Eighth Annual
American Chemical Society Illinois-Iowa
Undergraduate Research Conference

October 8, 2016
Rogalski Center
St. Ambrose University

Schedule of Events

9:30-10:30 Registration, poster setup, and breakfast

10:30-12:00 Research talks (15 min/talk with 5 min for questions)
Abstracts found beginning on pg. 2

The Effect of the Removal of a Salt Bridge on the Activity of the FNR Transcription Factor
Sobhi Kazmouz, Monmouth College

Development of a Chemical-based Electrode for Reflectron Time of Flight Mass Spectrometry
Jonathan Nederhoff, University of Northern Iowa

Insulin: Its Structure, Function, and Interaction in Model Cell Membranes
Kate Saulcy, Monmouth College

Stable Isotope Chemistry in Titan Haze Aerosol
Allison Wold, University of Northern Iowa

12:00-1:00 Buffet lunch

1:00-2:00 Poster presentations
1:00-1:30 – poster presentations with an odd numbered abstract
1:30-2:00 – poster presentations with an even numbered abstract
Abstracts found beginning on pg. 4

2:00-3:00 Keynote address and recognition of students
Achieving Tenure and Beyond:
The Life of a College Professor at a Liberal Arts College
Audra Goach Sostarecz, Ph. D, Monmouth College
Abstract and biography found on pg. 12

Research Talk Abstracts

Abstract #1

The Effect of the Removal of a Salt Bridge on the Activity of the FNR Transcription Factor

Sobhi Kazmouz and Laura Moore
Chemistry Department, Monmouth College

This investigation focused on studying the effect of a salt bridge interaction on the activity of fumarate nitrate reductase (FNR), a global transcription factor that regulates anaerobic respiration in E. coli bacteria. The salt bridge interaction was an attraction between the R group of the aspartate-130 residue and that of the arginine-140 residue. The effect of the salt bridge was studied by mutating the plasmids holding the FNR gene using site-directed mutagenesis and placing them back into a strain of E. coli supercompetent cells using a transformation reaction. Two mutant variants of FNR were prepared where each involved replacing one of the residues constituting the salt bridge with another one of an oppositely charged R group. The activity of FNR was then measured in these mutants and compared to a positive and negative control by setting up a β-galactosidase assay and measuring the amount of enzyme that hydrolyzes 1 nmole of ONPG (ortho-Nitrophenyl-β-galactoside) per minute by the technique of UV/Vis spectrophotometry. The final results showed that the activity of FNR actually decreased upon removing the salt bridge.

Abstract #2

Development of a Chemical-based Electrode for Reflectron Time of Flight Mass Spectrometry

Jonathan Nederhoff, Dmytro Kravchuk, Madison Flesch, and Curtiss Hanson
Department of Chemistry and Biochemistry, University of Northern Iowa

Laboratory use of mass spectrometry (MS) is becoming the most prevalent analytical technique for molecular identification included in many industries such as biotechnology and forensics. The instruments require precise electric fields to provide maximum resolution and transmission efficiency. The basis for our proposed method of analysis is the creation of an electric field generated by a multi-potential ion guide (MPIG) electrode. By varying the conductivity of the surface of the electrode, it is possible to use the single electrode as a voltage dividing device which alters the potential field generated by the ion guide at different locations. We are developing a technique in which a single MPIG electrode can create a reflectron region in a time of flight mass spectrometer. In our instrument, two separate reflecting fields will be created at each end of the drift region to permit the ions to oscillate between the reflectrons. In addition to the reflectrons, the electrode will create electric fields that constantly redirect the ions back towards the flight axis, eliminating the divergence and subsequent ion loss. The motion of the ions in the resulting fields will increase the resolution of the mass spectra by reducing the effect of the energy variance of ions. Presented is the design and construction of that prototype mass spectrometer which contains the proposed chemically treated MPIG electrode.

Abstract #3

Insulin: Its Structure, Function, and Interaction in Model Cell Membranes

Kate Saulcy, Debbie C. Crans, and Audra Sostarecz
Chemistry Department, Monmouth College

Insulin is a polypeptide hormone that is created and used by a healthy human body to regulate blood sugar. The specific conformation that an insulin molecule adopts affects the stability and functionality of the hormone. Interactions with lipids, specifically Dipalmitoylphosphatidylcholine (DPPC) causes conformational changes in the shape of the insulin molecule and its state of aggregation. The Langmuir technique can be used to create monolayers of insulin, both human recombinant and bovine. Samples of insulin were mixed with lipid, at varying ratios, to determine any molecular interactions between the two compounds and to determine to what extent they interact. At a 25% Insulin/75% DPPC ratio, insulin makes a monolayer of DPPC more fluid. At a 75% Insulin/25% DPPC ratio, DPPC orders the insulin molecules. Subcutaneous injection exposes insulin molecules to lipid and this interaction appears, due to the disappearance of a phase transition on the mixed isotherm, to cause the insulin molecules to adopt a hexameric conformation. As the most active form of insulin is the monomer, this may account for less effective or incorrect dosing of insulin.

Abstract #4

Stable Isotope Chemistry in Titan Haze Aerosol

Allison Wold[1], Thomas Gautier[2], Joshua Sebree[1], and Melissa Trainer[2]
[1]University of Northern Iowa, Department of Chemistry & Biochemistry
[2]Planetary Environment Laboratory, NASA Goddard Space Flight Center

Titan, a moon of Saturn, has a thick atmosphere made up of N_2 and a few percent CH_4, with a surface pressure of 1.5x that of Earth. Titan's atmosphere is believed to be that similar to that of early Earth before the rise of molecular oxygen. Even though the atmospheric conditions of Earth at the time of the origin of life are not known, it has been shown in previous experimental studies that prebiotic molecules such as amino acids and nucleobases can be formed via atmospheric synthesis. Studying Titan's atmosphere can give new insights into prebiotic chemistry and habitability. One significant source of information on the history and evolution of the atmosphere is the measurement of stable isotopes that comprise each chemical species, specifically $^{12}C/^{13}C$, $^{14}N/^{15}N$ and D/H in major gases such as N_2, CH_4, and higher order hydrocarbons. The fractionation associated with the formation of Titan aerosol analogs are explored in the laboratory as a function of environmental parameters. Gas mixtures were flowed into a reaction chamber, where they underwent UV-irradiation via a deuterium lamp. The resulting aerosol samples were collected and analyzed using isotope-ratio mass spectrometry (IRMS). This project focused on pyridine (C_5H_5N) and nitrogen mixtures, with and without CH_4, as a function of pressure. We will show the results of organic isotopes for these aerosol products, as compared to the starting molecules, to provide a more complete picture of how stable isotopes may be processed and distributed in Titan's atmosphere.

Poster Abstracts

Abstract #1

An Investigation into the Antibacterial Properties of Essential Oils

Antonetta A. Axup and Audra G. Sostarecz
Chemistry Department, Monmouth College

Langmuir Monolayers of sweet orange essential oil, the phospholipids dipalmitoylphosphatidyl-choline (DPPC), dipalmitoylphosphatidylglycerol (DPPG) and E.coli lipid extract were used to investigate the antibacterial properties of essential oils. The Langmuir Monolayer technique is a useful one for the formation of model cell membranes by allowing analysis of the interactions between the molecules and their organization capabilities. Monolayers using the sweet orange oil as a subphase with DPPC added were found to be more fluid, and to be less stable, as indicated by a low surface pressure at low molecular areas when compared to monolayers with ultra pure water as the subphase. Similarly, monolayers using the sweet orange oil as a subphase with the E. coli lipid extract added were found to be more fluid, and to be less stable, as indicated by a low surface pressure at low molecular areas when compared to monolayers with ultra pure water as the subphase. These results were also found with the trials of DPPG. Further investigations will involve using a simpler gram-negative model, such as 1,2-dipalmitoyl-sn-glycero-3-phospho-L-serine (DPPS), since E. coli is a more complex gram-negative model, and observing those results in the orange oil, changing the concentration of the oil in the subphase and using different essential oils as subphases.

Abstract #2

Determination of Lidocaine Concentration Found in Common Drug Store Creams using High Performance-Liquid Chromatography Diode Array Detection

Olivia Bennett, Brandi Hosford, Ian South, Keegan Steele,
Kelly Giddens, Andrew Axup, and Joshua Stratton
Department of Chemistry, St. Ambrose University

Lidocaine is one of the most commonly used anesthetics that is found in local analgesic creams and has the potential to cause adverse side effects due to overuse or misuse. The purpose of the study was to determine the accuracy of product labels in displaying lidocaine concentrations. It was then compared to the maximum dosage allowance of lidocaine per twenty-four hour period. Aspercreme, RectiCare and Lidocaine 4% (generic numbing cream) were purchased for this experiment. Methodology included solid-liquid extraction of lidocaine and analysis using High Performance Liquid Chromatography Diode Array Detection (HPLC). Measured values were found to be significantly different from literature values that were labeled on the bottles. The literature values for the percentage of lidocaine in Aspercreme, RectiCare, and Lidocaine 4% were 4%, 5%, and 4% respectively. The confidence intervals (95% C.I.) did not include any of the literature values for the specific creams: Aspercreme 4.80 ± 0.5%4, RectiCare 7.50 ± 0.46%, and Lidocaine 4% 5.00 ± 0.72%. However, to ensure systematic error was absent in this experiment replication and further research should be conducted. A small sample size of nine trials per cream and a lack of randomization make it difficult to draw generalized conclusions from the data and further analysis is needed.

Abstract #3

Examining the Effects of Propolis on Cancer Cell Membranes and Bacterial Cell Membranes

Brittney Book and Audra Sostarecz
Chemistry Department, Monmouth College

Langmuir-Blodgett Monolayers of propolis and phospholipids is examined for antibacterial and anti-cancerous properties. The Langmuir Monolayer technique allows for the analysis of the organization of amphiphilic molecules at an air-water interface and is, therefore, a useful technique for the formation of model cell membranes. Propolis is a green-yellow to red-brown resinous material collected from various vegetation around the hive and used to cover the walls of the hive, keep out intruders, and keep out harmful pathogens. There are different chemical compositions of the propolis based on the vegetation at the geological location. As a result, the biological activity of the propolis is related to the plants native to the site of collection (toreti, 2013). In general, both propolis types increased the molecular area thereby breaking up apart the bacterial cell membrane lipids. Specifically, the American propolis not only increased the molecular area but also increased the compression modulus indicating that the propolis molecules penetrated the monolayer and interacted with the tail groups of the dipalmitoylphosphatidylethanolamine (DPPE).

Abstract #4

Formation of N-N bonds as a tool for Synthesis and Drug Development

Broddie Davis, Amy Wollenburg, and Michael Prinsell
Chemistry Department, Monmouth College

Molecules with nitrogen-nitrogen (N-N) bonds have exhibited promising biological activity, but are often synthesized by substituting a preformed hydrazine derivative. This research program focuses on developing a method for creating N-N bonds, using a nucleophilic nitrogen and an electrophilic nitrogen attached to a leaving group. This method would be used to synthesize natural products, and derivatives with potential biological activity.

Abstract #5

Determination of Potassium Levels in Organic and Conventional Bananas Using Atomic Absorption Spectroscopy

Erin Dunn, Matt Mahoney, Carissa Origer, Emily Studt,
Andrew Axup, Joshua Stratton, and Kelly Giddens
Department of Chemistry, St. Ambrose University

Organic produce is grown without synthetic pesticides or chemical fertilizers. In recent years, the demand for organic produce has increased exponentially, yet it remains unclear whether or not the organic method of growing is synonymous with higher levels of nutrients. Potassium, an important nutrient found in bananas, used in the human body to build proteins and muscle. This study sought to compare the potassium levels in organic and conventional bananas. We digested the bananas, filtered the solution, and analyzed the diluted solution with atomic absorption spectroscopy. From this study, we found that there was no significant difference between the potassium levels in organic (13.08 ± 0.57 mg/g) and conventional bananas (12.36 ± 0.47 mg/g).

Abstract #6

Increasing Concentration of Acetaldehyde Due to Thermal Degradation of PET Plastic

Jacob Hayles, Julia O'Conner, Paul O'Connor, Danielle Sheddan,
Joshua Stratton, Kelly Giddens, and Andrew Axup
Department of Chemistry, St. Ambrose University

Acetaldehyde is a known carcinogen and can lead to very detrimental health defects. It is believed that acetaldehyde can leach out of the walls of PET plastic after thermal degradation. Thermal degradation was induced in six solutions, three water and three alcohol, within PET plastic bottles. A solid phase extraction method was used to extract acetaldehyde from each of the sample water or alcohol bottles placed in the water bath. To extract the acetaldehyde, LiChrolut EN 200 mg 6 mL standard PP- cartridges were labeled, and ~500 mL of the samples were pulled through the cartridges at 2 mL/minute. The samples were eluted with DCM. Gas Chromatography-Mass Spectrometry was used to analyze the extracts to determine the concentration of acetaldehyde leached into the solution from the PET plastic. We were not able to find a significant amount of acetaldehyde in any of our alcohol or water samples. Therefore, we cannot draw any definitive conclusions from our experimental data. In the future, we would like to use different, less pure types of alcohol in the PET plastic bottles while retaining the same basic experimental setup. Also, we would like to measure the effects of a range of temperatures on acetaldehyde.

Abstract #7

The Effect of the Removal of a Salt Bridge on the Activity of the FNR Transcription Factor

Sobhi Kazmouz and Laura Moore
Chemistry Department, Monmouth College

This investigation focused on studying the effect of a salt bridge interaction on the activity of fumarate nitrate reductase (FNR), a global transcription factor that regulates anaerobic respiration in E. coli bacteria. The salt bridge interaction was an attraction between the R group of the aspartate-130 residue and that of the arginine-140 residue. The effect of the salt bridge was studied by mutating the plasmids holding the FNR gene using site-directed mutagenesis and placing them back into a strain of E. coli supercompetent cells using a transformation reaction. Two mutant variants of FNR were prepared where each involved replacing one of the residues constituting the salt bridge with another one of an oppositely charged R group. The activity of FNR was then measured in these mutants and compared to a positive and negative control by setting up a β-galactosidase assay and measuring the amount of enzyme that hydrolyzes 1 nmole of ONPG (ortho-Nitrophenyl-β-galactoside) per minute by the technique of UV/Vis spectrophotometry. The final results showed that the activity of FNR actually decreased upon removing the salt bridge.

Abstract #8

Purification and Investigation of Lactate Dehydrogenase Enzymatic Activities

Colton Martens and Ritu Gurung
Department of Chemistry, St. Ambrose University

Enzymes are biological catalysts that control most biochemical reactions in an organism. To study the role of an enzyme, a model enzyme, lactate dehydrogenase (LDH) was used which catalyzes the reversible reaction whereby pyruvate is reduced by NADH to form lactate. LDH was purified from beef heart using chromatography and electrophoresis techniques. A spectrophotometer was used to monitor the LDH activity from L-lactate oxidation. The enzyme protein concentration was also determined by using a spectrophotometer.

Abstract #9

Design and Development of Thermally Controlled Aerosol Chamber

Nicholas Pauley, Clare Laubenthal, and Joshua Sebree
Department of Chemistry and Biochemistry, University of Northern Iowa

The earliest atmosphere of Earth was highly reductive, composed of mostly nitrogen, methane and trace carbon monoxide, among other species. From this environment life arose. With atmospheres composed of ~95% nitrogen and several percent methane with trace other species, Titan and Pluto are terrestrial bodies in the solar system with atmospheres similar to the Earth ~3-4 billion years ago, and provide us the opportunity to study an atmosphere similar to the primordial Earth. In order to better understand these atmospheres, NASA sent two spacecraft into the outer solar system: the Cassini spacecraft, currently in orbit around Saturn, and the New Horizons spacecraft, which is still sending back data from its July 2015 flyby of Pluto. In order to aid in the interpretation of the returned data, we have constructed a cryogenic aerosol chamber to synthesize aerosol analogs (tholins). Tholins are complex organic mixtures that may contain pre-biotic molecules. Photolysis of trace organics in a nitrogen system can be performed at temperatures that are more accurately matched to Titan and Pluto, with the chamber being cooled to as low as 150 K. By varying the cooling conditions, it is possible to adjust the reaction temperature of the reactant gases and alter the aerosols produced.

Abstract #10

The Effect of pH on the Reversible Metachromasy of Crystal Violet on TiO_2

Katherine Plotzke and Shoshanna Coon
Department of Chemistry and Biochemistry, University of Northern Iowa

The reversible metachromasy of acidic slurries of crystal violet dye solution and titanium dioxide powder was investigated using time-lapse video, UV-Visible spectroscopy, and visual observations. Acidified crystal violet dye solutions become more transparent with time, reaching an equilibrium with a colorless product. Acidified slurries change pH as they dry, ranging from more acidic than the original slurry to an ending state less acidic than the original slurry. Dried acidified slurries exposed to water vapor exhibit reversible metachromasy that is dependent on the dye concentration on the surface. Acidified slurries dried in the absence of water vapor do not become more basic as they fully dry, but rather display enhanced aggregation of the dye molecules. This research has expanded the understanding of the phenomenon of reversible metachromasy.

Abstract #11

GC/QQQ Limits of Detection for Biomolecules in Abiotic Aerosols

Madeline C. Roach, Tate M. Christensen, and Joshua A. Sebree
Department of Chemistry and Biochemistry, University of Northern Iowa

A large number of laboratory experiments have been carried out in attempts to recreate the atmospheric chemistry of both the early Earth and Titan. While their results were groundbreaking at the time, further work since has determined their atmosphere was more reducing then that of the Earth. Since then, many groups have attempted to create biological compounds from prebiological atmospheres. The largest obstacles to overcome in working with and characterizing lab-generated aerosols are those of the large number of species formed and the limited sample amounts. To that end, we have worked to develop a new method for aerosol analysis. Taking advantage of the chemical nature of many prebiotic molecules which contain acid hydrogens, the aerosols are derivatized with MTBSTFA allowing for selective solvation of only the derivatized compounds. The dissolved compounds are then injected into a GC-MS/MS triple-quad operating in trapping mode on the first quadrupole. The combination of derivatization and triple-quad analysis has allowed for the development of a method that is both selective for prebiotic molecules and extremely sensitive. Using this new method, called Multiple Reaction Monitoring (MRM) we were able to detect as little as 40 femptomoles of derivatized compounds.

Abstract #12

Enzymatic Oxidation of Phenols

Bradley E. Sturgeon, Nadia Ayala, and Benjamin Stillwell
Chemistry Department, Monmouth College

Tyrosine is a non-essential amino acid with phenol functionality that contributes to structural and functional proteins. HPA is a model compound with a phenol group that partakes in oxidation naturally. These phenols form radical intermediates during oxidation which are responsible for the resulting stable products. We have investigated various means of oxidation and will present data resulting from using an immobilized enzyme bioreactor. The products have been analyzed by HPLC and separated via flash chromatography.

Abstract #13

Surface Modification of Ion Conducting Ceramic Particles

Samuel Veroneau and Robert Miller
Department of Molecular Engineering, University of Chicago

This project describes the functionalization of ion conducting ceramic particles for use in battery membranes. Solid state and lithium-air batteries promise higher energy density and higher specific capacity than conventional lithium batteries. However, even the most contemporary lithium based batteries face an inherent shortcoming: they don't make use of a metallic lithium anode. This is not without reason, as such anodes promote destructive growths within batteries known as dendrites. Thus, to make use of metallic lithium anodes, dendrite growth must be suppressed. One possible approach to this is through the use of ion conducting ceramic membranes. Such membranes have been shown to significantly curtail dendrite growth while still permitting the flow of ions. However, the production of such membranes is difficult and demanding. To streamline this process, the ceramic particles embedded in the membrane need to be readily dispersed in a polymer solution. To achieve this, it was hypothesized that the surfaces of ion conducting ceramic particles could be functionalized using small molecules. Lithium and sodium conducting ceramic particles were functionalized by molecules with long carbon chains and various head groups, including carboxylic acids, phosphonic acids, and silanes. Using various techniques, mainly atomic force microscopy (AFM) and x-ray photoelectron spectroscopy (XPS), the surfaces of these ceramic particles were analyzed to determine how, and to what extent, the surfaces of the ceramic particles were functionalized. This project provided an initial understanding to the functionalization of ion-conducting ceramic particles, with the hope of implementing the results to create more effective and efficient batteries.

Abstract #14

Designing a Model Cell Membrane to Investigate the Absorption of Nanoparticles in Our Skin

Brandi Yoder and Audra Sostarecz
Chemistry Department, Monmouth College

The Langmuir Monolayer Technique is used to study surface chemistry and can be used to model the cell membrane of a eukaryotic cell. Liposomes can also be used as a model due to the lipid bilayer that is produced, allowing for the interpretation of how particles interact with the hydrophilic and hydrophobic regions of the membrane. Once a standard concentration of lipids found in the membrane can be determined and liposomes made reproducibly, nanoparticles of titanium dioxide and zinc oxide will be introduced to investigate how metals interact within the cell membrane, in order to ultimately determine if the particles in over the counter beauty products embed our skin. The compression isotherms of four lipids that are major components of the epithelial cell membrane were taken at body temperature in order to interpret how the lipid behaves in the skin. Liposomes were considered as a technique to study the bilayer due to the use of fluorescence when making them. A fluorescent lipid is introduced to the lipid or lipids that are being studied and the liposomes are then tested using a fluorimeter that allows for a graphical display of the excitation and emission. The compression isotherms have been interpreted and the fluorimeter mastered.

Keynote Address

Achieving Tenure and Beyond: The Life of a College Professor at a Liberal Arts College

Audra Goach Sostarecz, Ph. D
Chemistry Department, Monmouth College

Abstract

A love of teaching is not the only requirement for a career as a professor. Both small colleges and large universities have requirements of service and scholarship for their faculty. Deciding to pursue a career in college teaching requires one to evaluate where they want to focus their time so that the correct type of institution is chosen. At small colleges, like Monmouth College, professors split their time up into teaching, service, and scholarship with the emphasis being on teaching, followed by service, and then scholarship. In order to earn tenure, you need to find the right balance between these three areas but these three areas are not always mutually exclusive. Additionally, you don't always have the time to dedicate "equally" to each of these three areas. I want to share with you my experience (10 years) as a tenured faculty member at a small liberal arts college. Specifically, I will discuss what is required, in terms of teaching, service, and scholarship, of a faculty member to earn tenure; how to critically evaluate your work for your tenure portfolio; how to find the right balance as a faculty member; and what kinds of faculty/student scholarship one can do as a professor at a small college.

Biography

Dr. Audra Goach Sostarecz received her Ph.D. in Chemistry from The Pennsylvania State University in 2004 before which she earned a B.S. in Chemistry (ACS accredited) from Muhlenberg College in Allentown, PA. Audra then spent two years doing postdoctoral research in the area of biophysical chemistry at the University of Pennsylvania in the Institute for Medicine and Engineering. Since 2006, Dr. Sostarecz has been a member of the faculty at Monmouth College in Monmouth, IL where she currently holds the position of Associate Professor of the Chemistry Department. Audra teaches analytical chemistry (quantitative analysis and instrumental), forensic science, and a freshman introduction to liberal arts seminar. She also has an active undergraduate research group which investigates the use of model membrane systems for the investigation of drug delivery and drug effectiveness through Langmuir monolayers and Atomic Force Microscopy. She has published research papers with undergraduates and with her collaborator at Colorado State University while at Monmouth. Audra has also published a paper in *J. Chem. Ed*. on curricular research with her husband, Dr. Michael Sostarecz, who is an Associate Professor of Mathematics at Monmouth. Audra has been a member of Faculty Senate, Curriculum Committee, Finance Committee, Admissions and Academic Status Committee, numerous search committees, the Quantitative Reasoning Committee, the President's Planning and Priorities Committee; and, most recently, a chair of a subcommittee for the college's reaccreditation by the Higher Learning Commission. Audra, in her free time, enjoys spending time with her husband and two sons.