits material to build a part, layer by layer. The influence of print settings on the magnetic properties of parts printed with composite filament has not yet been fully characterized. Here, a magnetic filament consisting of PLA (polylactic acid) polymer and 40wt.% iron was used in an FDM process to print magnetic samples of different length, width, infill percentage, and infill print orientation (along vs against the shape anisotropy). A vibrating sample magnetometer (VSM) was used to determine the effect of these different print structures on the magnetic response to an applied magnetic field. Hysteresis loops for each sample were measured with the magnetic field applied along the longitudinal and transverse directions of the part and used to compare the magnetic susceptibilities between different print structures. The results show that infill orientation has a prominent effect on the magnetic properties; however, as infill percentage increases, this effect diminishes and the effect of the macroscopic shape becomes dominant. Determining how shape, infill orientation, and infill percentage affect the magnetic properties of printed parts will help in understanding how an FDM process can be utilized to tune magnetic properties and incentivize FDM as a method for manufacturing magnetic components.

27. **Jennifer Cerda**
Specific Binding Interactions of Cytochrome C and β-Lactoglobulin with Gold Nanoparticles by Protein Footprinting
Advisor: Erin Carlson
Sponsoring Program: Center for Sustainable Nanotechnology
Home Institution: St. Thomas University
Abstract: Dedicated nanoparticle research began in the 1960s, and since then nanoparticles have become a great asset in numerous scientific fields. Nanoparticles are used in many diverse applications and especially in the medical field. Gold nanoparticles (AuNP) have been particularly successful due to their characteristics. AuNP do not show signs of toxicity, making them suitable for medical use. However, upon introduction into biological systems, AuNP form a corona made up of proteins and other biomolecules. The identity of the corona ultimately determines the biological fate and toxicity of the AuNP. The Center for Sustainable Nanotechnology is studying how nanoparticles interact with biological systems. We examine the model 1 proteins cytochrome c (cyt c) and β-lactoglobulin (BLA) to determine their specific interactions with AuNP. We examined two mode 1 systems: cyt c and 4 nm MPA-coated AuNP and BLA with 20 nm citrate-coated AuNP. To determine the specific protein-nanoparticle interactions, we utilized protein footprinting, a method that examines the differentially labeled amino acids that are solvent accessible of free vs bond proteins. Lysine specific labeling indicates Lys 72, 25, 27, and 79 are important in binding of cyt c to 4 nm MPA-AuNP. Oxidative footprinting is now being applied to examine BLA-AuNP interactions.

28. **Megan Charity**
Skateboards vs. Cybersickness
Advisor: Victoria Interrante
Sponsoring Program: Computer Science
Home Institution: Virginia Commonwealth University
Abstract: A constant issue when developing for virtual reality environments with partial immersion comes from the motion sickness a user experiences while moving in the virtual world. Environments attempt to solve this issue of dissociation between the natural movements of the user in reality and the in-world virtual movements by implementing a variety of systems: teleportation by having the user point the controller to a place in the environment, artificial locomotion - or joystick control similar to controlling avatars in 3D games, or motion controllers that are rely solely on certain movements of the body such as swinging the arms or running in place. However, a mode of transportation that has not been fully explored in academia are vehicles. This paper explores the use of low-acceleration vehicles - vehicles that are not strongly affected by the effects of drag when in motion - as a means to combat cybersickness and nausea from the lack of a total feeling of motion while still retaining immersiveness in the virtual environment for the user.

29. **Sarah Claessens**
Synthesis of Novel Substituted Monomer for Copolymerization with Lactide
Advisor: Thomas Hoye
Sponsoring Program: Center for Sustainable Polymers
Home Institution: Gustavus Adolphus College
Abstract: Sustainable polymers have become increasingly more sought after. Polylactic acid (PLA) has proven to be compostable and sustainable in origin, however PLA is unsuitable for certain applications, such as film blowing, due to its low melt strength. To increase the melt strength, we synthesized a new monomer from citric acid to be copolymerized with PLA. This monomer was synthesized in three steps without using protecting groups. We developed a method to purify the compounds via recrystallization, distillation, and/or column chromatography. This potential copolymerization of this novel monomer with lactide is capable of inducing branching, a method known to increase its melt processing strength. Potential applications of this copolymer are varied, but most notably is the manufacturing of plastic grocery bags that degrade in a much shorter time frame than current materials.

30. **Jennifer Conner**
Characterization of the Core/Shell Interface and Oxidation of Si/SiN Core/Shell NCs
Advisor: Andre Mkhoyan
Sponsoring Program: MRSEC
Home Institution: Arizona State University
Abstract: Semiconductor nanocrystals (NCs) are of wide interest within materials science due to their highly tunable optoelectronic properties, which are different from those of their bulk counterparts. The optical properties of fluorescent NCs can be further improved by coating the NCs with protective shells. We are interested in finding sustainable, non-toxic NCs that could be feasible alternatives to the widely used semiconductor NCs that are made from toxic materials such as CdSe. In this study, we investigated the elemental distribution across the core/shell interface of nonthermal plasma-grown Si/SiN core/shell NCs by fitting computational models of the NCs to scanning transmission electron microscopy – electron energy loss (STEM-EEL) spectrum images. Additionally, we have employed these methods to analyze the physical changes to the NCs upon oxidation. The focused investigation on the structure of Si/SiN NCs will educate future improvement to the synthesis of core/shell NCs, thus optimizing their optoelectronic properties.

31. **Caroline Jiachen Dai**
ALTERNATING FLOW (AF) HYDRAULIC PUMP
Advisor: James Van de Ven
Sponsoring Program: CCEFP
Home Institution: University of MinnesotaTwin Cities
Abstract: Alternating flow hydraulic pump is a variable displacement pump that applies the concept of alternating flow achieved through a piston pairs that share a common cylinder. When the two pistons are in phase, the pump outputs maximum flow. When the two pistons are out of phase, fluid is shuttled back and forth between the two pumping chambers, therefore resulting in no net flow output. This pump aims to be efficient across a wide operating range.

32. **Matthew Danbury**
X-Ray Scattering and Nonlinear Conductivity Measurements of Strongly Correlated Materials
Advisor: Martin Greven
Sponsoring Program: MRSEC
Home Institution: Cornell University
Abstract: Scattering and transport measurements represent two paradigms of techniques for probing condensed matter systems by allowing one to deduce their structural and electronic behaviors, respectively. Used in ensemble, these techniques provide a powerful platform for advanced materials characterization and the investigation of fundamental physical phenomena such as those found in strongly-correlated materials, where non-negligible electron-electron and exchange interactions manifest in coherent macroscopic behaviors such as ferromagnetism and high-temperature superconductivity. $La_xSr_{1-x}CoO_3$ (LSCO) thin films, extensively studied within IRG-1, are a system which undergoes an insulator-to-metal transition accompanied by ferromagnetic ordering when a gate bias is applied. Here we present work done by in-operando synchrotron x-ray scattering to further characterize the structural changes LSCO undergoes with gating. When compared with previous transport measurements, this structural information may provide additional insight into the doping mechanisms of LSCO. Also of interest are high-temperature superconductors, distinguished by their complex phase diagrams where relations between competing forms of ordering are not fully understood. Here we present work done to apply contact-free nonlinear conductivity – a technique for performing ultra-sensitive measurements of non-trivial phase features – to a wider class of thin film and exfoliated materials. This technique has the potential to discern between different proposed pairing mechanisms in these materials.

33. **Nathan Davies**
Modeling Scavenging for a Hydraulic Free Piston Engine
Advisor: Zongxuan Sun
Sponsoring Program: CCEFP
Home Institution: Macalester College
Abstract: Modeling scavenging, the process in which exhaust gas is discharged from a cylinder and fresh air is drawn in, is important in order to maintain stable operation of a hydraulic free piston engine. This engine differs from a regular combustion engine because it does not have a crankshaft to transfer the energy it generates mechanically; instead, it uses the force generated during combustion to push hydraulic fluid into accumulators to store fluid power energy. However, without a crankshaft to keep the pistons in regulated motion, maintaining stable control and operation of the engine becomes more difficult. An active piston motion controller has been developed to act as a virtual crankshaft by using energy stored within the accumulators to regulate the piston to follow a predefined trajectory. In order to help improve this controller, we developed a model for scavenging using MATLAB Simulink. This model allowed us to analyze how changing different parameters, such as intake manifold pressure, intake manifold temperature, piston displacement, and air-fuel ratio, affected the mass, pressure, and temperature within the cylinder during one engine cycle. This model can be used in the future to help improve the virtual crankshaft control scheme in order to improve stable operation of the hydraulic free piston engine.

34. **Hector De Santiago**
Phase purity & chemical composition of La1-xSrxCoO3 nanoparticles synthesized via halide- and nitrite-based molten salts
Advisor: Christopher Leighton
Sponsoring Program: MRSEC
Home Institution: University of Texas Rio Grande Valley
Abstract: Perovskite oxides have demonstrated significant properties, such as high temperature superconductivity, colossal magnetoresistance, ferroelectricity, and metal-insulator, structural, and magnetic phase transitions. Perovskite cobaltites doped with alkaline-earth metals, have shown a magneto-electronic phase separation which in bulk systems is heavily influenced by stoichiometry. Also, magneto-electronic phase separation behavior may be affected by dimensionality. Therefore, nanoparticles (NPs) of La1-xSrxCoO3 (x = 0, 0.05, 0.10, 0.20, 0.30) were recently synthesized through a binary-nitrite ionic flux method (a new approach) and previously through a sol-gel with binary-chloride ionic flux synthesis (an older approach). These NPs were studied as a function of composition and particle size to determine the influence of these effects on the stoichiometry and magnetic properties. Currently, x-ray diffraction (XRD) has demonstrated that both methods can make perovskite NPs at low temperatures and calcination times for all concentrations, but the newer type of NPs contained Si contamination and the old type NPs formed SrCO3 at high Sr concentrations. In addition, Scherrer's equation found an average particle size decrease of 15.42 nm for the new NPs. Furthermore, scanning electron microscopy (SEM) and energy dispersive analysis of x-rays (EDAX) also have hinted to smaller particle sizes with less stoichiometric variations in Sr content for the new NPs. Further work will focus on making cleaner new NPs, taking structural characterization analysis, and beginning magnetometry measurements.

35. **Hannah DuBois**
Active Learning Classification Tool
Advisor: Junaed Sattar
Sponsoring Program: Computer Science
Home Institution: University of Minnesota
Abstract: Image data sets can be extensive and contain images that may not be related to the project at hand. Image labeling is also costly and requires humans for classification. Using a Support Vector Machine, Active Learning Methods, and more compact image features image labeling can become more efficient and allow for specific images relating to the project to be displayed.

36. **Ahmad El Shakoushy**
Rectifier Device Implementation via Wide Band Gap Oxide Semiconductor and Transition Metal Dichalcogenide
Advisor: Steven Koester
Sponsoring Program: MRSEC
Home Institution: San Francisco State University
Abstract: The core of the research project is to implement a rectifier (pn-junction) device by utilizing a transition metal dichalcogenide: (p-doped) WS2 in conjunction with a wide-band-gap oxide material: (n-doped) β-Ga_2O_3. The reason for using these specific materials involves the fact that β-Ga_2O_3 is a highly stable semiconductor, and that it is an excellent choice to pair with WS2 due to the band alignment configuration. The first 2D material to be discovered was Graphene; it was found to exhibit many useful physical properties at the atomic-layer-level. However, the major limiting factor of Graphene is that it lacks the presence of a band gap. This is precisely why we turn to a class of materials known as TMDs(Transition-Metal-Dichalcogenides). TMDs are a new subclass of 2D materials that consist of a transition metal sandwiched between 2 atomic layers of a Chalcogen. We are most interested in TMDs at the monolayer because that is when they exhibit a direct band gap. This means that TMDs can be instrumental in the design and implementation of many optoelectronic and electronic devices. Firstly, I will utilize a technique known as mechanical exfoliation to thin these materials to the monolayer-level, so I can employ this feature. Secondly, Raman spectroscopy will be utilized in conjunction with optical microscopy to perform characterizations, and to measure sample thicknesses on a finalized substrate. Finally, electrodes will be connected to the device and efficiency testing will take place. We anticipate that our distinctive choice of materials will result in a highly efficient rectifier(pn-junction) device.

37. **Kavinraaj Ella Elangovan**
Ion Gel gating of Strontium Stannate Thin Films
Advisor: Bharat Jalan
Sponsoring Program: UROP
Home Institution: University of Minnesota Twin Cities
Abstract: Alkaline earth stannates such as barium stannate and strontium stannate have become an integral part of semiconductor technology due to their optical transparency and high room temperature carrier mobility. Strontium Stannate, in particular, has obtained a lot of attention due to its wide band gap and low lattice parameter allowing it to be easily matched to substrates. In this experiment, we attempted to induce carriers in Strontium Stannate thin films using the method of ion gel gating which uses the concept of the electric double layer capacitor. The ion gel (a combination of an ionic liquid and a block copolymer) acts as a dielectric and generates strong electric fields which induce a high carrier density at the thin film surface. $SrSnO_3$ thin films were grown using Hybrid MBE and transistor devices were fabricated on it using argon ion milling and sputter deposition. Hall measurements were conducted and the resistance was measured for different temperatures at varying gate voltages. The resistance was found to decrease for higher potentials and the peak carrier density and mobility of the carriers were calculated to be 9×10^{18} cm^{-3} and 49.2 $cm^2V^{-1}s^{-1}$ respectively. From the experiment, we concluded that ion gel gating was an effective method to induce carriers in $SrSnO_3$ thin films without chemical doping.

38. **Begad Elmelligy**
Measuring and Characterizing Gate Defined Nano-structures Using High Quality 2D Materials
Advisor: Ke Wang
Sponsoring Program: Physics REU
Home Institution: University of Wisconsin River Falls
Abstract: The ability to use two-dimensional materials to make electrical devices has been on the rise. To acquire high-quality electrical contact, special techniques have been developed to encapsulate the given two-dimensional material such as graphene. Here, we use hexagonal boron nitride to encapsulate the two-dimensional material, which is graphene, niobium diselenide and molybdenum disulfide in our case, then apply a contact geometry in which we metallize only the 1D edge of the 2D graphene layer. In graphene heterostructures, this enables high electrical performance, including high electric mobility. During the given research period, we were able to encapsulate all the listed 2D materials in order to perform some measurements on them. Some of the measurements include testing the mobility and observation of quantum hall effect.

39. **Jack Erhardt**
Use of Basic DNA Mutations as Genetic Operators in Neural Network Training
Advisor: Marc Riedel
Sponsoring Program: UROP
Home Institution: University of Minnesota Twin Cities
Abstract: Feedforward artificial neural networks provide a framework to develop algorithms for data classification, such as recognizing images of handwritten digits, by training against example data. Stochastic gradient descent, a common method of performing this training, can become stuck in this training process and over-optimize small parts of the network data while failing to make larger improvements in other areas. This can be combated by introducing random changes to the network to force it to retrain in new ways. In this research, a novel method of mutation is proposed based on DNA mutation phenomena. Neural network data is transcribed from three dimensions down to a one-dimensional data string. During this transcriptions, random weights can be inserted, and network weights can be deleted, forming localized frame shifts and introducing variability to the network. This data string is then transcribed back into three dimensions of network data. Three variations of this genetic operator are proposed, and each is evaluated in regard to the amount of change it induces in a neural network, the reduction in percent accuracy of image classification networks due to the mutation, and the ability of the network to retrain following this mutation.

40. **Alexander Feistritzer**
Computational Calculation of the Fractal Dimension for Catalytic Zeolites
Advisor: Paul Dauenhauer
Sponsoring Program: Center for Sustainable Polymers
Home Institution: University of Chicago
Abstract: Computational box-counting methods were used to quantify the fractional dimension of a variety of catalytically active zeolites. While zeolites are useful tool to synthesize monomers from biomass, each monomer precursor has a different reactivity to a particular zeolite, leading to costly and time-intensive screenings. Previous work has used effective volume to describe the difference in zeolite reactivity by characterizing the networks of pores in terms of their effective size, but fails to describe differences in reactivity as a consequence of the chemical, rather than structural, composition of the zeolite. Attempts to use surface area fractals, which characterize only the outer surface of the zeolite, have been done, but this does not address the channels that give the zeolite their catalytic properties. This work demonstrates that volumetric fractal dimension, calculated through a box-counting technique, can be used to characterize zeolites by incorporating both structural and chemical composition. By comparing to adsorbate experimental data that had been used to calculate the fractal dimension, it is seen that the computational method employed here, using only crystallography data, provides reliable results.

41. **Dylan Frikken**
Mu2e Tracker Construction: Straw and Sense Wire Tensioning
Advisor: Ken Heller
Sponsoring Program: Physics REU
Home Institution: University of Wisconsin River Falls
Abstract: The Muon to Electron Conversion experiment (Mu2e) is an experiment looking to observe a process which is an example of Charged Lepton Flavor Violation (CLFV). The University of Minnesota has been tasked with constructing the drift-tube particle detector portion, called the tracker, of the Mu2e experiment. The tracker's metalized Mylar straws have been shown to sag with age, reducing the effectiveness and lifetime of the experiment. Measurements of the straw relaxation were taken to determine the relaxation rate. A device was made, using Arduino and Vernier Dual-Range Force sensors, to pull the straws to the required tension and store the tension to a database. This device will ensure that each of the straws in the tracker will have an initial tension high enough to ensure the operation time can be met.

42. **Kayla Gephart,** Salamong Xiong
Optical Characteristic Measurements of Crystalline Silicon (c-Si)
Advisor: Shaul Hanany
Sponsoring Program: Physics REU
Home Institution: St Olaf College
Abstract: We report on measurements of the transmission through crystalline silicon (c-Si) samples, with various resistivities, at 110 GHz. The microwave source directed electromagnetic waves of normal incidence onto samples of c-Si. We calculated transmission for each sample by comparing the power detected with and without the c-Si sample in the sample holder. We used the transmission values to determine the respective dielectric loss tangents of each sample. We upgraded the equipment to improve the accuracy of the previous experimental setup. In the process of obtaining this data, we aligned the setup, as well as detected and characterized systematic uncertainties in the equipment.

43. **Grecia Gonzalez**
Influence of substrates on the conductivity of rubrene single crystals
Advisor: Daniel Frisbie
Sponsoring Program: MRSEC
Home Institution: University of Texas Rio Grande Valley
Abstract: Organic field effect transistors (OFETs) based on organic semiconductors (OSCs) have rapidly surged given the flexibility, low cost, lightweight and environmental friendly characteristics. Among OSCs, rubrene single crystals provide an ideal platform for charge transport study due to the demonstrated high mobility in OFETs and the resulting benchmark performance. Preliminary research has concluded that the conductivity of rubrene crystals greatly depends on the substrate utilized. For example, the conductivity of rubrene crystals on silicon dioxide (SiO2) can be 3-4 orders of magnitude higher than the conductivity of free-standing rubrene crystals. This research will focus on the alteration of the substrate to study the direct influence of substrate on the conductivity of the device. A comparison will be made between free-standing crystals and crystals on SiO2, Al2O3, and polymer substrates. The devices will be fabricated on Si/SiO2 wafers by conventional lithography technique, and the rubrene crystals will be placed between two gold electrodes and serve as conductors for the current-voltage measurements. Other techniques, including atomic layer deposition and spin-coating, will be used to fabricate the Al2O3 and polymer substrates. This experiment will provide valuable information on the possible mechanism of interfacial doping of organic semiconductors.

44. **Grace Gretz,** Courtney Olson and Isaac Prichett
Characterization of the Bulk of nCB Liquid Crystals by FTIR and Polarized Microscopy
Advisor: Aaron Massari
Sponsoring Program: NSF
Home Institution: University of Minnesota
Abstract: This research aims to characterize the phase transitions in the bulk of nCB liquid crystals throughout a cooling and heating cycle. Fourier transform infrared spectroscopy (FTIR) and polarized microscopy were utilized to study these phase transitions. Shifts in peak center and broadening of peak width observed in the spectra measured by FTIR indicated phase transitions. Those temperatures corresponded to visible phase transitions seen with polarized microscopy.

45. **Carole Hall,** Ashleigh Adams
Simplicial Complexes of Zero-Sumfree Sets
Advisor: Eric Stucky, Kaisa Taipale
Sponsoring Program: SECANT
Home Institution: University of Minnesota, Twin Cities
Abstract: Additive combinatorics is the study of counting objects in the context of a natural additive operation. One major goal in this field is to find the maximum size of an *l*-zero-sumfree subset of a general abelian group. In this project, we applied the theory of simplicial complexes to find this value in the case of the cyclic group of integers modulo *n*. Consider the set of all *l*-zero-sumfree subsets of the integers modulo *n*; this is a simplicial complex denoted by $D(n,l)$. We varied the parameters n and l and explored the resulting facet structures, Cyclic Sieving Phenomena, and Whitney numbers. We determined these characteristics for two distinct classes of $D(n,l)$: first, when $n = 2l$, and second, when n is twice a prime number and $n - l < 4$.

46. **Nathan Harper**
Investigating the Reactivity and Growth of Iron Oxide Nanoparticles Using Catechol
Advisor: Lee Penn
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Emory University
Abstract: Hematite and goethite, two iron oxides, exist as nanoparticles in anaerobic aqueous environments. In the presence of aqueous iron (II), iron oxide nanoparticles reduce oxidized environmental pollutants; Fe(II) in solution is oxidized to Fe(III) and incorporated into the bulk crystal. The new iron oxide layer may be of a different form than the original nanoparticle; goethite has been shown to grow on hematite nanoparticles, altering the reactivity of the nanoparticle. Previous work in the Penn group found that Natural Organic Matter (NOM) hinders the reduction of nitrobenzenes. To simplify the many functional groups in NOM, this experiment replaces NOM with catechol (1,2-dihydroxybenzene). For the concentrations conducted in these experiments, roughly 15% of the catechol in solution binds to the nanoparticle surface, likely blocking reactive sites. We have found that catechol in concentrations as low as 2uM decreases the reactivity of hematite nanoparticles. XRD analysis is being performed to determine if catechol suppresses goethite growth on hematite. For goethite nanoparticles, 20uM catechol slows the reaction, and TEM analysis will determine if catechol causes certain facets to grow faster. Further work will show if catechol displaces adsorbed Fe(II) from the iron oxide surface, which could also account for hindered reactivity.

47. **Greta Helmel**
Trumpler 16 and Eta Carinae: Astrometry and the Evolution of Spectral Lines
Advisor: Roberta Humphreys
Sponsoring Program: Physics REU
Home Institution: Macalester College
Abstract: I present two interrelated projects done as a part of the University of Minnesota's summer 2018 Research for Undergraduates Physics and Astronomy program. In the first, I investigate new parallax data from the recent Gaia Data Release 2 for various stellar OB associations and clusters in the Milky Way Galaxy. One of these, Tr 16, contains the massive star Eta Carinae. Analysis of the Gaia parallaxes reveals a discrepancy between Eta Carinae's adopted distance of 2300 pc and the mean parallax of related stellar members, suggesting that Eta Carinae may be farther away (and as such, more luminous) than previously determined. Though already assumed to be the most luminous star in the galaxy, these findings would increase its luminosity by almost 30%. In the second project, I extract and begin analysis of spectra from Eta Carinae taken by the Hubble Space Telescope. I report on changes in these spectra from 2012 to 2018, confirming the continuation of certain trends in the star's behavior. One feature has since resolved in an unprecedented way, and may have implications for the stellar wind density.

48. **Michaela Howk**
Toward Isomorphous "Bridge-Flipped" Isomers: Investigations of 3-Pyridyl and Hydrazine-Based Systems
Advisor: William Ojala
Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: Pairs of molecules we define as "bridge-flipped isomers" differ structurally only in the orientation of a bridge of atoms connecting two major molecular moieties. Examples occur among the benzylideneanilines, where the isomerism is Ar1-CH=N-Ar2 vs. Ar1-N=CH-Ar2, and among the phenylhydrazones, where the isomerism is Ar1-NH-N=CH-Ar2 vs. Ar1-CH=N-NH-Ar2 (Ar = aryl). We use single-crystal X-ray diffraction to determine whether bridge-flipped isomers are isomorphous, crystallizing into the same molecular packing arrangement. Isomorphous pairs may form interesting solid solutions; non-isomorphous pairs may serve as seed crystals for each other and thereby induce formation of new isomorphous crystalline forms. Assuming that the occurrence of similar molecular packing motifs in both members of a bridge-flipped isomeric pair might encourage their isomorphism, and to promote formation of motifs defined by nitrogen···iodine Lewis acid-base contacts, we have begun the synthesis and crystallization of a 3-pyridine-derived system of benzylideneanilines bearing iodine substituents. The anticipated shared motif would be zigzag molecular chains defined by nitrogen···iodine contacts. Concurrently we have begun the synthesis and crystallization of diimines based on hydrazine. Crystal structures of these derivatives will be compared to those of their bridge-flipped analogues, the corresponding diimines based on glyoxal. Samples are now in preparation for X-ray crystal structure analysis.

49. **Gabriel Hurtado**
Photoluminescence of Silicon Quantum dots with Silicon Nitride Shell from Nonthermal Plasma
Advisor: Uwe Kortshagen
Sponsoring Program: MRSEC
Home Institution: The University of Texas Rio Grande Valley
Abstract: Quantum dot (QD) semiconducting materials have developed strong interest due to their nanoscale properties. Their wavelength of emission can be tuned depending on the size of the quantum dot. Because of these unique properties, QDs have been used for photoluminescence (PL) applications such as TVs and LED lighting. Silicon QDs with a silicon nitride (SiNx) shell will be developed using a nonthermal plasma reactor and their emission wavelength during an oxidation process will be studied using Time-Resolved PL. We expect the SiNx shell to provide an air-stable and environment friendly state during oxidation. The thickness and synthesis constraints of the SiNx shell will be studied to determine their effect on emission Lifetime and Quantum Yield. This will help us determine which quantum dots will have the performance for different applications.

50. **Johanna Jernberg**
Designing 3D printed holders to measure magnetic anisotropy within thin-film samples
Advisor: Xiaojia Wang
Sponsoring Program: MRSEC
Home Institution: College of Saint Benedict
Abstract: Magnetic anisotropy can be simply defined as the preference for magnetization to lie in a particular direction within a sample. This property is important when looking at magnetic thin films – the anisotropy in a film can influence other important properties, such as thermal stability and the ease of switching the magnetization direction. This is seen when comparing a film with perpendicular anisotropy (PMA) versus a film with in-plane anisotropy, with PMA normally being preferred due to the better expression of the properties mentioned above. When looking at Iron Palladium (FePd) alloy films, it is believed that they may exhibit cubic anisotropy as well as the more common uniaxial anisotropies. If this is the case and cubic anisotropy has similar benefits to PMA, it could make affect how we view and make this thin film technology. To test this theory, a small sample must be suspended in a magnetic field at exactly 45 degrees from vertical. To do this, a holder made of 3D printed plastic is needed to load the sample in the correct position, while not interfering with the magnetic field. This holder has been created, and with it we will be able to more easily and accurately test for cubic anisotropy within the film of FePd.

51. **Victoria Jones**
Functionalized Graphene Oxide for Targeting Ovarian Cancer Spheroids
Advisor: Samira Azarin
Sponsoring Program: MRSEC
Home Institution: The Pennsylvania State University
Abstract: As the deadliest gynecological cancer, ovarian cancer presents a pressing women's health issue, and only in the past decade have multicellular aggregates (spheroids) been widely recognized as metastatic. Spheroids are not only capable of intra-abdominal dissemination, but also tend to resist drug and radiation therapies, and, therefore, pose a significant challenge when designing effective treatments. Accordingly, we aim to develop a selective, non-invasive method of addressing spheroids when treating ovarian cancer by using hyaluronan-functionalized, PEGylated graphene oxide (HA-PEG-GO). We have shown that PEGylation of graphene oxide increases overall biocompatibility and stability in the biological milieu without adversely affecting its ability to inhibit adhesion of spheroids to extracellular matrix proteins. However, PEG-GO interacts with cancer cells and healthy cells indiscriminately. In future work, we intend to further functionalize PEG-GO with hyaluronan and exploit CD44, a hyaluronan-binding surface protein that is overexpressed in cancerous cells, to induce preferential association of HA-PEG-GO with spheroids. This novel selectivity would reduce harm to healthy cells and indicate HA-PEG-GO's superiority as a therapeutic delivery system. Furthermore, we plan to investigate methods of inducing cancer cell death (e.g. photodynamic therapy) using HA-PEG-GO, though demonstrating that HA-PEG-GO could preferentially bind to spheroids to prevent dissemination would be significant in and of itself

52. **Zoe Kearney**
Detections of Extended X-ray Emission around Radio Galaxies
Advisor: Lawrence Rudnick
Sponsoring Program: Physics REU
Home Institution: University of Massachusettes, Amherst
Abstract: On the scales of galaxies to galaxy clusters, the hot plasma of the intracluster medium produced by thermal bremsstrahlung is detectable in the x-ray. However, our current inability to study the ICM at above z >1.5 indicates that we are lacking important information on the evolution of galaxy clusters and cluster environments. Using archival data from the Chandra Satellite, we aim to search for the ICM around Radio Galaxies from the Third Cambridge Catalogue, as Radio Galaxies have been shown in the past to be strong indicators of clusters. For strong, extended x-ray emission on the cluster scale, the ICM can be searched for directly. However, for non detected extended emission sources, the method of stacking provides a means to indirectly probe the ICM. In conducting a stacking experiment, our original sample from Massaro et al. 2018 supposedly contained 109 Third Cambridge Catalogue radio sources with no extended x-ray emission. As a result of further analysis on this sample, the previous criteria used for identifying extended sources was determined to be bias and overlooked additional extended sources. From this sample, we now present newly detected extended x-ray emission associated with the ICM, from radio sources marked previously unresolved or un-associated in literature. Further work will be done on the stacking experiment with the sources that are unambiguous in containing non-extended x-ray emission.

53. **Steven Kelly**
Temperature Dependence of Raman Spectra for Organic Solvents
Advisor: David Blank
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota, Twin Cities
Abstract: This investigation seeks to both qualitatively and quantitatively compare the vibrational, or Raman, spectra of various organic solvents taken at different temperature points in the liquid phase. The temperatures of samples of Toluene, Chloroform, and Cyclohexane solvents are altered using a heating element, and the Raman spectra of these solvents are collected using a 633nm CW Laser to probe the solvents and Bragg filters to allow for the spectra to be taken in both the stokes and antistokes region. Comparing the Raman spectra for each solvent at each temperature point, the relationship between the temperature of a solvent and the altering of the population distribution along its vibrational energy levels can be qualitatively reasoned from the changes in shape and position of the solvents' raman peaks. Broadening of raman peaks and less energetic raman shifts with increasing temperature are attributed to solvent molecules having a higher density in more energetic vibrational states. Finally, these collections of experimentally obtained temperature-dependent raman spectra are compared to temperature-dependent Raman spectra as computed using the density of states, DOS, for each solvent obtained through the Wang-Landau model. Quantitative resemblance between empirical and computational data would be a significant victory for computational spectroscopic research as well as have significant bearing on the interpretation of Ultrafast spectra.

54. **Maria Kloiber**
The Effectiveness of Computational Disease Treatment Identification
Advisor: Rui Kuang
Sponsoring Program: Computer Science
Home Institution: St. Olaf College
Abstract: Drug repositioning—the process of applying existing drugs to new purposes—significantly reduces the cost and time required for drug development. This study investigated the effectiveness of a bi-random walk algorithm for the prediction of associations between networks of drugs, genes, and diseases, which is a common approach to computational drug repositioning (Kuang, 2015). In this study, different types of simulations were designed to test the algorithm's accuracy in predicting relationships between the three similarity networks. The designed simulations either consisted of random connected networks or networks containing distinct patterns. Prediction accuracy was assessed by removing several known internetwork relationships from the data and evaluating the algorithm's ability to rediscover those relationships. Overall, our research provides further insight into potential strategies for optimizing the effectiveness of drug repositioning.

55. **Grant Knappe**
A Renewably Sourced Pyrone for the Synthesis of Sustainable and Degradable Polymers
Advisor: Theresa Reineke
Sponsoring Program: MRSEC
Home Institution: University of Delaware
Abstract: The ability to synthesize degradable polymers from renewable sources has become increasingly important due to the stress that current industrial polymeric materials impose on the environment. Towards this synthetic end, various monomers have been synthesized from 5-hydroxy-3-methyl-2-pyrone, a renewably sourced unsaturated cyclic ester. Methacrylation of the pyrone and its reduced lactone derivative has yielded monomers for use in radical-type polymerizations. Additionally, derivatives of the lactone are synthesized in order to generate linear polyesters via ring opening polymerizations (ROP). Homopolymers from the mechacrylated pyrone were synthesized via uncontrolled, free radical polymerization and controlled, reversible addition-fragmentation chain transfer (RAFT) polymerization; these polymers were subsequently characterized with size exclusion chromatography (SEC). Ring opening polymerizations (ROP) were attempted on ring strained lactones, and the polymerizations were tracked via nuclear magnetic resonance (NMR) spectroscopy. The synthesized polymers represent progress towards creating sustainably sourced and degradable polymers with desirable thermomechanical properties.

56. **Hannah Kolsky**
Bismuth (III) Subsalicylate as a Greener Polymerization Catalyst in Teaching Lab Experiments
Advisor: Jane Wissinger
Sponsoring Program: Center for Sustainable Polymers
Home Institution: Loyola University Chicago
Abstract: Many instructors are hesitant to adopt teaching lab experiments that use tin (II) 2-ethylhexanoate ($Sn(Oct)_2$) as a ring-opening transesterification poymerziation (ROTEP) catalyst due to toxicity and environmental concerns. Recent literature reported that bismuth (III) subsalicylate (BiSS), the active ingredient in the over-the-counter medication Pepto-Bismol, was an effective catalyst for ROTEP of L-lactide. Previous researchers in the Wissinger Group developed a teaching experiment that employed BiSS as the catalyst in end block formation of a triblock polymer. A pilot run of the experiment in Spring 2018 was encouraging, but several areas of improvement were identified. The objective of the current research is to improve yield and the physical copolymer properties produced in this lab experiment. The procedure involves synthesizing a poly(δ-valerolactone) (PVL) homopolymer on Day 1 and end-blocking it with poly(L-lactide) (PLA) on Day 2 using the BiSS catalyst. Through a series of trials, revisions were made that improved student yield and PLA incorporation when implemented in a laboratory for the second time. Additionally, research to improve the mechanical properties of the copolymer is being done by varying the composition of the midblock. Overall, both data and student feedback indicate a positive development toward creating an effective polymer synthesis teaching lab experiment that instills excitement for sustainable polymers in future chemists.

57. **Grace Kresge**
Methylcellulose Hydrogels: Templated Fibril Formation onto Cellulose Nanocrystals
Advisor: Frank Bates
Sponsoring Program: MRSEC
Home Institution: Princeton University
Abstract: The thermoreversible gelation of methylcellulose (MC) has been widely studied for decades and is commonly utilized in commercial food products, personal care products, and pharmaceuticals. MC undergoes a sol-gel transition above a critical temperature that depends on a variety of system parameters. The transition is driven by the assembly of the polymer chains into fibril structures of a uniform diameter (~15 nm). Cellulose-based additives have recently been studied as a methodology to tune the storage modulus of MC. In this research, cellulose nanocrystals (CNC) were added to MC solutions in relatively low concentrations (0.01-1%). Rheological characterization of MC-CNC solutions shows a trend of decreasing gelation temperature and maximum storage modulus as CNC concentration is increased. The effect on the the structure of the MC system with the addition of CNCs was characterized before and after the sol-gel transition using small angle x-ray scattering (SAXS). It was found that the CNCs did not changed the characteristic diameter of the MC fibrils. The interactions between the MC fibrils and CNCs were imaged using cryo-transmission electron microscopy (cryo-TEM). A decrease in the average length of the MC fibrils was observed upon the addition of CNCs. The goal of future research will to observe the relationship between the CNCs and the nucleation of MC fibrils. The MC fibrils have exhibited some affinity to nucleating onto the CNCs. In the future, this could be applied to enhanced tunability of the MC system, allowing for the templating of the gel structure onto CNCs.

58. **Elizabeth LaCasse**
Synthesis of Precursor Salt, Triazolilydium Bromide
Advisor: Marites Guino-o
Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: Lanthanide-based luminescent materials can be used for anything from anti-counterfeiting measures to biomedical applications; however, lanthanide(III) ion luminescence alone is too weak to be useful. Thus, a ligand is used to act as an "antenna" by transferring energy to the lanthanide(III) ion to increase luminescence and protect it from being quenched by other molecules. Our lab group investigates the ability of N-heterocyclic carbenes (NHCs) to act as a ligand. This poster focuses specifically on the synthesis of Triazolilydium Bromide, a precursor salt. Its formation was tracked by 1H NMR Spectroscopy. Our results show that we have successfully synthesized the precursor salt, but in low yields. In the future, we will continue to work on optimizing the precursor synthesis and coordination with lanthanide(III) ions.

59. **Houadraa Lee**
Delaying Evolution to Increase Product Yield During Fermentation
Advisor: Romas Kazlauskas
Sponsoring Program: Project SEED
Home Institution: 2018 Graduate, Open World Learning Community, St Paul Public Schools
Abstract: Microorganisms are top contenders for genetic engineering to produce products such as biofuel, therapeutics, and commodity chemicals. However, evolution imposes a challenge to fermentation, i.e., the process of growing microbes to make products. During fermentation, cells reproduce and replicate. Inevitably, random mutations occur in the genome, some of which disable the cell of making the product. In turn, this frees the cell from the production cost, allowing it to grow quicker. Over time, such mutants will be strongly selected during competition and take over the population, eventually ending one fermentation batch. This research aims to develop a method that delays this negative effect of evolution on fermentation. The design seeks to distribute the cost of production among many copies of plasmids in Escherichia coli (E. coli) cells. Plasmids are genetic material independent from the chromosomes which can be engineered to generate products or in this case, green fluorescent protein (GFP). If a disabling mutation occurs to one plasmid among many others, this results in only a marginal effect on the total GFP yield. Hence, the mutation will not be strongly selected. This research can be applied to solving real world problems like the demand for alternatives to fossil fuels.

60. **Thomas Lee,** Andrew Morgenstern
Dispersion and Structure in Magnetic Thermoplastic Polyurethane Elastomer Composites
Advisor: Brittany Nelson-Cheeseman
Sponsoring Program: UROP
Home Institution: University of St. Thomas
Abstract: Using solvent casting to produce polymer composites allows for greater control over the method and therefore degree of particulate dispersion when compared to a polymer melt. The standard solvent casting method is used to prepare iron/magnetite and polyurethane (PU) composites for extrusion as magnetic, thermoplastic elastomers in 3D printing applications. Thin films were produced in order to study the dispersion and clumping of particulate, while thicker slabs were produced to study their porous structure. The solvent used in producing the PU composites was dimethylformamide (DMF). The method involved dissolution of the PU; dispersion of the magnetic particulate to concentrations of 20, 30, and 40 w/w%; drying by several methods; and characterization of the dispersion and structure. The choices of air drying at room temperature, using a dehydrator, or drying in a vacuum oven all prominently affected the degree of porosity in the resulting composite. When using iron powder as particulate (<150 μm), clumping was not apparent; however, when using magnetite as particulate (2-4 μm), noticeable clumping became apparent.

61. **Tanner Leighton**
Astrophysical Transient Classification Using Machine Learning
Advisor: Lucy Fortson
Sponsoring Program: UROP
Home Institution: University of Minnesota
Abstract: Our project, motivated by upcoming synoptic sky surveys, aims to streamline classifying astrophysical transient phenomena. Instead of making a series of detections and classifying retrospectively, we are developing machine learning benchmarks that classify observed sources as 'supernovae' (SNe) or 'not SNe' based solely on first detection and contextual information associated therewith. With current technology, SNe are usually detected around their peak luminosity. Astrophysicists would like to identify them prior to that peak (difficult due to temporal limitations), and our faster classification approach will enable this possibility. Only a few spectra exist of SNe shortly after explosion, and these observations can be the key to definitively linking specific types of stars to the SNe they create. To avoid wasting time and resources, we are putting emphasis on minimizing the number of false positive classifications (i.e. classifying a source that is not a supernova (SN) as a SN). This corresponds to maximizing the purity score of the classifier. However, since SNe are rare events, we cannot completely neglect the completeness score and thus are opting to use the F1 score, which combines purity and completeness, as our main performance metric. We evaluate classifier performance compared to the baseline 'all SN' classification scheme, where all sources are given the label 'SN.' Machine learning performance of the Naive Bayes (NB) algorithm is reported.

62. **Cynthia Lopez,** Tyler Josephson, Robert DeJaco
"Universal" Gas Separation by Adsorption onto Zeolites
Advisor: J. Ilja Siepmann
Sponsoring Program: Nanoporous Materials Genome Center
Home Institution: University of Minnesota
Abstract: All-silica zeolites are crystalline solids made of silicon and oxygen atoms. Some zeolites adsorb one type of molecule more strongly than others, which lets them be used in separation processes. To explore the possibility of using zeolites to separate gases in gas chromatography, we want to understand how the molecules' physical and chemical properties affect their adsorption strength, and whether different zeolites are suitable for separating different gases. To address these questions, we performed Monte Carlo simulations in the Gibbs Ensemble with two simulation boxes, one for the zeolite and one for the gas phase. These simulations reveal which molecules adsorb to the zeolite, and which molecules prefer to remain in the gas phase. Sixteen different gas molecules commonly encountered in gas chromatography were adsorbed into three zeolites, VFI, MFI, and MWW, which have 1-, 2-, and 3-dimensional pores of different pore sizes. The effects of temperature and the ratio of gas molecules to zeolite were also investigated. This study is expected to provide chemical intuition on the number of molecules adsorbed and selectivity from gas phase into zeolite.

63. **Kelly Low,** Jason Palesse
Hydraulic Valve for Miniature Surgical Robot Applications
Advisor: Perry Li
Sponsoring Program: CCEFP
Home Institution: University of Minnesota - Twin Cities
Abstract: Robotics plays a significant part in surgery due to the advent of new minimally invasive surgical techniques such as single port access (SPA) surgery and natural orifice transluminal endoscopic surgery (NOTES). These surgical techniques bring lesser postoperative pain, faster recovery, and better cosmetic results. The use of fluid power is explored at micro-scale as the maximum allowable diameter of the whole surgical robot is small. A ring-based flapper valve is designed to control the movement of an artificial muscle actuator. The prototype of the artificial muscle actuator is molded with silicon and consist of three chambers that are filled with fluid. These three chambers are connected to the outlet of the valve. To provide useful 3-dimensional manipulation, the valve regulates the supply pressure inside the actuator chambers such that the contractile force can be produced by the actuator. If one silicon actuation chamber is actuated, the module bends. If two chambers are simultaneously actuated with the same pressure, the module bends along intermediate directions. If all three chambers are simultaneously inflated with the same pressure, the module elongates. The valve has a ring that can slide axially and radially to control the stiffness of the actuators and control the opening of the orifices. To test it experimentally, Solidworks and 3D printing are used to create a model that can accurately position the ring. Different sets of data for different positions are collected and analyzed.

64. **Khoi Luu**
Total Synthesis and Reactivity of Sterically and Charge-enhanced Thiourea Catalysts
Advisor: Steven Kass
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Grinnell College
Abstract: Previous work in Kass group proved the enhanced reactivities of positively-charged Thiourea catalysts over Schreiner's thiourea. Computational data suggested that the introduction of a tert-Butyl group to the previously studied catalyst could improve its reactivity as well as its enantioselectivity for the Friedel-Craft akylation reaction. Significant progress has been made toward the total synthesis of the target molecule. The Grignard addition step was challenging and required Lanthanide metals to facilitate addition over aldol reaction. N-H insertion step shown promising result and is currently being optimized. The key chiral moiety for the catalyst will be achieved after separation by chiral HPLC and deprotection of carbamate protecting group. The rest of the molecule can then be achieved by coupling of the previously synthesized isothiocyanate. The performance of the catalyst will be evaluate through the Friedel-Craft reaction between N-methylindole and trans-β-nitrostyrene.

65. **Anna Makar-Limanov**
Incorporating Reprocessibility into Sustainable Photocurable Acrylates
Advisor: Theresa Reineke
Sponsoring Program: Center for Sustainable Polymers
Home Institution: Amherst College
Abstract: crylates are a common material used for photocurable applications such as light-based three-dimensional (3D) printing due to their fast polymerization kinetics and economic viability. However, most acrylic resins used as photopolymers are derived from petroleum-based feedstocks and are not recyclable. This project endeavors to tackle these sustainability issues by developing reprocessible photocurable acrylate resins suitable for stereolithography from lignin-based natural phenolics. We incorporated a thermoreversible Diels-Alder (DA) moiety in the form of a furan-maleimide adduct into a biorenewable predecessor: a dithiol linked eugenol diacrylate. The synthesis of the new diacrylate monomer takes 5 steps and applies benign chemicals and solvents with green routes. Additionally, we synthesized diluent monoacrylates from 4-propyl guaiacol and 4-methyl guaiacol in order to modulate glass transition temperature and thermomechanical properties in resin formulations. We investigated the retro-DA reaction of the diacrylate and its precursor before acrylation by spectra and thermal characterizations and also tested reprocessibility with preliminary binary formulations. It was found that UV irradiation caused an irreversibly crosslinked network and reduced retro-DA reactivity, probably due to unsaturation in both the diacrylate monomer and impurities. Further work on purifying the diacrylate monomer and understanding the effects of UV irradiation on the furan-maleimide structure will be conducted to guide the design of reprocessible and photocurable resins.

66. **James Meagher**
The Coordination of 1,3-bis[2-pyridal)methyl]-1H-imidazolylidene to the Fe3+ Ion
Advisor: Marites Guino-o
Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: Iron complexes are cheaper than the noble metal complexes, thus ideal for application such as catalysts, spin-crossover (SCO) complexes, and multifunctional molecular sensors. We aim to explore the SCO properties of the Fe3+ ion with an N-heterocyclic carbene (NHC) ligand. When a metal ion is exposed to a square planar, tetrahedral, or octahedral coordination environment, the d orbital is split, causing the orbitals to have different levels of energy. This allows for a high spin or low spin configuration. We would like to investigate how the coordination of the Fe3+ ion is affected by 1,3-bis[(2-pyridal)methyl]-1H-imidazolylidene. Herein, we will outline our attempts towards the synthesis of the target Fe3+ NHC specie. We employed 1H NMR, FTIR, and UV-Vis spectroscopy to track the progress of our reaction.

67. **Marianne Meyersohn**
Kinetics of the organophosphoric acid catalyzed ring opening polymerization of methyl caprolactones
Advisor: Marc Hillmyer
Sponsoring Program: Center for Sustainable Polymers
Home Institution: California Polytechnic State University
Abstract: Thermoplastic elastomers (TPEs) developed from renewable feedstocks have recently become viable alternatives to petroleum-based TPEs. Methyl caprolactones (MCLs) are potentially renewable monomers that can be polymerized and incorporated into TPEs as the rubbery midblock. This work explores the bulk polymerization kinetics of γ-methyl-ε-caprolactone (γMCL), a 1:1 mixture of β-methyl-ε-caprolactone (βMCL) and δ-methyl-ε-caprolactone (δMCL), and a 1:1:1 mixture of γMCL, βMCL, and δMCL using diphenyl phosphate (DPP) as an acidic organocatalyst. The goal of this work is to determine if the position of the methyl substituent on caprolactone monomers has an impact on rate of polymerization, thermal properties, and mechanical properties. Additionally, the use of DPP as an acid organocatalyst is explored as a more environmentally sustainable alternative to traditional tin based catalysts. Polymerization kinetics were studied by ^{1}H NMR spectroscopy to determine conversion as a function of time. At 100°C, P(γMCL), P(βMCL-co-δMCL) and P(βMCL-co-γMCL-co-δMCL) follow zero order kinetics in monomer. Polymer thermal and mechanical properties were studied using thermogravimetric analysis, differential scanning calorimetry, and dynamic mechanical thermal analysis.

68. **Willa Mihalyi-Koch**
Designing Efficient Quantum Dots for Luminescent Solar Concentrators
Advisor: Vivian Ferry
Sponsoring Program: MRSEC
Home Institution: Hamilton College
Abstract: Luminescent solar concentrators (LSCs) use luminophores embedded in a polymer waveguide to concentrate direct and diffuse sunlight onto a solar cell. Concentration of solar radiation onto a solar cell can improve efficiency and reduce cost. However, significant losses of incoming and emitted light can limit the ability of LSCs. In this work, we synthesized colloidal quantum dots to limit reabsorption and increase quantum yield, two loss mechanisms related specifically to luminophore material itself. To reduce reabsorption, we synthesized core-shell quantum dots structures through which the Stokes shift can be increased by altering the thickness of the shell. To increase quantum yield, we incorporated a high band gap semiconductor, ZnS, into core-shell heterostructures in order to localize carriers in the core. Although a ZnS shell will promote localization, which can prevent trap states introduced by the environment, it will also increase the lattice mismatch, which can introduce more trap states. Therefore, when ZnS is used alone as a shelling material, a reduction in quantum yield can occur. For this reason, we synthesized CdSe cores with CdS shells (a material with a smaller lattice mismatch) before coating these shells with outer layers of ZnS and CdZnS. We found that although the CdSe/CdS quantum dots still had the highest quantum yield (70%), the quantum yield of CdSe/CdS/CdZnS and CdSe/CdS/ZnS quantum dots could be increased to 64% and 53%, respectively, by increasing the number of CdS preliminary layers, synthesis times, and the ratio of CdS to ZnS in alloyed layers.

69. **Carlex Morales Cruz**
Optimization and Uniformity studies of Aluminum thin film deposition by magnetron sputtering on Si/SiO2 Wafers
Advisor: Dr. Xiaojia Wang
Sponsoring Program: MRSEC
Home Institution: University of Puerto Rico at Mayagüez
Abstract: Aluminum thin films commonly serve as metal transducers because of their large thermo-reflectance coefficient, good conductivity and their strong adhesion to the sample beneath. The magnetron sputtering technology is suitable for large-area deposition of thin films with a relatively high deposition rate. The aim of this work is to study through electrical properties and thickness the sputtering deposition uniformity of aluminum thin films on Si/SiO2 substrates. Improvement in the electrical conductivity measurements of the aluminum thin film will lead us to measure better the thermal conductivity of future samples. Advancing the thermal properties understanding of composites materials and modern electronic devices.

70. **Andrew Morgenstern,** Nathan A. Fischer, Thomas M. Calascione, and Thomas J. Lee
Thermoplastic Magnetorheological Elastomer for Fused Deposition Modeling
Advisor: Brittany Nelson-Cheeseman
Sponsoring Program: UROP
Home Institution: University of St. Thomas
Abstract: In manufacturing, fused deposition modeling (FDM) has gained prominence in applications involving modeling, prototyping, and production. As FDM grows in its scholastic and commercial functions, a need for alternative materials has arisen. This research focuses on the development and testing of a thermoplastic magnetorheological elastomer (TMRE) for potential use as FDM filament. MREs are unique smart materials of high elasticity and magnetic susceptibility that allows for magnetically induced mechanical deformation. Most MREs are thermosets, which inhibits the material from use in FDM. Printing with TMREs could lead to new properties and applications due to new sub-structures that are available through FDM. Our TMRE was created utilizing solvent casting techniques to disperse magnetic particulate within a polyurethane matrix which was then extruded into FDM filaments using a Filastruder. Initial mechanical and magnetic property data of the filaments was obtained using an MTS tensile tester and vibrating sample magnetometer (VSM). Preliminary testing shows that multiple processing factors, such as the drying method, extrusion feeding, extrusion temperature, and particulate percentage, play important roles in the solvent casting and extrusion processes leading to a range of materials properties. Future efforts will focus on further isolating these factors to determine their impacts on the material properties and utilize them to control the properties of the final TMRE filaments.

71. **Ella Morone**
Toward Isomorphous "Bridge-Flipped" Isomers: Investigations of 4-Pyridyl and Glyoxal-Based Systems
Advisor: William Ojala
Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: We are investigating the crystal structures of pairs of molecules we define as "bridge-flipped isomers." These molecules differ structurally only in the orientation of an atom bridge connecting two major components of the molecules, such as aryl groups. Examples can be found among the benzylideneanilines, where the isomerism is Ar1-CH=N-Ar2 vs. Ar1-N=CH-Ar2, and among the phenylhydrazones, where the isomerism is Ar1-NH-N=CH-Ar2 vs. Ar1-CH=N-NH-Ar2 (Ar = aryl). Using single-crystal X-ray diffraction, we are determining how frequently such pairs are isomorphous, crystallizing into the same molecular packing arrangement in the solid state. Isomorphous pairs may form interesting solid solutions. Based on the premise that the occurrence of similar molecular packing motifs in at least one dimension in both members of a bridge-flipped isomeric pair might encourage their isomorphism, we have begun the synthesis and crystallization of a 4-pyridine-derived system of isomers with iodine substituents; the anticipated shared motif would be close intermolecular N…I Lewis acid-base contacts. Concurrently we have begun the synthesis and crystallization of diimines based on glyoxal. Crystal structures of these derivatives will be compared to their bridge-flipped analogues, the corresponding diimines based on hydrazine. Samples are now in preparation for submission for X-ray crystal structure analysis.

72. **Victor Nartovich**
Architectural Shake Down of Shape Memory Alloy Knitted Actuators
Advisor: Julianna Abel
Sponsoring Program: UROP
Home Institution: University of Minnesota
Abstract: Shape memory alloys (SMAs) are a thermally active smart material that can produce 2-8% actuation strain under moderate forces. They can be integrated into knitted fabric structures, called active knits, which creates a textile capable of simultaneously reaching high strains and moderate forces. However, without proper preconditioning, or shaking down, the properties of active knits are inconsistent. A detailed comparison of the properties of SMA knits was performed. Three tests of varying styles and lengths were performed on both raw and preconditioned knits. The preconditioned knits were found to be more responsive to varying forces and their properties were more stable as compared to the not shaken down knits. For a not shaken down knit, the displacement per force increment added during the pull-out test varied from 0.1-7.9mm as compared to 0.2-1.3mm for the preconditioned knits. These findings have significant implications for developing new low mass and low volume orthostatic intolerance garments, both for space travel and for conventional medical use. The results show that a shaken down active knit has more reliable properties and are easier to manipulate than not shaken down knits.

73. **Mikayla Newby**
Synthesis, coordination, and luminescence of 1,3-bis[(2-pyridal)methyl]-1H-benzimidazolylidene with lanthanide(III) ions
Advisor: Marites Guino-o
Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: Lanthanide based luminescent materials have many applications, in medical equipment's, forensics, and anti-counterfeit fields. However, their luminescence are weak because the transition is parity forbidden. To increase luminescence, a ligand acts as an antenna to absorb light and transfer the energy to the lanthanide(III) ion through the antenna effect. In our group, we aim to explore an N-heterocyclic carbene's (NHCs) ability as an "antenna" to lanthanide(III) ions. Herein we report our preliminary results in the coordination of the NHC- 1,3-bis[(2-pyridal)methyl]-1H-benzimidazolylidene with its coordination with lanthanum(III), europium(III), and gadolinium(III) ions. These reactions were tracked by 1H NMR and FTIR spectroscopy, and mass spectrometry. Our results reflect that the coordination of the precursor NHC with lanthanide(III) ions was successful and further steps will be taken to crystallize the products to identify the crystal structures.

74. **Allen Nguyen,** Addison Desnoyer
Titanium Catalyzed Coupling Reactions of Triazoles and Alkynes: An Unexpected Synthesis of Halovinyl Sulfides
Advisor: Ian Tonks
Sponsoring Program: UMN Chemistry- Lando
Home Institution: University of Central Arkansas
Abstract: One of the main focuses of research in the Tonks group is synthesizing N-heterocycles, such as pyrroles, using titanium based redox catalysis. Surprisingly, the Tonks group has recently discovered a titanium-catalyzed coupling reaction between N-sulfonyl-1,2,3-triazoles and alkynes, resulting in the unexpected synthesis of halovinyl sulfides. Vinyl sulfides are used in a wide variety of synthetic processes and are important precursors to a broad range of bioactive molecules. The current state-of-the-art method of synthesizing vinyl sulfides, transition metal catalyzed hydrothiolation, requires the use of less abundant and toxic noble metal catalysts. Furthermore, many hydrothiolation methods have problems with selectivity. Our research has demonstrated that vinyl sulfides can be synthesized using cheap and abundant titanium catalysts with high selectivity. The products were characterized with 1H and 13C NMR spectroscopy after purification by column chromatography. Reactions with radical capture agents suggest that the synthesis proceeds via a radical mechanism. This new reaction pathway has shown promise as an alternative and complimentary method to currently used technology for the synthesis of vinyl sulfides.

75. **Keely Nistler**
Biodegradable Polymers as Microemulsion Drug Delivery Systems
Advisor: Chung Wang
Sponsoring Program: UMN Biomedical Engineering Department
Home Institution: University of Minnesota Twin Cities
Abstract: Nearly 90% of all the drugs in the pharmaceutical development pipeline are hydrophobic and poorly soluble in water, meaning that such drugs are less effective than ideal. To increase absorption of drugs, microemulsions have been studied to enhance drug delivery. In the Wang Lab, novel biodegradable polymers were synthesized and used to create microemulsions. In order to evaluate the potential of two biodegradable block copolymers for microemulsions, ternary phase diagrams were constructed to determine what conditions the oil-in-water microemulsions formed and the morphology as well as stability of the microemulsions. In each sample a blend of a hydrophobic and a hydrophilic polymer was created. Numerous trials were conducted with variations in polymer ratio and concentration in aqueous buffer, along with high or low-energy methods of dispersion. Each sample was characterized by Dynamic Light Scattering to identify the conditions under which the polymer mixture forms stable sub-micron size emulsions with low polydispersity. These experiments resulted in two phase diagrams that will serve as important guidelines for later optimization of microemulsion delivery systems for poorly soluble drugs.

76. **Nathan Noma**
Linkage Configurations in a Variable Displacement Linkage Motor
Advisor: James Van de Ven
Sponsoring Program: CCEFP
Home Institution: University of Minnesota
Abstract: Concepts associated with Professor Van de Ven's previous projects were used to design a motor for use in small construction vehicles. These previous projects include an in-line variable displacement linkage pump as well as a radial version of the linkage pump. The motor will be designed so that it is as compact as possible, while being more efficient in the low-RPM and high-torque range, making it consume less energy while still being effective in all ranges of operation. The premise of the research conducted this summer was to find a way to situate the components of the motor in space in order to make it as compact as possible, while assuring that there will be no interference between linkages. In addition, the motor needs to be in double-shear, meaning it must be supported on both sides in order to evenly distribute loads. To do this, the previous iterations of the linkage pumps were analyzed since the motor design is derivative from the previous pumps, and then a function was created that displays exactly how large of a space is needed depending on the number of pistons. Furthermore, different linkage configurations were conceptualized so that side-loading would be at a minimum, and then SolidWorks models were created to demonstrate what these would look like alongside various adjustment mechanisms.

77. **Allison Norman**
Engineering Protein Expression
Advisor: Benjamin Hackel
Sponsoring Program: MRSEC
Home Institution: Alcorn State University
Abstract: The molecular characterization of proteins has been widely studied to derive treatments for cancers and other diseases. In this experiment, the purpose is to improve the bacterial expression of protein scaffold variants that bind to desired biomarkers relevant to the disease being studied. The scaffold protein of interest, Gp2, has two diversified regions yielding differences in expression levels across variants. We propose to test the expression of the Gp2 variants in a high-throughput yeast secrete and capture assay as a proxy for bacterial expression. First, preliminary controls will be completed to ensure the assay is functional: such as ensuring the conjugation of the capture antibody, the induction of conjugated yeast, and minimal cross-talk between cells. The controls will conclude by using previously validated Gp2 variants to ensure that high bacterial expressing proteins will also perform well on the yeast secrete and capture assay. Finally, a collection of one million variants will be screened to determine which characteristics of the diversified regions correlate to bacterial yield.

78. **Fiki Owhoso**
Lead-Free Perovskites for Optoelectronic Applications
Advisor: Lee Penn
Sponsoring Program: MRSEC
Home Institution: University of Florida
Abstract: Perovskite materials are used as light absorbers in solar panels. These materials are made up of an organo-metal-halide structure. Current perovskites solar cells have a power conversion efficiency (PCE) of over 20%, however these perovskites contain lead which can be toxic for disposal. Several lead-free alternative perovskite materials have been proposed for use in solar panels but have so far resulted in lower PCE devices. Methylammonium indium iodide (MA3In2I9) is one such lead-free alternative that has yet to be synthesized. We will investigate the synthesis of MA3In2I9 in solid state and from solution by systematically studying the crystallization of this material. By varying experimental parameters such as substrate identity, substrate washing procedure, reaction time and temperature, and ambient atmosphere we hope to identify the best procedures to develop large single crystals and thin films for solar panel applications. X-ray diffraction, light microscopy, and UV-Vis spectroscopy will be used to characterize the products.

79. **Jason Palesse,** Kelly Low
Hydromechanical Transmission for Motor Vehicles
Advisor: Perry Li
Sponsoring Program: CCEFP
Home Institution: Milwaukee School of Engineering
Abstract: A hydro-mechanical transmission (HMT) is a continuously variable transmission consisting of a pair of hydraulic axial piston pump/motors attached to a mechanical gear train in parallel. Mechanical gears are highly efficient so transmitting power partially through gears instead of only hydraulics improves efficiency. Continuously variable transmissions are often desirable in motor vehicles because they allow for easy controllability, fast response time, and for the engine to operate at it most efficient speed for the power demand requirement. Traditional HMT's use a planetary and coupling gear attached to the hydraulic components to transmit power both hydraulically and mechanically which leads to a bulky and expensive transmission. In this project, an alternative HMT with an inline configuration, called the Hondamatic, was investigated. The Hondamatic subsumes the mechanical gear train which makes it much more compact and economical. A 3D prototype of the Hondamatic was developed using Lulzbot 3D printers to make the kinematics of the transmission easier to understand. Additionally, distributor valve timing was explored through modeling and simulation to improve the transmission efficiency. Simulation results demonstrated a significant improvement in efficiency compared to the traditional Hondamatic, especially at low displacements, which would lead to reduced fuel consumption.

80. **Breanna Pederson**
In Vivo Study of Plant Receptor Function
Advisor: Casim Sarkar
Sponsoring Program: UROP
Home Institution: University of Minnesota
Abstract: Plants recognize pathogen biomolecules known as elicitors and trigger an immune response which can lead to a hypersensitive response (HR) of localized cell death. Ethylene-inducing xylanase (EIX) is a fungal protein that acts as an elicitor in some tomato cultivars. EIX is recognized by the transmembrane receptor LeEIX2 which then signals the cell and causes HR. Our lab had previously identified segments of LeEIX2 that recognize EIX in vitro. This project extended these findings in vivo. The LeEIX2 gene was mutated in a number of different regions, including its putative EIX-recognizing domains; then, each of these genes was cloned into a bacterial vector, purified, sequenced for verification, transfected into Agrobacterium tumefaciens, and transiently expressed in Nicotiana benthamiana. Suprisingly, in most cases, these LeEIX2 mutations, including those in non-interacting regions, led to ablation of signaling. We hypothesize that this may be due to a lack of protein expression, so additional experimentation is being planned to directly measure LeEIX2 abundance in vivo. A better understanding of LeEIX2 sequence-function relationships will help to elucidate its role in plant immunity.

81. **Kelly Lou Pelicano**
Traction Testing of a Hydraulically-Actuated Surgical Soft Robot
Advisor: Timothy Kowalewski, Gillian McDonald
Sponsoring Program: CCEFP
Home Institution: Southern Utah University
Abstract: The surgical soft robot consists of three segments that are hydraulically-driven to move through a cannula in the human body. The design of the soft robot in use is an inchworming robot whose first and third helical segments anchor into structures without occluding blood flow, while the second segment extends to progress the robot along the tube.
This poster presents a method for experimentally determining the traction forces that develop between the helical segments and acrylic cannula, a critical component needed to understand the behavior and locomotion of the proposed soft robot. A CNC lathe and TAP Plastics Liquid Rubber were used to manufacture the helical segments, while a test bench setup consisting of an acrylic tube (25.4mm ID), low-friction pulley, and hanging masses were used to determine the traction force a helical segment achieves before slipping. The coefficient of static friction between the robotic segment and acrylic surface was determined using the inclined plane method.
This work could be extended to include traction tests for actuators of different sizes, as well as different environments such as simulated human tissues or porcine arteries.

82. **Tara Pereira**
Cause of Abandonment and Churn Probability for Sleep Apnea Treatment
Advisor: Jaideep Srivastava
Sponsoring Program: Computer Science
Home Institution: University of St. Thomas
Abstract: The overall goal of this project was to look at trends of the churn probability, or probability that a patient will stop treatment, of sleep apnea patients using time series clustering. This will help hospital staff know when to intervene in a patient's treatment and what additional support they may need.

83. **Megan Prien**
Investigation into the green synthesis of b-methylvalerolactone from 3-methyl-1,5-pentanediol using Oxone for a teaching lab experiment
Advisor: Jane Wissinger
Sponsoring Program: UMN Chemistry- Lando
Home Institution: University of Wisconsin-Whitewater
Abstract: Recent discoveries by the University of Minnesota's Center for Sustainable Polymers (CSP) demonstrated that block polymers of poly(β-methylvalerolactone) and PLA have interesting mechanical properties and are thus an excellent target for a new teaching laboratory experiment. Currently the monomer β-methylvalerolactone (BMVL) is not commercially available and is synthesized many different ways including an intramolecular cyclization of 3-methyl-1,5-pentanediol. Copper Chromite was previously used as the oxidizer in the synthesis of BMVL from 3-methyl-1,5-pentanediol, and is known for being hazardous to aquatic environments. The focus of this research is to investigate the green synthesis of BMVL from 3-methyl-1,5-pentanediol using Oxone as the oxidizing agent to be used in a multi-step synthesis of a triblock polymer. Based on literature precedence, various reaction conditions were explored combining 3-methyl-1,5-pentanediol with Oxone and a catalytic amount of NaCl in an ethyl acetate/water biphasic mixture. A mixture of products was observed, including the desired BMVL, by GC-MS and 1H-NMR spectroscopy in varying amounts depending on temperature, concentration and stoichiometry of the reaction. Continuous work is being done to optimize the reaction and to increase the yield of BMVL.

84. **John Proper**
3D Printing Injection Head for Soft Robots
Advisor: Timothy Kowalewski
Sponsoring Program: CCEFP
Home Institution: University of Minnesota
Abstract: Soft robotics has empowered robots to maneuver, traverse, and conform to environments that traditional robots cannot. Current state-of-the-art in soft robotics are fiber-reinforced elastomeric enclosures (FREES) which consist of an elastomeric tube wrapped in stiff fibers at specific angles. Soft actuator technology could be improved by continuously varying the mechanical properties of the elastomer throughout the entire actuator, thus broadening the possible deformations of soft robots. This could be accomplished through additive deposition of variable-property elastomer on a cylindrical surface akin to 3D printing. However, traditional 3D printing is not appropriate to the required mixing and curability of elastomers. Given these limitations, a prototype injection head is proposed for the manufacturing of variable stiffness soft actuators. The injection head design consists of custom 3D-printed syringe plungers concentrically fitted around a leadscrew and driven by a NEMA 23 stepper motor. The syringes contain two compatible elastomers that when mixed, feature a range of material properties depending the mixture ratio. The syringes deposit the appropriate elastomer mixture ratio after passing through a static mixer via position control of each syringe plunger. Commercially available fluid dispensers were used in the design to minimize curing damages. Such a design would be able to verify the capacity of creating variable mechanical properties with a mixture of elastomers such as polyurethane.

85. **Andrew Ramirez**
Method Comparison for Chemisorption of Supported Platinum Catalysts
Advisor: Paul Dauenhauer
Sponsoring Program: MRSEC
Home Institution: University of California, Davis
Abstract: Measuring the size of platinum nanoparticles deposited on a support material is crucial to determine the turnover frequency for various catalytic reactions. Static and pulse titration are the two adsorption methods to estimate the dispersion, surface area and crystallite size of these platinum particles. Transmission Electron Microscope (TEM) and X-Ray Diffraction (XRD) are other methods to support these values. In order to quantify these adsorption methods, carbon monoxide was flowed through an alumina supported platinum catalyst with a known dispersion factor. The static method uses a constant flow of carbon monoxide gas and is quantified by equilibrium pressure, whereas the pulse method streams a known amount of carbon monoxide and measures the uptake that did not adsorb onto the catalyst. The static method is hypothesized to be more precise than the pulse method because the experimental time run is longer and measured not only the physisorption, but the combination on chemisorption and physisorption for carbon monoxide.

86. **Nathan Ranly**
Synthesis of 3DOM W-SiC Nanocomposite Material
Advisor: Andreas Stein
Sponsoring Program: UMN Chemistry- Lando
Home Institution: University of Cincinnati
Abstract: Three-dimensionally ordered macroporous (3DOM) materials contain a periodic porous structure through three dimensions. The continuous structure of 3DOM materials also enables the creation of monolithic pieces for mechanical studies and the infiltration of the pores with other materials to create composite materials. These properties make 3DOM materials suitable choices for studying the role of the interface in nanocomposite deformation due to their regular structures and extensive interfacial area available within the pores. A metal-ceramic composite material of 3DOM W and SiC, through heat treatment, could form a unique interface containing W5Si3 and WC that may affect the hardness, toughness, and strength of the larger system. Phase determination and morphology study can be accomplished through XRD, SEM, and TEM analysis. XRD analysis of the results of early experiments shows a very high WC content in the composite material, with smaller amounts of W and SiC.

87. **Raquel Reilly**
Utilizing fluorination and small molecule tethering to understand the stability and structure of the KIX domain
Advisor: William Pomerantz
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Fairfield University
Abstract: The KIX domain of the coactivator CBP/p300 is involved in the regulation of hundreds of genes, some of which have applications in memory formation, hematopoiesis and the inflammatory response. Despite its wide array of applications, only one crystal structure of the KIX domain has been reported. In previous work, tethering small molecules has proved to be an effective method for stabilizing the KIX domain to obtain a crystal structure. Incorporating fluorinated amino acids also stabilizes the protein, but little information is known as to why this occurs. The focus of this project is to tether a small molecule to a mutated cysteine, and incorporate fluorinated tyrosines into the KIX domain. Herein, we plan to crystallize the fluorinated KIX domain tethered to the small molecule to compare the stability and structure of the protein to the wild type KIX domain. Additionally, in future work, we plan to co-crystallize the molecule tethered to the protein with other reported small molecules to potentially identify a new ligand binding site. Our study will ultimately allow for a greater understanding of the structure and stability of the KIX domain.

88. **Roberto Reyes Sáez**
Alternative substrates for hybrid MBE grown BaSnO_3 to achieve record-high electron mobilities
Advisor: Bharat Jalan
Sponsoring Program: MRSEC
Home Institution: Univesrity of Puerto Rico at Humacao
Abstract: mobilities
Complex oxides with perovskite structure display very interesting properties like superconductivity, magnetism, and metal-to-insulator transition behavior. Scientists have been studying these materials in more detail and recently have drawn their attention to BaSnO_3 as a potential transparent conductor because of its wide band gap and high electron mobility at room temperature. Recent papers have reported mobilities up to 〖150 cm〗^2 V^(-1) S^(-1) on PrScO_3, a perovskite substrate, using hybrid molecular beam epitaxy approach. The hybrid MBE technique has produced pristine BaSnO_3 films and other complex oxides with nearly ideal surfaces, supported with structural characterization techniques. Although it has been demonstrated that MBE is an excellent deposition technique, dislocation defects have also been reported. Imperfection of the film growth due to lattice mismatch between thin films and the substrates introduce dislocation defects degrading the electronic properties of materials. We explored the possibility of using alternative substrates as an approach of increasing the critical thickness (h_c), minimizing dislocations throughout the films, and enhancing electronic properties on epitaxial films. Using Matthews-Blakeslee equation for critical thickness with MgAl_2 O_4 Spinel (001) and Gd_3 Ga_5 O_12 Garnet (001), we have shown high theoretical critical thickness of BaSnO_3 films grown on these substrates. Also, we report thermal stability of substrates at typical MBE conditions by annealing samples in a furnace at 900°C under oxygen atmosphere.

89. **Benjamin Rorem**
Electronic Conduction Through Free-Standing Nanocrystalline Films
Advisor: James Kakalios
Sponsoring Program: Physics REU
Home Institution: Gustavus Adolphus College
Abstract: The dark conductivity of free-standing thin films of nanocrystalline silicon (nc-Si), as well as nanocrystalline zinc oxide (nc-ZnO), were measured as a function of temperature and exposure to atmosphere. Previous studies of nc-Si films with nanocrystal (NC) diameters of 12 nm and 5 nm found that the conductivity decreased as a function of air exposure time, with a time dependence related to the NC diameter. A third sample was measured, and the stretched exponential time dependence was compared to the previous studies. Zabrodskii Reduced Activation Energy analysis was consistent with Arrhenius behavior. The nc-ZnO samples, unlike nc-Si, were encapsulated so they did not undergo changes with air exposure. Resistances of six nc-ZnO samples were tuned using intense pulsed light (IPL) and atomic layer deposition (ALD) of Al2O3. In contrast to prior studies of nc-ZnO films which found a T^1/2 temperature dependence, the conduction for four of the six samples exhibited a Mott-Variable Range Hopping (VRH) temperature dependence, while two supported Efros-Shklovskii.

90. **Owen Roszkowski**
Virtual Seafaring: Data-Driven Virtual Atoll Reconstruction and Storytelling for Cultural Heritage
Advisor: Daniel Keefe
Sponsoring Program: Computer Science
Home Institution: University of Minnesota-Twin Cities
Abstract: This project aims to synthesize aspects of computer science and humanities for Micronesian cultural heritage. We are making a virtual recreation of some Micronesian islands and a navigation system true to the culture's seafaring traditions. It will be a virtual reality experience driven by real-world data to create as realistic an environment as possible, and with a storyline and narration to educate about the culture and society. This will allow us to teach traditional seafaring techniques to users which can be physically performed in VR. The main problem we focused on is how we could combine the 'hard' science of data-driven world simulation with the human touch required to educate about a culture in a respectful and truthful manner. We have succeeded in making a framework with basic movement, realistic terrain, and realistic sky elements in Unity. In the future, we hope to make all currently-implemented aspects even more realistic and believable and incorporate more historical and cultural information about Micronesian society.

91. **Mikayla Roth**
Cold Sintering of Semi-crystalline Yttrium Aluminate Powders
Advisor: David Poerschke
Sponsoring Program: UROP
Home Institution: University of Minnesota
Abstract: Typical sintering methods for ceramic materials require high pressures and temperatures. Cold sintering is an alternative method that generally uses temperatures up to 200 °C. The cold sintering method in this study was performed on three synthesized powders of different composition. The synthesized powders included pure alumina (Al2O3), 43.75 mol% Y2O3-Al2O3 (in the two-phase garnet and perovskite field) and 37.5 mol% Y2O3-Al2O3 (yttrium aluminum garnet). The powders were synthesized using a reverse co-precipitation process. Each powder composition was separated into three samples, with each composition having a sample treated at 600 °C, 800 °C, and 1100 °C to obtain different crystallinities. Following these heat treatments, the powders were cold sintered at 180 °C with 100 MPa applied pressure using water as the transport media. The powders and subsequent pellets were analyzed with x-ray diffraction. The 600 °C powder samples all appeared amorphous, and the 800 °C powder samples had small, broad peaks indicating semi-crystallinity. The 1100 °C samples showed distinct crystallinity with tall, narrow peaks. The pellet crystallinity agreed with these results, having no apparent difference. The pellet densities were measured using the Archimedes method and compared to theoretical densities to examine the overall densification. The ratios of the experimental density and the theoretical densities for the 600 °C pellets were found to all be approximately 0.36, indicating very similar densification.

92. **Meena Sae Chao,**
Method development for a Prunus beta glucosidase enzyme assay
Advisor: Jerry Cohen
Sponsoring Program: Project SEED
Home Institution: Washington Technology Magnet School, St Paul Public Schools
Abstract: Beta glucosidase enzyme are responsible for the hydrolysis of compounds that are linked to β-glucosides. Arbutin is a hydroquinone with a glucose attached. In this experiment, we're detecting bounded volatile in Arbutin that are freed by using enzymatic hydrolysis assay and the job of the conjugates. For this hydrolysis assay, we developed a method for making a buffer for the powdered enzyme then we transferred it in new test tubes containing arbutin, β-glucosidase, Potassium Phosphate buffer and with a disk which allows it to absorb the released volatiles during the reaction in the water bath. The disk were then absorbed by the buffer to run it through the LCMS, the chromatogram showed no peaks of Hydroquinone suggesting β-glucosidase is not cleaving Arbutin or the disk was contaminated. This can help us design different project in the future such as using concentration of enzyme or Arbutin.

93. **Itzel Salgado**
Electronic Noise Reduction in Power Regenerative Hydrostatic Wind Turbine Testbed
Advisor: Kim Stelson
Sponsoring Program: CCEFP
Home Institution: San Diego State University
Abstract: Currently, on the Power regenerative hydrostatic Wind Turbine testbed, there are about 28 sensors to measure the performance of the system. Due to the large number of sensors on the testbed, as well as the high frequency signals from the environment, there is a noise appearing in the signal received from the system. These signals are not reliable and hard to estimate the actual value; therefore, it was essential to find different techniques to reduce the amount of noise and increasing the signal strength. A new wiring schematic was designed to eliminate existing ground loops and twisted pair wires were used to eliminate crosstalk. All electronics were enclosed in a box to make it more accessible and less prone to picking up higher frequencies from the environment. To also prevent aliasing occurring due to high frequencies in signals, second order Butterworth low pass active filters were implemented to the signals before the analog to digital conversion. With the elimination of high frequency noise and crosstalk between signals, the noise to signal ratio decreased and made the data more reliable.

94. **Laura Salo**
Probing Stellar Populations and Galaxy Cluster Dark Matter Using Microlensing Events
Advisor: Patrick Kelly
Sponsoring Program: Physics REU
Home Institution: Hillsdale College
Abstract: When a distant star behind a galaxy cluster becomes temporarily aligned with a stellar-mass object near the critical curve in the galaxy cluster, the distant star appears extremely magnified. Such events, known as microlensing events, can reach extreme magnifications near the cluster caustic. The most distant star yet seen was discovered as a microlensing event using the Hubble Space Telescope in 2016. Following this observation, it has become desirable to know how many of these super-magnified stars, achieving magnifications up to many thousands, our current and future telescopes are capable of detecting. We wrote a computer program that uses a Monte-Carlo simulation and takes into account the mass-density of stars in the foreground galaxy cluster and the magnifications at those distances from the cluster center. The user is allowed to specify which filter to simulate on either the Hubble Space Telescope (HST) or the James Webb Space Telescope (JWST), and which of six galaxy clusters to use as a lens, along with the minimum flux detection and the number of epochs. We find that the number of super-magnified stars seen is sensitive to the initial mass function (IMF), and could be used to constrain the average slope of the IMF at higher redshift. The frequency and intensity of microlensing peaks also depends on the abundance of primordial black holes, since these would act as microlenses. Thus, constraints can also be placed on the nature of galaxy cluster dark matter.

95. **Pablo Samaniego**
Indirect potentiometric determination of polyquaternium polymer concentrations by titration with an anionic surfactant (1-dodecyl sulfate)
Advisor: Philippe Buhlmann
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota
Abstract: Polyquaternium polymers are positively charged molecules commonly used in the personal care industry. Due to their prevalent usage, particularly in shampoos and hair conditioners, these polycationic polymers are now present in sensitive aquatic ecosystems. For that reason, the development of an analytical method for the determination of their concentrations is important. Therefore, in this study we propose an indirect potentiometric detection technique based on the titration of polycationic polymers with 1-dodecyl sulfate, an anionic surfactant. Binding interactions of 1-dodecyl sulfate with the polyquaternium polymers were characterized using poly(vinyl chloride) ion-exchanger membranes for 1-dodecyl sulfate. With the knowledge of those binding constants, additions of 1-dodecyl sulfate to solutions containing polyquaternium polymers were monitored using ion-exchanger electrodes, which allowed for the determination of the polyquaternium polymer concentration. This technique can be extended for the detection of other polyquaternium polymer species.

96. **David Sanchez**
Double Network Ion Gels
Advisor: Tim Lodge
Sponsoring Program: MRSEC
Home Institution: University of Texas Rio Grande Valley
Abstract: Ionic liquids serve as nonvolatile solvents that display high thermal stability and ionic conductivity. They have applications as actuators, separation membranes, polymer gel electrolytes, fuel cell membranes, and ion battery components. Solidifying the ionic liquid, while maintaining transport properties, is essential for particular technological applications. This can be achieved through the incorporation of a polymer network in ionic liquid through chemical or physical crosslinking. One of the ways to form a physically crosslinked network is by gelation of triblock copolymers in the ionic liquid of interest that results in soft and flexible ion gel. On the other hand, a brittle ion gel can be formed through in situ polymerization of monomers in ionic liquids with a compatible crosslinker that yields a chemically crosslinked network. We aim to incorporate both of these aforementioned networks; a heavily crosslinked, brittle, polymer network with high yield strength and a highly elastic triblock copolymer network. The combination could potentially result in a double network ion gel with high toughness while retaining desirable ionic transport properties. Ionic liquid, 1-ethyl-3-methyl imidazolium bis(trifluoromethane sulfonyl)imide (EMI TFSI), will be used as a solvent for the double network. Methyl methacrylate will be polymerized through free radical polymerization to create poly(methyl methacrylate) (PMMA) crosslinked with ethylene glycol dimethylacrylate (EGDMA), resulting in the chemically crosslinked network. The second network will comprise of polystyrene-poly(ethyl acrylate)-polystyrene copolymer (SEAS).

97. **Jonathan Schillinger**
Ring Opening Metathesis Polymerization and the Use of Pyridine to Remove Excess Ruthenium
Advisor: Marc Hillmyer
Sponsoring Program: UMN Chemistry- Lando
Home Institution: East Stroudsburg University
Abstract: Ring opening metathesis polymerization (ROMP) using substituted cis-cyclooctenes in the presence of a chain transfer agent (CTA) can produce functionalized polyalkenamers for a variety of applications. The synthesis of 3-ethyl-cyclooctene was scaled up to a combined yield of 206 g. This monomer was then used to create low molecular weight polymers with relatively low polydispersity indices (M¬n: 5.2 kDa, Đ: 1.3). The molecular weight and dispersity information were obtained by end-group analysis of 1H-NMR spectra and THF-SEC data from a MALS detector respectively. Additionally, varying concentrations of pyridine were evaluated post-polymerization to remove the excess ruthenium catalyst without requiring multiple precipitations. Using 100 or greater molar equivalents of pyridine to catalyst proved visually effective in removing excess ruthenium from the polymer.

98. **Andrew Schmitz**
Characterization and Colocalization of a Quinine-Based Polymeric Gene Delivery Vector.
Advisor: Theresa Reineke
Sponsoring Program: Independant Research
Home Institution: Univeristy of Minnesota
Abstract: Genome engineering technology has been rapidly improving in recent history. With new innovations like CRISPR/Cas9, clinical human gene therapy is becoming increasingly attainable. A significant barrier to gene therapy often lies in the delivery of macromolecules, like DNA, to the cell nucleus in a process known as transfection. Cationic polymers have been used as non-viral alternatives for this process, as they promote delivery by binding DNA to form polyplexes which are taken into a cell through endocytosis. Prior work on this project included the development of a polymer-based delivery vector that was synthesized by the free radical copolymerization of naturally-derived quinine with 2-hydroxyethyl acrylate (HEA), which demonstrated exceptionally high transfection efficiency and cell viability compared to commercial standards. The polymer was analyzed by thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC). Thermal analysis showed that increasing the amount of quinine incorporation within the polymer yielded a corresponding increase in the polymer's glass transition temperature (Tg). The size and zeta potential of the polymer-DNA complex was probed with dynamic light scattering (DLS). Furthermore, 3D colocalization image analysis was performed to probe the polyplex's ability to escape entrapment by degradative acidic vesicles (endosomes or lysosomes) within the cell. Polyplexes were formed with a Cy5-labelled GFP plasmid, and the polyplexes were introduced to HEK-293T cells (human embryonic kidney cells) that were stained with Lysotracker Red to show acidic vesicles. The cells were imaged via using multichannel widefield fluorescence microscopy at multiple time points. Upon deconvolution, colocalization of plasmid DNA and Lysotracker-positive regions was determined using systematic pixel analysis, which demonstrated that the quinine copolymer could achieve levels of endosomal escape similar to a commercially-available polymer-based gene delivery agent. Future work will utilize other spectroscopic methods to verify this finding.

99. **Governess Simpson,** Ariadne Sinnis-Bourozikas, Megan Zhao, Sahar Aseeri
A Virtual Reality Investigation of the Impact of Wallpaper Pattern Size on Qualitative Spaciousness Judgments and Action-based Measures of Room Size Perception
Advisor: Victoria Interrante
Sponsoring Program: Computer Science
Home Institution: University of Minnesota - Twin Cities
Abstract: Visual design elements influence the spaciousness of a room. Although wallpaper and stencil patterns are widely used in interior design, there is a lack of research on how these surface treatments affect people's perception of the space. We examined whether the dominant scale of a wallpaper pattern (i) impacts subjective spaciousness judgments, or (ii) alters action-based measures of a room's size. We found that both were true: participants reported lower subjective ratings of spaciousness in rooms covered with bolder (larger scale) texture patterns, and they also judged these rooms to be smaller than equivalently-sized rooms covered with finer-scaled patterns in action-based estimates of their ego- centric distance from the opposing wall of the room. This research reinforces the utility of VR as a supporting technology for architecture and design, as the information we gathered from these experiments can help designers and consumers make better informed decisions about interior surface treatments.

100. **Rohan Sinha**
Hypergraph Based Model for Task Group Evolution
Advisor: Jaideep Srivastava
Sponsoring Program: UMN Computer Science REU for Computational Methods for Discovery Driven by Big Data
Home Institution: University of Arizona
Abstract: Task groups, defined as a small group of people driven by some professional or personal purpose to complete a task, are of growing interest to researchers and sociologists, with respect to applications to maximize efficiency and performance of the groups. To test the relationship between a task group's stability and productivity, along with other experiments, we used the DBLP publication dataset. The DBLP dataset has computer science publication data for over 40 years. This data was used to construct a temporal hypergraph, where hyperedges represent publication groups, and vertices represent individual authors of those groups. Using metrics of hyperedges (such as group variability and attention span) as a measure of distraction, and how frequently the group published a paper as a measure of productivity, a model was built to predict the future formation of task groups. More specifically, to predict whether a task group would reoccur, gain members exclusively, and loose members exclusively.

101. **Andrew Smith**
Solid-State Studies of Derivatives Formed by Reaction of Nitrogenous Bases with Aldoses: The Crystal Structure of the 2-Fluorophenylhydrazone of D-Mannose
Advisor: William Ojala
Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: We are chemically combining aldoses with nitrogenous bases to determine by single-crystal X-ray diffraction whether the derivatives formed are either open-chain Schiff bases or cyclic glycosylamines. Previous work in our laboratory has shown that D-mannose tends to yield glycosylamines upon reaction with substituted anilines but Schiff bases upon reaction with substituted phenylhydrazines, which differ from the anilines by only a single N-H moiety; we are now extending this investigation to other aldoses. Concurrently we are using these carbohydrate derivatives as a context in which to investigate the possible role of close intermolecular fluorine…hydrogen interactions in defining their crystal structures. Our previous work has shown that the 3-fluorophenylmannopyranosylamine and the 4-fluorophenylmannopyranosylamine are isomorphous (exhibiting the same solid-state molecular packing arrangement) while the 2-fluorophenylmannopyranosylamine assumes a different molecular packing arrangement, one isomorphous with the non-halogenated N-phenylmannopyranosylamine. A characteristic fluorine…hydrogen interaction is conserved in the isomorphous 3-fluoro and 4-fluoro compounds. To examine such interactions further, we have now synthesized and determined the crystal structure of the 2-fluorophenylhydrazone of D-mannose. In this Schiff base structure the fluorine atom interacts with neighboring C-H groups but not with neighboring O-H groups. Future work will include determination of the crystal structures of the 3-fluoro and 4-fluoro analogues.

102. **Michael Stodolka**
Solid-State Studies of Halogenated Benzonitrile Oxides and their Dimers: The Crystal Structure of bis(2-fluorophenyl)Furoxan
Advisor: William Ojala
Sponsoring Program: University of St Thomas- Chemistry
Home Institution: University of St. Thomas
Abstract: Benzonitrile oxides (Ar-C≡N+-O-, where Ar = aryl) are known to dimerize in solution, the identity of the dimer (furoxan or 1,2,5-oxadiazole-N-oxide vs. dioxadiazine vs. 1,2,4-oxadiazole-N-oxide) being dependent on the reaction conditions. The goal of this project is to use single-crystal X-ray diffraction to elucidate the course of solid-state dimerization and to determine to what extent the identity of the solid-state dimerization product depends on the molecular packing arrangement of the parent benzonitrile oxide. Our recent work has focused on the furoxan dimer. In previous work we found the crystal structures of bis(3-chlorophenyl)furoxan and bis(3-bromophenyl)furoxan to be isomorphous (having the same solid-state molecular packing arrangement), but we found the bis(4-chlorophenyl)furoxan and bis(4-bromophenyl)furoxan not to be isomorphous. We have now determined the crystal structure of the bis(2-fluorophenyl)furoxan. This structure is not isomorphous with its chlorinated analog, nor is it isomorphous with either the bis(4-fluorophenyl)furoxan or the diphenylfuroxan, structures previously reported by other workers. Our future studies will focus on obtaining crystal structures for other similarly halogenated furoxans, and in particular that of the bis(3-fluorophenyl)furoxan, to investigate potential intermolecular interactions such as halogen…halogen close contacts and halogen…hydrogen close contacts (especially any close F…H contacts) that define the crystal structures of these compounds.

103. **John Sunderland**
Flame Synthesis of Lanthanum-Doped Barium Stannate (La:BaSnO3)
Advisor: Chris Hogan
Sponsoring Program: MRSEC
Home Institution: Creighton University
Abstract: Perovskite oxides, cubic structured crystals of the formula ABO3, are a general area of research interest due their wide variety of potential applications, including semiconductor materials and catalysts. Barium stannate (BaSnO3) has a perovskite oxide structure, and it exhibits interesting electronic characteristics, such as n-type conductivity and higher carrier concentrations, when it is doped with lanthanum at the A-site. Lanthanum-doped barium stannate (La:BaSnO3) films are synthesized using a novel and scalable flame synthesis method. Nanoparticles are created via pyrolysis in a flame from a precursor solution of 2-ethylhexanoic acid, tin (II) 2-ethylhexanoate, barium acetate, and lanthanum hydroxide. The synthesized products are impacted onto alumina substrates at supersonic speeds to grow the films. The films are then annealed in a furnace at 1100 degrees Celsius. X-ray diffraction (XRD) is used to structurally characterize the samples. Using XRD, it was found that all samples exhibited near identical structure to barium stannate, which indicates successful doping. However, scanning electron microscopy (SEM) images show an abundance of cracks in the films, which inhibits their potential use as a semiconductor. Possible solutions to this problem, such as physical compression and a substrate coating of a poly(methyl methacrylate) (PMMA) and acetone solution, are investigated.

104. **Aarya Suryavanshi**
Wheel Loader Energy Usage Optimization and Hardware-in-the-Loop Validation
Advisor: Zongxuan Sun
Sponsoring Program: CCEFP
Home Institution: University of Southern California
Abstract: The energy usage of wheel loader is to be optimized and validated using hardware-in-the-loop (HIL) technology. For this project, the lifting motion of a wheel loader was modeled both through analysis and through simulation. These models were integrated into a complete wheel loader model, which included the working and driving circuits, which will be connected to a physical engine. This hardware-in-the-loop technology can then be used to evaluate the performance of a wheel loaders in an efficient, safe, and economical fashion.

105. **Avery Swank**
Enhancing Education of Seafaring Navigation Techniques Using Virtual Reality
Advisor: Daniel Keefe
Sponsoring Program: Computer Science
Home Institution: University of Minnesota - Twin Cities
Abstract: The purpose of this research is to enhance the educational experience of seafaring navigation techniques. It will show users firsthand the different types of navigation methods used by Pacific Islanders many centuries ago. Virtual reality gives users a level of exposure to these skills that is unparalleled to learning it through any other system. Data has proven that virtual reality is the best medium to teach educational concepts because digitally recreated experiences is the most long lasting education technique.

106. **Bengt Symstad**
Calcium Zirconium Phosphates as High Temperature Environmental Barrier Coatings for Silicon Carbide
Advisor: David Poerschke
Sponsoring Program: UROP
Home Institution: University of Minnesota
Abstract: Jet engines run more efficiently as their operating temperature is increased. Currently, engines' maximum operating temperature is limited by the melting temperature of the nickel alloys that make up the structural components of the engines (approximately 1300°C). One material suggested as a replacement is silicon carbide, which has a melting temperature of 2700°C. However, it requires coatings, called environmental barrier coatings (EBCs), to protect it from the harsh combustion reactions in the engine. Unfortunately, silicon carbide has a lower thermal expansion than current common EBCs, meaning the EBCs flake off when the system is at high temperatures. Theoretically, a composite of a common EBC and some material with a lower thermal expansion than silicon carbide could be tailored to have thermal expansion that matches silicon carbide. This experiment tests the viability of four related low thermal expansion ceramics ($CaZr_4(PO_4)_6$, $CaHf_4(PO_4)_6$, $SrZr_4(PO_4)_6$, and $SrHf_4(PO_4)_6$) in this situation. The ceramics were synthesized through solid-state reactions. They were then categorized using x-ray diffraction. They were heated to 1300°C to assess whether they are thermally stable at jet engine operational temperatures. The compositions which are stable will be formed into a composite with an EBC (ZrO_2) and again heated to assess their thermal stability in the composite. If the composites are stable, then they theoretically may be tailored to the thermal expansion of silicon carbide, though that is currently beyond the scope of this experiment.

107. **Haley Tarbox**
Constructing Farnesylated Anti-EpCAM CSANs For Cancer Immunotherapy
Advisor: Mark Distefano
Sponsoring Program: UMN Chemistry- Lando
Home Institution: Hofstra University
Abstract: Chemically Self-Assembling Nanorings (CSANs) can be functionalized with groups such as protein binding domains for cancer targeting or peptide sequences with the potential to be farnesylated. Farnesylation is a post-translational protein modification where a farnesyl is added to the cysteine of a C-terminal CaaX box motif, such as CVIA. Farnesylation, by adding a hydrophobic isoprenoid, encourages association with cell membranes, enabling the farnesylated CSANs to modify T cells' surface for cancer immunotherapy. We have designed two constructs for CSAN formation, both of which target Epithelial Cell Adhesion Molecule (EpCAM), which is overexpressed on the cell surface of several cancers. One construct consists of a fibronectin-based EpCAM targeting domain fused to DHFR2 and has a terminal CVIA sequence for farnesylation. The other construct utilizes the promiscuity of PFTase to introduce an azido-farnesyl analog to a prenylatable EpCAM-binding DARPin protein. Through a DBCO-PEG5-DBCO linker, the EpCAM-binding DARPin protein can be linked to the general CSAN construct, offering an alternative way to construct cancer-targeting CSANs without the need for new fusion proteins. Both constructs could be used for CSAN formation and subsequent anti-cancer applications.

108. **John Thomalla**
Soft Hydraulic Burrowing Robot
Advisor: Jim Van de Ven
Sponsoring Program: CCEFP
Home Institution: Saint Cloud State University
Abstract: Underground utility installation often requires expensive, large equipment which is usually inaccurate and is destructive to the soil surface. The proposed solution utilizes a high force, soft hydraulic burrowing robot; specifically a system of McKibben actuators comprising of extension, excavation, and traction segments. With stability in pressures as high as 2000 psi, the burrowing system will create a worm like locomotion through soft soils, creating an innovative, cost efficient, and environmentally friendly method of soil excavation. Beyond utility installation, the impact of the research may extend to help innovate fields involving mine and IED detonation, searching for fossil fuels, anchoring of offshore rigs, and pipe inspection.

109. **Celina Tragesser**
Vintage Balanced Variable Vane Pump
Advisor: Kim Stelson
Sponsoring Program: CCEFP
Home Institution: University of Minnesota
Abstract: Vane pumps are one of the most attractive pumps in the hydraulic industry, due to their efficiency and low-noise characteristics. There are three types of vane pumps used in industry today, but none compare with the ideal overall performance and efficiency of a fourth type: a balanced variable vane pump. This summer we are testing a rare Vicker's Variable Balanced Vane Pump, which was discontinued a few decades ago, with the goal of evaluating performance characteristics in comparison to the types used in industry today.

110. **Jose Valdez**
Synthesis of Charged Membranes using Polymer-Induced Microphase Separation for Water Purification
Advisor: Marc Hillmyer
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: Univestity of Minnesota Twin Cities
Abstract: Charge mosaic membranes are materials with positively and negatively charged domains used for piezodialysis, a method of water desalination whereby ions permeate through a membrane instead of water. Current charge mosaic membranes lack charged domains on the nanometer scale and full membrane penetration of the domains required to be effective. Block polymers which are capable of self-assembling on the nanoscale provide an ideal avenue to achieve efficient membranes. In this work, the method of Polymerization-Induced Microphase Separation (PIMS) was used to synthesize tricontinuous polymers with separate self-assembled charged domains with full membrane penetration. The tricontinuous material was synthesized from pre-anionic and pre-cataionic homopolymer components, Poly(n-propyl styrene sulfonate ester) and Poly(vinylbenzyl chloride), and a divinylbenzene cross-linked matrix. The separate pre-anaionic and pre-cataionic domains were functionalized via exposure to trimethylamine to deprotect the sulfonate ester to the sulfate and convert the benzyl chloride to a benzyl ammonium via an SN2 reaction. Tricontinuous polymers membranes with separate charged domains were successfully synthesized and functionalized as confirmed by IR and small angle x-ray scattering (SAXS).

111. **Alexis Valencia**
The Stochastic Background due to a Binary Black Hole - Neutron Star System
Advisor: Vuk Mandic
Sponsoring Program: UROP
Home Institution: School of Physics and Astronomy
Abstract: In 2015, the LIGO and VIRGO detectors observed gravitational waves from a collision of two black holes. These waves not only proved that direct detection of gravitational waves was possible but they also showcased the opportunity to observe the universe in a completely new way. For every individually identified source of gravitational waves there are a great number of other unidentified sources that are too small to be isolated and detected. They still contribute an amount of signal which ultimately add up to form a stochastic (random) background of gravitational waves. Previous studies of this background have been performed on binary systems of two black holes or two neutron stars. This study will extend the past work by developing a new model of the stochastic background due to binary systems composed of one black hole and one neutron star.

112. **Kristen Vogt**
Bio-production of isoprene using engineered E. coli
Advisor: Kechun Zhang
Sponsoring Program: Center for Sustainable Polymers
Home Institution: The College of New Jersey
Abstract: With growing concern regarding the depletion of fossil fuels, it has become increasingly important to design syntheses that are both sustainable and renewable. Recent advances in synthetic biology and metabolic engineering techniques have enabled the biosynthesis of non-natural metabolites in genetically engineered *Escherichia coli* (*E. coli*). One application of these strategies is the biosynthesis of citramalate, a chemical precursor to isoprene. The biosynthesis of isoprene using fermentation offers a more green and cost-effective alternative to harsher methods used in chemical processes. In this work we examine citramalate production in both wild type and knockout (Δ*leuC* and Δ*leuD* coding for 2-methylmalate hydrolyase) *E. coli* strains expressing the citramalate synthase (*CimA*) enzyme. *CimA* works to redirect natural metabolism by combining pyruvate with acetyl-CoA to catalyze the synthesis of citramalate. Wild type and knockout *E. coli* strains accumulated approximately 8.5 g/L and 13.4 g/L of citramalate respectively during 48 hours of fermentation. This resulted in over 52% and 82% of the theoretical maximum yield respectively from glucose as the sole carbon source. The ~1.6 fold increase in citramalate production affirms the ability of Δ*leuC* and Δ*leuD* knockout strains to drive metabolic flux forward by decreasing feedback inhibition from L-isoleucine production thereby increasing product yield.

113. **Alan Wang**
Predicting Body Position Using a Smart Insole and Machine Learning
Advisor: Zhi Yang
Sponsoring Program: Biomedical Engineering
Home Institution: University of Minnesota
Abstract: A great deal of research has been done involving wearable sensors and machine learning. However, the majority of this research has focused on detecting and categorizing the action the wearer is performing, whether it be recognizing abnormal gait or differentiating between walking and running. Inferring the exact joint positions instead of simply categorizing the movement can have wider applications in medicine and entertainment. For instance, gait analysis is often done in a dedicated lab with multiple cameras or other sensors to record joint movement and forces. For situations where such a complicated data collection setup is not practical, using wearable sensors and inferring the joint movement could be a solution. We have developed a system which uses wearable sensors to determine the joint positions of the wearer represented as points in space. This system uses the FreeWalker smart insole, an unobtrusive, wireless insole which only requires a nearby computer to record and process the acquired data. We apply deep learning algorithms to the insole data in order to generate the wearer's joint positions. Data gathered from the smart insole includes pressure from eight different points on each foot as well as acceleration and orientation. A ground truth was established using Microsoft's Kinect sensor, which uses multiple cameras and infrared light to determine the positions of a human body's joints. A deep learning model incorporating convolutional layers and long-short-term memory (LSTM) was trained and tested using the data gathered from these sources.

114. **Kathleen Wang**
Empirical and computational studies drive understanding of the mechanism of silane-mediated reductions of phosphine oxides
Advisor: Courtney Aldrich
Sponsoring Program: UMN Chemistry- Heisig Gleysteen
Home Institution: University of Minnesota
Abstract: Phosphorus(III) compounds are widely used in organic chemistry as catalysts to promote a wide range of reactions. Frequently, these reactions rely on the strength of the phosphorus-oxygen to drive the reaction to completion, resulting in the generation of stoichiometric amounts of phosphorus(V) oxides which frequently complicate purification of desired products. Current work in this field has focused on the in-situ regeneration of the active phosphorus(III) catalyst with reported by employing silanes as a chemoselective reductant. Recently, we disclosed the discovery of a novel silane reducing agent, 1,3-diphenyldisiloxane (DPDS), which presents unparalleled chemoselectivity with mild conditions, placing it at the forefront of green, industrially-desired phosphine oxide reductions. However, during our efforts to compare this novel reduction system with previously-reported silane-mediated reductions, we noted that the kinetic schemes governing these reductions did not correlate with the purported mechanism. Instead, we propose an alternative mechanism that proceeds through a lower-energy, 6-membered transition state, featuring a stabilizing hydrogen bond between the phosphine oxide and the reducing agent, in addition to the hydride transfer typical of these reactions. To further probe the mechanistic underpinnings of this reaction, empirical and computational experiments were conducted to identify key electronic and energetic effects. Herein we report kinetic and thermodynamic evidence that corroborates experimentally-observed trends and led to the proposal of a novel mechanism.

115. **Charity Wangari**
Study of Dynamic Pitching for Wind Turbine Blades
Advisor: Kim Stelson
Sponsoring Program: CCEFP
Home Institution: University of Minnesota
Abstract: Current pitch control techniques on wind turbine blades are based on the assumption of incoming steady wind, and are not applied for optimal energy extraction after cut-in and before rated wind speed are reached (zone 2 of the wind turbine operation). The main goal of this study is to use dynamic pitching in this region to extract optimum energy from the wind. Dynamic pitching in wind turbines deals with changing the angle of attack of the blades periodically to increase or decrease the loading on them. By using computational fluid dynamics, the DU96-W-180 airfoil was tested to evaluate how much of an impact dynamic pitching has on the aerodynamic characteristics of the airfoil (lift, drag and moment). These tests included both steady and unsteady wind conditions, in addition to steady-state and dynamic pitching simulations. Preliminary results show that there is a significant change in the aerodynamic characteristics especially with the lift coefficient which shows a 50% improvement when compared to steady-state pitching. Therefore, the results present a need to address this problem to increase the efficiency of wind turbines using dynamic pitching.

116. **Alex White**
Chemical Propulsion Methods of Platinum Janus Particles
Advisor: Xiang Cheng
Sponsoring Program: MRSEC
Home Institution: Columbia University
Abstract: Nano-scale colloidal particles become Janus particles when their surface is chemically asymmetric. The varied composition of Janus particles gives them interesting properties whose applications include microprobes, micromotors, electronic paper, and solid surfactants. Using metal evaporation, polystyrene and silica colloids have one hemisphere coated with platinum to form Janus particles. Upon being released into a solution of hydrogen peroxide, chemical propulsion of the particles is produced. By varying the sizes of monomer and dimer Janus particles, the mechanisms of chemical propulsion may be better understood.

117. **Leah Wofford**
End Group Effects on Aqueous Self Assembly of Diblock Copolymers
Advisor: Mahesh Mahanthappa
Sponsoring Program: MRSEC
Home Institution: New Mexico State University
Abstract: Amphiphilic molecules self-assemble in selective solvents such as water to yield a plethora of morphologies including discrete micelles packed on a lattice (I), hexagonally packed cylindrical micelles (H), bicontinuous networks (N), and lamella (L). The self-assembly is driven by the need to decrease unfavorable contacts between the hydrophobic and aqueous domains. During the summer of 2017 an REU student in our group discovered that aqueous dispersions of polyethylene-b-polyethylene oxide (PE-PEO) polymer form various discrete micellar morphologies including a Frank-Kasper σ phase which consists of 30 micelles of 5 different types in a tetragonal unit cell. This was the first report of the formation of the intermetallic σ phase in solutions of diblock polymers. We speculate that self-assembly of the polymer can be manipulated by varying the end groups of the polymer. We will replace the hydrophilic –OH end group with a less polar –OCH3 group, and an ionic –SO3Na group and thoroughly investigate its effects on the polymer phase behavior in water. We will map the concentration- and temperature-dependent phase diagram using differential scanning calorimetry (DSC), and small-angle X-ray scattering (SAXS). Correlating the phase behavior with the end-groups will furnish insights into controlling self-assembly of aqueous diblock polymer solutions via minute molecular modifications.

118. **Chittra Xiong**
Calibration Free Ion Selective Electrode Measuring Chloride in Solvents
Advisor: Philippe Buhlmann
Sponsoring Program: Project SEED
Home Institution: Como Park Senior High, St Paul Public Schools
Abstract: Ion Selective Electrodes (ISE) are sensors that measure the concentration of a specific ion in a sample. ISE's today require individual calibrations that takes time to process, to eliminate this routine we've made a hydrophilic redox buffer with: Agar powder, Co(II) and Co(III) and positioned it between the hydrophilic Anion Exchange Membrane and gold electrode. This makes the Ion Selective Electrode more reproducible therefore calibration free because the redox buffer prevents changes in the electrical potential, it defines the potential between the membrane and the metallic phase. An electrode body holds together the Anion Exchange Membrane, redox buffer, and gold electrode. A reference electrode is placed in the same solvent as the gold electrode to create a full circuit. Both of the electrodes are connected to a computer that calculates the electric potential of the selected ions. The computer displays a slope, which the points can be identified as values with the Nernstian equation. The calibration plot is expressed in terms of change in potential per decade of concentration change (mV/decade). A calibration free sensor with redox buffer will save time, money, and be stable in the long term

119. **Qeng Xiong**
Protein Prenylation: Farnesyl Diphosphate Analog and its Usage in Disease Research
Advisor: Mark Distefano
Sponsoring Program: Project SEED
Home Institution: Washington Technology Magnet School
Abstract: Protein prenylation is a post-translational process that attaches a 15 or 20 carbon isoprenoid moiety to a cystine at the C-terminus of a protein. Protein prenylation occurs in eukaryotes and is found in cell signaling pathways of CaaX proteins that regulate crucial cellular functions. One such example of a CaaX protein are Ras proteins, an overexpressed protein in some types of cancer. The isoprenoid moiety from farnesyl diphosphate (FPP) is enzymatically attached to a cysteine amino acid near the C-terminus of a protein by the enzyme protein farnesyltransferase (PFTase). In this research, we synthesized an FPP analog by protecting, oxidizing, and incouperating an alkyne functionality on farnesol. This FPP analog incouperated with a terminal alkyne is able to undergo a copper click reaction with fluorescent molecules, enabling for the targeted labeling of Ras proteins. By clicking green fluorescent proteins (GFP) onto the alkyne and then releasing it into a tissue sample, the protein will be able to seek out and attach to Ras proteins. This demonstrates how FPP can be used to identify Ras proteins in cancer cells.

120. **David Zegeye**
Probing Additional Gravitational Lensing Effects of Supernova iPTF16geu
Advisor: Liliya Williams
Sponsoring Program: Physics REU
Home Institution: Haverford College
Abstract: Gravitational lensing is an effect of General Relativity, where the gravitational potentials of massive objects are able to bend the light path of nearby sources, making the position of the observed source differ from where the source is actually located. If the potential is strong enough, the object can act as a lens when the source is in the project line-of-sight, and produce multiple images with a given magnification. However, there may be discrepancies in the predicted and observed magnifications of the images. This difference can be resolved when accounting for additional microlensing due to stars in the lensing galaxy. Supernova Type 1a, iPTF16geu, is a lensed source that still has a discrepancy between the predicted and observed magnifications of the system, even after accounting for microlensing due to stellar populations. We present a more detailed gravitational lensing model to account for the discrepancy observed in the magnifications of iPTF16geu. We find that our more realistic model is an improvement from simpler lensing models, but there still is a small discrepancy between predicted and observed magnifications. This suggests the possibility of ongoing millilensing caused by additional objects, such as dark matter substructures, in the lensing galaxies.

Teacher Poster Presentations
Listed Alphabetically by Presenting Author

121. **Jason Belter**
Green Chemistry in PLAin sight
Advisor: Jane Wissinger
Sponsoring Program: MRSEC
Home Institution: Nova Classical Academy
Abstract: Polylactic Acid (PLA) is a biodegradable, inexpensive, and readily available polymer. In collaboration with Boston College a lab activity was developed to highlight one possible use for this polymer: cleaning up oil spills. The experiment involves making thin films of PLA with different characteristics, immersing them in a simulated oil spill and measuring their ability to adsorb dodecane (our simulated oil). This work sought to investigate a number of different sources of PLA to provide extensions and modifications to the standard protocol and allow teachers to more easily customize the experiment to meet their curricular needs. Shelf stability of the PLA/solvent mixture was also tested, and methods for more precisely measuring small volumes of the viscous polymer were explored. The experiment highlights a number of principles of Green Chemistry and sustainability while also giving students hands on experience with polymer chemistry. Further topics such as plastics in our society and their effect on human health and the environment engage students in real-world problems to be solved.

122. **Cassandra Knutson**
Teaching Green: Engaging High School Chemistry Teachers in Sustainability
Advisor: Jane Wissinger
Sponsoring Program: MRSEC
Home Institution: White Bear Lake High School
Abstract: If tomorrow's chemists are today's students, then it is essential that they are given the tools and knowledge needed to create healthy and safe products and processes for humans and the environment. In an effort to share resources that empower educators and students to practice sustainability through green chemistry, we delivered a three day workshop to twenty high school chemistry teachers from Minnesota for the second consecutive summer. The workshop participants received instruction and resources on the pillars of sustainability and the principles of green chemistry while gaining hands-on experience with safer cost-effective labs that are drop-in replacements for traditional high school chemistry labs. In addition, participants explored two polymer-based experiments that focus on plastics and their connections to sustainability and relevance to society. Several modifications were made to this summer's workshop in response to the participant survey feedback received last summer. Survey feedback from this summer's workshop participants was extremely positive, and it was evident that the changes made were successful. Following the workshop, an experiment that explores the synthesis of bioplastics and the rates of their degradation was refined for publication for a high school audience to address the need for green chemistry curricula that align with standards and support inquiry-based learning.

123. **Michael Maudal**
Microfluidic Device Design for High School Implementation Using Shrinky-Dinks®, PDMS, and Cricut Maker
Advisor: Christy Haynes
Sponsoring Program: MRSEC
Home Institution: Cherry Creek High School
Abstract: Microfluidics is the study of the behaviors of fluid through micro-channels. Microfluidic devices utilize small volumes of fluids that flow through a device with channels of the micrometer scale designed to achieve specific results. There is a need to teach new innovative science practices related to microfluidics and challenge student to engage in engineering practices correlated with science. This experiment utilizes previous accepted ways to construct microfluidic devices using polydimethylsiloxane (PDMS) and redesigns these practices to provide high school teachers the ability to construct reliable, repeatable, reproducible, and cost effective microfluidic devices. This key finding in this experiment was that using a Cricut Maker to design and cut out channels in Shrinky-Dinks® film provided a higher success rate that could be implemented best in a high school classroom. Microfluidic devices can be used for a multitude of purposes and offers students opportunities to develop engineering skills, reduce chemical volumes in teaching labs, and explore a variety of chemistry topics, such as acid-base chemistry.

124. **Natalie Strauss**
Using Enzymes for Teaching Kinetics in High School Chemistry
Advisor: Ben Hackel
Sponsoring Program: MRSEC
Home Institution: Osseo Public Schools
Abstract: Kinetics is an engaging topic in the Minnesota High School Chemistry curriculum with many opportunities for lab work and demonstrations. It is sometimes difficult for students to see how the labs and demonstrations about kinetics might relate to their everyday lives. This lab work builds on work about enzyme specificity for a higher level chemistry class to look at how enzymes can be used to teach about kinetics in a general level high school chemistry classroom. Students use basic household materials and colorimetry to study how enzymes degrade substrates under varying conditions and relate this learning to real life enzymatic activity in the body and in products such as laundry detergent.

125. **Jennifer Kersten[1], Paul Good[2], Dan Johnson[3]**
Capillary-Assisted Printing of Conductors and Resistors
Advisor: Daniel Frisbie
Sponsoring Program: MRSEC
Home Institution: [1]Richfield High School, [2]St. Francis High School, [3]University of Minnesota
Abstract: The subject of electricity and basic circuits is a fundamental component of most high school physics courses. The electronics industry is constantly evolving, which provides the opportunity to make the content of a high-school-level physics course up-to-date and relevant. Printed electronics give students a glimpse into cutting-edge circuitry with a myriad of potential uses. By utilizing capillary flow to create these electronics, cost and complexity of manufacture would be kept to minimum. Research was done producing both conductors and resistors on flexible substrates. In the lab, work was done with both hand and inkjet printing, although it is anticipated that the use of hand printing is most reasonable for high school students in the classroom. Success was obtained in the production of conductors that were used in the lighting of mini holiday lights and resistors that were used in lighting LED bulbs, both components produced with a range of resistance values. After research in the printed electronics area, it is expected that printed circuits could be introduced into a physics curriculum to strengthen the connection between learning of basic circuits, with conductors and resistors, and current scientific research.