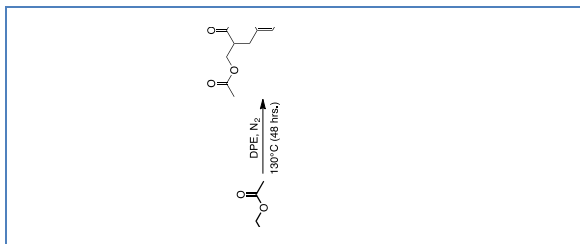


Synthesis of Crosslinked Polymers Utilizing 2-Bromo-3-Hydroxypropionic Acid

Cristel Bateria
The Ohio State University

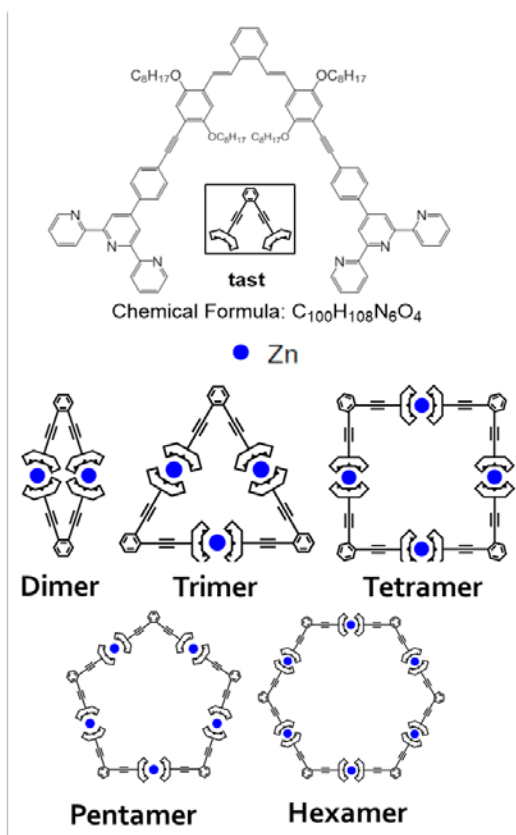


Polycondensation of lactic acid and 2-bromo-3-hydroxypropionic acid under acidic conditions yields poly(lactic acid-co-2-bromo-3-hydroxypropionic acid). This functional copolyester undergoes a crosslinking reaction in the presence of diphenyl ether, presumably via a dioxolenium ion that is generated at the brominated sites. The dioxolenium ion is generated at elevated temperatures or in the presence of silver salts such as silver trifluoromethanesulfonate, and reacts with diphenyl ether by an electrophilic aromatic substitution. We are developing this crosslinking chemistry further by incorporating the 2-bromo-3-hydroxypropionic acid unit into other condensation polymers such as polyurethanes and other polyesters; by investigating other electron-rich aromatic compounds such as anisole that will react with the polymeric dioxolenium ions; and by developing crosslinking agents based on multiple 2-bromo-3-hydroxypropionic acid units that will react with commercial aromatic polymers such as polyetherketones, poly(phenylene oxide), and polystyrene. The structures and molecular weight of the new array of crosslinkable polymers will be characterized using nuclear magnetic resonance spectroscopy, and gel permeation chromatography, respectively. The thermal, mechanical and/or rheological properties of the crosslinked polymers will be characterized using a differential scanning calorimeter, an Instron and/or a rheometer, respectively. Preliminary results support the proposed rearrangement, indicated by the bromohydrin methine shift in the H NMR spectrum of the reaction product between the crosslinking unit and diphenyl ether under heat.

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

Using Ion Mobility Spectrometry (IMS) to Differentiate Metallomacrocycle Structures and Defining Experimental Collision Cross-Sections

Anthony Brautigam
The University of Akron, Akron, OH



Collision cross-section (CCS, Ω) data was determined experimentally for metallomacrocycle (MMC) structures using ion mobility spectrometry (IMS) hyphenated to electrospray ionization time-of-flight mass spectrometry (ESI-ToF-MS). The MMC was synthesized by the chelation of bisterpyridine ligand derivatives (tast) to zinc atoms, and the subsequent addition of PF_6^- counter-anions. Potential MMCs in question include dimer, trimer, tetramer, pentamer, and hexamer species. IMS added a second dimension of separation to help elucidate MMC structures, and aided in obtaining experimental drift times (t_d).

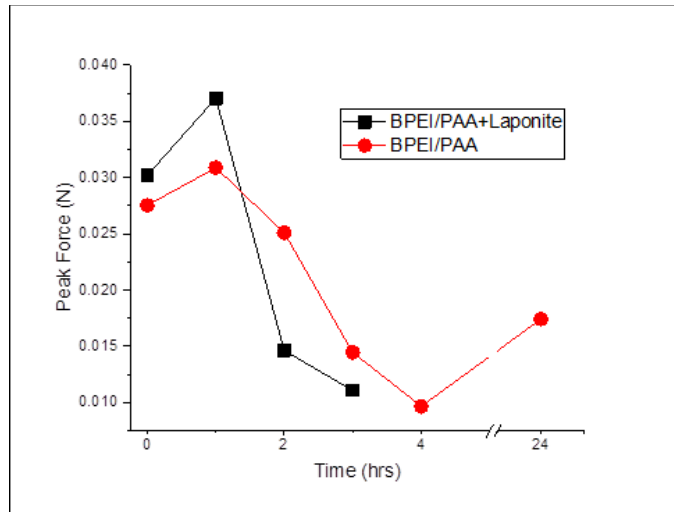
Experiments conducted on Zn-tast revealed multiple dimer, trimer and tetramer MMCs. Mass spectrometry analysis clarified the existence of Zn-tast MMCs with varying amounts of PF_6^- counter-anions, resulting in MMCs with diverse net charges, and subsequently several detectable molecular mass to charge (m/z) distributions. Using poly-DL-alanine, as a standard calibrant, corrected drift times were calculated for the determination of experimental Zn-tast MMC CCS values.

^a Selim Gerişlioğlu; ^a Kevin Endres; ^b Andreas Winter;
^{*a} Chyrs Wesdemiotis; and ^{*b} Ulrich Schubert
^a The University of Akron, Akron, OH

^b Friedrich-Schiller-University Jena, Jena, Germany

Force Generation and Mechanical Movements in BPEI/PAA Actuating Materials

Erick Brown
St Mary's University



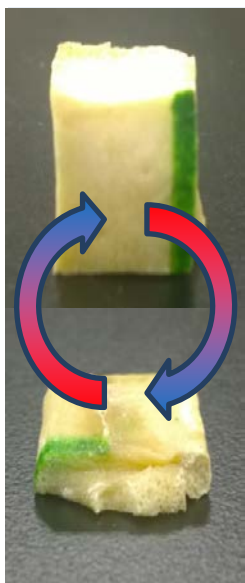
Polyelectrolytes are charged polymers and they can be built up into larger assemblies by using attractive forces between positively and negatively charged polyelectrolytes. Weak polyelectrolytes are only partially charged under most conditions, but they are still attracted to one another via electrostatic forces. These few amount of attractions makes organic solvents, such as ethanol, easily get in between the two polyelectrolytes. These organic solvents can cause mechanical movement through dehydration. Dehydration of polyelectrolytes in layer-by-layer assemblies upon exposure to organic vapor results in a rapid dimensional change that can be used for actuation. By using branched Polyethylenimine (BPEI) and poly (acrylic acid) (PAA), in a layer by layer film we use the shrinking and swelling of the film to produce measureable mechanical movement and force. These films have self-adhesive properties and self-healing with the addition of water. Films were also tested

that had clay particles to see the effect this produced. After exposing the films to solvents the force and mechanical movement of the films diminish by about 42 percent after each hour, but recovered by 25 percent after exposure to water. Films with clay particles created films with a higher peak force, but diminished the film's self-healing properties. Producing smart materials which react to specific external stimuli will apply to various uses, including artificial muscles, cantilever sensors, automated switches, and microbots.

Advisors: Nicole Zacharia, Kane Gu, Medhi Lohrasbi. University of Akron

Fabrication and characterization of thermally induced shape-memory latex foam

Joely Carpio
Florida State University

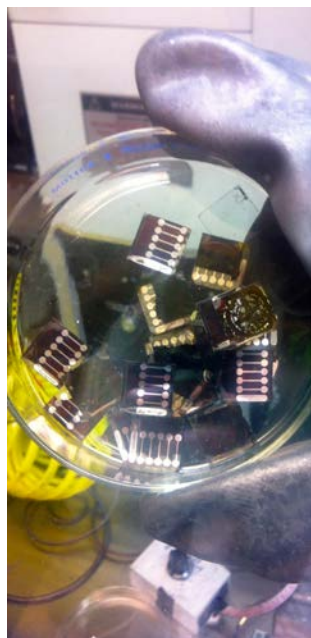


Shape-memory polymers (SMPs) are smart materials capable of changing shape when first deformed, fixed into that temporary shape, and then exposed to an external stimulus, such as heat or electricity, to recover the initial shape. This shape-memory effect can be observed in latex foam swollen in molten stearic acid. After deformation of the foam above the melting temperature of the acid, the crystallization of the acid forms a temporary network within the crosslinked rubber, fixing the shape. Shape recovery is initiated by melting the crystal network. Compression molding was used to fix the foam into a compressed shape. Each iteration of shape-memory cycling demonstrated fixities greater than 90%. For recovery, the first run yielded over 100%; this was attributed to residual strain in the latex fabrication, which recovered the length of the foam longer than its initial length. Subsequent cycles showed recoveries of $100\% \pm 10\%$.

Advisor: Kevin A. Cavicchi, The University of Akron, Department of Polymer Engineering

The Development and Efficiency of Hybrid Perovskite Solar Cells

Bethany Davidson
Texas A&M University - Commerce



The research in the field of renewable energy has been pushed extensively as time goes on. Although methods have been discovered, the demand for more efficient techniques has been a struggle. In the field of solar cells, it is not only the usage of nonrenewable resources that is a concern for the manufacturing of these products, but also the extensive environmental control. Through the idea of using polymers as a way to create solar cells we eliminate the costly construction requirements for the facilities needed to synthesize these materials and the prospect of exhausting resources.

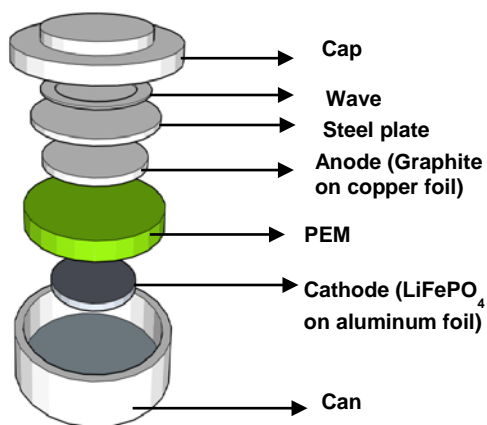
By using a process of sonicating, we are able to purify the indium tin oxide (ITO) coated glass substrates, and followed by ultra violet light treatment, we change the surface energy and work function of the ITO substrate. Our PEDOT:PSS (poly(3,4-ethylendioxythiophene)-polystyrene-para-sulfonic acid) is then spin coated on in an atmosphere environment under a vent-a-hood. Later substrates are moved into a gloved box filled with nitrogen to have the active layer composed of donor polymer and PCBM (1-(3-methoxycarbonyl) propyl-1-phenyl[6,6]C₆₁) acceptor spin coated on. Lastly, by using a thermal evaporator the aluminum top layer is added. Through different formulas for the active layer the goal is to eventually produce a solar cell that can compete with the multi-crystalline silicon solar cells that are used at a 14%-19% efficiency.

Advisors: Dr. Xiong Gong;
Mentor: Chang Liu

Dept. of Polymer Engineering, The University of Akron, Akron, OH 44325

Development of Ion-Conductive Polymer Electrolyte Membranes by Complexation of Polyethylene Glycol-Amino Carbamate with Bis(trifluoromethane)sulfonimide Lithium Salt

Janel Dempsey
John Carroll University



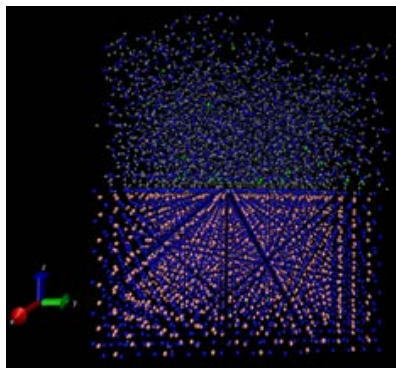
Most lithium-ion batteries used today consist of lithium salt dissolved in ethylene carbonate solvent, a low viscosity liquid that facilitates diffusion of lithium ion, but is also flammable. We suggest replacing this flammable solvent with a new electrolyte system that retains free movement of lithium ion and binds well with the electrodes of the battery. Although polymer electrolyte membranes (PEMs) are advantageous because they are nonflammable and chemically stable, they possess low ionic conductivity at low temperatures and are often brittle.

Bis(trifluoromethane)sulfonimide lithium salt (LiTFSI) was chosen as the lithium-containing ionic salt used in the proposed PEM due to its high conductivity in any medium and low toxicity of the TFSI anion. Varying compositions of lithium salt and polyethylene glycol-amino carbamate (PEGAC) were prepared to determine a temperature vs. composition phase diagram of the two components. Differential scanning calorimetry revealed that while all samples possessed glass transition temperatures below 0° C, those with lower weight percentages of lithium salt remained rubbery solids at lower temperatures. The ionic conductivities of these samples were determined by impedance measurement and plotted as a function of temperature. Upon determination of the ionic conductivities of identical fractions of polyethylene glycol diacrylate (PEGDA), used in commercial lithium-ion batteries, and LiTFSI, the PEGAC/LiTFSI system showed higher ionic conductivities at all temperatures. At present, the working voltages of full constructed batteries containing lithium iron phosphate cathodes and graphite anodes are being measured. Cyclic charge-discharge tests will also be performed to measure the performance of this constructed battery over time.

Advisors: Guopeng Fu, Dr. Thein Kyu – University of Akron College of Polymer Engineering

The Structure of Water on Charged Sapphire Surfaces

George Louis Eason
Christian Brothers University



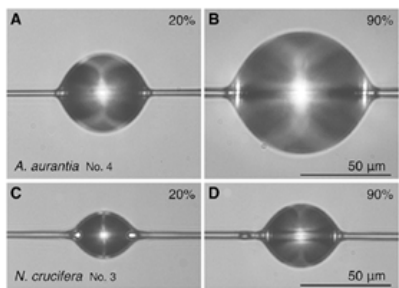
Molecular Dynamics Simulations is commonly used to study and predict physical properties of materials. Of interest in this research are the interfacial surface properties of water on positively and negatively charged sapphire surfaces. Surface charge is manipulated by adjusting the ion type and concentration in ‘solution’ and by doing so, the properties at that surface are affected. With a known volume and mass, along with a specified concentration of ions, more detailed studies of water-sapphire surface interactions are conducted. Visual Molecular Dynamics software is used to visualize the systems and create multimedia representations of what occurs. A 20% negatively charged surface has been simulated, made by placing OH⁻ groups on the substrate and neutralizing the system with Na⁺ ions, resulting in a total count of 15012 atoms. Simulation time was 4 ns, and densities of the substrate, water, and Na⁺ with respect to the normal of the substrate surface (z axis) were calculated using a binning partition of dz as 1.0 Angstroms. The bulk density of water was reached about 7 Angstroms away from the surface, sapphire density oscillated about the accepted density range due to layering and its crystalline structure, and Na⁺ density peaked an Angstrom above the interface, indicating a strong migration of positive ions to the negatively charged surface. Molecular orientation and the mean cos(Θ) as a function of distance from the sapphire surface were also calculated, and these indicated a strong effect of the negatively charged surface. Water molecules oriented themselves with their dipole moment pointing towards the substrate surface, with the mean cos(Θ) achieving a minimum at the interface of about -0.3 at the sapphire-water interface, and increasing in value as z increased.

Advisors: Dr. Mesfin Tsige, Mr. Selemon Bekele, The University of Akron

Understanding the Function of Hygroscopic Organic Salts in Viscid Spider Glue

Jordan Fitch
University of Mount Union

Orb web spiders utilize viscid silk, a type of capture silk, which displays a unique hygroscopic response. As a result of this uptake in water from their surroundings the spiders have produced a glue that reaches its maximum adhesion at the foraging humidity for each species of spider which can be anywhere between 30-90% RH depending on the species. The changes in adhesive properties of the glue originate from a change in viscosity as the glue absorbs water from its surrounding atmosphere increasing the glue droplets overall size. Previous work has hypothesized a source of variation in glue to be the hygroscopic organic salts. We have measured the mass uptake of these hygroscopic salts as a function of humidity using a microbalance modified to control humidity. From this data several potential trends relating the amide and the trimethylamine functional groups to large hygroscopic responses were identified. This study helped explain how spiders tune the adhesive properties of their glue using organic salts.

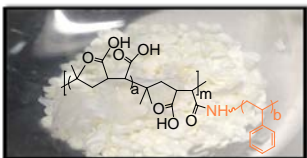


Opell et al. *J. Exp. Biol.* **216**, 3023-3034

Advisors: Gaurav Amarpuri, Dharamdeep Jain, Dr. Ali Dhinojwala, Dr. Blackledge, University of Akron

Synthesis of a Hydrogel via Grafting of Polystyrene onto an Isobutylene-Maleic Anhydride Alternating Copolymer

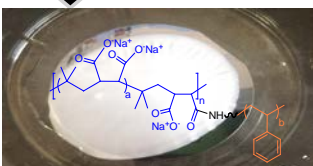
Taylor Freeman
Washington and Jefferson College



DMF
Chloroform



NaOH (aq)



Hydrogels are formed by networks of hydrophilic polymer chains swollen by a large amount of water. They do not dissolve in water because all polymer chains are integrated into one network by either covalent or physical crosslinks. With their high water content, minimal surface friction, and degree of flexibility, hydrogels are ideal materials for a number of biomedical applications such as wound dressings and eye implants.¹ However, in the absence of reinforcement hydrogels have been known to display extremely weak mechanical properties. The purpose of this project is to develop a strong hydrogel using lessons learned from rubber reinforcement. The precursor polymer for hydrogel was synthesized via grafting amine-terminated polystyrene onto an isobutylene-maleic anhydride alternating copolymer. Hydrogels were processed through development, neutralization, and swelling of a precursor polymer film with an aqueous basic solution. Polystyrene glassy domains act as physical crosslinks and reinforcing fillers to give the gel high strength. The hydrogel will be characterized using tensile tests to determine its strength.

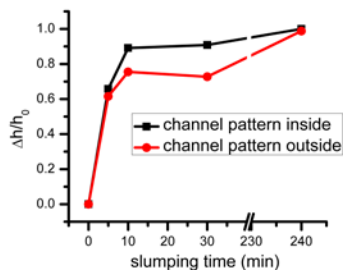
¹ Ahmed, Enas M. "Hydrogel: Preparation, characterization, and applications: A review." *Journal of Advanced Research* 6 (2015): 106. Print.

Advisors: Dr. Li Jia, The University of Akron

Slumping of Hierarchically Patterned Thermoplastic Polymer Thin Films

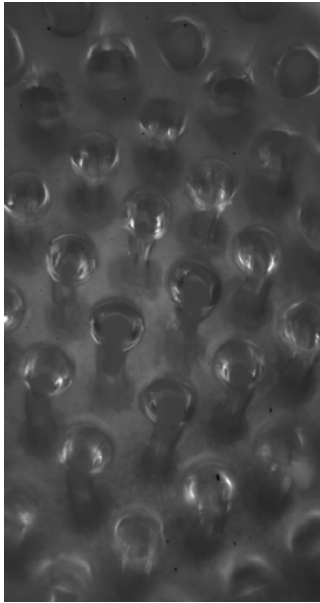
Abigail Gresser
Wright State University

Hierarchical patterning of thermoplastic polymer thin films can be achieved by layering nano and micro-scale patterns onto the films using nanoimprint lithography. This process creates conditions far from equilibrium, and residual stress remains within the patterned polymer. These stressed patterns are susceptible to "slumping", a form of decay in which the height of the pattern and the sharpness of the features decrease. The slumping of the nanopattern in hierarchically patterned polystyrene films is expected to progress at a slower rate due to the stabilizing presence of the micropattern. Additionally, the phenomenon of slumping is expected to be governed by two separate driving forces: residual stress and diffusion. Atomic force microscopy (AFM) will be used to measure the vertical height differences after the films are exposed to temperatures higher than the glass transition temperature, and the slumping behavior is expected to meet time-temperature superposition.



slumping behavior is expected to meet time-temperature superposition.

Advisors: Dr. Alamgir Karim, Ying Chen, College of Polymer Science and Polymer Engineering, The University of Akron



Synthetic Gecko Adhesion at Different Humidity Settings

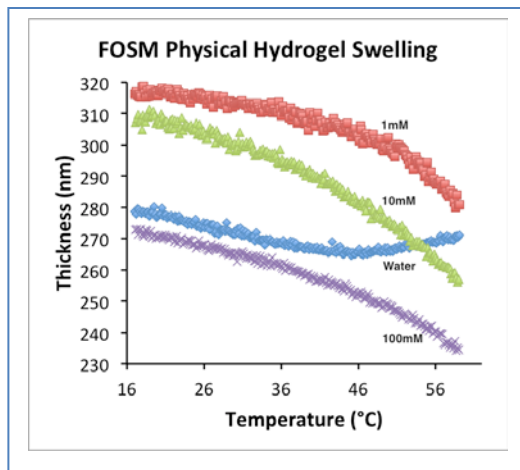
Oscar J. Guerrero
University of Texas Rio Grande Valley

Geckos have been shown to adhere to many surfaces, including extreme environments, such as under at different humidity percentages. Hence, when creating synthetic gecko hairs, the effects of humidity on these are considered. In fact, synthetic gecko hairs have been shown to respond to humidity just like the hairs of geckos. Therefore, the synthetic gecko adhesion as a function of humidity is studied with the goal to find out why humidity affects its adhesion on different surfaces. This was done through shear tests and JKR tests on three humidity settings at room temperature. Such tests are done on the hydrophilic surface glass and the hydrophobic surface OTS coated glass to observe the effects of humidity on each. Outcomes of this research could help with the design of fibers whose application may include on climbing up any surface on buildings for shipping, cleaning, and simply moving stuff up either for construction or other purposes in different humidity environments.

Advisors: Dr. Ali Dhinojwala, The University of Akron

Impact of Salt Concentration on Temperature Dependent Swelling of Physically Crosslinked Hydrogel Thin Films

Andrew Johnson
Geneva College



The swelling behavior of hydrogels in water with ions is important for their use *in vivo* or for transdermal drug delivery. The swelling of the hydrogel impacts its ability to transport therapeutic molecules. In this work, we aimed to understand the influence of both salt and temperature on swelling of physically crosslinked hydrogels. Two different random copolymers containing N,N-dimethylacrylamide (DMA) and either: 2-(N-ethylfluorooctane sulfonamido) ethyl *acrylate* (FOSA) or 2-(N-ethylperfluoro-octane sulfonamido) ethyl *methacrylate* (FOSM) were examined to understand the impact of the nature of the physical crosslink on swelling. These copolymers were coated on as thin films on silica coated quartz crystals. The swelling changes were measured using spectroscopic ellipsometry (SE) and Quartz Crystal Microbalance with Dissipation (QCM-D) as a function of temperature from 15 to 60 °C to obtain thickness and mass information, respectively. Due to the physical constraint of the substrate, the swelling occurs only in the thickness direction. The influence of salt on the swelling is non-monotonic with an increase in the swelling for low salt (NaCl)

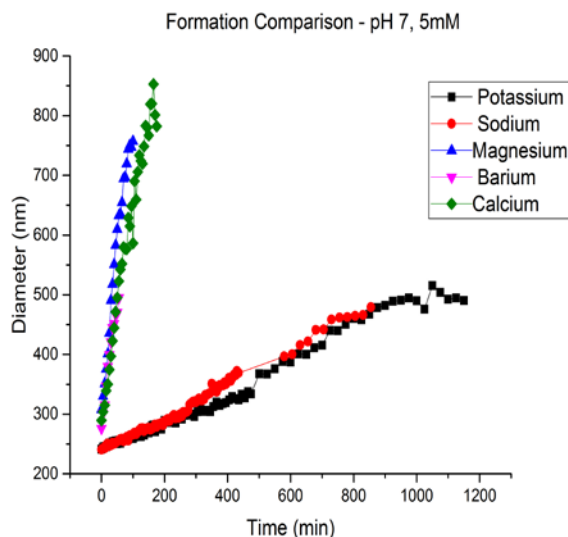
concentration (1 and 10 mM) and a decrease at the highest concentration (100 mM) in comparison to pure water. In general, the swelling decreases as temperature increases. In pure water, there is an increase in swelling at temperatures greater than 43 °C. This temperature corresponds to the T_g for the physical crosslink nanodomains. All of the salt solutions show continued decreased thickness trend above 43 °C. As the salt solutions continue to swell, this suggests that the relaxation of the nanodomains is suppressed by the ions from the salt.

Advisor: Dr. Bryan Vogt, University of Akron, Department of Polymer Engineering
Graduate Mentor: Clinton Wiener, University of Akron, Department of Polymer Engineering

Evaluating Polyelectrolyte Complex Stability in the Presence of Ionic Kosmotropes and Chaotropes

Matthew Knierman

Rose-Hulman Institute of Technology



Previous research on the behavior of weak polyelectrolytes in aqueous solutions proves the accelerated formation and coagulation of polyelectrolyte multilayers (PEMs); additionally, the addition of salts in low concentrations assists in the formation of coacervates. While change in salt concentration has been studied, change in cation and anion has not. Therefore, the objective of this set of experiments is to observe and determine the effects of changing the complexed cation or anion in a Branched Polyethylenimine (BPEI) / Polyacrylic Acid (PAA) complex in order to assess the kinetics of forming these complexes both in initial formation and stability over time. These changes will be assessed using a zeta potential analyzer to take DLS measurements over an extended period of time. Several variables are affected by changing ions, such as charge, electronegativity, and atomic radius. Since these variables cannot be isolated, analysis consists of comparing trends seen in the data to the Hofmeister Series or elemental trends. For

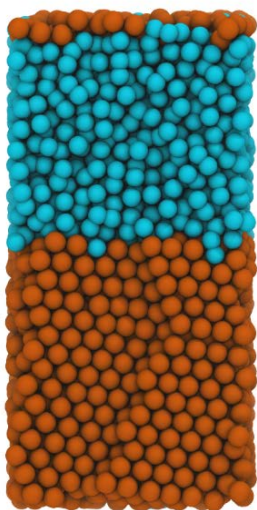
these experiments, both effective particle diameter and polydispersity will be considered over time.

Advisors: Dr. Nicole Zacharia, Huan Zhang – University of Akron

Glass Formation near Covalently Grafted Interfaces

Jonathan Lee

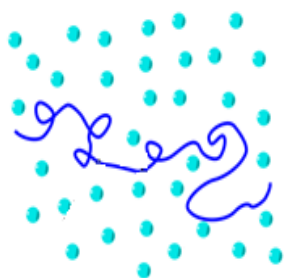
Rose-Hulman Institute of Technology



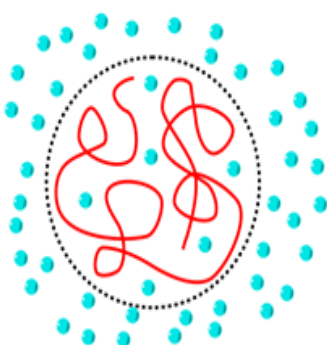
We investigated the effects of the interfacial energy between nanoconfined crystalline and amorphous polymer domains on the glass transition temperature of the amorphous polymer. By employing a molecular dynamics simulation software, we simulated a nanolayered system of an amorphous and crystalline domain. This was used to obtain the segmental relaxation time τ_α , used to characterize the effects of the crystalline layer on the dynamics of the amorphous layer. The results showed that the glass transition temperature T_g of the amorphous polymer increases linearly with interfacial energy. By comparing to a bulk system, we see that as the interfacial adhesion energy increases, it causes a shift from enhanced to hindered dynamics in the amorphous polymer, indicated by the increasing T_g . This information will be useful in the development of semicrystalline polymers and thermoplastics, where such rigid amorphous fractions exist.

Advisors: Dr. David Simmons, Jayachandra Hari Mangalara, University of Akron – Department of Polymer Engineering

Water soluble



Coacervate



Increasing the Thermoresponsivity of Coacervate-Forming Biodegradable Polyesters

Michael R. Martinez

California Polytechnic State University

Thermoresponsive polymers are widely studied within the biomaterials field due to their promise as controlled drug delivery agents, injectable scaffolds, and responsive coatings. However, most of these materials lack biodegradability. Recently, the Joy lab has reported a new class of thermoresponsive biodegradable polyesters (TR-PEs) inspired by polyacrylamides and elastin-like proteins (ELPs). The polyesters exhibit tunable cloud point temperatures (T_{cp}) in aqueous solution as shown via UV-vis spectroscopy, $^1\text{H NMR}$, and DLS. However, the T_{cp} of all TR-PEs remained low ($<15^\circ\text{C}$), and higher thermal responsivity would be beneficial for many applications. This study examines the synthesis, polymerization, degradation, and analysis of a new TR-PE bearing a more hydrophilic pendant group, bis-2-methoxyethylamine (BMEA), in the aims of raising T_{cp} . The effect of molecular weight, cosolutes, and comonomers on the resulting thermal response and resulting coacervates is investigated.

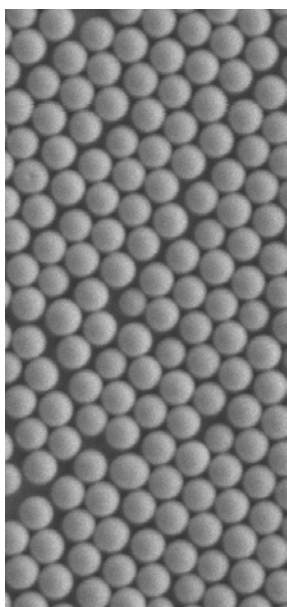
Advisors: John P. Swanson, *Abraham Joy

University of Akron Department of Polymer Science – Akron, OH. 44325

Janus Particles to Clean Oil-Spills

Julia Meyer

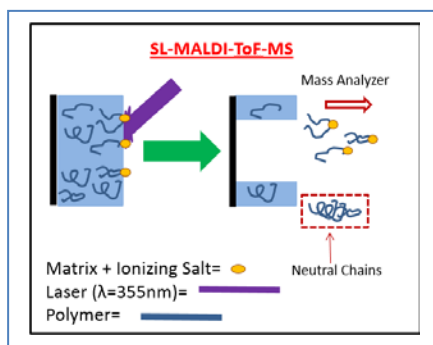
Stark State College



Oil and water do not mix and that is a problem for oil spills because they are difficult to clean. Oil spills happen from accidents when transporting oil or from oil drilling. Using dispersants such as surfactants has known to be one of the best ways to clean oil spills by reducing the interfacial tension between oil-water phase. In this project, Janus particles with anisotropic surface properties are designed to serve as amphiphiles that are expected to form stable emulsions during oil clean-up process. Hydrolysis and condensation of tetraethyl orthosilicate, ethanol, water, and ammonia hydroxide formed hydrophilic silica particles. Langmuir-Blodgett (LB) deposition was used to create colloid monolayers onto silicon wafers. A polydimethylsiloxane sheet was placed onto the monolayer which were heated to 100°C under pressure for a few hours. Silica particles were monodisperse, the environment of the LB process was kept dust-free and the surface pressure was allowed to increase until particles were close enough to create well aligned monolayers. The corresponding isotherm was monitored. SEM images of monolayer showed particles were homogenous in size and closely packed. Silica particles were embedded successfully into polydimethylsiloxane under specified conditions. Methyltrichlorosilane will be used to modify the surface of silica particles to make it hydrophobic. Janus particles will be monitored in action in water and oil using a camera. The surface of the oil will decrease in size showing the interaction with water and oil.

Evidence for Proposed Mechanism of Surface Layer Matrix-Assisted Laser Desorption Ionization Time-of-Flight Mass Spectrometry (SL-MALDI-ToF-MS)

John Meyerhofer
Saint Vincent College



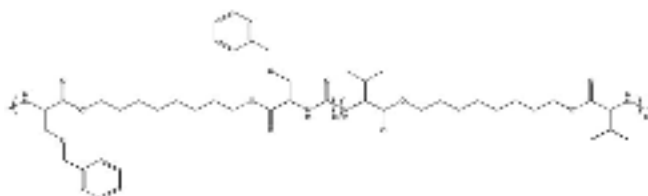
Surface Layer Matrix-Assisted Laser Desorption Ionization Time-of-Flight Mass Spectrometry (SL-MALDI-ToF-MS) is a powerful new technique that when better understood will prove extremely useful in synthetic polymer analysis. It allows for the identification of the repeat unit, end group identity, architecture, and molecular weight of a polymer in an ultrathin layer at the surface of a film. What is unique about this technique is that the matrix and salt necessary for MALDI analysis are placed on the analyte surface without using solvent, minimizing perturbation of the surface and confining analysis to the chains in direct contact with the matrix and salt. Films of nearly monodisperse (polydispersity index < 1.03) polystyrene of various thicknesses were analyzed. The number average molecular weight, M_n , derived from spectra obtained from surfaces with SL-MALDI are an average of 340

Daltons lower than those obtained with conventional MALDI, which probes the molecular weight distribution averaged over all depths. This shift is consistent as film thickness decreases from 90 to 16 nm. These results indicate that the ionization process for SL-MALDI occurs on the surface rather than in the gas phase, since if ionization were in the gas phase, the probability of ionization of a chain from deeper in the sample would be the same as that of a chain from the surface. They also suggest surface enrichment can be detected even for blends with a more subtle entropic driving force than quantified previously.

Advisors: Jake Hill, Dr. Mark D. Foster; Department of Polymer Science, University of Akron.

Phosphorylated Serine-Valine PEU Copolymer as a Caddisfly Mimic Adhesive

Emily O'Brien
The University of Akron



There are many forms of synthetic adhesives, but none replicate the diversity of adhesives created in nature without forfeiting strength. Caddisflies have been shown to produce strong underwater adhesives compatible with virtually any surface^[1]. We aim at synthesizing an adhesive of this caliber with equally diverse capabilities. Caddisfly silk fiber contains about 15% serine residues out of which 60% are

phosphorylated. Phosphoserine residues crosslink with divalent cations like Ca^{2+} to impart strength to the fiber^[2]. We attempted to synthesize a Poly(ester-urea) copolymer of serine-valine amino acids to mimic the caddisfly's natural silk. A copolymer with 20% serine concentration was synthesized to study the impact of phosphorylation on adhesion. The monomers were synthesized through esterification reactions. The valine monomer was synthesized in the presence of pTSA and toluene in combination with 1,8 octanediol, followed by recrystallization for purification. The serine monomer was synthesized in an argon atmosphere in combination with DIC, DPTS, and anhydrous DCM. The serine 1,8 monomer was synthesized through DIC coupling of N-Boc-O-Bzl-serine. The monomer was then purified by column chromatography using hexane and ethyl acetate mixture as the eluent. The copolymer was synthesized by interfacial polymerization using triphosgene at a ratio expected to generate a fiber with 20% serine composition. The copolymer was characterized by ¹H NMR, IR, DSC, TGA and contact angle measurement. From NMR about 18% of the serine monomer was introduced in the copolymer. The benzyl groups on the polymer are then deprotected by hydrogenation using 10% Pd/C catalyst. Phosphorylation of the polymer is currently being tested.

[1] Li, A., Jia, M., Ma, Y., Jiang, W., & Wan, X. (2014). Humid Bonding with a Water Soluble Adhesive Inspired by Mussels and Sandcastle Worms. *Macromolecular Chemistry and Physics Macromol. Chem. Phys.*, 429-459.

[2] Stewart, R., & Wang, C. (2013). Adaptation of Caddisfly Larva Silks to Aquatic Habitats by Phosphorylation of II Tihrin Series. *Biomacromolecules*, 909-924.

Advisors: Dr. Matthew Becker, Vrushali Bhagat, at The University of Akron

Understanding the Effects of Freezing Water on Failure of Transmission Pipeline Coatings

Kelsey Ortiz
Trine University

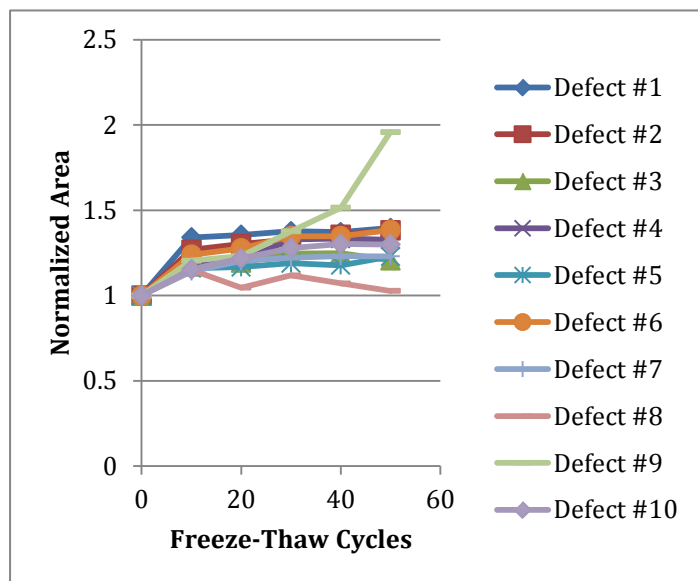


Figure 1: Normalized Area of Defect vs. Freeze Thaw Cycles on 203- μm thick polyurethane coating

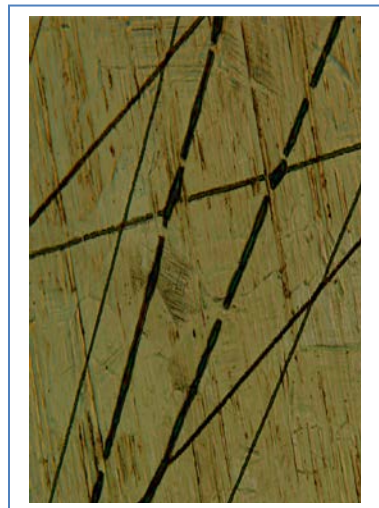
propagating. As a result of this research, it was found that after 50 freeze/thaw cycles, the defects in the polyurethane coating (203- μm thick) expanded in area after 10 cycles, but then stayed constant (see **Figure One**). Additionally, after 200 cycles, there was no crack propagation from defects in 203- μm thick polyurea coating. Similarly, after 50 cycles, there was no crack propagation from the defect in 1600-micron thick urea coating. In conclusion, defects in polyurethane coating expanded (but did not crack) due to polyurethane's elastic property. Polyurea is much stiffer than polyurethane, and has resisted crack propagation thus far.

Advisors: Dr. Sadhan Jana, Maher Al Rashed
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Electrospinning of metal oxide and metal carbonate fibers from low cost precursors for anodes in sodium ion batteries

Jake Polster
The College of Wooster

Redox-active metal oxides can exhibit high energy densities when used as anodes in Na^+ batteries. However, the low ionic conductivity of these materials leads to slow transport of Na^+ ions through the solid host, which limits their rate capability. In this study, we seek to overcome these transport limitations through metal oxide nanofibers by electrospinning to decrease the transport path length through the active material. ZnCo_2O_4 is known to exhibit excellent cycling stability and is examined as the model metal oxide in these studies. To fabricate these nanofibers, we utilized metal nitrates ($\text{Zn}(\text{NO}_3)_2$ and $\text{Co}(\text{NO}_3)_2$) as

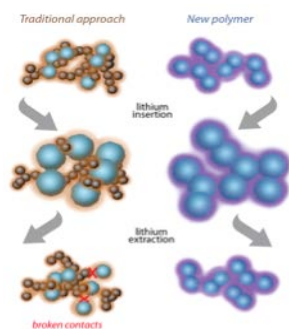


low cost metal sources and citric acid to control oxidation through a carbonate intermediate. The spinning dope also contained high molecular weight poly(ethylene oxide) (PEO; $M_w = 5,000,000$ g/mol) to provide the requisite extensional viscosity to promote formation of nanofibers. In order to assess the effect of size on electrochemical performance of ZnCo_2O_4 anodes, fibers were fabricated by electrospinning solutions with varying PEO concentrations (0.5% - 0.85%) and applied voltages (10 kV- 25 kV) to control the average diameter. Electrospinning solution containing 0.85% PEO led to formation of a stable Taylor cone and fibers with average diameter of ~ 3.25 μm , while solutions containing lower PEO concentration generally exhibited poor spinnability with significant droplet formation. Calcination of the well-defined spun fibers to their corresponding ZnCo_2O_4 oxides (350 $^\circ\text{C}$) reduced the fiber diameter to ~ 2 μm ($\sim 36\%$ reduction in fiber diameter). Future studies will involve chemical characterization of metal oxide fibers and testing these fibers as anode materials in Na^+ batteries.

Advisors: Sarang Bhaway, Dr. Bryan Vogt, The University of Akron College of Polymer Science and Polymer Engineering.

Novel Polymers for Energy Storage

Katrina Piemonte
Ithaca College



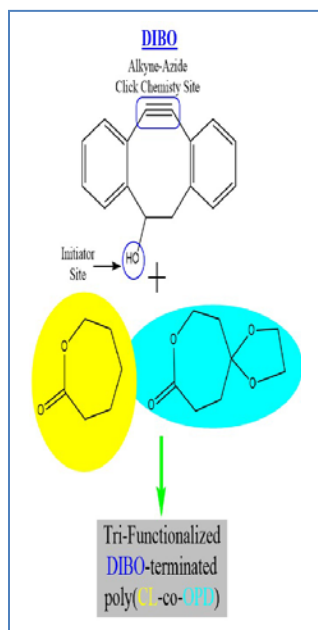
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With the ever increasing concern regarding the use of non-renewable sources of energy, there has been a shift toward discovering green energy sources with recharging capabilities. Lithium-ion batteries offer promising energy producing capabilities due to their high energy density and power density. The electrode material, usually silicon (Si), has high theoretical specific capacitance, but undergoes a large volume expansion and contraction upon lithiation and delithiation. These volume changes result in loss of contact between the electrode and current connector, severely hindering the cycle life of these batteries. Polymers as binders accommodate expansion and contraction, thus limiting pulverization, increasing the cyclization of the battery, and retaining capacity. To achieve polymers with strength and flexibility, we used varying ratios of Poly(acrylic acid) (PAA) to small crosslinker molecules. The resulting polymeric binders were tested in electrodes of lithium-ion batteries by analyzing capacity, efficiency, and cycling performance using the Neware Measurement System. Lithium ion batteries created with polymeric binders have exhibited decreased capacitance fade, a promising outcome when facing the challenges of silicon expansion. We will continue to work toward the creation of a better lithium ion battery with a silicon electrode to achieve a battery that has no capacitance fade, increased efficiency, and increased cycle life.

Advisors: Dr. Yu Zhu; The University of Akron

Functionalized Nanofiber Scaffolds for Nerve Regeneration

Jacob Schimelman
Case Western Reserve University



A scaffold is needed to induce the differentiation of embryonic stem cells (ESCs) to neural progenitor cells without the use of xenogeneic factors for neural regenerative applications. Tri-functionalizing a poly(ϵ -caprolactone) (PCL) co-polymer scaffold with the peptides RGD, FGFp, and YIGSR will specifically induce differentiation to neural progenitor cells. The scaffold is manufactured via electrospinning, a technique known to produce fine-tunable fibers in the nanoscale. The significance of this approach is the metal-free click chemistry utilized for tethering each of the peptides to the scaffold. To end-functionalize PCL, 4-dibenzocyclooctynol (DIBO) is used as an initiator in the PCL co-polymer synthesis. This novel click chemistry functionalization process surpasses the current state-of-the-art which is a nanofiber having only a single, tethered peptide functionalization site. The synthesis of DIBO consists of four reactions. This summer, three of the four products of the reaction scheme have been synthesized. PCL of targeted molecular weight was synthesized and is being used to optimize electrospinning parameters in order to achieve a fiber diameter between 300 nm and 400 nm, which is native to extracellular matrix.

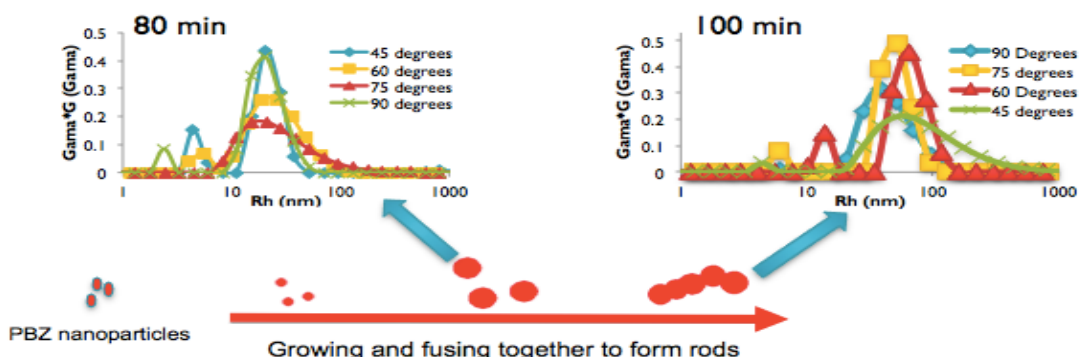
Advisors: Elena Silantjeva, Matthew L. Becker. University of Akron

Understanding of nanometer size building blocks in preparations of gels and aerogels from polymeric precursors

Shantel Thomas

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Advisors: Dr. Sadhan Jana and Dr. Tianbo Liu, University of Akron, Akron, Ohio



The question of my research is how the nanometer sized space-filling networks of polymers form and builds a polymer aerogel. The networks of aerogels are created by nucleation and growth or by spinodal decomposition but no evidence has been presented. The main aspect of this research is to study the growth of these networks in gelation syndiotactic polystyrene and polybenzoxazine from solutions while creating the aerogels. Using laser light scattering technology on gelation process, the investigation of how the solid polymer network forms is established. The mode of solid network formation correlates to the porosity and the surface area of the polymer aerogels. From results, as the concentrations of polybenzoxazine increases the gelation time decreases. Using dynamic light scattering, the data shows that the behavior of polybenzoxazine particles in NMP creates rod-like particles in the solution. Over a period of time, the particles start at a smaller size and grow bigger and then eventually fused together to form the rods. As for syndiotactic polystyrene in THF, the particles in the solution form a fibril-like network. The method of phase growth is still in question whether or not the spheres grow bigger and bigger to form rods that fuse together to make the fibers or if the solution automatically form the fibers.