

13th Annual Northeast Ohio Undergraduate Research Symposium

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Case Western Reserve University (CWRU)
Kent State University (KSU)
NASA Glenn Research Center (NGRC)
The University of Akron (UA)

1. Effectiveness of Lignin/PVAm (Polyvinylamine) Coated Filter Paper in Removal of Pb²⁺ from Water

Morgan Bright^a, Dexter Heath^b, Alycia Lewis^b

^aWest Virginia State University, ^bCentral State University

Lead tainted water proves to have negative effects on the health of a community and its water infrastructure. The aim of this research is to examine the effectiveness that Kraft lignin and Polyvinylamine (PVAm) would have on removing traces of lead ions from water. Solutions with known concentrations of lead ions were prepared ranging from 1 ppm to 200 ppm. Several filter papers were coated with a mixture of deionized water, lignin, and/or Polyvinyl-amine. A fixed volume of 5 ppm lead solution was passed through all filter paper samples. Pb²⁺ concentration in the filtrates was measured using atomic absorption (AA) spectroscopy to determine the effectiveness of lignin and PVAm in removing Pb⁺. There was a detectable decrease in the concentration of all the filtrates tested, however, the data shows that the filter paper coated with both lignin and PVAm had the lowest concentrations at



4.6 ppm in comparison to filtrates that passed through the coated filter paper of lignin and PVAm individually which yielded results of 4.8 ppm. The results indicate that while lignin and PVAm adsorb lead individually, the PVAm enhances the adsorption properties of the lignin. After examining the effect of a tenfold increase in concentration of both lignin and PVAm on the filter paper, a drastic decrease in lead concentration was observed, with the lowest recorded concentration being 3.02 ppm.

Advisors: Dr. David Schiraldi; Case Western Reserve University. Dr. Suzanne Seleem; Central State University.

2. Development of a Selective and Rapid Approach to Directly Detect and Quantify Toxic Algal Microcystin in Bodies of Water

Andrew Congdon

Kent State University

Changing environmental conditions have allowed harmful algae blooms (HABs) consisting of cyanobacteria to flourish in the Great Lakes. Many of these cyanobacteria produce microcystins, a class of toxins, which accumulate in the water supply leading to serious ecological harm. Microcystins are a cyclic-heptapeptide endotoxin that is released upon cell lysis. Resistant to various common proteases, microcystin remains active over a wide range of temperatures and pH.

Current approaches for controlling HAB toxins rely on predictions of HAB growth patterns, so preventative measures can be taken before critical levels are reached. Early detection methods focus on acquiring large amounts of data quickly, but lack the specificity and sensitivity required for such a task. High performance liquid chromatography coupled with electrospray ionization mass spectrometry (HPLC-ESI-MS) is capable of detecting the very slight molecular differences between microcystin variants as well as quantify the amount of toxin present in water at very low concentrations; unfortunately, HPLC-ESI-MS requires extensive sample preparation.

Here, we propose the development of a rapid and inexpensive mass-spectrometry approach to differentiate and quantify toxin levels in large numbers of water samples from Lake Erie. This method uses an inexpensive paper substrate to concentrate bacteria, lyse the cells, and directly ionize cellular molecules for MS analysis. This paperspray ionization, as it is called, is a newer method of ionization that will allow for samples to be analyzed as they are collected, without the need for preparation. Such an approach would be faster than current technologies while still retaining the sensitivity of HPLC-ESI-MS.

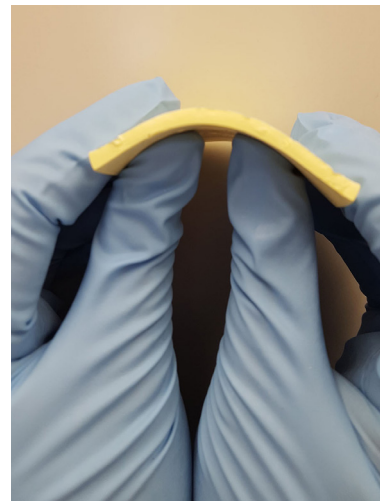
Primary Advisor: Dr. Jacob Shelley, Co-Advisor: Dr. Joseph Ortiz; Kent State University

3. Polyimide Aerogel Coatings for Carbon Nanotube Wires and Yarns

Jessica Cashman

Rochester Institute of Technology

Polyimide aerogels are desirable for many aerospace and commercial applications due to their high porosity, low density, low thermal conductivity, and their superior mechanical properties. Polyimide aerogels with increased flexibility would be ideal for coating carbon nanotube wires and yarns for use as the low dielectric layer for lightweight data cables. The flexibility of the aerogel can be increased depending on the polyimide oligomer backbone structures. In this research, 1, 3, 5 triaminophenoxybenzene (TAB) was used as cross-linker. The combination of aliphatic diamine, 1,12-diaminododecane (DADD), and aromatic diamine, 4,4'-oxydianiline (ODA), was used to form polyimide oligomers with a dianhydride that is either 3,3',4,4'-biphenyl tetracarboxylic dianhydride (BPDA) or pyromellitic dianhydride (PMDA). The aliphatic diamine, DADD, was varied from 25-100 mol %. The weight percent of the cross-linked polyimide was varied from 8-10 w/w%. The properties of the aerogel, including density, shrinkage, porosity, and contact angle are typically affected by the polyimide backbone structures. The aerogels in this study will also be characterized by thermal gravimetric analysis (TGA), FTIR, NMR, pycnometry, scanning electron microscope (SEM), and mechanical testing. Favorable formulations will be used to coat carbon nanotube wires. The figure demonstrates the flexibility of a 0.22cm thick aerogel with a formulation of 90 mol % DADD, 9 w/w %, and uses BPDA as the dianhydride.



Advisors: Dr. Mary Ann Meador, Stephanie Vivod, Dr. Haiquan Guo; NASA Glenn Research Center

4. Relationship Between Surface Energy and Filtration Performance of Gels and Aerogels

Safiya Best

Siena Heights University

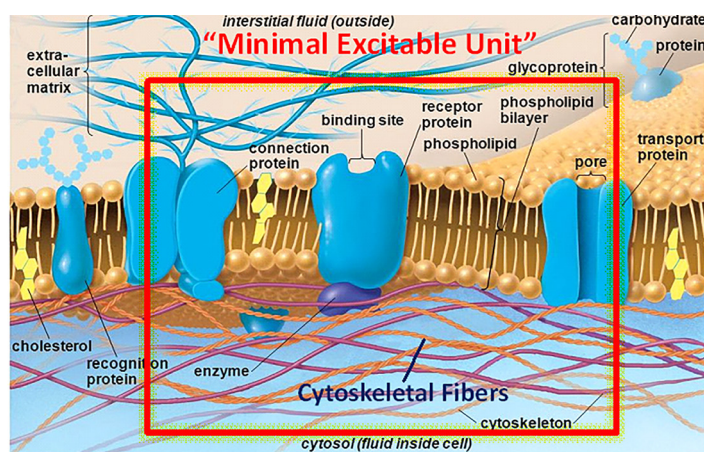
Aerogels are highly porous materials that have low density and low thermal conductivity. Currently, silica aerogels are used primarily for insulation purposes with some aerospace applications. Dr. Jana's group is looking at polymeric aerogels (and gels) for other potential applications such as nanofiltration of air particles and diesel and water filtration, the latter being the focus of this study. This study looks at polymer-solvent interactions that affect the morphology of the aerogel (gel) in two ways: (1) pore size distribution and (2) structure at the polymer surface. It is anticipated that these two effects will influence the filtration performance parameters of both flux and filtration efficiency. This study looks at the effects of (1) materials, (2) solvent, and (3) concentration on the above-mentioned filtration performance parameters. Aerogels will be formulated from three different methods, namely: (1) thermoreversible gelation (syndiotactic polystyrene), (2) one-step synthesis (polyurea) and (3) two-step/prepolymer synthesis (polyimide). Characterization techniques include contact angle measurements, skeletal and bulk density measurements, and filtration performance characteristics.

Advisors: Dr. Sadhan Jana, Nicholas Teo; The University of Akron

5. On the Possible Role of Intracellular Fibers in the Mechanism of Nerve Signal Transmission and Anesthetic Action

Evan Chou and Noah Geller
Cornell University, University of Pennsylvania

While many studies have focused on the lipid membrane, cytoskeletal fibers have been recently suspected to play a role in nerve signal transmission. One proposal by Dr. Wnek is that the mechanism of nerve signal transmission is governed by ion-induced swelling that propagates with a soliton-like signal along the polyanionic cytoskeletal fibers. The goal of this project is to study how poly(acrylic acid), a system analogous to cytoskeletal fibers, behaves in the presence of local anesthetic compounds. A poly(acrylic acid) brush system was synthesized by performing surface initiated atom transfer radical polymerization off of a silicon wafer. According to the theory put forth by Dr. Wnek, when exposed to local anesthetic compounds and ions commonly found in the cell, the poly(acrylic acid) brush should undergo contraction that would lead to changes in brush thickness. These thickness changes will be precisely measured by neutron reflectometry. Using these methods will provide insight into the possible mechanism by which anesthetic compounds affect nerve signal transmission through cytoskeletal fibers.



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Advisors: Dr. Gary Wnek, Dr. Michael Hore; Case Western Reserve University

6. Impact of Chain Architecture on the Thickness Dependence of Physical Aging Rate of Thin Polystyrene Films

Gregory Brown
The University of Akron

The dynamics of polymer thin films have been demonstrated to be significantly altered from the bulk, but the origins of such differences are not well defined. In this work, we seek to understand the differences in the structural dynamics (or physical aging) of polystyrene (PS) through branching and other well defined architectures (comb and centipede). The aging dynamics of ultrathin films (< 30 nm) differ from relatively thick films (100-150nm) with linear PS thin films aging more rapidly than the relatively "bulk-like" thick films. Ellipsometric measurements are used to characterize the physical aging rate of the films. The change in film thickness and refractive index as the films are held below the glass transition temperature (T_g) provides a simple measure of the physical aging. In this study, four different architectures (linear, comb, 4 arm star, and centipede) will be investigated. For each PS architecture, the aging rate will be determined for film thickness ranging from 10nm to 100nm over aging temperatures from 65C to 95C. Preliminary investigation shows that the branching of the PS will decrease the aging rate.

Advisors: Dr. Bryan D. Vogt, Elizabeth Lewis; The University of Akron

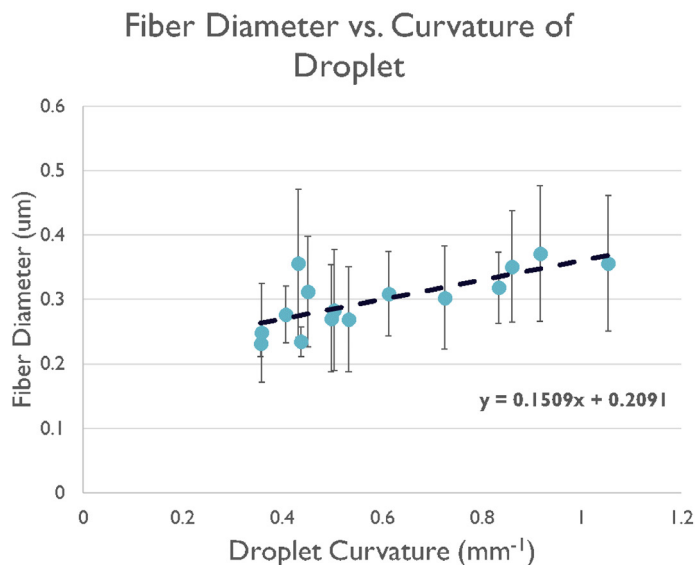
7. The Effect of Polymer Solution Droplet Curvature on the Diameter of Electrospun Nanofibers

Amy Caron

University of Massachusetts, Lowell

Electrospinning is used to form nanofibers for applications like filtration, tissue scaffolding, internal drug delivery, and wound dressing. Fibers are generally around 80-500 nanometers in diameter; if fibers could be consistently made with much smaller diameters, such as 8-10 nanometers, they could be used in solving more problems. Through the method of applying a high voltage between a solution of polymer and a collector, fibers can be formed. In the apparatus we made the droplet can be photographed and analyzed; the fibers can be viewed on a scanning electron microscope. The droplet becomes a conical jet due to electrical potential so the fibers can spin from the solution. Future work may show that the size of the jet has a more direct correlation to the diameter of the nanofibers. Manipulating the curvature of the polymer solution droplet appears to have a direct effect on the diameter of the polymer nanofibers.

Advisors: Dr. Darrell Reneker, Suqi Liu;
The University of Akron



8. Enzyme Catalyzed Esterification of Telechelic Polymers

Clive T. Chirume

Central State University

There are a number of hydroxyl functional polymers that can be modified to produce functionalized polymers for the preparation of well-defined block copolymers. For example it possible to attach a carboxylic acid function reversible addition fragmentation chain transfer (RAFT) agent to a hydroxyl end-functional polymer to generate a macromolecular RAFT agent through the formation of an ester. While different methods have been developed for carboxylic acid/alcohol esterification reactions a recent route is using an enzymatic catalyst, which requires mild reaction conditions compared to other approaches. The objective of this project is to investigate the esterification of poly (butadiene) and poly (ethyleneoxide) using Novozyme 435 a commercial enzymatic catalyst for esterification. If this is successful, the synthesis of block copolymers will be investigated. After quite a number of experiments we have synthesized a macromolecular RAFT agent using polybutadiene and COOH-RAFT-COOH with ratio 1.1/1 and a 10% wt. Novozym Catalyst. We also have tried to add a co-solvent and see it made any difference in the formation of the ester. The most element to this esterification process is the environment. With the CTA (chain transfer agent) synthesized, we would like to investigate the synthesis of Block co-polymers through RAFT polymerization.

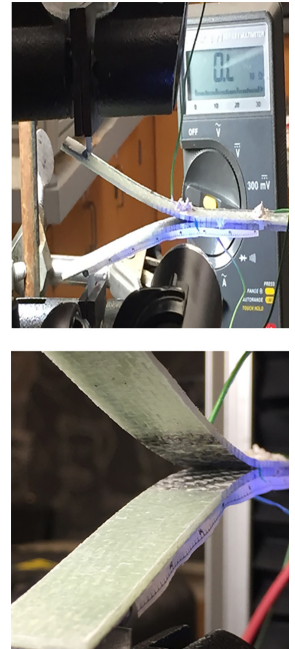
Advisors: Dr. Kevin Cavicchi, Junyoung Seo; The University of Akron

9. Toughening Glass Fiber Composites Using Carbon Nanotube Bucky Paper as Interleaf

Daniel Kovtun
Johns Hopkins University

Currently, composite structures in the form of laminates are extremely susceptible to crack propagation along the laminar interfaces. Delamination is one of the most prevalent life-limiting crack growth modes in laminate composites. Interleaving has been employed as a crack arrester in fiber reinforced composites. Carbon nanostructure Bucky paper (CNS-BP) is a macroscopic aggregate of cross-linked carbon nanotubes (CNTs) which has the potential to be used as interleaf in composite materials due to its mobility, scalability, and ease of production. The purpose of this research is to modify glass fiber composites with a thin deposition of BP in the interlaminar region in an effort to toughen epoxy composites widely used in aerospace, automotive, and wind energy industries. Before deposition, the CNS-BP was treated with oxygen plasma to improve its adhesion with the polymer matrix. The CNS-BP was deposited via shearing force to impart a very thin coating in the middle of the composite. Laminates prepared via hand layup and compression molding were tested in Mode I and Mode II to measure interlaminar fracture toughness. The results show that Mode I toughness is slightly improved in the CNS-BP composites, while Mode II fracture toughness remains the same. While the mechanical properties are not drastically improved, it is important to note that the modified material now has conductive properties that may enable potential structural monitoring of the composite.

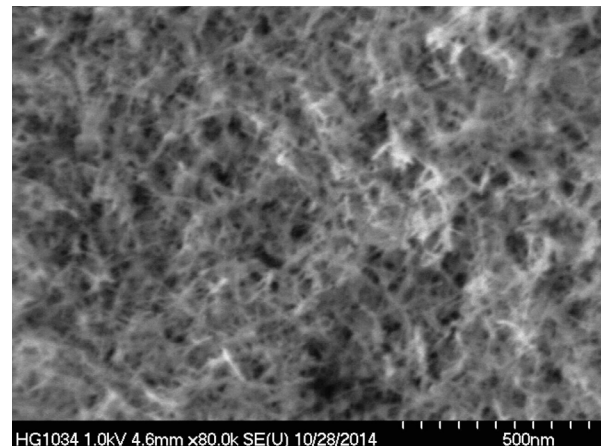
Advisors: Professor Ica Manas-Zloczower, Dr. O. Kravchenko, Dr. D. Pedrazzoli; Case Western Reserve University



10. Synthesis and Application of High-Temperature Aerogels

Matthew Meyer
Miami University

Aerogels are well-known to exhibit unique characteristics which make them excellent low-density thermal insulators. They are currently being investigated for a number of aerospace applications, two of which are the focus of this work. The first application is as a thermal insulation and sublimation protection material for thermoelectric space power systems. Trials were conducted using alumina aerogels prepared from various methods to encapsulate thermoelectric couples in order to determine if the materials are compatible. First, an acid-catalyzed process was used, which caused a reaction with the thermoelectric material. A base-catalyzed process was also tried, which resulted in a relatively weak and unstable gel. Currently, a method of reinforcement for the base-catalyzed process is being considered along with a separate yttrium-containing gel. The second application for aerogels is for high-temperature structural seals for spacecraft. Aluminosilicate gels were synthesized before being used to make composites with fabric, paper, and felt reinforcements. Measurements were then taken to determine air permeability using a Frazier 3000 Air Permeability Tester. The results are being analyzed to determine the best materials and configuration for a multi-layered seal design. Additionally, methods for increasing the flexibility of the composites are being investigated.



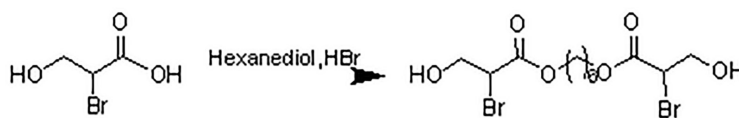
Advisors: Dr. Frances Hurwitz, Dr. Haiquan Guo, Jeffrey DeMange; NASA Glenn Research Center

*Image: Aerogel microstructure

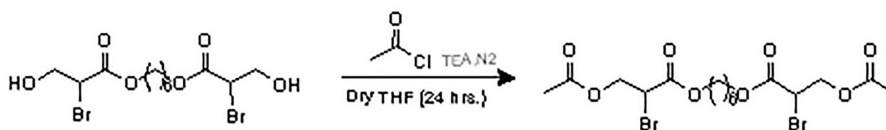
11. Development of Cross-linking Agents Based on 2-Bromo-3-Hydroxypropionic Acid and Their Application to Commercial Polymers

Pamela Dees
Central State University

A method to produce functional copolyesters by incorporating 2-bromo-3-hydroxypropionic acid (BrH) was developed by the Pugh group.¹ Poly(lactic acid) (PLA) copolymers containing BrH units cross-link with diphenyl ether due to the formation of a dioxolenium intermediate formed in the presence of either a silver salt or at elevated temperatures. In this project, 2-bromo-3-hydroxypropionic acid will be investigated as a potential molecule to cross-link electron-rich aromatic thermoplastic polymers. The research consists of two main steps: 1) synthesize multifunctional cross-linking agent, and 2) test the ability of the crosslinking agent to crosslink a variety of commercial polymers. Reactions, shown in Schemes 1 and 2, to form the multifunctional cross-linker have been established. Four commercially available, aromatic containing polymers will be reacted with the brominated cross-linker and evaluated based on the resulting materials' physical and chemical characteristics. If the four aromatic commercial polymers do not react with the brominated cross-linker, then additional commercial polymers will be tested.



Scheme 1.



Scheme 2.

Advisors: Dr. Coleen Pugh, Carolyn Scherger, Tyler Tommey; The University of Akron

12. Synthesis of Synthetic Mimics Enriched Tryptophan Copolymers for the Use in Antimicrobial Studies

Jason Ewing
Stark State College

With the continued overuse of antibiotics and the persistent mutation and resistance of microbes, a new source of antimicrobial agents have become a necessity in today's overpopulating world. A possible, new class of antimicrobial agent is being developed within the Joy research group. Within our lab, polyurethanes are being synthesized to mimic the innate immune response found in all forms of life known as host defense peptides (HPDs). These broad spectrum peptides have been shown to obtain an affinity as natural antibacterial agents which have the ability to kill both gram-positive and gram-negative bacteria, as well as, envelope viruses, fungi and parasites. Due to tryptophan's interesting properties and important role as an innate defense mechanism, the focus of the research is to create a mLys/mTrp copolymer that mimics biological amino acids in order to study its effect in killing *Staphylococcus aureus*, a gram (+) and *Escherichia coli*, a gram (-) bacteria.

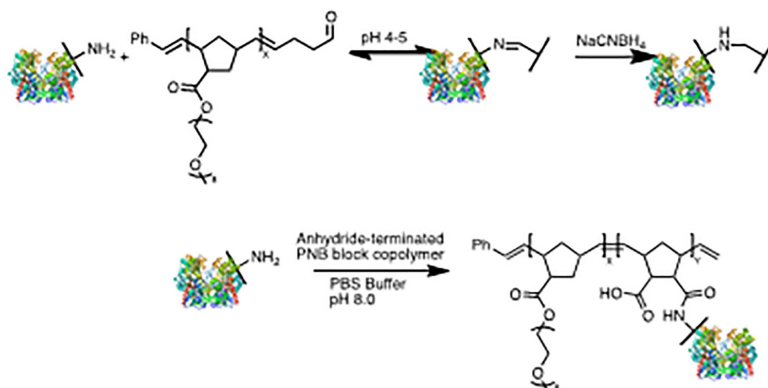
Advisors: Dr. Abraham Joy, Steven Mankoci; The University of Akron

13. Enzyme Stabilization via Conjugation of Water-Soluble Polynorbornenes

Karl Fetsch

University of Wisconsin – Madison

PEGylation is a process in which polyethylene glycol (PEG) polymers are conjugated to the surface of a protein, often to hydrophilic lysine residues or to the N-terminus of the polypeptide chain. This imparts improved biological, chemical, and thermodynamic stability to the protein, which is very useful to medical procedures where proteins are administered as drugs. However, PEGylation may also cause reduced biological activity due to blocking of enzymatic active sites by PEG polymers. This is in part due to the random coil conformation adopted by PEG in solution. One possible alternative uses PEG-conjugated polynorbornene (PNB), which adopts a well-defined rigid spiral conformation in aqueous phase which may mitigate the activity issues seen with PEG. Additionally, PNB is synthesized with



ring-opening metathesis polymerization (ROMP), a G3 catalyzed reaction that yields very low dispersity polymers, ensuring uniform properties. Three proteins, glucose oxidase (GOx), hen egg white lysozyme, and type II horseradish peroxidase were selected for conjugating with PNB. Aldehyde-terminated PNB was used for conjugating with protein N-terminals and anhydride-terminated PNB was used for conjugating with lysine residues. Initial results show that 10kDa molecular weight aldehyde terminated PNB can be conjugated to type II horseradish peroxidase.

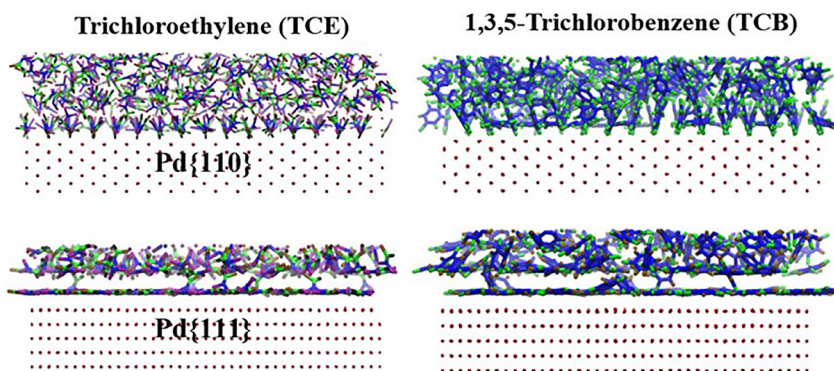
Advisors: Parker Lee, Melanie Hutnick, Jacqueline Wallat, Prof. Jon Pokorski; Case Western Reserve University.

14. Adsorption of Organic Contaminants on Hybrid, Hierarchical Nobel Metal System: A Molecular Dynamic Study

Emily A. Gerstein

University of Wisconsin Milwaukee

Chlorinated organic contamination of groundwater is a major environmental concern that has prompted material innovation towards hybrid nanomaterial based detection technologies. In particular, nanospheres of different zero valence metals, such as palladium (Pd) have been shown to exhibit enhanced catalytic remediation in its ability to capture small pollutants, such as halocarbons, and also in high rates of dechlorination. To minimize the amount of precious metals in remediation, an understanding of the effect of size and facet distribution on organic adsorption is essential. In the proposed study, the utility of Pd for remediation applications is investigated through



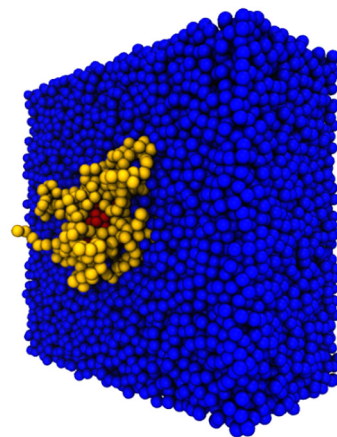
the examination of trichloroethylene (TCE) and isomeric 1,3,5-trichlorobenzene (TCB) adsorption on different facets of Pd. All-atom molecular dynamics (MD) simulations, with validated potentials, are employed to quantify the adsorption of these organics on Pd {100}, {110} and {111} facets. The effects of temperature and facet type are analyzed. Additionally, trends in the dependence of epitaxial site selection on FCC facet adsorption, role of molecular matching and orientation and adsorbate flexibility are evaluated. The proposed work provides quantification of the relative roles of various interactions that contribute to soft-epitaxial adsorption.

Advisors: Dr. Mesfin Tsige, Dr. Kshitij C. Jha; The University of Akron

15. Simulation of Glass Formation near Covalently Grafted Nanoparticles

Esther Grossman
Ohio University

A popular technique for synthesizing nanocomposite materials while avoiding nanoparticle aggregation is to covalently graft some of the surrounding polymer to the nanoparticle. In this study, we employ molecular dynamics simulations to analyze the way the dynamics change at the interface of the nanoparticle and the surrounding polymer with respect to changes in grafted chain length, grafting density, and intermolecular attraction between the nanoparticle and the polymer. We found that a prominent dynamical shift resulted from changes in each of the three parameters. We measured these dynamic shifts by way of the glass transition temperature (T_g). As expected, T_g increased as grafted chain length increased, the rate of increase trending downward as we reached greater chain lengths. In densely grafted systems with a fairly attractive nanoparticle-polymer van der Waals interaction, $\epsilon=1$, T_g near the particle interface increased upwards of 15%, while the sparsely grafted systems saw a similar increase. Interestingly, the densely grafted systems with a fully repulsive van der Waals interaction saw a much smaller increase, evidencing the strength of the intermolecular forces present near the interface. The extent of the repulsive behavior is even clearer in the sparsely grafted systems, where T_g decreased close to the nanoparticle. In addition, we conducted a preliminary investigation into the ratio of grafted chain length to matrix chain length (n_g/n_m) in order to isolate wet brush and dry brush properties. We found that all of our systems had wet brush character (relatively low grafting density and large n_g/n_m).



Advisor: Dr. David S. Simmons, Venkatesh Meenakshisundaram, Jui-Hsiang Hung; The University of Akron

16. Modulating Silica-Rubber Interface by Biorenewable Urushiol-Derived Silanes

Kianna Jimenez
Barton College

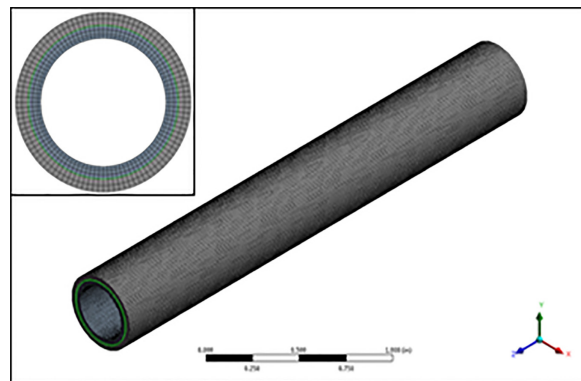
For this project, silica particles were explored as reinforcing fillers. For non-polar rubber like SBR, this reinforcing process requires a coupling agent that will have the ability to form a durable covalent bond between the rubber and silica filler to enhance the attachment. Commonly, a silane coupling agent (e.g., TESPT) is used in industry. This project involved synthesizing urushiol, a catechol with an unsaturated 15 carbon tail, combined with sulfur to act as the coupling agent between the silica and rubber. The rubber compounds reinforced with silica particles modified by the sulfide urushiol (SUDS) were studied. SUDS reinforced SBR provided a lower viscosity during mixing. With SUDS, the rubber-filler interaction was improved. Non-linear storage modulus (G') drop at small strain was either eliminated or suppressed. Due to the improvement of rubber-filler interaction, the cured compounds showed 30% increase in 100% stress and 40% increase in 300% stress. In summary, the sulfide urushiol has the potential to function as a coupling agent. Future research will focus on the coupling mechanism of sulfide urushiol.

Advisors: Dr. Li Jia, Xuesong Yan; The University of Akron

17. Modeling the Flow of a Multilayered Polymeric System through a Die with Applied Radial Shear

Patrick T. Getty
University of Chicago

Multilayered polymeric systems set on an annular flow path are used to create pipes that exhibit enhanced properties not available in their monolayered counterparts. These properties arise from the system's many, concentrically circular layers. In the extrusions we performed to create multilayered systems, the extrudate had displayed significant distortion of the rings comprising its outer layers. The application of radial shear to the melt as it passes through the die had been demonstrated experimentally to eliminate this distortion. In order to confirm that the application of radial shear eliminates this distortion and to determine the optimal processing parameters for future extrusions, we are designing computational simulations of such extrusions. These simulations are performed with ANSYS POLYFLOW—a finite-element computational fluid dynamics program. POLYFLOW's Interface surface condition (above, green) allows the movement and interaction of different polymeric layers to be observed.



The parameters of the simulations—notably, flow boundary conditions, slip conditions, and angular velocity of the rotating outer wall—are varied in order to attain a model that most accurately reflects the physical experiments and their results. A referential constraint on the moving Interface condition—seemingly regardless of the conditions set for the aforementioned variables—drives the interface towards the outer wall of the die, resulting in non-converging simulations. Thus, the ability of POLYFLOW to effectively model multilayered extrusions is found to be limited for the currently proposed simulation setup. To resolve this issue, alternate simulation models, including varied melt geometries, are currently being tested.

Advisors: Maia, João; Case Western Reserve University. Schneider, Tyler; Case Western Reserve University.

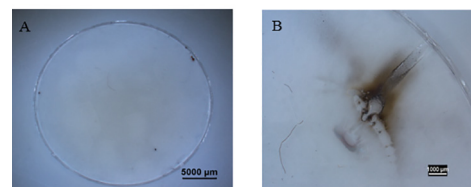
18. Self-Healable Electrical Insulation for High Voltage Systems

Paula-Marie Mensah
Southern University Agricultural & Mechanical College

Dielectric breakdown in polymer insulation is commonly caused by electrical treeing. Developing an electrical insulator that possesses high dielectric strength, structural integrity, thermal stability, and low affinity to moisture are important features to prevent damage to electrical components, fires, or a compromise to safety. Polyimide and fluoropolymers are commonly used in aircraft electrical insulation, but using polyimide absorbs moisture which poses a fire hazard. Fluoropolymers have high temperature stability, but these polymers are difficult to bond to neighboring materials surrounding the insulator, thus leading to air gaps and ultimately premature dielectric failure. The objective of this project is to develop a new insulation system with better longevity and reliability through implementation of self-healing technology. Surlyn ®8940 is a commercial ionomer ethylene acid-based copolymer that previously demonstrated repetitive self-healing behavior through reversible ionic crosslinking. Unlike traditional self-healing polymers, reversible crosslinking allows a material to undergo multiple self-healing events while regaining full recovery strength. Our goal is to assess the use of this material as an insulator to determine if healing can occur following dielectric breakdown. The breakdown voltages of all samples were measured and was observed to increase with increasing sample thickness. Optical microscopy was used to monitor damage following dielectric breakdown and self-healing. Moisture absorption of the neat polymer was examined to ensure that moisture uptake of the samples was negligible. Identifying appropriate processing methods to develop multi-layer self-healing electrical insulation is also being investigated.

Advisor: Dr. Tiffany Williams; NASA Glenn Research Center

*Image: Seal-healing Surlyn ®8940 polymer sample before (A) Dielectric Breakdown testing and after (B).



19. Understanding Fouling and Absorption in Polynorbornene Membranes for Biobutanol Separation

Anna Kersey
Trine University

The desire to reduce dependency on fossil fuels has led to significant interest in the development of new renewable liquid fuels for transportation. Biobased ethanol has emerged as the dominant biofuel additive for transportation, but there are several key detriments of ethanol as a biofuel such as low energy density and high miscibility with water. These shortcomings can be overcome by biobutanol. The limited compatibility of butanol with most biological substrates, typically below 1 vol%, leads to significant costs in the separation and recovery of the biofuel. Passive recovery methods, such as absorbents and membranes, provide an energy efficient method for in situ product recovery, but challenges remain in the efficient recovery. To address these challenges, we investigate polynorbornene chemistry-based membranes, which involve copolymers of hydroxyhexafluoroisopropyl norbornene (HFANB). By altering the hydrophobic comonomers, we seek to understand how these comonomers impact the separation and recovery of butanol through fundamental measurements with quartz crystal microbalance (QCM). QCM will be used to understand how the comonomer impacts the mass uptake of butanol in the polynorbornene polymer thin films. The polynorbornenes were spun coat onto gold-plated quartz sensors to obtain films with thicknesses of approximately 1 μm , as determined by spectroscopic ellipsometry. The butanol absorption in the polynorbornene was determined as a function of butanol-water concentration. With this initial understanding of butanol interaction with the norbornene, we will determine how additives to the fermentation broth, such as anti-foaming agents, impact the uptake. This examination could indicate the effectiveness of these polymers as membranes to be used in the separation of biobutanol using a cost effective means from these low yield fermentation processes.

Advisors: Dr. Bryan D. Vogt, Clinton Wiener; The University of Akron

20. Functionalized Nanofibers for Nerve Regeneration

Olivia Manahan
Ball State University

According to the National Institute of Neurological Disorders and Stroke, an estimated 20 million people in the United States have some form of peripheral nerve damage per year.¹ Given the limited regeneration rate of this tissue type, our efforts to differentiate stem cells into nerve cells using a polymer nanofiber scaffold may provide a solution. Our research seeks to produce a biodegradable nanofiber scaffold functionalized with peptides to promote differentiation of stem cells into nerve cells.

The scaffold's polymer backbone will consist of units of ϵ -caprolactone (ϵ -CL) and 2-oxepane-1,5-dione (OPD). This ratio is dependent on the desired degradation potential and functional sites for peptide attachment. Thus far, our scaffolds have been made from ϵ -CL alone using less costly 5-norbornen-2-ol initiator while testing different catalysts and reaction conditions. Although considered more ideal for its lack of metal toxicity, the fully organic 1,5,7-triazabicyclo[4.4.0]dec-5-ene catalyst with which the first polymerizations were attempted was unsuccessful. Instead, $\text{Mg}(\text{BHT})_2(\text{THF})_2$ has been used in its place. The most recent polymerizations have yielded polymers with a broad molecular mass distribution. Therefore, variations in reaction concentrations are being tested for more ideal materials.

Following each successful polymerization, electrospinning is used to create both randomly-oriented and aligned nanofibers that mimic extracellular matrix. The quality of these fibers have been assessed using scanning electron microscopy. These nanofibers will then be functionalized with bioactive YIGSR and RGD peptides, thought to promote cell attachment, migration, and differentiation. Following functionalization, samples are then sent to our collaborators to perform cell studies with mESCs.

Advisors: Dr. Matthew L. Becker, Elena Silantyeva; The University of Akron

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21. Exploring a Multi-Layered Polysulfone/Polyamide 6,6 System for Fibrous Filtration

Mason Dearborn
University of Southern Mississippi

A multi-layer polymeric system of Polysulfone/Polyamide 6,6 fibrous filters was fabricated via a several-step process. The materials were chosen for their potential for chemical and high-temperature resistance for use in extreme filtration conditions. The Polysulfone and Polyamide 6,6 were co-extruded using a melt-based method and multiplied vertically, with Polystyrene being used as a separating layer. The numbers of domains were 8192 x 32, and 3 and 6" dies were used. After extrusion, the fibers were stretched at a certain temperature and strain rate in order to improve the crystal orientation, to decrease the thickness of the filters for removal of the separating layer, and to decrease pore size. Extensive scouting was done to optimize the two aforementioned parameters in order to achieve the largest draw ratio. Once these parameters were set and fiber tapes created, tapes were laid perpendicular to each other and delaminated using high-pressure water-jets to expel the Polystyrene separating layer, creating two-ply fibrous filters. These filters are able to be tested for filtration efficiency with differing sizes of particles.

Advisors: Dr. Eric Baer, Cong Zhang, Xinting Wang; Case Western Reserve University

Image: Proposed mechanism for sequestration of furosemide into PAA-PEO complex

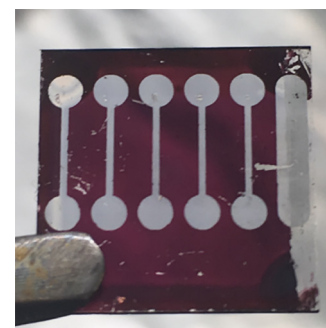


22. Effects of Precursor Solvent Polarity on the Organolead Halide Perovskite Photoactive Layer in Perovskite Solar Cells

Nate Orndorf
Grand Valley State University

As carbon emissions and global temperatures continue to rise, it is imperative that a clean, renewable energy source replaces oil. Organolead Halide Perovskite hybrid solar cells (pero-HSCs) have quickly emerged as a promising technology for renewable energy, due to the superb photovoltaic properties of the perovskite photoactive layer. However, such a fast-crystalizing hybrid material usually shows poor film morphology with various crystal grain boundaries, numerous pin-holes, and low homogeneity, which decreases the device efficiency and enlarges the batch-to-batch deviations of the corresponding solar cell performance. In this study, we tuned the two-step spin-coated perovskite film quality of the pero-HSCs by varying the polarity of the $\text{CH}_3\text{NH}_3\text{I}$ precursor solvent, and determined whether it can influence the final device performance. Pero-HSCs have high potential as a cheap replacement of the expensive silicon solar cells that are currently used, but more work on improving the efficiency and lifetime is a necessity before commercialization.

Advisors: Dr. Xiong Gong, Kai Wang; The University of Akron



23. Synthesis of 2-(2-(2-((4'-Cyano-[1,1'-biphenyl] 4-yl)oxy)ethoxy)ethoxy)ethyl Acrylate Monomer for Polymer Electrolyte Membrane in Lithium-Ion Battery Applications

Juliana Pasquini Martins
Colorado State University

Lithium ion batteries are one of the most commonly used media to store electric energy. Consequently, improvements on this type of battery would directly affect many types of equipment, from cellphones and small electronics, to cars and even power plants. Although these batteries have high conductivity, the lithium-ion battery is a very dangerous system, mainly because its electrolytes contain flammable solvent. Therefore, polymer electrolyte membranes have been developed to replace the electrolytes currently used. Polymers have higher flash points, reducing the flammability, and they can be designed to have a high conductivity by constructing pathways for lithium-ion conduction. To achieve the desired structure, I have synthesized an acrylate monomer with a cyanobiphenyl mesogen attached to the polymerizable group through an oligooxyethylene spacer; this monomer can be oriented in response to an external field due its dipole moment and is photo-polymerizable.

Advisors: Dr. Coleen Pugh, Dr. Thein Kyu; The University of Akron

24. Stability of Block Copolymers Thin Films during Direct Immersion Annealing

Alessandro Perego
Brigham Young University

Nano architectures in ordered block copolymers (BCP) thin films have inspired a variety of new applications. For example, the uniformly sized and shaped nano domains formed in the films have been used for nanolithography, nanofiltration, and high-density information storage media. Direct Immersion Annealing (DIA) is a novel and robust annealing technique, developed by Modi et al¹, that has been shown to enhance the quality and rate of ordering in BCP thin films. In fact, DIA has the potential to overcome the major drawbacks of thermal and solvent vapor annealing. As for now, DIA results have been reported for substrates with relatively high surface energy and there have been no studies performed concerning the effects of surface energy on the stability of BCP thin films during DIA. In this experiment we use a gradient surface energy substrate coat it with a thin film (~100 nm) of PS-PMMA and anneal using DIA for varying amounts of time. This allowed us to investigate the role that surface energy plays in the stability of the film during the annealing process. Our results show that the stability of BCP thin films during DIA is highly dependent of the surface energy of the substrate. Additionally we were able to determine a critical surface energy transition point (γ_c) which clearly marks the separation from stable to unstable region and which can be correlated to the surface energy of the solvent mixture.

Advisor: Dr. Alamgir Karim, Melanie Longanecker, Namrata Salunke; The University of Akron

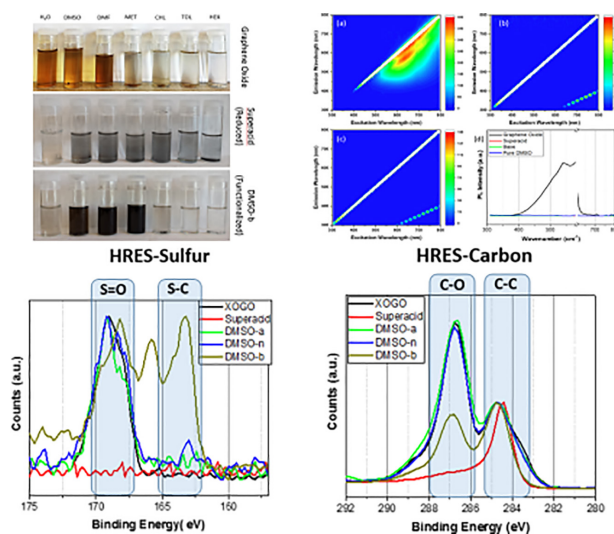
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25. Selective Reduction and Functionalization of Graphene Oxide using Thiols

Michael Mellon
Kentucky State University

Highly oxidized graphene oxide (XOGO) is a promising 2D nanosheet material that can be used in a wide range of applications due to its ability to be covalently functionalized, antimicrobial and gas barrier properties, and use of a precursor to thermal and conductive materials, if reduced. This work focuses on selectively inducing the functionalization or reduction on a XOGO nanosheets by changing the pH of the solution. Specifically, thiols were used to either reduce the oxygen functional groups on the XOGO, leaving a fully conjugated sheet, or covalently attaching small molecules to the carbon atoms. This study shows how the pH of the reaction medium dictates the chemical reactions that take place. Moreover, this study employs fairly accessible equipment and shows potential for scalability. The main thiol used in this study was 2-mercaptoethanol and both polar protic and aprotic solvents were explored. In a polar protic solvent, the thiol did not functionalize XOGO, in contrast to the results in aprotic solvents, which allowed the thiol to add functional groups to the XOGO sheets. In superacidic conditions and polar aprotic solvent thiol caused a significant reduction of XOGO. Conversely, using the same solvent in basic conditions allowed thiol to functionalize the sheets. Future work includes exploring other thiols and varying the degree of functionalization.

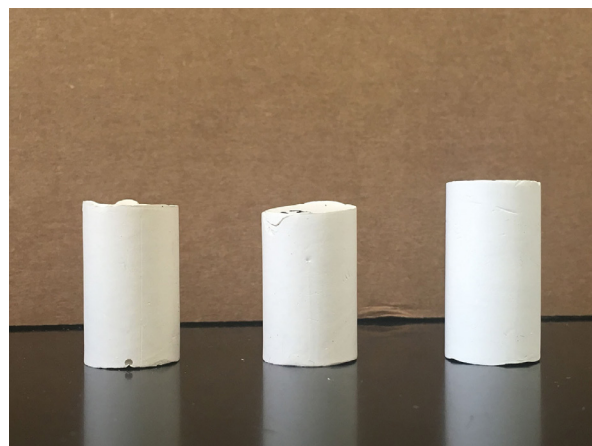
Advisors: Prof. Emily Pentzer, Dr. Al de Leon; Case Western Reserve University



26. Polyamide Aerogels Cross-linked to Enhance the Strength of the Polymer Chain Backbone

José J. Maldonado Méndez
Universidad de Puerto Rico – Río Piedras

Aerogels are solid materials characterized by high porosity, diminutive pores, large internal surface areas and low density. These materials have a variety of applications that include insulation, high performance antennas and harsh aerospace environment applications. Polyamide aerogel are lightweight and higher in strength than other polymer aerogels. This is due to the amide linkage in each repeat unit that allows the polymer chains to interact through hydrogen bonding. The mechanical properties that these polyamide aerogel possess should be enhanced through the addition of a cross-linker, which will covalently bond the polymer strands together. To fabricate the polyamide aerogel, a solution of a para-substituted diamine (p-phenylene diamine) is combined with the para-substituted, terephthaloyl chloride (TPC) in a polar aprotic solvent (NMP) at low temperature in the presence of calcium chloride (CaCl_2) to keep the polymer soluble until fully reacted. After the gels form, they are soaked in either 1,3,5-benzenetricarbonyl trichloride (BTC) or triisocyanate Desmodur N3300A which react with the amine end groups of the polymers and cross-links them. After supercritically drying to obtain the polyamide aerogel, density, porosity and shrinkage is measured. Higher formulated molecular weight oligomers in the aerogel produced higher density and shrinkage, probably because less cross-linking is present. Mechanical property measurements are in progress.

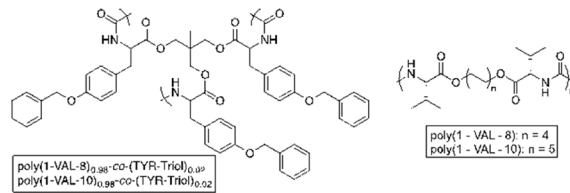


Advisors: Dr. Baochau N. Nguyen, Dr. Mary Ann Meador, Dr. Rocco P. Viggiano; NASA Glenn Research Center

27. Synthesis and Characterization of Linear and Branched Amino Acid – Based Poly(ester urea)s for Hernia Mesh Repair

Lindsay L. Robinson
The College of Wooster

Current polymeric mesh for hernia repair fail to simultaneously possess sufficient mechanical strength to act as a scaffold for native tissue regeneration while also being biodegradable. 1 Amino-acid based poly(ester urea)s (PEUs) are of interest for soft tissue engineering applications as they generate benign hydrolysis products, exhibit tissue compatibility, and have tunable mechanical and degradation properties.^{2,3} Thus, in this study, we sought to investigate the potential use of linear and hyperbranched valine – based PEUs for hernia mesh repair and assess the effect of branching units on biomechanics and degradation.



Interfacial polymerization of a branched tri-*O*-benzyl-L-tyrosine-1,1,1-trimethylethane triester monomer (TYR-Triol) with either linear bis(_L-valine)-octane 1,8-diester (1-VAL-8), bis(_L-valine)-decane 1,10-diester (1-VAL-10) monomers and triphosgene afforded the respective hyperbranched polymers: poly(1-VAL-8)_{0.98}-co-(Triol-TYR)_{0.02} and poly(1-VAL-10)_{0.98}-co-(Triol-TYR)_{0.02}, each with a 2% branch density. Differential Scanning Calorimetry (DSC) data of previously synthesized linear poly(1-VAL-8) and poly(1-VAL-10) reveal that the glass transition temperatures (T_g) are above body temperature; thus the materials are viable for biological applications. The elastic moduli obtained from tensile testing of fabricated poly(1-Val-8) and poly(1-Val-10) show that the linear materials possess mechanical strength comparable to polypropylene, a commonly used rigid, nonresorbable mesh, while also being biodegradable. Linear poly(1-VAL-8) and poly(1-VAL-10) tensile bars were subcutaneously implanted in rats, which will be harvested at 2 and 4 months to assess the effect of enzymatic degradation on mechanics. Identical thermal, mechanical, and *in vivo* biomechanics studies of hyperbranched poly(1-VAL-8)_{0.98}-co-(Triol-TYR)_{0.02} and poly(1-VAL-10)_{0.98}-co-(Triol-TYR)_{0.02} will be conducted upon completion of large scale synthesis and fabrication.

Advisors: Dr. Matthew L. Becker, Nathan Z. Dreger; The University of Akron

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28. Gluing Gels by Soft Nanoparticles

Ryan Sayko
Allegheny College

Nanoparticles have been recently shown to act as effective adhesives between two soft materials. Using a combination of theoretical calculations and molecular dynamics simulations, we investigated the contact mechanics of a soft nanoparticle at the interface of two gel-like surfaces. Depending on the nanoparticle size and the elastic modulus of both nanoparticle and gels, the nanoparticle could be in a bridging or Pickering state. The contact radius and deformation of the nanoparticle into the two gels are recorded in an equilibrium state. We studied the potential of mean force between the equilibrium contact state and the separated state by using the Weighted Histogram Analysis Method. Simulation results show that not all soft nanoparticles achieve a larger work of separation compared with a rigid nanoparticle. We propose a model to describe the relationship between the moduli of a nanoparticle and soft gels versus the work of separation.

Advisors: Dr. Andrey Dobrynin, Zhen Cao, Heyi Liang, Adam Woods; The University of Akron

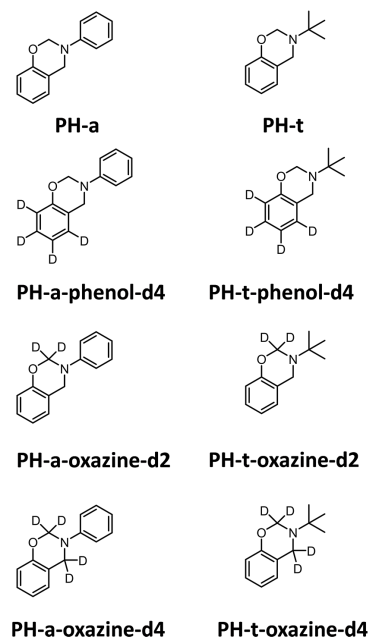
29. Reassignment of the Characteristic Band of Benzoxazine IR Mode Using Isotope Compounds

Victoria M. Sedwick^a, Lu Han^b, Hatsuo Ishida^b

^aWinston-Salem State University, ^bCase Western Reserve University

Benzoxazines are characterized by a 960-910 cm^{-1} band in infrared spectroscopy. This band was originally assigned to the C—H out-of-plane bending of the benzene to which oxazine ring is attached. However, it was identified that the peak had been incorrectly assigned. This was confirmed by analyzing the IR spectra of benzoxazine monomers with a fully substituted benzene ring which possesses no CH groups. In order to assign the characteristic peak in FTIR properly, the vibrational mode that is attributed to the 960-910 cm^{-1} band was studied using IR spectra of deuterated isotopes of 3-phenyl-3,4-dihydro-2H-1,3-benzoxazine (PH-a) and 3-tert-butyl-3,4-dihydro-2H-1,3-benzoxazine (PH-t). The isotopes that were synthesized for each involved deuteration around the benzene ring of phenol (PH-a-phenol-d4, PH-t-phenol-d4), deuteration of the carbon in the 2 position on the oxazine ring (PH-a-oxazine d2, PH-t-oxazine d2) and deuteration of both carbons in the oxazine ring (PH-a-oxazine-d4, PH-t-oxazine-d4). The IR spectra were analyzed based on the frequency shifts of various vibrational modes. This study will help monitor polymerization behavior of benzoxazines using IR spectroscopy.

Advisor: Dr. Hatsuo Ishida; Case Western Reserve University

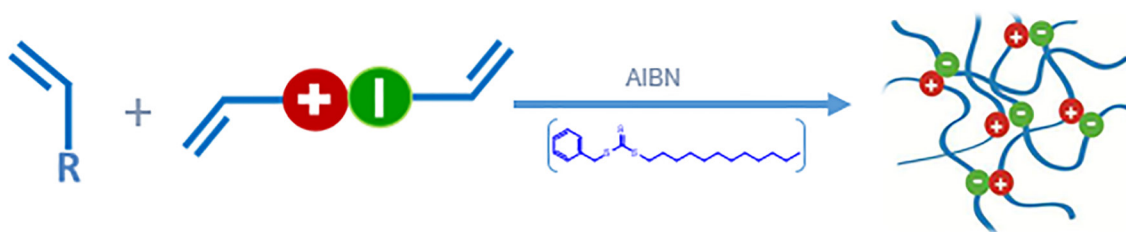


30. Abstract: Synthesis and Characterization of Polyampholyte Ionomers

Timothy Schoch

California Polytech State University

The goal of this project is to investigate ion-pairs as cross-linkers for responsive materials. Specifically, this data is for comparison to previously fabricated RAFT polyampholyte ionomers from n-butyl acrylate (nBA) and ion-pair comonomers or ionic monomer with pendant counter-ions. Vinyl-benzyl trialkylphosphonium-styrene sulfonate ion-pair comonomers and their pendant counter-ion derivatives were synthesized and then reacted together with nBA to form polyampholyte ionomers, both with and without RAFT agent. By varying the ratio of the two ionic monomers while keeping the total ionic to neutral monomer ratio constant, we were able to study another facet of ion-pair crosslinking. Characterized by Rheology, these polymers exhibited a diverse range of thermo-mechanical states based on their content of ion-pair cross-links. Furthermore, analogous ionic acrylates were synthesized as future candidates for generation of new polyampholyte ionomer.



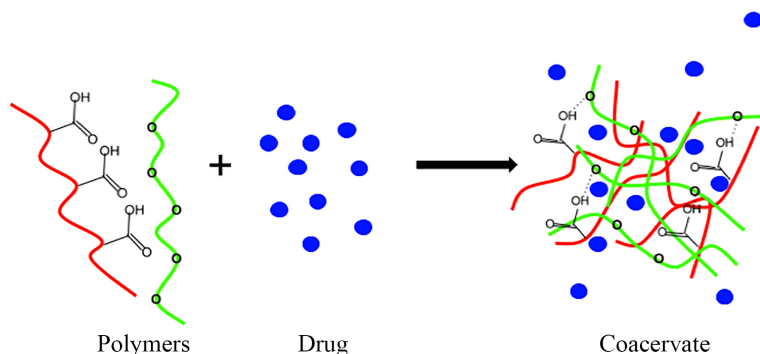
Advisors: Dr. Kevin Cavicchi, Guodong Deng; The University of Akron

31. Sequestration of Pharmaceutical Compounds into Complex Coacervates

Amy Seymore
Lorain Community College

Hydrogen-bonding interactions between polyacrylic acid (PAA) and polyethylene oxide (PEO) in an aqueous solution lead to the formation of an interpolymer complex (IPC). During this process, a liquid-liquid phase separation results in complex coacervation forming a water rich phase and a dense, polymer-rich phase. The poly(acrylic acid)/poly(ethylene oxide) coacervate has been studied in terms of pH, turbidity, dynamic light scattering, and FT-IR. During phase separation, the polymer-rich phase can selectively sequester small molecules based on various intermolecular interactions such as hydrophobic interactions and hydrogen bonding. This study deals with the sequestration of Furosemide into the complex coacervate. Furosemide is a powerful diuretic drug used to treat excessive fluid build-up or swelling in those with heart failure, liver scarring, and kidney disease as well as in treatment of high blood pressure. It works by decreasing sodium reabsorption by the kidneys. The goal is to test the sequestration ability of the PAA/PEO complex system and to extrude the polymer-rich phase containing furosemide. 51 percent of the drug was successfully loaded into the complex via hydrophobic interaction between the drug and the IPC. Possible applications include controlled drug delivery via 3-D printing of a complex polymer scaffold implant containing furosemide.

Proposed mechanism for sequestration of furosemide into PAA-PEO complex

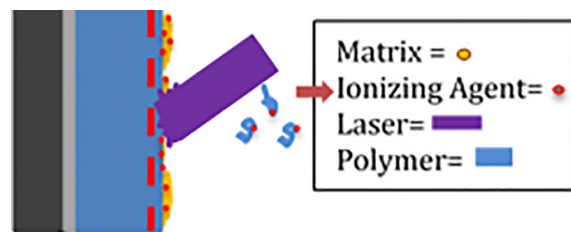


Advisor: Dr. N.S. Zacharia; The University of Akron

32. Surface Analysis by Mass Spectrometry Techniques to Understand Biomolecule Incorporation into Oxime Hydrogels

Sarah Swilley
The University of Southern Mississippi

Hydrogels are becoming more prevalent in modern science as biological applications advance. From drug delivery to tissue engineering, the applications of hydrogels are vast, yet there are few techniques readily available to test for an average pore size throughout the polymer gel, as well as determining biomolecular displacement.



The established method to calculate average mesh size is through a series of Flory-Rehner equations. The major drawback of this method is that these equations assume a perfectly crosslinked network, which is unrealistic experimentally. Surface Layer-Matrix-Assisted Laser Desorption Ionization Mass Spectrometry (SL-MALDI-MS) and MALDI-MS imaging will be applied to qualitatively and quantitatively determine the average pore size of oxime hydrogels. We will introduce a mixture of biomolecules of various sizes and conformations to the surface of the swollen hydrogel, and allow for the mixture to diffuse throughout the gel. Then a SL-MALDI-MS analysis of an air-dried sample will be completed in order to determine which biomolecules remain at the surface of the gel. Depending on which molecules penetrate into the gel, the relative mesh size can be determined. After completing the surface layer analysis, MALDI-MS will be utilized to probe slices of the gel and to map the displacement of biomolecules within the hydrogel.

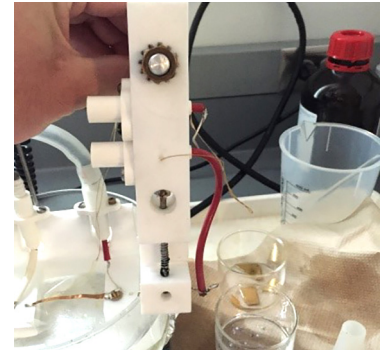
Through conventional MALDI-MS it was found that DHB would be the best matrix to use with these proteins, and a 100:10:1 volume to volume ratio of myoglobin: ubiquitin: insulin would provide the best spectrum. An absence of proteins was observed in our SL-MALDI analysis, so a solid phase extraction was performed with water to isolate any of remaining proteins from cross sections below the surface of the gel. The proteins were then extracted to be analyzed in conventional MALDI. The spectrum yielded information which showed insulin was present in the deeper layers of the gel.

Advisors: Dr. Chrys Wesdemiotis, Kevin J. Endres; The University of Akron

33. Dielectric Breakdown Strength of Aluminum Isotactic Polypropylene

Rhett Carpenter-Thompson
Central Michigan University

Throughout scientific literature, polymers have been shown to exhibit high breakdown strength and metallic particles have been proven to have infinitely high dielectric constants [1]. Theoretically, the combination of the high breakdown strength of a polymer and the high dielectric constant of a metal would result in a material with characteristics of high breakdown strength and high dielectric constants; an ideal candidate for high energy film capacitors. In this study, this notion was put to the test with isotactic polypropylene, a high breakdown strength polymer, and aluminum particles. We found that while the dielectric constant does experience a moderate increase, the polypropylene with aluminum nanocomposites cannot maintain the original breakdown strength. These results stem from the field emission of aluminum under the influence of a high field. The aluminum's field emission capabilities allow for electrons to more easily pass from the aluminum into the polypropylene, making the polypropylene more conductive, and resulting in lower breakdown strength.



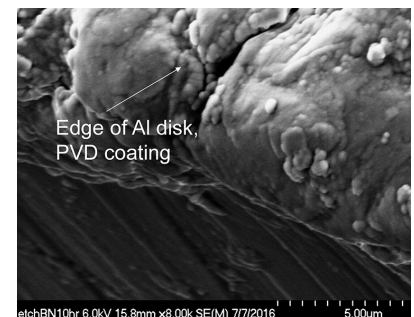
Furthermore, factors such as purity of the aluminum, specific area of electric exposure, and crystallinity of the polypropylene are also known to play a role in breakdown strength [2]. To understand how aluminum plays a role in increasing or decreasing breakdown strength of this dielectric material, the percent volume and particle size of aluminum was manipulated. Results show the higher the volume of aluminum, the lower the breakdown strength values. The importance of these results is that field emission from metallic nanocomposites is too high to be beneficial as a film capacitor material.

Advisors: Dr. Lei Zhu*, Guoqiang Zhang; Case Western Reserve University

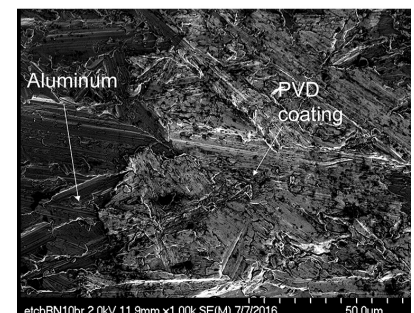
34. Evaluation of Boron Nitride Deposition Techniques on Metal and Polymeric Substrates

Jeremy Walker
University of Houston

Lightweight materials with good thermal properties are needed for use as dielectric insulators in future hybrid electric propulsion aircraft. Boron nitride (BN) may provide these desired properties without increasing the weight of electrical components if thin film/coatings can be utilized. We investigated the feasibility of depositing BN on two substrates using two methods: layering BN directly onto an aluminum or polymeric substrate via PVD, and painting a BN solution onto a chemically etched PFA film. We tested the dielectric strengths of the materials produced and found that aluminum coated with BN via PVD resulted in no change in the dielectric response compared to neat aluminum. For the PFA films, we found that dielectric strength increased marginally with etching time; however, etched films painted with BN solution and those coated with BN via PVD both had dielectric strengths that were lower than uncoated films. Processing modifications and other deposition methods are being evaluated.



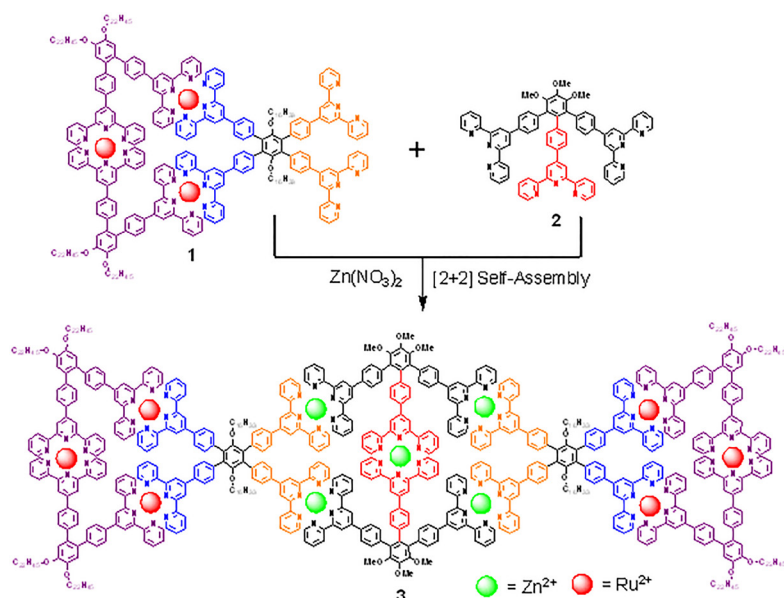
Advisors: Dr. Maricela Lizcano, Dr. Eugene Shin; NASA Glenn Research Center



35. Design, Construction, and Characterization of Supramolecular Building Blocks and Materials

Breanna Tomiczek
Saint Vincent College

Coordination driven self-assembly has become an extensively studied aspect of supramolecular chemistry in which interactions between a metal and an organic ligand can lead to diverse structures of a discrete size and shape relating Nature, mathematics, and synthetic chemistry altogether. Over the past few years we have synthesized several unique supramacromolecules using terpyridine based multidentate ligands including triangle, spoked wheel, bowtie, and butterfly shaped molecular architectures. In continuation of our study to develop new discrete macromolecules based on terpyridine ligands, herein we successfully synthesized a novel rhomboidal shaped metallo-supramacromolecule **3** by the heteroleptic self-assembly of tris-terpyridine ligand **2** and the 60° bis-terpyridine molecular complex **1** with $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$. Methods of characterization used to confirm the synthesis of the desired macromolecule **3** include NMR spectroscopy, ESI-MS, and ESI-TWIM mass spectrometry.



Advisors: Dr. George R. Newkome, Sourav Chakraborty; The University of Akron

36. Polybutadiene Graft Copolymer for Improved Silica Filler Dispersion

Annette Valceschini
California State University Chico

Silica, a material found in nature, is used as a filler in rubber compounds for tires. Due to the polar nature of silica, the dispersion of the filler into a non-polar rubber matrix is poor. The objective of this experiment was to improve the filler dispersion of a rubber compound by synthesizing a polybutadiene graft copolymer coupling agent with grafts containing 2,3,4,5,6-pentafluorostyrene (PFS) and (dodecyloxy)diethoxy(4-vinylphenethyl)silane ($\text{StSi}(\text{ODod})(\text{OEt})_2$). The PFS interacts with the carbon black by arene-perfluoroarene interactions and the $\text{StSi}(\text{ODod})(\text{OEt})_2$ will covalently bond with the surface silanols on the silica filler. These non-covalent and covalent interactions enhance the carbon black and silica filler dispersion in the rubber compound. The graft copolymer was synthesized using a recently synthesized dodecyloxydiethoxy(4-vinylphenethyl)silane monomer. The graft copolymer was characterized using ^1H and ^{19}F NMR spectroscopy, and gel permeation chromatography (GPC). The coupling agent was compounded using a rubber tire tread compound recipe in three stages. The rubber compound was analyzed by curing behavior, advance polymer analysis (APA), storage modulus, tensile strength, and dynamic mechanical analysis (DMA) testing.

Advisors: Dr. Sadhan Jana, Dr. Coleen Pugh, Nicole Swanson, Hamad Albehajjan, Darnell Wims; The University of Akron

37. Design of Aperture Sensor for Sensory Restoration Prosthesis

Victoria Volk
St. Ambrose University

Sensory feedback is provided by stimulating the residual nerves in an amputee's arm via electrodes that have been implanted around those nerves. The electrodes use information that has been sent from sensors embedded in a prosthetic hand to provide the stimulation that causes sensation. The prosthesis has four different embedded sensors: three pressure sensors in the thumb, index, and middle fingers, and an aperture sensor between the thumb and index finger. Repeated use of the sensory restoration prosthesis led to variability in the aperture sensor readings, causing inconsistent stimulation for the user. The challenge addressed in this work is to create a more reliable aperture measurement system under the expected use conditions. A wooden block test was designed to test the robustness of the aperture sensor under expected use conditions in combination with the reliability and linearity testing already in place. Design changes were implemented to stabilize all of the aperture sensor components to withstand the different forces applied against them during use of the prosthesis. Following the design changes, aperture sensor readings had an increased accuracy over an extended period of time based on the wooden block test results. The wooden block test can therefore be used as a measure of the aperture sensor robustness under expected use conditions, creating a more reliable aperture measurement system.



Advisors: Dustin Tyler, PhD, Emily Graczyk; Case Western Reserve University

38. Contact-Killing Antimicrobial Thermoplastic Polyurethanes for Catheter Applications

Caroline Watt
Ohio State University

Catheters are used routinely in a number of extended durative surgical procedures. Catheter-associated urinary tract infections (CAUTIs) and catheter-related blood stream infections (CRBSIs) occur in a significant number of cases; the consequences of these infections are a \$2.3 billion annual cost to the U.S. health care system and contribute to 80,000 deaths per year.¹ The current methods for preventing catheter related infections are impregnation or coating of biocide on the catheter which releases said biocide to kill the bacteria. The problems with these approaches are the loss in effectiveness over time and the overwhelming use of antibiotics, which may lead to bacterial resistance.^{2,3} To solve this problem, we are incorporating quaternary ammonium compounds by surface functionalizing thermoplastic polyurethane (TPU) containing 3-allyloxy-1,2-propanrdiol in the backbone, which provides a site for post-processing functionalization through a disulfide-ene click reaction using Irg-2959 as a photo initiator. The structure of the QAC-disulfides were confirmed using 1H-NMR and XPS was utilized to confirm the presence of QAC functionality on the surface. Possessing QAC functionality on the surface of the TPU should provide a contact-active material with antimicrobial activity towards both gram negative and gram positive bacteria.⁴ To produce most effective antimicrobial TPU, a series of QACs containing various spacer lengths between the polymer backbone and the quaternary ammonium group (3, 6, and 8 carbons) and various alkyl tail lengths (10, 12, and 16 carbons) will be explored. The antimicrobial effectiveness will be tested against gram-positive and gram-negative by our collaborators at Cook Medical.

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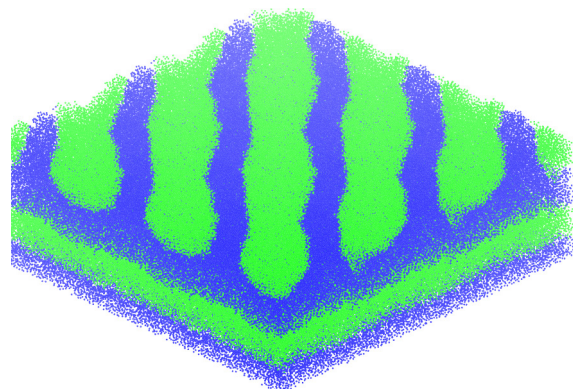
Advisors: Dr. Matthew L. Becker, Zachary K. Zander, Yaohua Gao, Joe Conti, Alec Cerchiari; The University of Akron

39. The Effects of Substrate on the Morphology of Solvent-Swollen Block-Copolymer Thin Films

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The unique property of micro-phase separation in block copolymers (BCPs) has shown a great potential for the development of self-assembling nanostructures for a wide range of applications including microelectronics and microlithography. In thin film form, BCPs morphologies can be used as a template for pattern transfer onto an underlying substrate. Casting a BCP thin film from solvent(s) onto a substrate often results in non-equilibrium and kinetically-trapped disordered states with poor, uneven pattern formation. Heating the films above the limiting glass-transition temperature (T_g) leads to better long-range order and registry. However, with increasing molecular weight, thermal annealing becomes impractical. Solvent vapor annealing offers an effective route to obtain patterned structure via exposure of BCP thin-films to solvent(s), decreasing the bulk T_g of the blocks while increasing mobility. To understand the dynamics of phase separation and ordering during solvent annealing, we perform coarse-grained molecular dynamics (MD) simulations of solvent-swollen BCP films to systematically study the effects



of changing the film thickness, the interactions of copolymers and solvents, the relative volume fraction of constituting blocks and solvents, and the strength of the substrate. The end goal of this study is to ultimately develop a phase diagram for BCP thin films as a function of different swelling ratios, block fractions, substrate-polymer interactions.

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40. Effect of Chain Interpenetration in Polymer Brushes on the Study of Surface Layer MALDI Desorption

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Due to technological advances at the nanoscale, the ability to observe materials at interfaces has become crucial. The use of polymer brushes to analyze the behavior of trace materials has been discussed in scientific literature, but this technique has yet to be investigated. Being able to distinguish materials that have either adsorb to the surface of brushes or absorbed into the system of brushes is of great significance and is the first step in understanding surface segregation and how it affects surface layer analysis. Surface layer matrix-assisted laser desorption ionization time-of-flight mass spectrometry (SL-MALDI) is an emerging, surface sensitive, analytical technique that may be capable of making this distinction without alteration to a system.

The role of brush/free chain interpenetration on SL-MALDI analysis is explored in this study. We hypothesize that even though chains captured by the brush surface may be located partly within the brush they can still be desorbed and ionized so, therefore, they may be detected. Furthermore, in this process, it is significant to study how readily embedded chains can be released from the surface and to what extent this will affect surface measurement. In this experiment, in order to obtain a SL-MALDI spectrum, a solvent-free MALDI technique is used. This technique utilizes a dry powder to avoid disturbing the surface. The sample to be used consists of two layers: a brush layer and a perdeuterated polystyrene (dPS) layer.

Advisors: Dr. Mark Foster, Jake Hill; The University of Akron

41. Optimizing the Ionic Conductivity of a Solid Polymer Electrolyte

Daniel Whitcomb
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It has long been desired to use Lithium metal as the anode for Lithium-ion batteries instead of graphite, as Li can provide approximately ten times greater energy density. This has been difficult to achieve due to the tendency of Li ions to deposit on the surface of Li metal in liquid electrolyte, growing dendrites that can eventually pierce the membrane of the cell. The challenge for researchers has been to develop a solid polymer electrolyte (SPE) that offers a comparable ionic conductivity to that of a liquid electrolyte and can withstand a wide range of temperatures. The SPE will be comprised of a Lithium salt (LiTFSI), a polymer [poly(ethylene glycol) diacrylate (PEGDA)] with a well-conformed structure and high tensile strength, and a plasticizer (succinonitrile) to lower the glass transition temperature of the polymer and to dissociate the electrolyte. The goal of this project is to determine optimal film thickness as well as a precise plasticizer to polymer to ionic salt ratio that offers a SPE with the best ionic conductivity at various temperatures. This will be accomplished by assembling cells using stainless steel electrodes and SPE's of constituent ratios ranging from 25% to 40% by mass and measuring the resistivity by way of A.C. impedance testing in a variable temperature range of 25°C to 120°C. The ratios of 25:40:35, 35:40:25, and 35:30:35 exceeded the DOE requirement at 25°C, and all ratios except for 40:35:25 exceeded the requirement by 60°C.

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42. Understanding the Role of Surface Chemistry and Humidity in Gecko Adhesion

Chelsea Zoltowski
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Geckos have been studied due to their amazing ability to adhere to a multitude of surfaces. It has been found that an increase in humidity increases a gecko's adhesion for live animal testing. It was believed for a long time that gecko hairs are made of keratin until recently where it was found that geckos leave footprints behind. These footprints were analyzed using mass spectroscopy among other techniques and a phospholipid, dipalmitoylphosphatidylcholine (DPPC), was identified to be a key unbound lipid in the gecko's toe pads². To eliminate animal behavior, we have tested individual strips of lamella isolated from a gecko's shed to see if a similar trend in adhesion is observed with increasing humidity. Our results indicate that force trends obtained with sheds differ from the live gecko testing. To study the role of the lipids we delipidized the toe sheds and tested them at varying humidities and compared the results to the untreated sheds.

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