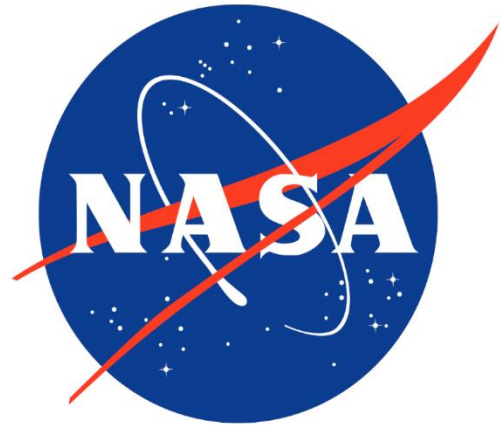


The 16th Annual

August 2nd, 2019

Northeast Ohio Undergraduate Research Symposium (NOURS)



The
University
of Akron



CASE WESTERN RESERVE
UNIVERSITY EST. 1826



*Hosted by the Cleveland State University REU Site
Synthesis, Assembly, and Characterization of Soft Matter*

Co-sponsored by Case Western Reserve University, Kent State University, NASA Glenn Research Center, the University of Akron, and the National Science Foundation



CLEVELAND STATE UNIVERSITY

Sixteenth Annual Northeast Ohio Undergraduate Research Symposium August 2nd, 2019

Welcome

The Cleveland State University (CSU) Soft Matter REU program is excited to host the 16th annual Northeast Ohio Undergraduate Research Symposium (NOURS). We would like to extend a warm welcome to all the undergraduate student researchers and to our colleagues from Case Western Reserve University, Kent State University, NASA John H. Glenn Research Center, and the University of Akron. By hosting this symposium, we are pleased to continue the long running tradition of bringing together advisors and summer undergraduate researchers, many of whom are supported by National Science Foundation Research Experiences for Undergraduates (REU). We look forward to an interesting and productive meeting that highlights the research completed this summer by undergraduates in the fields of polymer science and engineering, chemistry, soft matter physics, chemical and biomedical engineering and material science. We would like to congratulate each presenting student on their hard work and perseverance during this summer research session.

The "Synthesis, Assembly, and Characterization of the Soft Matter" REU at CSU is a collaborative effort between the Department of Physics and Department of Chemical and Biomedical Engineering. In the last three years, the CSU Soft Matter REU has hosted twenty-six students from a variety of colleges and universities across the US in nine research labs.

Acknowledgements

This symposium would not be possible without support of the CSU's Office of Research led by Dr. Jerzy Sawicki (Vice President for Research), the College of Graduate Studies led by Dr. Nigamanth Sridhar (Dean of the College), the College of Sciences and Health Professions led by Dr. Meredith Bond (Dean of the College), and CSU's Undergraduate Summer Research Award (USRA) program led by Dr. Daniel Simon (Associate Vice President for Research). We would like to thank the Physics Department led by Dr. Petru Fodor and the Chemical and Biomedical Engineering Department led by Dr. Joanne Belovich for their support. Special thanks to all undergraduate students who are presenting today, their research advisers and mentors, and program directors/managers for making 16th Annual NOURS possible. Finally, we must thank NSF (REU Award # 1659541).

Dr. Kiril A Strelitzky, PI of the Soft Matter REU at CSU

Dr. Jessica Bickel, co-PI of the Soft Matter REU at CSU

Research Symposium Schedule

All events will be taking place in the Student Center ballroom room SC311 on the third floor of the Student Center (#22 on the map below).

| | |
|-----------------|--|
| 8:30am-9:00am | Registration & Breakfast |
| 9:00am-9:05am | Opening Remarks |
| 9:05am-10:05am | Keynote Speaker – Dr. Bill Meyer from NASA Glenn |
| 10:05am-10:20am | Break |
| 10:20am-11:35am | Student Presentations Part 1 (5 Presentations) |
| 11:35am-12:00pm | Group Photo |
| 12:00pm-1:00pm | Lunch |
| 1:00pm-2:00pm | Student Presentations Part 2 (3 Presentations) |
| 2:00pm-3:00pm | Poster Session #1 (Odd Poster Numbers) |
| 3:00pm-4:00pm | Poster Session #2 (Even Poster Numbers) |
| 4:00pm-4:15pm | Closing Remarks |
| 4:15pm-4:30pm | Poster Takedown |

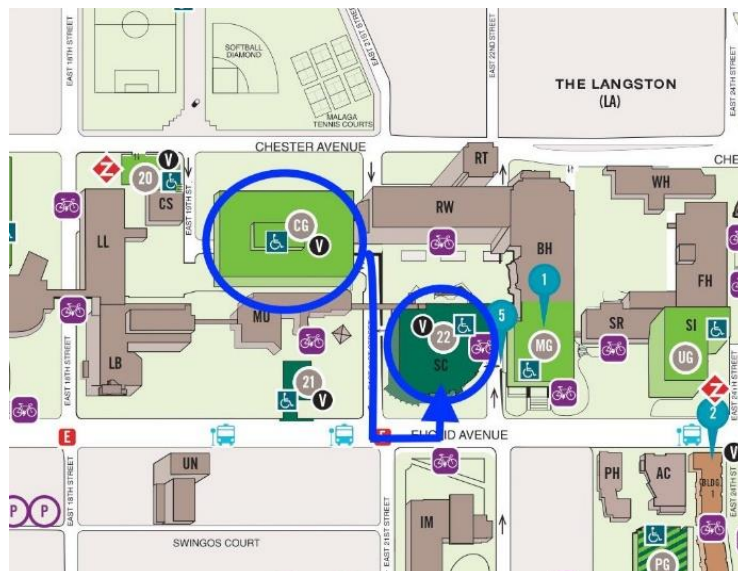
Directions from the central parking garage (CG) to the symposium:

Exit the parking garage right onto East 21st Street.

Take a left onto Euclid Ave.

Take another left to enter the student center.

Proceed to the third floor for NOURS.



16th Annual Northeast Ohio Undergraduate Research
Symposium

Keynote address:

Finding Solutions within Solutions



**William (Bill) V. Meyer, Ph.D.,
Principal Scientist, USRA Fellow
ARA – Advanced Research Associates
(USRA), NASA Glenn Research Center**

Abstract: A brief (and selective) overview of NASA's microgravity colloids program will be shared. This presentation will include an examination of past, present, and planned microgravity colloids research on the International Space Station (ISS). This will highlight work with P&G and Universities in the U.S., Europe, and South Korea, focusing on their science and the techniques used to obtain it.

Biography: Dr. William (Bill) Meyer is a USRA Principal Scientist and Fellow employed at NASA Glenn Research Center. He was initially brought on by NASA to run Advanced Technology Development programs in bulk and surface light scattering. These programs started with a room full of optics, lasers, detectors, and electronics – worked to have them enhanced, miniaturized, and to reduce their power needs and fragility – permitting these types of instruments be used for colloids experiments on the Space Shuttle and on ISS. These microgravity colloids experiments returned several pleasant surprises. Working with NASA HQ he started and plays a significant role in nurturing and growing NASA's colloids program which is flying over a dozen experiments on ISS with science teams from around the world. Bill has organized several international conferences on light scattering whose proceedings were published as special issues of Applied Optics. He has received NASA's Exceptional Technology Achievement Medal and their Exceptional Public Service Metal, along with a Silver Snoopy Award - NASA astronauts' personal award. Bill has an undergraduate degree in philosophy, and a PhD in physics from the University of Amsterdam.

Friday, August 2, 9am, SC 311 (Student Center Ballroom)

Sixteenth Annual

Northeast Ohio Undergraduate Research Symposium

Oral Presentation Schedule

| | |
|-----------------|---|
| 10:20am-10:35am | Lauren Syrup (Kent State University), “Development of neural/glial co-culture for remyelination studies in neurodegenerative disease,” pg. 19, abstract #22 |
| 10:35am-10:50am | Megan Elizabeth Yankulov (University of Akron), “Consequence of Hydrogel Chemistry on Dry and Underwater Adhesion,” pg. 31, abstract #48 |
| 10:50am-11:05am | Quinton Wright (Cleveland State University), “Microfluidic Synthesis and Characterization of Lead Iodide Perovskite Nanoplatelets,” pg.23, abstract #31 |
| 11:05am-11:20am | Jacob Duckworth (Cleveland State University), “Optical Trapping to Investigate Cilia Mechanics,” pg. 31, abstract #47 |
| 11:20am-11:35am | Theresa Nosel (NASA Glenn), “3D Printing of Polyimide Aerogels,” pg. 30, abstract # 45 |
| <hr/> | |
| 1:00pm-1:15pm | Walid Abuhashim (University of Akron), “The Design of 3D-printed Scaffolds for Wound Infections and Inflammation,” pg. 30, abstract #46 |
| 1:15pm-1:30pm | Cole Harlow (NASA Glenn), “.Multivariable Stress Chamber for Partial Discharge Measurements,” pg. 29, abstract #43 |
| 1:30pm-1:45pm | Matthew Sunthimer (Kent State University), “Explorations in cancer treatment: G-Quadruplex binding kinematic,” pg. 26, abstract #37 |

Sixteenth Annual
Northeast Ohio Undergraduate Research Symposium
Poster Presentations

- | | | | |
|-----|---------------------------|-----|-------------------------------|
| 1. | Lindsey Speare (KSU) | 32. | Amanda Dershem (UA) |
| 2. | Elizabeth Amory (UA) | 33. | Alyssa Agler (KSU) |
| 3. | Yuliana Ospina Yepes (UA) | 34. | Grace Burkhart (CWRU) |
| 4. | Ruth Eckman (UA) | 35. | Avery M Gould (UA) |
| 5. | Tristan LaCombe (NASA) | 36. | Jose Luis Pena (UA) |
| 6. | Ifeyinwa Okafor (KSU) | 37. | Matthew Sunthimer (KSU) |
| 7. | Khoa D. Tran (UA) | 38. | Peter Howard (CSU) |
| 8. | Allison Reardon (UA) | 39. | Claire T Senger (UA) |
| 9. | Mansi Peesapati (CWRU) | 40. | Zoe Moore (CWRU) |
| 10. | Adam Chan (UA) | | Victoria McLaughlin (CWRU) |
| 11. | Jacob Martin (CSU) | 41. | Kristen Campobasso (KSU) |
| 12. | Tyler Galbraith (KSU) | 42. | Zane Tolbert (UA) |
| 13. | S Scanlon (CWRU) | 43. | Cole Harlow (NASA) |
| 14. | Tyler Knisley (KSU) | 44. | Stephen F. Adasonla (UA) |
| 15. | Dylan Valente (KSU) | 45. | Theresa Nosel (NASA) |
| 16. | Robert M. Walker (UA) | 46. | Walid Abuhashim (UA) |
| 17. | Corahgan Whipple (KSU) | 47. | Jacob Duckworth (CSU) |
| 18. | Sam Tietjen (CSU) | 48. | Megan Elizabeth Yankulov (UA) |
| 19. | Elizabeth Phinney (KSU) | 49. | Melica Nikahd (NASA) |
| 20. | Emily Williamson (KSU) | 50. | Alexandra Yungblut (KSU) |
| 21. | Andrew Scherer (CSU) | 51. | Tyler Leibengood (CSU) |
| 22. | Lauren Syrup (KSU) | 52. | Mickey Yu (CWRU) |
| 23. | Erik Feeley (KSU) | 53. | Elijah Holder (KSU) |
| 24. | Benjamin Bosela (CSU) | 54. | Naazneen Ibtehaj (CWRU) |
| 25. | Anna Ellis (CSU) | 55. | Bradley Lockhart (CSU) |
| 26. | Adam DeLong (NASA) | 56. | Alex Lovins (KSU) |
| 27. | Kaylynn Cooper (CWRU) | 57. | Jason Vaughn (UA) |
| 28. | Zachary Adams (CWRU) | 58. | Rumbila Abdullahi(UA) |
| 29. | Cagatay Yilmazoglu (UA) | 59. | |
| 30. | Mario Alberto (CSU) | | |
| 31. | Quinton Wright (CSU) | | |

Sixteenth Annual
Northeast Ohio Undergraduate Research Symposium
Poster Presentations (Alphabetical)

- | | | | |
|-----|--------------------------|-----|-------------------------------|
| 10. | Adam Chan (UA) | 22. | Lauren Syrup (KSU) |
| 26. | Adam DeLong (NASA) | 1. | Lindsey Speare (KSU) |
| 56. | Alex Lovins (KSU) | 9. | Mansi Peesapati (CWRU) |
| 50. | Alexandra Yungblut (KSU) | 30. | Mario Alberto (CSU) |
| 8. | Allison Reardon (UA) | 37. | Matthew Sunthimer (KSU) |
| 33. | Alyssa Agler (KSU) | 48. | Megan Elizabeth Yankulov (UA) |
| 32. | Amanda Dershem (UA) | 49. | Melica Nikahd (NASA) |
| 21. | Andrew Scherer (CSU) | 54. | Naazneen Ibtehaj (CWRU) |
| 25. | Anna Ellis (CSU) | 38. | Peter Howard (CSU) |
| 35. | Avery M Gould (UA) | 31. | Quinton Wright (CSU) |
| 24. | Ben Bosela (CSU) | 16. | Robert M. Walker (UA) |
| 55. | Bradley Lockhart (CSU) | 58. | Rumbila Abdullahi (UA) |
| 29. | Cagatay Yilmazoglu (UA) | 4. | Ruth Eckman (UA) |
| 39. | Claire T Senger (UA) | 13. | S Scanlon (CWRU) |
| 43. | Cole Harlow (NASA) | 18. | Sam Tietjen (CSU) |
| 17. | Corahgan Whipple (KSU) | 44. | Stephen F. Adasonla (UA) |
| 15. | Dylan Valente (KSU) | 45. | Theresa Nosel (NASA) |
| 53. | Elijah Holder (KSU) | 5. | Tristan LaCombe (NASA) |
| 2. | Elizabeth Amory (UA) | 12. | Tyler Galbraith (KSU) |
| 19. | Elizabeth Phinney (KSU) | 14. | Tyler Knisley (KSU) |
| 20. | Emily Williamson (KSU) | 51. | Tyler Leibengood (CSU) |
| 23. | Erik Feeley (KSU) | 40. | Victoria McLaughlin (CWRU) |
| 34. | Grace Burkhart (CWRU) | 46. | Walid Abuhashim (UA) |
| 6. | Ifeyinwa Okafor (KSU) | 52. | Yu (CWRU) |
| 47. | Jacob Duckworth (CSU) | 3. | Yuliana Ospina Yepes (UA) |
| 11. | Jacob Martin (CSU) | 28. | Zachary Adams (CWRU) |
| 57. | Jason Vaughn (UA) | 42. | Zane Tolbert (UA) |
| 36. | Jose Luis Pena (UA) | 40. | Zoe Moore (CWRU) |
| 27. | Kaylynn Cooper (CWRU) | 59. | |
| 7. | Khoa D. Tran (UA) | | |
| 41. | Kristen Campobasso (KSU) | | |

2) Effect on the Chain Network of Glassy Polymers from Biaxial Extension

Elizabeth Amory

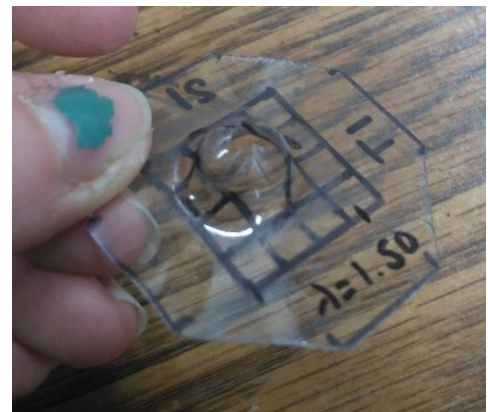
Rowan University

Travis Bate

Dr. Shi-Qing Wang

University of Akron

In a prior study, a molecular model (*J. Chem. Phys.* **141**, 2014) was proposed to explain the yielding and brittle-ductile transitions of glassy polymers. However, the effect of biaxial extension was not explored. Based on our understanding, we expect an increase in ductility when sample is biaxially drawn because twice the number of chains is involved. In this study we began to investigate the effects of biaxial extension on glassy polymers such as polymethyl methacrylate (PMMA), bisphenol-A polycarbonate (PC), and polylactic acid (PLA). The effect of temperature was considered. For temperatures greater than the glass transition temperature T_g we used a custom apparatus that pulls a sample from four sides simultaneously. For temperatures less than T_g we used a customer-made pump system to expand the sample using pressurized water. Using the pump, both PC at ambient and PMMA at 70 °C show ductile behavior and fail at $\lambda = 1.47$ and 1.35, respectively. The effect of pre-melt stretching is currently under investigation.



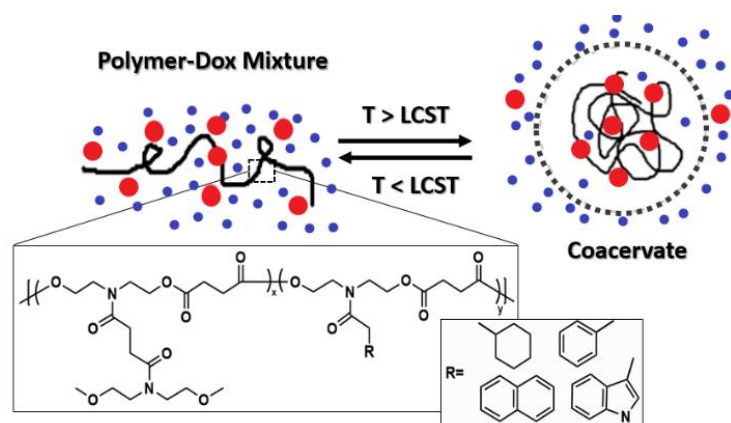
3) Synthesis and characterization of coacervate forming thermoresponsive polyesters for Doxorubicin encapsulation

Yuliana Ospina Yepes
Mangaldeep Kundu, Dr. Abraham Joy

Universidad de Antioquia, Colombia
The University of Akron, Ohio

Encapsulation of chemotherapy drugs, like Doxorubicin (Dox), is a common strategy to reduce toxicity and increase the biological activity against tumor cells^[1]. Coacervate-forming thermoresponsive polyesters (TR-PEs) provide a smart method for drug encapsulation simply by changing temperature of the polymer-drug mixture above the lower critical solution temperature (LCST)^[2]. In this work, Dox was encapsulated inside degradable TR-PEs containing amino acid mimicking pendant groups.

The high molecular weight (65-80 kDa) TR-PEs were synthesized by carbodiimide-mediated polymerization. NMR and GPC techniques were used to characterize the copolymers. Also, UV-vis spectroscopy was used for the cloud point temperature (T_{cp}) measurements (14-29 °C) and to monitor polymer degradation qualitatively. Fluorescence microscopy was used to probe the encapsulation of Dox. The successful encapsulation and release of Dox was monitored by UV-vis spectroscopy. There is a burst release for the initial hours because of the diffusion phenomena. By varying the pendant functional groups, it is possible to increase the efficiency of encapsulation. This study demonstrates that TR-PEs can be exploited as an easier method for drug encapsulation in cancer therapy.



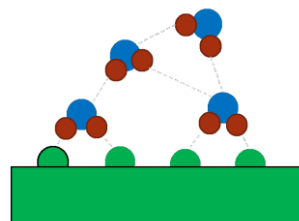
[1] Park, J.; *et al.*, *Nanomedicine*, **2009**, 5(4):410–418. [2]
Cruz, M. A.; *et al.*, *Macromolecules*, **2018** (7):477-481.

4) Impact of Degree of Hydrophobicity on Hydrogen Bonding Percolation at Water-Polystyrene Interface

Ruth Eckman
Dr. Mesfin Tsige
Selemon Bekele

Grove City College
University of Akron
University of Akron

In previous simulations by Bekele and Tsige on the properties of interfacial water molecules in contact with polystyrene surfaces of varying polarity [J. Phys. Chem., 122, 9015-9020 (2018)], a marked change in the rates of interfacial hydrogen bond relaxation times and diffusion of interfacial water molecules was observed at a polarity of about $0.06 N_O / \text{\AA}^2$, which the authors suggested to be the hydrophobic/hydrophilic transition point. In this work, we seek to discover a microscopic explanation for this change in particular and the hydrophobic/hydrophilic transition in general by analyzing interfacial hydrogen bond networks at various degrees of polystyrene surface polarity. As in the original work, geometric criteria based on atomic position are used to determine the presence of hydrogen bonds, and only bonds between water molecules within 3.75\AA of the polymer surface are considered. A modified version of the extended Hoshen-Kopelman algorithm for non-lattice environments developed by Al-Futaisi and Patzek with updates from Metzger, Irawan, and Tsotsas is used to calculate hydrogen bond cluster size at various degrees of surface polarity. Analysis of hydrogen bonds between substrate oxygen and interfacial water molecules indicates a slight change in the rate of cluster quantity growth at approximately $0.04 N_O / \text{\AA}^2$, shortly before the $0.06 N_O / \text{\AA}^2$ point at which the bond relaxation time and interfacial diffusion rate changes were observed in Bekele and Tsige's work. In the future, we hope to further elucidate the implications of these findings with more exhaustive computational and geometric analysis and to explore the hydrophobic/hydrophilic transition in similar systems with different substrates.

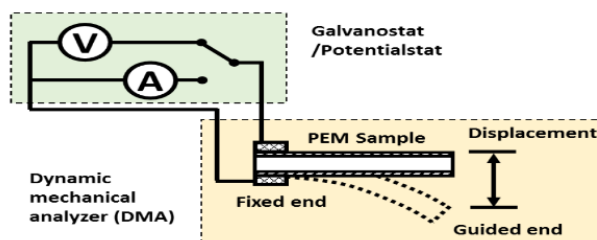


7) Flexoelectric properties of polymer electrolyte membranes based on PEGDA-co-PEGMEA network and Magnesium bis(trifluoromethanesulfonimide)

Khoa Tran
Hamad Albehaijan, Thein Kyu

St. Mary's University
The University of Akron

Solid-state polymer electrolyte membranes (PEM) were originally developed for solid-state Li-ion battery. According to our previous study, these PEMs possess flexoelectric properties, that is, the generation of electrical energy from mechanical deformation. Membranes fabricated from poly (ethylene glycol) diacrylate (PEGDA) are of particular interest because of their simple fabrication. Here, we confirmed the flexoelectric effect of the studied PEM by showing that current and voltage magnitudes are directly proportional to the amplitude of the mechanical deformation. Composition (PEGDA:PEGMEA)/Mg(TFSI)₂ 80/20 shows the highest ionic conductivity at room temperature (~2.56 μS/m). However, the composition (PEGDA:PEGMEA)/Mg(TFSI)₂ 70/30 presents the highest flexoelectric performance (flexoelectric coefficient, $\mu \sim 502 \mu\text{C/m}$). A plausible explanation is that the magnitude of the strain gradient also plays an important role in flexoelectricity. The higher rigidity of sample (PEGDA:PEGMEA)/Mg(TFSI)₂ 70/30 induces a higher strain gradient upon deformation. Additionally, the introduction of dangling PEGMEA side-chains to PEGDA network is proven to be an effective way to improve ionic conductivity and flexoelectric performance.



8) Using Stimuli-Responsive Polymers to Passively Collect/Expel Water Vapor

Allison Reardon
Dr. Hunter King
Aida Shahrokhian

Hanover College
The University of Akron
The University of Akron

Around the world, freshwater scarcity is becoming a more renowned problem. Water vapor can be turned into a source of freshwater by utilizing smart polymers for water vapor capture and release. Poly(N-isopropylacrylamide) (PNIPAM) is one of these smart polymers that is responsive to temperature. When electrospun, the PNIPAM fibers are fibrous in structure, thus allowing for a high amount of surface area for water vapor collection and expulsion. At temperatures below its lower critical solution temperature (LCST), which is around 32°C, PNIPAM exhibits hydrophilic properties and can collect water vapor whereas at temperatures above its LCST it exhibits hydrophobic properties and expels it. In this study, there are four main objectives. The first objective is to characterize the fibers using the scanning electron microscope (SEM) for size and uniformity, thermogravimetric analysis (TGA) for degradation temperature which is around 400°C, and then differential scanning calorimetry (DSC) for glass transition temperature (T_g). The second objective is to thermally crosslink the PNIPAM chains by finding an optimum temperature that is not much higher than its melting point so that the fibers keep their fibrous structure instead of turning into fiber melts, which will allow them to retain a higher surface area. This was investigated using Fourier transform infrared spectrometry (FT-IR) and rheometry. The rheology results show that the gelation temperature of PNIPAM is about 155°C. However, isothermal crosslinking of the polymer for longer period at lower temperatures (120°C) was confirmed using FT-IR. The third objective is to determine how well the fibers collect and expel water vapor in an environmental chamber with controlled relative humidity and temperature for which calibration curves were acquired.

Adam Chan

Grove School of Engineering at the City
College of New York

Tao Zhu

The University of Akron

Dr. Xiong Gong

The University of Akron

Researchers have been focused on perovskite solar cells (PSCs) as an alternative to silicon solar cells due to relative cost effectiveness and the drastic rise in photoconversion efficiency in perovskite solar cells. Efficiency has increased from 3.8% to 23.7% since the discovery of perovskite solar cells in 2009[1]. However, PSCs come with drawbacks such as instability and low absorption spectrum. Thus, we want to optimize the solar cell device structure so that it will minimize energy losses. Perovskite materials exist as hybrid materials with the general formula ABX_3 , where A is methylammonium or formamidium (both organic ions), B being lead or tin ions, X being halide ions[2]. When using lead halide PSCs, absorption spectrum is 800 nm. However, lead-tin blended PSCs have an absorption spectrum of 1040 nm which is correlated to a decrease in bandgap[3]. By introducing n-type conjugated polymer NDI-DPP, it can fulfill three roles (1) low bandgap to broaden absorption spectrum[4], (2) balance hole and electron transfer mobility[4] and (3) potentially forming hydrogen bonds with perovskite ions and its own strong withdrawing groups, potentially hindering ion migration[5]. For future work, we aim to work with lead/tin blended perovskite solutions and NDI-DPP to further enhance the efficiency of perovskite solar cell devices in addition to minimizing energy losses.

16) Formation of Epoxy-based Reactive Coordination Polymers with Transition Metal Ions

Robert Walker
Dr. Ruel McKenzie
Sainath Jadav

The University of Mount Union
The University of Akron
The University of Akron

Coordination polymers are formed from the stereoregular complexation of metal cations with organic ligands. The high surface area and porosity of coordination polymers are attractive for applications in gas storage, separation, and catalysis¹. Previously, a multi-ligand and reactive coordination polymer was synthesized by combining the ionic liquid (IL), 1-ethyl-3-methylimidazolium dicyanamide (EMIM DCA), with an epoxy resin and sodium ions. In this work, attempts are made to synthesize a transition metal-based reactive coordination polymer using the same ionic liquid and epoxy resin system. Transition metals are known for forming stable complexes and may contribute to the structural integrity, service life and functionality of a coordination polymer. For example, transition metals are conductive and are used as catalysts. The introduction of transition metals in the structure of epoxy-based coordination polymers broadens industrial applications of this technology, as well as contributes to the understanding of the coordination polymers in the research community. The transition metal ions in this study are nickel and cobalt. Both nickel dicyanamide and cobalt dicyanamide were synthesized through a metathesis reaction to limit the introduction of exogenous anions into the system. The synthesized salts had low aqueous solubility limit. Thus far, synthesizing transition metal-based reactive coordination polymer using the proposed ligands has proved challenging with limited success. However, transition metals were successfully introduced into the alkali-earth metal system (Na ion) to produce a dual metal containing system. The cobalt system in particular, underwent many unique color changes during processing as a result of the changes in its hydration state. The synthesized coordination polymers are birefringent and were characterized using polarized optical microscopy.

29) Investigating the structure of atmospheric plasma polymerized thin films

Cagatay Yilmazoglu
Brenna Rossi
Mark D. Foster

University of Akron
University of Akron
University of Akron

Plasma Enhanced Chemical Vapor Deposition (PECVD) in vacuum has been used to deposit uniform thin films from vaporized monomer without releasing volatile organic solvents into the environment. These films tend to be highly crosslinked, and, when deposited from appropriate monomers, have been shown to slow corrosion when applied to metals. However, the inconvenience and expense of depositing in a vacuum chamber has hindered the application of this technique by industry. Therefore, attention has turned toward atmospheric plasma polymerization (APP) methods, which are performed under ambient conditions. While several groups have demonstrated that PECVD in vacuum can deposit films that are laterally very uniform, and some have studied such films with techniques such as X-ray reflectivity (XRR), there are no published reports of successful XRR characterization of APP-films. In order to deposit films uniform enough to do XRR, the deposition conditions were optimized. XRR data from a film of sufficient lateral thickness uniformity can be analyzed to obtain information on the film surface roughness, roughness of interface with the substrate, and variation in structure with depth with a resolution of 1-2 nm. Characterizing film at this level makes it possible to both compare the structures of APP films with the structure of films made using vacuum deposition and to further optimize APP film deposition to provide uniform corrosion protection.

32) Synthesis of Hyperbranched Polymethacrylates Using an Inimer Approach

Amanda Dershem
Dr. Coleen Pugh
Gavan Lienhart, Chenying Zhao

Siena Heights University
University of Akron
University of Akron

Hyperbranched polymers have a variety of unique characteristics that make them suitable in applications for which linear polymers are insufficient. Among these unique properties are low viscosity, high solubility, and the potential to maximize the number of available functional groups in the molecule. In this study, hyperbranched polymethacrylates were synthesized using ATRP and then characterized. Inimers—precursors to polymers that have an initiating site as well as the monomer unit—were synthesized as the starting material for the ATRP reactions. Due to their dual nature, inimers are excellent for synthesizing hyperbranched polymers, as they have multiple sites where chain growth can take place. After the specific reactions were optimized, NMR, DSC, and GPC were used to characterize the inimers and subsequent polymers produced. Of particular focus in this study was the poly(butyl methacrylate) molecule, which verified the versatility of the procedure as the second successful polymethacrylate synthesis.

Figure 3—Reaction schematic for hyperbranched polymethacrylate synthesis using an inimer approach

35) Mechanical Reinforcement of Elastomers with Changes in Filler Network Structure and Silane Coupling Agent

Avery Gould
Dillon Presto
Mark D. Foster

John Carroll University
University of Akron

A major challenge in dispersing silica filler in elastomers is the difference in polarity between the silica and rubber, which results in poor reinforcement. Silane coupling agents enhance the interaction between silica filler particles and rubber. We have investigated how (3-mercaptopropyl)trimethoxysilane (S1) and bis-(3-triethoxysilypropyl)-disulfide (S2) affect dispersion and the quality of elastomer reinforcement in elastomeric compounds with styrene butadiene rubber (SBR). We have also analyzed how these silane coupling agents affect the hierarchical structure of the silica filler network from the nanoscale to the microscale with ultra-small-angle X-ray scattering (USAXS). In addition to structural analysis, we have elucidated the dynamics of nanoscale structural rearrangements of the silica particles in these filled rubber systems with X-ray photon correlation spectroscopy (XPCS). We observe that S2-treated silica creates smaller, denser aggregate structures than does S1 silica. XPCS results show that the smaller structures in the S2-treated system are correlated with more rapid structural rearrangements at small oscillatory strain amplitudes (~0.5%). However, there is a crossover in behavior with increase in strain amplitudes. At the largest strain amplitude probed (~24%), the most rapid rearrangements are observed for untreated silica. Thus, the most optimal silane coupling agent depends on the strain amplitudes characteristic of the target application.

36) Nutrient Transport in Hydrogel Scaffolds for Tissue Engineering

Jose Luis Pena
Kaitlyn Mawhinney, Dr. Sadhan Jana

Texas A&M University
University of Akron

Gels are three-dimensional porous interconnected structures that have been increasingly studied for drug delivery systems and implants in tissue engineering. The porosity and pore size of the gel may be tuned using an emulsion as a template to construct macro-voids in a mesoporous network. The purpose of this research is to study nutrient transport in emulsion templated polyurea hydrogels for their application in tissue engineering of lumbar intervertebral discs. The sol consists of Desmodur N3300 in dimethylformamide (DMF) and water which yields urea once gelation occurs. The process is accelerated by using triethylamine as a catalyst (TEA), and *n*-heptane is used as the dispersed phase. The gels are subjected to solvent exchange from DMF to water with acetone as a bridging solvent to yield water-filled monoliths. Diffusivity of sodium chloride was measured through three different gels: control and emulsion-templated PUA, using 30 and 60 v/v% *n*-heptane as the dispersed phase. The diffusion coefficients of the gel samples were measured in a controlled environment in a diffusion box at constant pressure, temperature, concentration, and contact surface area. Diffusivity rate appeared to increase with increased porosity. In the most precise measurements, the diffusion coefficient of the 60 v/v% *n*-heptane templated gel was almost three times greater in magnitude in comparison with the control polyurea, which is attributed to the lower polymer content and large voids created in the gel network.

39) Effect of Chemical Structure and Reaction Time on the Swelling Properties of Polyelectrolytes in Various Solvents

Claire Senger
Juan Marin
Dr. Kevin Cavicchi

University of Minnesota Twin Cities
The University of Akron
The University of Akron

An ion-pair comonomer (IPC) of styrene sulfonate (SS) and trioctyl vinylbenzyl phosphonium (TOP) chloride has recently been shown to form a high glass transition temperature (190C) thermoplastic polyampholyte complex when polymerized (TOP-SS), which is difficult to achieve in non-ionic carbon-carbon backbone polymers through free radical polymerization. In this work, we seek to understand how the polymer will swell when exposed to water and other solvents. Four other similar polymers will also be tested to determine the cause of any swelling in the polymer, each varying in bonding or structure. The TOP-SS polymer has double bonds at both the cation and anion, allowing for cross-linking on both sides. The tested variations include giving the anion or cation a single bond instead of a double bond, the size of the anion, and increasing the amount of charges in the monomer. The IPCs for the polymerizations will be synthesized using nucleophilic substitution and ionic exchange reactions, and the polymers were synthesized via RAFT polymerization for 15, 24, and 48 hours. It was found that the TOP-SS and SS-TOP-TOP-SS, the polymer with more charges, polymerized for 15 hours did not significantly swell in water, but did so in ethanol, both gaining 80 to 100% in mass over six hours. The SS-TOP-TOP-SS polymer not swelling in water indicates that even with more charges, the water can still not break up the network and hydrophobicity is high. The swelling in ethanol indicates that the networks are hydrophobic and are broken down by the ethanol. Further work is being done in the cases of the other three polymers.

42) Structural Elucidation of Polymeric Surfactant Mixture by Hyphenated Multi-Dimensional Mass Spectrometry

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A surfactant is a chemical that decreases the surface tension between two liquid phases. They can be found in detergents, skin care products, cleaners, foods, and many other products. Surfactants are composed of hydrophobic and hydrophilic groups, with the ratio of these two controlling the physical properties. To increase performance, surfactants are regularly complex mixtures, containing both natural and synthetic moieties. In addition, because surfactants are often manufactured products, not much more information than the name is given. Due to this, their analysis can prove to be complicated, requiring hyphenated separation techniques. Hence, ultrahigh performance liquid chromatography ion mobility mass spectrometry (UPLC-IM-MS) was used to separate and characterize a commercially available surfactant comprised of a glycerol core, various degrees ethoxylation, and functionalized with fatty acids sourced from coconut oil (Resassol Coe, Res Pharma Industriale). UPLC facilitated separation of the surfactant based on relative polarity and IM facilitated separation based on shape and charge. Due to various compounds having similar polarities and/or shapes, combining the UPLC and IM techniques delivered greater separation and resulted in a much less complex spectra. Within the surfactant mixture, 23 unique distributions were observed and confirmed by accurate mass and tandem mass spectrometry. The degree of ethoxylation ranged from 3-13 with an average of 7 ethylene oxide units. The fatty acid profile was found to be as follows: 35% Lauric (C12), 17% myristic (C14), 13% capric (C10), 11% palmitic (C16), 9% gondoic (C20:1), 8% stearic (C18), 6% oleic (C18:1), 1% caprylic (C8). The observed fatty acid profile is similar to that of the coconut oil profile found in literature and both contain high percentages of lauric. However, stearic and gondoic fatty acids are not typically found in coconut oil. This suggests that the surfactant was not synthesized with solely coconut oil, but rather with a mixture of oils.

44) Investigation of Anomalous Hysteretic Losses in Mouse Tendons

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Elastic energy storage is widely seen in nature, responsible for allowing the human body to perform activities such as walking, running, and jumping. Tendons are the main site of elastic energy storage in vertebrates. In conjunction with skeletal muscle, tendons assist body movements by ways of energy conservation, power amplification, and power attenuation. The conventional wisdom of low energy loss in tendons states that a <10% of energy is lost when loading and unloading forces on large species. In the last two years, REU students found and confirmed that mouse tendons demonstrate an unusually high rates of hysteretic energy loss during stretch-shorten cycles. This eventually leads to a loss of more than 40% of the energy stored during stretching. This calls into question the validity of using mice when testing the effect of drugs or treatments on tendon properties. This project will re-confirm the previous findings and use new methodology to test for potential confounding effects such as change in osmotic pressure, temperature change, prolonged storage, and comparison to tendons of species (e.g. rabbit, squirrel, etc.). Video footage was recorded of the rabbit tendon samples to examine the uniform movement as loading and unloading forces were applied. Infrared imaging was also used to capture the loss of energy from these tendons in the form of heat. Results from this experiment have confirmed previous conclusions. Achilles tendons of mice, squirrel, rabbit, and chipmunk demonstrated a loss of energy ranging from 27%-33%. This proves that this anomaly is not exclusive to only laboratory mice, but also varying small rodents found in nature.

46) The Design of 3D-printed Scaffolds for Wound Infections and Inflammation

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Treating chronic wounds is challenging due to the multiple parameters that affect the healing of wounds. Chronic wounds cause persistent inflammation and serve as a site for the growth of bacteria and their entry into the circulatory and bodily systems. Patients with chronic wounds may undergo multiple rounds of bandage changes, leading to aggravation of the wound and patient discomfort¹. We are addressing some of the drawbacks of current chronic wound treatment by developing polymeric 3D printed scaffolds embedded with therapeutics that can maintain a sustainable release over several days. These scaffolds will decrease the number of changes in bandages. In our study, we used Diclofenac Sodium, a non-steroidal anti-inflammatory drug, and Ciprofloxacin HCl, an antibiotic. We incorporated the drugs separately at 1% and 5% of weight percentage into our polyesters, Alanine(70)-Coumarin(30)-Succinic acid (**Ala**) and Phenylalanine(70)-Coumarin(30)-Succinic acid (**Phe**). The polyesters with different pendant groups, analogous to alanine and phenylalanine, were synthesized by carbodiimide-mediated polyesterification². The UV crosslinked samples in PBS were placed in an incubator shaker at 37°C. Release of the diclofenac drug in **Phe** on average was 0.6% every hour for the first 6 hours, after 48 hours cumulative release was 15%. On the other hand, the cumulative release of drug in **Ala** could reach as high as 22% within 100 min. Our preliminary results suggest that the drug loaded scaffolds, **Ala** or **Phe**, showed different release profiles which can be customized to the desired drug release. In the future works, we will use rheology to obtain the optimum percentage of the drugs into the polymer and test drug release in 3D printed scaffolds.

[1] Boateng, J.; et al. A Review. *J. Pharm. Sci.* **2015**, *104* (11), 3653–3680.

[2] Gokhale, S.; et al *Biomacromolecules* **2013**, *14* (8), 2489–2493.

48) Consequence of Hydrogel Chemistry on Dry and Underwater Adhesion

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Developing adhesives that work in wet environments has been challenging because the presence of interfacial water hinders the formation of strong bonds between adhesive and substrate. This need is critical in many areas including biomedical devices, bone regeneration, and tissue repair. Surprisingly, hydrogels have demonstrated superior underwater adhesion in several studies. The aim of the present study is to understand the adhesion of hydrogels to hydrophilic substrates in dry and wet conditions. Further, we aim to understand how the chemistry of the hydrogel influences the adhesion behavior. Polyethylene-glycol dimethacrylate (PEGDMA) and Poly(2-hydroxyethyl methacrylate) (PHEMA) gels were synthesized utilizing photopolymerization by UV irradiation. Johnson-Kendall-Roberts adhesion geometry was used to detail their adhesion in dry and wet conditions. Sum frequency generation spectroscopy (SFG) was used to provide insights on the role of water at the contact interface and enables us to understand the interaction strength of hydrogel with substrate. Our results indicate that PEGDMA displays adhesion in both dry and underwater conditions, however adhesion is significantly lower in underwater conditions. HEMA-PEGDMA results indicate increased dry adhesion when compared to PEGDMA results. However, underwater adhesion was still significantly lower. SFG results with PEGDMA gels indicate that water is present at the interface in underwater conditions which correlates with decreased adhesion values. To identify whether the signal in hydroxyl region is due to water or surface hydroxyl groups, further SFG experiments will utilize deuterated water.

57) Adsorption of low molecular weight polyols in amphiphilic copolymers for biobutanol membranes

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Biobutanol represents a promising alternative to ethanol that can nullify the problems of ethanol, however its production by fermentation is limited by the low maximum (<3 wt% butanol) concentration. Membranes allow for continuous removal of butanol to improve the potential productivity of biobutanol, but the interactions of the membrane with components in the fermentation broth can alter long-term performance. Earlier work has demonstrated that membranes based on addition polymers of polybutylnorbornene-ran-polyhexafluoroisopropanolnorbornene exhibit promising performance for pervaporation separation of biobutanol. Here we seek to understand how the nature of the hydrophobic comonomer that acts as the mechanical reinforcement for the membrane influences swelling and mechanical properties in aqueous butanol solutions through a systematic variation in the alkyl chain length. The swelling of the membranes and changes in mechanical properties were determined using a quartz crystal microbalance with dissipation monitoring (QCM-D). The changes in energy dissipation and frequency of the quartz sensor when immersed in aqueous solutions containing 0-3 wt % butanol were analyzed in terms of a rheological power law model. As the alkyl chain length increased from methyl to decyl, there was not a significant change in the swelling, which suggests that the hexafluoroisopropanolnorbornene controls the interactions with both butanol and water.

58) Enhancing mechanochemical activation in bulk polymers by reinforcing chain alignment

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Activation of mechanophores in linear polymers have been successfully achieved through ultrasonication and single molecule force spectroscopy. However, there has been limited success when attempting activation by applying force to bulk materials. It has been reported, there is a correlation between polymer chain alignment and force-induced chemical reaction of the mechanophore. Thus, due to the poor alignment of the mechanophores in the direction of applied force, there is little mechanochemical activation when force is applied to bulk polymers. To overcome this challenge, we plan to align a bulk material by using two-stage thiol-acrylate Michael addition and photopolymerization reaction that was reported by Yakacki et al. This method allows for the preparation of a highly aligned monodomain nematic liquid crystalline elastomer activation of mechanophore in bulk material. For our LCE, we intend to incorporate the mechanophore gem dichlorocyclopropane to the backbone of the LCE mesogen and exploit the highly ordered morphology of the LCE to enhance total activation of the mechanophore by application of tensile stress to the bulk material. We have found that, by placing the gem dichlorocyclopropane mechanophore in between the two benzene rings of the mesogen interferes with the mesogen's ability to align, preventing the formation of a LC mesophase. To overcome this challenge, we intend to synthesize a diacrylate mesogen containing dichlorocyclopropane that is centered between two biphenyl units (that will act as the rigid cores), separated by alkyl spacers which should prevent the mechanophore from interfering with the alignment of the biphenyl units.