



Undergraduate Research and Networking at UMich

# Undergraduate Research Symposium

Abstract Book

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## Poster #1

### Optimizing Storage Conditions for In Vivo Microdialysis Samples

Brandee Dallas & Robert Kennedy

The brain's complexity makes it a focus in metabolomics research using in vivo microdialysis. To maintain the stability of neurochemicals in collected dialysate, optimal storage conditions are essential. While sample degradation is inevitable, proper storage ensures the most accurate results. This study investigates the impact of temperature, freeze-thaw cycles, and chemical stabilization via benzoyl chloride (BzCl) derivatization on a panel of 70 neurochemical compounds collected using in vivo microdialysis of a rat brain. The stability of the analytes will be tested over the course of three weeks and analyzed using liquid chromatography coupled with mass spectrometry (LC-MS). To test the temperature, the dialysate will be divided and kept at  $-80^{\circ}\text{C}$ ,  $-20^{\circ}\text{C}$ , and room temperature. Additionally, at each of these temperatures half of them will be stored derivatized with BzCl and the other half will be underivatized. The second part of the experiment will focus on the stability of the analytes across five freeze-thaw cycles and keeping the other conditions the same. We expect temperature to have the biggest impact on stability and freeze-thaw cycles will have the lowest.

## Poster #2

### **Improving throughput of droplet microfluidics coupled to Ion mobility-Mass spectrometry for screening of biocatalytic reactions**

Adriana Vargas-Figueroa, Laura Penabad-Peña & Robert Kennedy Ph.D.

Biocatalysis allows us to harness the selectivity of enzymes for commercial product synthesis. Within the context of non-native products, directed evolution (DE) is an application of biocatalysis which relies on artificially accelerating evolution of enzymes by stressing them towards a desired output. Liquid Chromatography coupled to mass spectrometry (LC-MS) is the industry standard technique for label-free screening of DE variants (~10<sup>4</sup> in a campaign); however, LC constitutes a throughput bottleneck due to its cycle time (3-10 min). During the last decade, high throughput screening of DE samples has been achieved by interfacing droplet microfluidics with electrospray ionization mass spectrometry (ESI-MS). However, these screens only quantify mass to charge and are unable to monitor isomers resulting from site-specific reactions. To this end, the Kennedy lab has developed droplet microfluidics coupled to nano electrospray cyclic ion mobility-mass spectrometry (nESI-cIM-MS) allowing isomer separation in the ms timescale. Current throughput is of 5 seconds per droplets. The work herein aims to increase the rate of droplet infusion to 1 Hz by further miniaturizing channel dimensions to increase linear payload. To accomplish this, channel width was reduced from 100  $\mu\text{m}$  to 50  $\mu\text{m}$  and a gradient of different acetonitrile to water solutions was tested to find the optimal interfacial tension between the droplets and the carrier fluid. To validate the effect of miniaturization on throughput, the infusion of droplets from both tubing dimensions was validated at the same flow rate. Once our method was optimized, benzofuran dimers were infused at 1 Hz, in 50  $\mu\text{m}$  tubing over 3 passes of the ion mobility cell. The improvements upon throughput in this project result in a 5-fold improvement in screening time over the current droplet-CIM method.

### Poster #3

#### Effect of “Fixed” Negative Charges in Peptide Anion Tandem Mass Spectrometry

Teresa Lee, Steven A. DeFiglia & Kristina Håkansson

Negative ion electron capture dissociation (niECD) involves electron (~3.5–6.5 eV) attachment to peptide anions, yielding charge increased precursor ions. This technique primarily generates c'/z• fragments and retains acidic post-translational modifications (PTMs), like sulfation and phosphorylation. We proposed that niECD requires a zwitterionic precursor ion and showed that a fixed positive charge can rescue niECD for peptide anions recalcitrant to electron capture. Here, we explore the effect of “fixed” negative charges in niECD and negative ion collision induced dissociation (nCID) by derivatizing peptides with a 4-amino-1-naphthalenesulfonic (ANSA) tag. While ANSA derivatization does not increase the number of acidic sites it instead increases the overall peptide acidity. The ANSA sulfonic group may also be more prone to salt bridge formation compared with a carboxylate group. ANSA-derivatized peptides showed varying degrees of altered niECD behavior. In particular, ANSA tagging of LHRH, a peptide with N-terminal pyroglutamic acid residue, showed significantly higher sequence coverage compared with the corresponding non-tagged peptide. One explanation could be the higher basicity of the N-terminal secondary amine in LHRH, favoring salt-bridged structures. We also explored tagging with ANSA structural isomers, which likely show different propensities for salt-bridge formation. Preliminary data for LHRH tagged with (5,2) compared with the previous (4,1) ANSA showed higher niECD efficiency for the (5,2) isomer. ANSA tagging also affected nCID: for LHRH both the 4,1 and 5,2 isomers showed preferential formation of y-type fragments, similar to a previous report.

## Poster #4

### mRNA detection in Lipid Nanoparticles

Amari Nwamba, Tanmay Chatterjee & Nils G Walter

The mRNA vaccines have emerged as essential tools. If we can harness the potential of mRNA technology, these vaccines will be able to enter the market and save lives. Our goal is to use spectroscopic technique to examine influenza vaccinations in order to quantitatively identify the lipid nanoparticle (LNP) composition. A hydrophobic dye Nile Red will be applied to image lipid nanoparticles. We aim to use single-particle analysis to quantitatively image and fingerprint the RNA and different lipid compositions of thousands of LNPs per sample. Our pipeline will also allow us to compare the compositional heterogeneity of several LNP preparations. The spectroscopic analysis will provide critical insights into not completely copied, but a substantial degree of heterogeneity in the packing density of RNA in LNP's and size dependent loading-size correlations.

## Poster #5

### **Analysis of Neurochemical Differences in Cocaine Response of Selectively Bred Rat Lines**

Nicholas M. Oliver, Pavlo Popov & Robert T. Kennedy

In comparison to bred low-responder (bLR) rats, bred high-responder (bHR) rats exhibit a heightened locomotive response to new environments, take more risks, and are more prone to compulsive drug-seeking behaviors. Previous research has demonstrated a relationship between these phenotypic differences and neurotransmitter signaling, particularly in behaviors associated with addiction. In this study, we aim to deepen our understanding of these differences by expanding the neurochemical panel and examining sex differences, with a specific focus on signaling within the nucleus accumbens in response to cocaine administration. Using liquid chromatography coupled with mass spectrometry, we analyzed a panel of 70 neurochemicals present within brain dialysate. Our findings reveal distinct differences not only between bHR and bLR rats but also between sexes.

## Poster #6

### **In situ Chlorine Oxidation of Volatile Organic Compounds in an Arctic Oil Field**

Claire Thomson, Andrew Jensen, Graham Frazier, Anya Romig, Izabella Antczak, Daun Jeong, Nicole Woodall, Kathryn Kulju, Brian Lerner, Megan Claflin, Jordan Krechmer, Andrew Lambe & Kerri Pratt

The Arctic atmosphere in springtime is influenced by a uniquely high abundance of chlorine radicals, which affect atmospheric oxidative chemistry and composition. As the Arctic warms, emissions from shipping and resource extraction are predicted to increase, in turn increasing emissions of volatile organic compounds (VOCs) to the Arctic atmosphere. Chlorine radicals oxidize VOCs from anthropogenic and natural sources to produce secondary organic aerosol (SOA), impacting human health and the climate. In situ field experiments can help constrain the fates of precursor compounds and production of oxidized compounds following chlorine radical reactions with VOCs in ambient air. From February to March of 2020, an oxidation flow reactor (OFR) was deployed at Oliktok Point, Alaska, to rapidly simulate chlorine radical-initiated photochemical oxidative aging of ambient air from the field site, which is characterized by heavy oil and gas operations, on real-world timescales of hours to days. A  $\text{NO}^+$  chemical ionization time-of-flight mass spectrometer was used to detect gas-phase VOCs in ambient air and downstream of the OFR. A series of OFR experiments demonstrated that many hydrocarbons are depleted through chlorine radical oxidation, leading to the production of oxygenated VOCs and halogenated VOCs. Observed hydrocarbon depletion rates in the OFR agreed with relative reactivities with chlorine radicals. The OFR further enabled identification of halogenated and oxygenated VOCs which were not readily apparent in ambient data. Better understanding halogen chemical processes and their interactions with VOCs is crucial for constraining future predictions of conditions in the Arctic atmosphere and similar environments.

## Poster #7

### RNA:RNA interactions between SreA riboswitch and prfA thermosensor

Jocelyn Chen, Aldrex Munsayac & Sarah C. Keane

*Listeria monocytogenes* is the etiological agent of listeriosis, a serious foodborne illness. Though it typically exists as an environmental saprophyte, *Listeria* is capable of inducing virulence gene expression to transition to an intracellular pathogen. *Listeria*'s virulence gene expression is controlled by a transcriptional activator, Positive regulatory factor A (PrfA). PrfA's translation is controlled by an RNA thermosensor (RNAT) in the 5' UTR. Although it has been found that SreA, a S-adenosylmethionine (SAM) riboswitch, can interact with the prfA RNAT to inhibit PrfA protein translation, this interaction remains largely unknown at the mechanistic level. To better understand the RNA:RNA interaction between the prfA RNAT and SreA riboswitch, we performed mutagenesis on the second-helix (P2) of SreA while maintaining the pseudoknot structure required to bind SAM. We used this pseudoknot SreA (SreA-PK) to investigate the sequence dependence of this region on the riboswitch:prfA interaction. To validate that SreA-PK is capable of binding SAM, we performed circular dichroism (CD), electrophoretic mobility shift assays (EMSA), and isothermal titration calorimetry (ITC). EMSA demonstrated that in the presence or absence of SAM, SreA-PK can still bind the prfA RNAT. Furthermore, we validated that SreA-PK can inhibit PrfA translation by performing in vitro transcription/translation (IVTT) assays. Our results show that SreA-PK is not capable of binding SAM, but it can still bind prfA RNAT and regulate PrfA expression. This suggests that there is minimal contribution from the P2 helix for translation inhibition, and that critical sequence elements lie elsewhere on the riboswitch.



## Poster #8

### Exploring the Diversity of prenylated-Flavin Dependent (De)carboxylase Enzymes

Fatima Danazumi, Anushree Mondal & Neil Marsh

My REU research at the University of Michigan centers on the study of protein chemistry, specifically protein overexpression, purification, and biochemical assay development, with a focus on prenylated-flavin-dependent decarboxylases (UbiD enzymes) and their applications in biocatalysis. UbiD enzymes are versatile catalysts that facilitate regio- and stereospecific reactions under mild conditions, making them attractive for sustainable chemical processes. They can function as carboxylases, which has generated interest in their potential use for CO<sub>2</sub> capture. We are currently assessing the (de)carboxylase activity of 64 new UbiD enzymes using various spectroscopic techniques, including high-performance liquid chromatography (HPLC) and mass spectrometry (MS). Our experimental strategy involves constructing a substrate library encompassing hydrocarbons (both aromatic and acyclic), heterocycles, and phenol-based aromatics for initial screening. The primary objective of this research is to identify UbiD enzymes that serve as robust decarboxylation catalysts for specific classes of molecules rather than to determine their native physiological reaction pathways.

## Poster #9

### **The interactions between TLT-1 and fibrinogen in the presence of D-domain peptides derived from fibrinogen**

M. Luxmore, S. Branfield & A. V. Washington

In the United States, approximately 900,000 people die annually from some variation of thrombosis. Fibrinogen's interaction with platelets plays a central role in the thrombosis processes, which makes it a promising target for anti-thrombotic interventions. In this study, we aim to develop a greater understanding of an IgG-domain containing receptor released from platelet  $\alpha$ -granules upon platelet activation known as TREM-Like Transcript-1 (TLT-1) and its interactions with the D-domain of fibrinogen. We hypothesized that the peptides derived from the D-domain of fibrinogen would inhibit the interaction between the fibrinogen and platelets. We used peptides representing the interactions in a competitive flow cytometry assay to ask if this domain affects the interaction between fibrinogen and platelets. Platelets were incubated with FITC-labeled fibrinogen and upon activation, the flow cytometer measured the change in the fluorescence associated with the activated platelets. Two different approaches were used in this study; washed platelets and whole blood. Initially, the study involved only washed platelets, but due to equipment difficulties it shifted to whole blood. The initial trial demonstrated inhibition of fibrinogen binding. However, every trial using whole blood indicated no inhibition. After returning to washed platelets, the results aligned with the whole blood results as opposed to the preliminary results and hypothesis. We are now investigating whether the purchase of a new lot of fibrinogen affected our results or if the peptides do not lead to the inhibition between the interaction of fibrinogen and platelets, which will be presented here.

## Poster #10

### **TLT-1, a platelet specific receptor, stabilizes clot formation and inhibits clot lysis**

P. Mehta, S. Branfield & A V Washington

Thrombosis is one of the leading factors for cardiovascular diseases. To combat this, physicians, practice intravenous thrombolysis using an anti-coagulant called Tissue Plasminogen activator (t-PA), which can lead to profuse bleeding. Key components for thrombus formation are platelets and a glycoprotein called fibrinogen. TREM-Like Transcript (TLT)-1 is a platelet specific IgG domain containing receptor present in the alpha-granules of platelets, which upon activation, migrates to the surface to bind to fibrinogen. This interaction of TLT-1 with fibrinogen has been known to stabilize clot formation. We hypothesized that TLT-1 facilitates stable clot formation by inhibiting clot lysis. First, we performed in-vitro and in-vivo clot lysis-time assays using a micro-plate reader (Tecan Spark) that measured the absorbance of the clots in the presence of plasminogen and t-PA. When compared to clots cleaved with t-PA in humans, clots with TLT-1 had decreased clot lysis consistently. Varying TLT-1 concentrations suggest that this is in a concentration-dependent manner. Following, we assessed the strength of the interaction between fibrinogen and TLT-1 during clot lysis using Western Blots. To validate our results in vivo, we obtained the plasma from wild-type (WT) and TLT-1 null mice and repeated the assay. In support of in-vitro studies, WT mice showed significantly less clot lysis as compared to the latter. This data suggests that TLT-1 facilitates clot stability by inhibiting clot lysis. This study can be used as a baseline for future anti-coagulant pharmaceutical applications.

## Poster #11

### Discovery of Novel Biocatalytic Reactions

Samantha L. Mena, Cole C. Meyer & Alison Narayan

Catalysis is an important tool for chemical synthesis. An emerging alternative to chemical catalysis is biocatalysis, which uses enzymes as inherently green and selective tools for a variety of chemical processes. Previous work in the Narayan lab has demonstrated successful use of the enzyme P450 for oxidative C–C coupling of naphthols to create substructures of important commodity chemicals and natural products. The intermediate of these transformations is a naphthyl radical, which hypothetically may be intercepted by a second radical acceptor to create novel products. In this work, we describe progress towards expanding the scope of P450-catalyzed oxidative C–C coupling reactions.

## Poster #12

### RNA:RNA interactions, an investigation of RNA regulatory mechanisms in *Listeria*

#### *Monocytogenes*

Marin O'steen & Skylar Posey

Listeriosis is a serious foodborne illness with high rates of hospitalization and mortality. The etiological agent of listeriosis, *Listeria monocytogenes*, normally exists as a non-pathogenic environmental saprophyte. Its transition into an intracellular pathogen is controlled by a transcription factor named positive regulatory factor A (PrfA). PrfA's translation in turn is governed by a temperature-responsive RNA element (RNA thermometer) in the 5' UTR of the *prfA* transcript. Additionally, another layer of regulation is imposed by a SAM-sensitive riboswitch (SreA) acting in a trans manner. While this interaction is known to occur, the mechanistic details underlying it remain unexplored. To determine the critical nucleotides necessary for this interaction, we performed targeted mutagenesis of the *prfA* thermosensor and SreA riboswitch. These mutations were designed to selectively disrupt predicted interactions found in our *prfA:sreA* structural models. These *prfA* mutants were investigated via circular dichroism (CD) to characterize their melting behavior. Furthermore, the ability of these *prfA* mutants to interact with SreA was evaluated via electrophoretic mobility shift assays (EMSAs). Our results demonstrate that the *prfA* mutants have similar thermodynamic properties to the wild-type *prfA* RNA thermometer and were able to distinguish between our interaction models. Further work will establish an in vitro translation construct incorporating this mutant *prfA* construct.

## Poster #13

### Investigating the Role of IMPDH2 and Glutamine Dependency in High Grade Serous Ovarian Cancer

Harini Ram, Noah Puleo, Dr. Rita Avelar, Dr. Matthew Knarr, Medhasri Jasti, Michael Nakashima & Dr.

Analisa DiFeo

High grade serous ovarian cancer (HGSC), the most common and lethal ovarian cancer subtype, is often diagnosed at Stage III or IV with limited treatment options. It forms aggressive late-stage tumors with metastatic potential and often recurs. Therefore, understanding the molecular mechanisms behind this malignancy is crucial for developing better treatments. Using residual tumor size data, we found that elevated miR181a, a pleiotropic driver of ovarian cancer, correlated with poor patient outcomes. However, in vivo experiments with miR181a expressing FTE cells did not show metastasis, suggesting other genetic alterations contribute to this aggressive phenotype. Notably, we found that elevated expression of the oncogene Myc, coupled with increased miR181a expression, led to more aggressive tumors. Both in vitro and in vivo models of these expression levels showed enhanced proliferation, stemness, and metastasis. Using RNAseq, we investigated the downstream pathway effectors behind these observations, identifying enriched purine metabolism with upregulated IMPDH2, a metabolic gene promoting cancer progression and the epithelial-to-mesenchymal transition. Additionally, we discovered that miR181a targets glutaminase (GLS), leading to increased glutamine levels and glutamine dependency. IMPDH2 knockdown was able to rescue this glutamine dependency in co-expressing combo cells as well as reduce tumor burden and metastasis in vivo. Furthermore, we found that FTE cells co-expressing miR181a and Myc were intrinsically resistant to platinum-based chemotherapy, suggesting that platinum-resistance could be driven by IMPDH2-regulated glutamine dependency. These findings have significant translational potential, as targeting IMPDH2 and glutamine dependency could improve treatment outcomes for HGSC patients with Myc and miR-181a co-expressing, platinum-resistant tumors.

## Poster #14

### **Deploying an environmentally sensitive fluorophore to define druggable transcriptional protein-protein interactions**

Lizzet Solache Salgado, Ryan Torres & Dr. Anna Mapp

The process of transcription relies on various protein-protein interactions. This includes those between Mediator and activator proteins, which play an important role in regulating gene expression. The binding interaction between Med23, a Mediator protein, and ESX, a transcriptional activator protein is critical in early development but is often dysregulated in cancer. For example, in one-third of breast cancers there is an overexpression of the ESX-Med23-controlled Her2 oncogene. Thus, it is important to understand how these proteins interact for potential future development of probes with the ability to inhibit this pathway. To characterize the interaction, the amino acid fluorophore 4-DMN was synthesized and incorporated into the ESX transcriptional activation domain (TAD). This synthetic mimic of tryptophan allows for fluorescence based binding experiments. These experiments provide a better understanding of the binding affinity between the two proteins and their mechanism of interaction.

## Poster #15

### Probing functional differences in hnRNPA2B1 RRM domains in the binding of pri-miR-20a

Sydney M. Steele, Cade T. Harkner, Yaping Liu & Sarah C. Keane

MicroRNAs are short (~20nt) RNAs which function to regulate gene expression. Primary microRNA-20a (pri-miR-20a) is an oncogenic miRNA whose processing is post-transcriptionally by RNA-binding proteins (RBPs). The apical loop of primary miRNA-20a is known to be a critical binding site for RBPs. Work by our group has shown binding of hnRNPA2B1 to the pri-miR-20a apical loop to form a 1:1 complex, which remodels the apical loop to be a better substrate for Drosha processing. However, it is not fully understood if one of the two tandem RNA recognition motif (RRM) domains preferentially binds pri-miR-20a and/or function differentially. ITC data shows similar binding affinities of each isolated RRM for pri-miR-20a, with similar affinity to the entire RNA-binding domain (RBD). To elucidate potential functional differences between RRM domains, we used site-directed RNA mutagenesis to target residues in each RRM known to facilitate RNA binding. We will investigate how these mutations in both isolated RRM domains and the full RBD impact the binding of pri-miR-20a using ITC, revealing potential functional differences between hnRNPA2B1 RRM domains.



## Poster #16

### Development of a Quantitative *in vitro* Pus7 Pseudouridylation Assay Using HPLC-UV

Sean Stroble, David Muzyka, Daniel Eyler, Kaley Simcox, Rachel Giles & Kristin Koutmou

Pseudouridine synthase (Pus) enzymes catalyze the isomerization of uridine to pseudouridine, the most abundant post transcriptional RNA modification. I'm particularly interested in Pus7, a eukaryotic pseudouridine synthase that interacts with RNAs containing a UGUAR consensus sequence. While this consensus sequence is known for Pus7, additional traits that determine *in vivo* substrate selection, such as substrate structure and enzyme characteristics, must be understood to elucidate the mechanisms behind Pus enzyme preferences. Previously, work has been done using electrophoretic mobility shift assays (EMSAs) to analyze protein binding and tritium release assays to assess kinetics. EMSAs cannot distinguish specific target binding as they report on all RNA interactions, and tritium release assays are prohibitively expensive for studies involving multiple-turnover kinetics. Here, we propose an alternative, non-radioactive approach to study Pus protein activity that integrates *in vitro* transcription, enzymatic digestion of RNAs to nucleosides, and high-performance liquid chromatography with UV detection (HPLC-UV). This novel assay will help reveal the characteristics that impact Pus7 binding and substrate selection using short oligonucleotide substrates that contain the consensus sequence.

## Poster #17

### **A human cell-free system to study mRNA translation initiation**

Isabella Vitanovich, Suada Leskaj, Wenzhao Dong & Jailson Brito Querido

Translation is a crucial cellular process responsible for protein synthesis. Translation initiation is the most tightly controlled and regulated step, beginning with eukaryotic initiation factors (eIFs) binding to the 40S small ribosomal subunit. A critical step in this process is the formation of the ternary complex (TC), which consists of eIF2, GTP, and initiator tRNA (tRNA<sup>iMet</sup>). Once assembled, the TC binds to the ribosome, delivering tRNA<sup>iMet</sup> to the decoding center. Under stress conditions, various kinases phosphorylate eIF2, leading to its inhibition and repressing global translation. To study the translation efficiency of different mRNA transcripts, we use a cell-free human in vitro translation system. This system allows us to assess the amount of translated protein by detecting a fluorescent signal embedded within the transcript sequence. However, since eIF2 is phosphorylated under various stress conditions, the efficiency of the cell extract used in in vitro translation can vary. A recent study finds that adding a truncated version of Growth arrest and DNA damage-inducible protein (GADD34 $\Delta$ 1-240) optimizes the translation assay by promoting dephosphorylation of eIF2 and restoring global translation (Bothe et al., 2024). To develop an optimized human in vitro translation system, we have expressed and purified human GADD34 $\Delta$ 1-240. After purifying, we will test the addition of GADD34 $\Delta$ 1-240 in translation assays with different lysates to understand if GADD34 $\Delta$ 1-240 will promote a functional translation system. Thus, we will be able to establish an efficient in vitro translation system, enabling our understanding of differences in translation output in the context of various diseases.

## **Poster #18**

### **Storytelling – Our Human Superpower**

Adam Almaleky, Carmel Price Ph.D. & Natalie Sampson Ph.D.

For decades, River Rouge factories have emitted toxic chemicals next door to marginalized residents. Most families in and around the surrounding Metro Detroit area are unaware of their heightened health risks due to pollution. Hence, in 2018, a community/academic-based organization called Environmental Health Research to Action (EHRA) was established to help educate, empower, and inspire a new wave of environmental justice advocates. Telling the stories of residents was central to captivating EHRA's high-school audience over the 10–12-day annual program in July. To assess EHRA's performance over the past five years, an analysis of over 100+ EHRA fellow survey responses from across the years was performed. Our study demonstrates that storytelling-based curriculums like EHRA are efficacious at educating, empowering, and inspiring students. We also identified a practical list of curricular improvements that can improve the success of EHRA and similar programs. In presenting the curriculum, analysis, and enhancements of ERHA's curriculum, we hope to inspire others around the globe to adopt similar programs in a global effort to eradicate environmental injustice.

## Poster #19

### **Synthesis and photochemical characterization of two novel polypyridyl ruthenium compounds for phototherapeutic anticancer applications**

Pieter Boer, Wessel Verbeet & Dr. Sylvestre Bonnet

Increasing the toxicity of photoactivated chemotherapy metal complexes after photosubstitution is a potential pathway towards a stronger anti-cancer effect. Ideally, this would be achieved without impacting the ability of the designated ligands to photosubstitute. This goal was pursued via the modification of a previously synthesized ruthenium(II) complex with dppn and dppz moieties; both are reported to produce singlet oxygen when incorporated into inorganic compounds and irradiated, as well as intercalate with DNA.  $[\text{Ru}(\text{dppn-bpya})(\text{py})_2]\text{Cl}_2$  ([1]Cl) showed photosubstitution of the axial ligands with meaningful quantum yields in deoxygenated water, and produced singlet oxygen with a substantial quantum yield of 0.74. These properties, in addition to interacting with DNA, give the compound potential as a dual action photoactivated chemotherapy agent once modified with active ligands.  $[\text{Ru}(\text{dppz-bpya})(\text{py})_2]\text{Cl}_2$  ([2]Cl<sub>2</sub>) did not produce singlet oxygen, but photosubstituted with greater quantum yields in deoxygenated conditions, though the compound still needs further investigation into its DNA binding. Both compounds displayed properties that are promising for use as photoactivated chemotherapy agents.

## Poster #20

### Synthesis, Structural, and Electrochemical Characterization of Novel Heterobimetallic Zinc Complexes

Ethan B. Chavarin, Claire Patterson & Joshua A. Buss

The oxidative functionalization of C–H bonds streamlines the production of useful feedstock chemicals and valuable pharmaceuticals. Activating these chemically inert moieties is quite challenging; however, in biology, metalloenzymes are known to enact these transformations with ease. One strategy nature uses to control C–H activation reactivity is the inclusion of multiple metals in enzyme active sites. The identity of these metals is hypothesized to be an important feature in dictating reactivity, and heterobimetallic enzymes have been shown to exhibit increased activity compared to their homobimetallic counterparts. Determining the effect of metal identity on reactivity remains a challenge, given the complex structure of these cofactors and difficulties isolating pure heterobimetallic species (homobimetallic impurities are often present in these cambialistic systems). Thus utilizing smaller, synthetic model complexes affords an opportunity to elucidate the structure/function relationships between metal identity and resultant oxidation reactivity. Prior work in the Buss group involved synthesis of a series of heterobimetallic NiII/MIII species (M = Mn, Fe, Co, Ni, Cu) upon a symmetric scaffold, allowing rigorous correlations to be drawn between metal identity and redox properties. To better understand the observed redox reactivity of these complexes, the heterobimetallic ZnMII congeners have been targeted synthetically. Taking advantage of the redox inactivity of the Zn(II) ion, cyclic voltammetry studies in conjunction with rigorous structural characterization via SCXRD and NMR, allow for the deconvolution of observed trends across the complete Irving-Williams series and aid in correlating metal identity with structural and electrochemical properties.

## Poster #21

### **Bulky Cyclic Silyl Amides: Designer Ligands for Linear Low-coordinate Metal Complexes**

Mason Flora & Joshua Buss

Single-Molecule Magnets (SMMs) are a topical target for synthetic chemists due to their potential applications in data processing and spintronics. Most molecular species demonstrating favorable SMM behavior likewise display a high order of axial anisotropy; as such, much attention has been directed toward elements with unparalleled single-ion anisotropy: linear coordination complexes of the lanthanide and actinide ions. These types of complexes boast state-of-the-art  $U_{\text{eff}}$  and blocking temperatures. One such class of compounds are monometallic Ln-SMMs supported by phthalocyanine ligands, which combine steric bulk and multiple coordination sites to enforce a double-decker or “sandwich” structure. Herein, the synthesis of unusually bulky cyclic silyl amides is targeted. The steric profile, enforced by four flanking benzyl substituents, creates a disc-shaped volume envisioned to favor linearity in low-coordinate metal complexes. Scrupulous ligand modification and metalation chemistry will be discussed, toward the aim of accessing structures suitable for next-generation SMMs.

## Poster #22

### Photoreactive Protein Bioconjugation of Metallacrowns

Sonja Francisco, Soroush Naseri, John Jeffers & Vincent Pecoraro

Metallacrowns (MCs), an inorganic analog of crown ethers, were first synthesized by Pecoraro and Lah in 1989. Since then, MCs have been explored further for applications in single molecule magnetism (SMM), lanthanide luminescence, and magnetic resonance contrast agents. Such contrast agents have been proposed to image metastasized cancer cells in the body. MCs that entered tumor cells would be exposed to visible light, and following a series of energy transfers, the lanthanide ions in the MC center cavity would be sensitized, resulting in a recordable NIR emission to determine the location of such cells. However, MCs have been limited in their biocompatibility due to their insolubility in biological conditions, minimal cellular uptake, and potential degradation, leading to toxic lanthanide release. Herein, we propose a biofunctionalization scheme utilizing a photoreactive crosslinker isophthalic acid derivative to couple a protein with an MC. Thereby, increasing cellular-compatibility, solubility, and potentially the stability of the MC in cells, yielding a safer and more effective contrast agent.

## Poster #23

### Coordination chemistry of f-elements using CMPO compounds with long alkyl chains

Brianna Gordon, Nancy Martinez & Shannon Biros

As researchers work to advance the use of alternative sources of energy, nuclear power remains a viable option. One current disadvantage with nuclear power is the production of radioactive metals that are harmful to the environment. Currently, organic ligands are used to extract these metals as a way to remediate nuclear waste. An active area of research is the synthesis of new organic ligands that will carry out these extraction processes more efficiently and will add to the current understanding of f-element coordination chemistry. Our group has prepared a series of tripodal carbamoylmethylphosphine oxide (CMPO) ligands as new extraction agents for f-elements. The ligands' extraction ability toward lanthanide ions (excluding  $\text{Pm}^{3+}$ ),  $\text{Th}^{4+}$ , and  $\text{UO}_2^{2+}$  will be presented. The influence of different CMPO substituents on the solution structure of the metal complexes was also investigated via luminescence and NMR studies.



## Poster #24

### Functionalization of PyTAP Ligands for Near-IR Imaging Metallacrowns

John Jeffers, Soroush Naseri, Franck Suzunet, Sonja Francisco, Alice Chen & Vincent Pecoraro

Visible light-emitting fluorophores have been of great importance in biological imaging since their emergence but are hindered by their limited tissue penetration and frequent photon scattering/reabsorption of biomolecules. Near-Infrared (NIR) light, however, penetrates tissues effectively with minimal absorptivity, making NIR-imaging agents a highly desirable target for high resolution biological imaging. Despite their promise, natural and synthetic NIR-emitting compounds remain limited, with a notable exception of trivalent lanthanide coordination compounds. Direct excitation of lanthanides rarely yields highly luminescent materials and remains inefficient due to Laporte selection rules for f-f transitions. Therefore, these lanthanides must be indirectly sensitized for NIR emission through the usage of organic chromophores which subsequently perform a series of energy transfers to the lanthanide's NIR emissive level. Taking advantage of this 'antenna effect', our lab utilizes supramolecular structures known as metallacrowns to sensitize the lanthanides. These trivalent structures contain a recurring N-M-O ring afforded by hydroxamic acids coordinated to a central lanthanide as well as various other possible ligands for polymeric structures. Recently, pyridazino-1,3a,6a-triazapentalenes (PyTAPs) have emerged as a promising class of fluorophores that contain a unique, stable zwitterionic 6/5/5 tricyclic scaffold that typically absorbs around 400-450 nm. The functionalization of these PyTAPs has been thoroughly investigated and proven successful for cellular imaging. Thus, with ideal chromophoric and nontoxic properties, in collaboration with the University of Orléans, we aimed to incorporate these fluorescent scaffolds into our dimeric 12-MCGa(III)L-4 metallacrown structures, as both functionalized hydroxamic acids and as bridging ligands in the creation of novel, NIR-emitting biological imaging agents.

## Poster #25

### Preparation of Sterically Protected Ligands to Model Key Hyponitrite Intermediate(s) in Flavodiiron Nitric Oxide Reductases

Christopher Kim, Michael O. Lengel & Nicolai Lehnert

Flavodiiron Nitric Oxide Reductases (FNORs) are used in certain bacterial systems to enzymatically reduce nitric oxide (NO) to nitrous oxide (N<sub>2</sub>O), thereby circumventing a key aspect of the mammalian immune defense mechanism against invading pathogens. Although a great deal is known about the binding of NO at the diiron active site and the product, N<sub>2</sub>O, less is known about the key intermediates involved. It has been proposed that hyponitrite ([N<sub>2</sub>O<sub>2</sub>]<sup>2-</sup>) is the key intermediate in the N-N bond forming step of this reaction, however, no intermediates have been experimentally observed thus far. Recently, Lehnert and coworkers have prepared a rare synthetic iron-hyponitrite complex (submitted for publication), providing structural and electronic insights into the key Fe-hyponitrite intermediate(s). However, in the current system, each hyponitrite unit coordinates to two diiron complexes, forming a tetranuclear iron species that is dissimilar to FNORs, which only possess two iron centers in the active site. Inspired by the design of 2,6-Bis[[bis(2-pyridylmethyl)amino]methyl]-4-methylphenol (H[BPMP]), which has been shown by Lehnert and coworkers to be a competent system for FNOR model complex mimics, we have prepared a novel ligand, H[(Py<sub>2</sub>(PyMes)<sub>2</sub>MMP)], in which an ortho mesityl on the pyridine of each ligand arm provides steric protection against the aggregation of larger clusters with the bridging hyponitrite ligand. Work is ongoing to prepare the metallated complex which will hopefully yield a more accurate synthetic model of the key Fe-hyponitrite intermediate(s) in FNORs.

## Poster #26

### Circumventing the Oxo-Wall with a Triazole-Based Ligand Scaffold

Sophia Lemieux, Benedict J. Elvers & Nicolai Lehnert

C-H bond cleavage and functionalization are crucially important and very challenging reactions in chemistry and biology. Within cells, enzymes with high-valent metal-oxo active sites capable of C-H bond activation are known, especially featuring manganese and iron as central metal ions. The active sites of these enzymes have been studied previously using bioinspired, synthetic model complexes, allowing for a deeper understanding of the mechanism for the C-H bond activation. Yet, studies of model complexes using late transition metals are much scarcer despite their promising reactivity described for small molecule activation. Despite missing a natural counterpart, cobalt shows very promising reactivity for C-H bond activation catalysis as shown for example by Anderson, Nam, Ray and others. This work is focused on the development of a new ligand scaffold capable of supporting a Co(IV) metal center and investigating their catalytic capabilities. In order to obtain the ligand scaffold to possibly stabilize high-valent cobalt oxo-complexes, a rational design approach was utilized. Tridentate ligands designed to create a trigonal-bipyramidal structure were synthesized via a multistep reaction, where an amine to triazene to tristriazolium pre-ligand approach was used. This pre-ligand would then be deprotonated to form a mesoionic carbene to allow for metal coordination. Initial results of this chemistry will be presented, highlighting the difficulties of producing a ligand scaffold with the possibility of internal acid-base reactions.

## Poster #27

### Photo-electrochemical Ethanol Oxidation by Cupric Tungstate in Neat Ethanol

Olivia Lyon, Ryan Van Daele & Bart Bartlett

Ethanol oxidation in neat ethanol has shown selectivity for the 2-electron product due to the swift acetalization that protects the aldehyde from being overoxidized to acetic acid. Discovering a noble metal free photo-electrocatalyst stable in neat ethanol is critical for wide scale adoption. Cupric tungstate ( $\text{CuWO}_4$ ) fits this description and is abundant and biologically benign. Through a sol-gel synthesis, pure phase  $\text{CuWO}_4$  thin films were made and verified by XRD. Constant potential chronoamperometry over 24 hours demonstrated stability of the cupric tungstate films for electrolysis. GC-FID indicated the presence of the 2-electron product with a faradaic efficiency of approximately 60% in TBAOTf and ~100% in HOTf. We hypothesized that  $\text{CuWO}_4$  would selectively form 1,1-diethoxyethane. However, product analysis shows the formation of 1-ethoxyethanol, the hemiacetal, in addition to 1,1-diethoxyethane.

## Poster #28

### Using Reactive Carbon Capture to Enhance Efficiency in Electrochemical CO<sub>2</sub> Reduction

Chidi Nnaji & Leila Filien

Carbon Dioxide(CO<sub>2</sub>) is a chemical that traps heat in the planet. While this is not inherently dangerous, the large increase in CO<sub>2</sub> in the last decades has caused it to become a growing concern. This is due to it causing an increased frequency and intensity of natural disasters. As a result effective strategies to reduce CO<sub>2</sub> in the atmosphere have become crucial. One way to do that is through electricity which has been shown to be capable of changing CO<sub>2</sub> into other compounds using transition metal catalysts like Cobalt Phthalocyanine (CoPc). Electrochemical CO<sub>2</sub> reduction is capable of not only lowering the amount of CO<sub>2</sub> in our atmosphere but turning it into something beneficial such as methanol or formic acid . The problem however with previous strategies for CO<sub>2</sub> reduction is that it requires pure CO<sub>2</sub> and atmospheric CO<sub>2</sub> is in much lower concentrations. We aim to use Reactive Carbon Capture (RCC) to directly reduce CO<sub>2</sub> in a captured form. This would be more energy efficient than traditional carbon capture and utilization (CCU) due to it not requiring thermal CO<sub>2</sub> release.

## Poster #29

### **Novel Copper Complex of an Asymmetric and Hydrogen Bonding Containing Derivative for the Reduction of Nitrite to Nitric Oxide**

Christian M.B. Pruitt, Glorimar Miranda-Mendez, Elizabeth C. Manickas, Mark E. Meyerhoff & Nicolai Lehnert

Nitric oxide (NO) is an endogenous gas that plays several key physiological roles in humans, including prevention of platelet adhesion/activation, inhibiting bacterial adhesion/proliferation, enhancing vasodilation, promoting angiogenesis, and aiding in wound healing. These benefits show NO to be attractive for the use in medical devices such as intravenous catheters. These catheters are known to be a point of blood coagulation and a source of infections by being an entry point for microbes into the body. Previous work has shown promising results from the development of multi-lumen catheters that electrochemically reduce nitrite ( $\text{-NO}_2$ ) ions (in buffer) to NO gas using Cu(II)-ligand complexes. The Lehnert laboratory has previously developed copper complexes that have been shown to very efficiently reduce nitrite, via electrochemistry, to form NO. This includes copper(II) BMPA (=bis(methylpyridyl)amine) and BEPA (=bis(ethylpyridyl)amine) scaffolds with attached carboxylate groups of different chain lengths. This work focuses on the development of an asymmetric scaffold known as MEPA (= (2-pyridin-2-yl-ethyl)-pyridin-2-ylmethyl-amine) with an amine as hydrogen donor group that would lead to an increased stability for the Cu-Nitrite complex. The ligand used to make this complex was purified and characterized using NMR spectroscopy, and the corresponding Cu(II) complex was characterized using UV-Vis spectroscopy and cyclic voltammetry. These complexes were then further studied in solution for their electrochemical capabilities to reduce nitrite to NO via bulk electrolysis. Here, using a Nitric Oxide Analyzer allows us to quantify the produced NO, and this information can be further used to determine the Faradaic efficiency of NO production under nitrogen and in the presence of different concentrations of  $\text{O}_2$ .

## Poster #30

### **Understanding the catalytic activities of mono-, bi-, and trimetallic cobalt pyridyldiimine (CoPDI) complexes, and their positional substitution effects in electrochemical carbon dioxide reduction.**

Jonathan K. Thompson, MD. Waseem Hussain & Charles C. L. McCrory

A promising strategy for the electrochemical reduction of carbon dioxide (CO<sub>2</sub>) are cobalt(III) pyridyldiimine (CoPDI) frameworks, which are able to selectively bind to CO<sub>2</sub> and reduce it to carbon monoxide (CO). Our goal is to ultimately maximize this electrochemical conversion by discovering characteristics that bolster the catalytic activity of CoPDI complexes. As such, we have synthesized benzene substituted CoPDI complexes from 4-bromo-2,6-diacetylpyridine in an effort to better understand the role of extended conjugation in relation to multimetallic systems, and relate their catalytic activity in CO<sub>2</sub> reduction. Specifically, we have synthesized para, meta and 1,3,5-benzene based multimetallic CoPDI's with the goal of finding an ideal structure for tuning electrochemical activity. Through use of cyclic voltammograms and controlled potential electrolysis, we are able to compare the catalytic effect of each CoPDI framework, and understand the behavior of these multimetallic systems. Additionally, we have also studied the properties of these CoPDI frameworks to determine the role of conjugation in relation to increased metal active sites, as well as the effect of through space and through bond activity for coordinating CO<sub>2</sub>. We notice an increased catalytic activity in 1,3,5-benzene substituted tri-CoPDI, followed by meta 1,3-benzene substituted bi-CoPDI systems. We will ultimately use these results to further tune the catalytic activities and develop various substituted CoPDI based catalysts, as well as in understanding other multimetallic catalysts.

## Poster #31

### Synthesis of photoactive manganese compounds with carbene ligands

William Tocco, Mirella Villani, Paul Lummis & Daniela Arias-Rotondo

Photoactive complexes of transition metals that can access charge-separated excited states when exposed to visible light are used in a variety of chemical applications, including dye-sensitized solar cells, photoredox catalysis, and water splitting. Regarding these applications, the powerhouses are complexes of ruthenium, iridium, and rhenium. The low elemental abundance of these metals makes them very expensive and problematic for large-scale applications. To create lower cost, more sustainable options for these photoactive coordination complexes, the more earth-abundant transition metals have been of interest. In our work, we explore the promising properties of manganese, the third most abundant transition metal on the Earth's crust. Manganese has a broad range of oxidation states; in particular, our work focuses on complexes of Mn(I) and Mn(II) with strong-field ligands derived from 2,6-bis(imidazolium-1-yl)pyridine (bim). In this poster, we discuss the synthesis of these complexes, as well as their characterization using x-ray crystallography, NMR, UV-vis spectroscopy, and electrochemistry.



## Poster #32

### Intercalating Group 1A Metals in WO<sub>3</sub> for Improved Photoelectrode Performance

Matias Moreno, Jake O'Hara & Bart Bartlett

The anodic half-reactions to generate H<sub>2</sub> as a renewable fuel has historically utilized the oxygen evolution reaction (OER). Unfortunately, the commercial value of O<sub>2</sub> is low and the reaction is highly rate-limiting. Yielding industrially relevant products and faster kinetics, chloride oxidation reactions (COR) serve as a favorable alternative half-reaction. To improve photocurrent densities during COR, intercalating select group 1A metals into WO<sub>3</sub> films can facilitate improved n-type doping of W<sup>+5</sup>. Synthesis of these intercalated semiconductor films begins by doping 1 mol % of group 1A cations. Results from replicable experiments of controlled potential coulometry (CPC) show a general periodic trend of current density following increasing atomic size. Herein, we hypothesize bulkier and heavier intercalants will show a larger W<sup>+5</sup> dopant density after a bias is applied, further demonstrating successful channel intercalation.

## Poster #33

### **Metal Organic Framework Interpenetration Suppression Through Tailored Lattice-Interacting Additives**

Samuel Chackerian, Cassidy Carey, Samuel Greco & Adam Matzger

Metal-organic frameworks (MOFs) have been proposed for the low-pressure storage of hydrogen gas due to their high surface areas and porosity. However, they have yet to meet predicted gas sorption properties due to low packing efficiency and framework interpenetration. Interpenetration results in a decrease in the surface area and accessible pore volume in practice, thereby leading to a reduction in guest storage capacity. Thus, the development of methods to synthesize non-interpenetrated MOFs with improved packing efficiency (influenced by crystal morphology) is crucial for enhancing their gas sorption capabilities. Herein, tailored lattice-interacting additives were employed to alter MOF morphology and suppress interpenetration during the solvothermal synthesis of cubic Zn<sub>4</sub>O MOFs. Among these, a novel MOF derived from biphenylene-2,6-dicarboxylic acid linkers was studied as an extension of IRMOF-8, a classic example of interpenetration under traditional solvothermal conditions. In situ imaging of MOF nucleation and growth under polarized light was employed to provide insights into the mechanisms of MOF interpenetration.

## Poster #34

### Electrochemical conversion of PVC to commodity chemicals

Grace Cook, Dr. Bertrand Neyhouse & Prof. Anne J McNeil

As society is increasingly wrapped in mass plastic consumption, plastic waste has become an issue that threatens the health of our communities and ecosystems. Poly(vinyl chloride) (PVC) is a versatile polymer material used in products from pipes to medical tubing to vinyl floors. Being the third-highest production volume polymer while also having the lowest post-consumer waste recycling rate, PVC faces recycling limitations due to its additives and the creation of gaseous hydrochloric acid when PVC is pyrolyzed. For this reason we are presented the opportunity to seek out safe and effective chemical recycling techniques. In this work, we electrochemically recycle PVC by stripping chloride from polymer waste and oxidizing it into molecular chlorine, which can be used to synthesize commodity-scale chlorinated products. We employ cyclic voltammetry and electrolysis to explore potential substrates and catalysts for electrochemical chlorination, leading toward sustainable and economical generation of commodity chemicals (e.g., vinyl chloride) from PVC waste.

## Poster #35

### Fundamental Study of Ge Nanowire Growth

Rachel Lee, Lauren Rich & Stephen Maldonado

We are studying the growth of individual Ge nanowires on ultramicroelectrodes (UMEs) through the electrochemical liquid-liquid-solid (ec-LLS) crystal growth mechanism. With growing interest in semiconductor nanowires for battery anode applications, Ge nanowires have become an emerging area of study. The formation and development of each microwire will be studied to improve understanding of Ge crystal behavior and growth from liquid metal electrodes. Previous work in the Maldonado lab has observed the nanowires exhibiting a coil-like structure and eutectic gallium-indium cap. We will thoroughly characterize the shape, structure, and length of Ge nanowires grown from Pt and Cu ultramicroelectrodes dipped in eutectic gallium-indium using optical and electron microscopes. Understanding of the fundamental behavior of Ge nanowire growth can be applied to improve efficacy and promote the appearance of desired characteristics (e.g. length and thickness) when growing Ge nanowires at larger scales.

## Poster #36

### Synthesis of Phase-Pure $\text{LiMn}_2\text{O}_4$ Spinel for Cobalt-Free, Low-Strain Lithium-Ion Batteries

Unaisa Islam, Shae Hagler & Bart M. Bartlett

The usage of lithium ion batteries (LIBs) are on the rise with the exponential production of electric vehicles and mobile devices. These batteries often contain cobalt—an element that comes with environmental, economic, and humanitarian concerns—as well as have limited life expectancies and low capacities due to large volumetric changes in the battery's crystalline structure. These volumetric changes, referred to as strain, occur during charging and discharging of the battery and induce cracks—which ultimately lead to cell failure. In order to address concerns in LIB cathodes regarding the presence of cobalt and strain,  $\text{LiMn}_2\text{O}_4$  (LMO) was synthesized as a cobalt-free material with potential application for low-strain cathodes. Through an initial hydrothermal synthesis and two subsequent annealing steps, LMO was synthesized without impurities. XRD scans demonstrated a phase-pure spinel structure in the  $Fd\bar{3}m$  space group. SEM data revealed submicron-sized particles with distinct but nonuniform morphologies. Additional work is currently underway to determine the relationship between concentration of solution and particle size and morphology.

## Poster #37

### **Molecular Structures of Poly(dimethyl siloxane) Incorporated with Silicone Oil Containing Phenyl Functionality**

Fernando Gomez, Samuel Roter, Daniel Rossi, Guangyao Wu, Maryam Safaripour, Dean Webster &  
Zhan Chen

Marine biofouling is a multibillion-dollar global energy and environmental problem. It increases fuel consumption by up to 40%, releasing 390 million tons of potent greenhouse gases, a major contributor to climate change. Poly(dimethyl siloxane) (PDMS) materials have been widely researched and applied as fouling-release coatings. Incorporation of silicone oil into PDMS could lead to antifouling properties of PDMS materials. In this research, we applied sum frequency generation (SFG) vibrational spectroscopy to study PDMS materials incorporated with a variety of silicone oils containing phenyl groups in air, in water, and in protein solution. It was found that surface structures of various silicone oils are varied, which results in different surface structures of PDMS with different oils incorporated. Such different PDMS surfaces interact with water molecules differently, leading to different surface hydrations. A model protein, fibrinogen, was used to study molecular interactions between oil incorporated PDMS and biological molecules. It was found that fibrinogen has different adsorption kinetics and adsorption amounts on different PDMS surfaces, while the adsorbed fibrinogen adopts bent structures. This study demonstrated that SFG can be used to deduce molecular structural information of silicone oil, PDMS, water, and fibrinogen in on surfaces/at interfaces in situ in real time. The incorporated oil could alter the surface structures of PDMS while different silicone oils incorporated into PDMS changed the PDMS surfaces differently, leading to varied interactions with water and biological media, influencing the antifouling and fouling release activities.

## Poster #38

### **Novel Functionalization of Aryl Iodides Involving Visible-Light Irradiation of Silver Nanoparticles**

Nina Aagaard, Taylor E. Spiller & Melanie S. Sanford

Silver nanoparticles (AgNPs), though mainly employed in biomedical sciences and consumer goods, have not been extensively researched for their applications in organic synthesis (Berger et al., 2019). However, recent exploration of localized surface plasmon resonance in silver nanoparticles has revealed potential for the use of Ag(0) as a photosensitizer, and there is a push to further explore its photochemical properties. In 2019, Wu et al. published a report of protodehalogenation and arylation of aryl halides via silver nanoparticles. They determined that AgNPs are able to generate an aryl radical that can then be protonated or selectively arylated. We propose that this aryl radical can also be trapped by Cu(II) to form a Cu(III) complex that, coupled with a nucleophile, culminates in a reductive elimination, opening the door for a host of different functionalizations.

## Poster #39

### **Palladium Catalyzed Alkyne Difunctionalization Reactions for the Synthesis of Tricyclic Ureas**

Andrew Cruz, Ella Chu & John P. Wolfe

This work will discuss palladium catalyzed alkyne difunctionalization reactions for the synthesis of tricyclic urea derivatives. Specifically, bromo-substituted phenyl ureas with alkyne tethers were used to create imidazo[1,5-a]indol-3-one scaffolds. These types of tricyclic ureas have been shown to have relevant pharmaceutical properties as antifungals and protease inhibitors. Advantages of this methodology include access to easily prepared starting materials to obtain complex or synthetically inaccessible tricyclic urea compounds. Preliminary mechanistic studies involve the oxidative addition of the aryl bromide, followed by a migratory insertion onto the tethered alkyne, and lastly a Csp<sup>2</sup>-Csp<sup>2</sup> reductive elimination. Using a phenyl urea compound as a model substrate, ligand and base screens were performed to determine optimal conditions for conversion.



## Poster #40

### Nickel Catalyzed Cross Electrophile Coupling of Aldehydes and Aryl (pseudo) Halides

Aidan Cosgrove, Sean Calvert & John Montgomery

The synthesis of ketones relies heavily upon the implementation of reductive and oxidative (or “redox”) processes. Chemists classically employ carbonyl addition chemistry where an organometallic nucleophile (often pre-formed from an aryl or alkyl halide) adds into an aldehyde and a subsequent oxidation reaction converts the secondary alcohol intermediate to the ketone. Although reliable, a more ideal method would be less periphrastic and achieve comparable reactivity from the same starting materials in a single step. Ongoing work in the Montgomery group seeks to address this gap in ketone synthesis using nickel-catalyzed C-H functionalization with aldehydes and aryl (pseudo)halides. However, common issue in C-H functionalization is regioselectivity, as the vast majority of organic molecules have many C-H bonds of similar bond dissociation energies (BDEs). However, we have identified a zinc/di-tert-butyl peroxide (DTBP) system that promotes highly selective hydrogen atom transfer (HAT) of formyl hydrogens. The resulting acyl radicals can be subsequently cross-coupled with an aryl electrophile by an Earth-abundant nickel catalyst. With our method, We have successfully synthesized a variety of (hetero)aryl ketones using this method. However, exploration of the substrate scope has revealed a strong preference for electron-deficient aryl coupling partners. Work investigating the compatibility of other aryl coupling partners is currently ongoing to engage electron neutral and rich aryl groups in productive coupling.

## Poster #41

### **A Search for Safer Plastics: Synthesis and Reproductive Toxicity Analysis of TMBPF Analogs**

Emma R. Elinski, Cole M. Higley, Katelyn D. Waligora, Aleksandra Kuzmanov & Shannon C. Timmons

Bisphenol A (BPA), an organic molecule omnipresent in common plastic consumer products, is classified as an endocrine-disrupting chemical (EDC). As an EDC, BPA mimics hormones such as estrogen to interact with hormone receptors such as ER $\alpha$  and ER $\beta$ . Interactions between BPA and estrogen receptors have been linked to several endocrine-related health disorders through interference in hormone signaling. BPA exposure also leads to meiotic errors, which result in poor reproductive cell quality, contributing to male and female infertility. Many analogs of BPA have been synthesized in an attempt to find a derivative with similar physical properties as BPA with low or no impact on human health. Unfortunately, current BPA analogs such as the most frequently used commercial alternative bisphenol S (BPS) have similar health effects as BPA. A promising new BPA alternative, tetramethyl bisphenol F (TMBPF), has gained attention due to its minimal *in vitro* estrogenic and androgenic endocrine activity as well as its negligible effects on female and male reproductive organs in animal studies. To further investigate the promise of TMBPF-type structures in the quest to discover safer plastics, five TMBPF analogs including novel phenolic ring substitutions will be prepared and tested for reproductive toxicity using *Caenorhabditis elegans*, a roundworm commonly used as a model organism. Progress toward the synthesis of TMBPF and analogs will be reported as well as initial reproductive toxicity findings.

## Poster #42

### **Synthesis and Chlorination of Des-Flouro Abemaciclib, a CDK4/6 Inhibitor Associated With The Treatment of Breast Cancer**

John Hammett, Annika Tharp, Diana Nichols, Lauralee Boon & Matthew Soellner

Female breast cancer is the leading cause of cancer incidence worldwide and accounts for more deaths in women than any other form of cancer. As such, the development of effective therapeutics to treat female breast cancer is of great research interest. Small molecule kinase inhibitors have shown clinical promise for a variety of indications. One such clinically approved therapeutic is Abemaciclib, a CDK4/6 Inhibitor used for breast cancer. Herein we describe a two-step method to synthesize Des-Flouro Abemaciclib, a variation of this drug, followed by a late-stage aromatic chlorination using Palau'chlor as the chlorinating agent. Analysis of other chlorinated kinase inhibitors has shown differential selectivity compared to their non-chlorinated counterparts. Further research is necessary to determine if similar effects on selectivity occur when using Chlorinated Des-Flouro Abemaciclib compared to unmodified Abemaciclib or pre-chlorination Des-Flouro Abemaciclib.

## Poster #43

### **"A Copper-Catalyzed Approach to Selective Ortho-Nitration of Arenes: Exploring C-H and C-F Functionalization Supported by Bidentate Directing Groups"**

Mireya A. Haran, Ila Y. Castro De la Torre & Melanie S. Sanford

Nitroaromatics are versatile organic scaffolds which act as building blocks and intermediates in the synthesis of numerous pharmaceuticals, materials, dyes, and agrochemicals. Traditionally, the nitration of arenes employs strong oxidants and acids. These methods suffer from poor regioselectivity and incompatibility with numerous functional groups. These harsh methods often involve lengthy multistep procedures or require pre-functionalized starting materials, leading to increased environmental impact and limited application in the synthesis of complex drugs and agrochemicals. An attractive alternative is the use of transition metal catalysts and nitrite salts, starting from an inert C-H substrate to yield the nitrated product. This approach minimizes by-product generation, improves functional group tolerance, and introduces regioselectivity. The use of earth-abundant copper, along with selection of the appropriate directing group, has been found to selectively C-H functionalize a variety of arenes. Recently, a copper-mediated C-H bond nitration of benzoic acid derivatives using sodium nitrite and a 8-aminoquinoline (AQ) directing group has been demonstrated, though with limited scope of arenes with electron withdrawing substituents. Herein we report, a study of the nitration of fluorinated benzoic acid derivatives guided by a bidentate directing group and preliminary studies to access inert C-F bonds. This work investigates the effect of various fluorinated derivatives and the influence of diverse solvents on the generation of the desired product.

## Poster #44

### **Ketone Synthesis Enabled by Nickel-Catalyzed Cross-Electrophile Coupling of Aldehydes and Alkyl Halides**

Tejas Kudva, Sean Calvert, Leo Vermaak, Austin Ventura & John Montgomery

Ketones are valuable synthons in organic chemistry, enabling a variety of key transformations. Traditionally, ketone synthesis is achieved via an aldehyde addition reaction using an organometallic carbon nucleophile followed by an oxidation of the resulting secondary alcohol. A more ideal method would allow ketones to be accessed from the same starting materials in a single step with improved functional group tolerance. Ongoing work in the Montgomery lab involves the development of a nickel-catalyzed aldehyde C-H functionalization approach to access ketones. In the proposed mechanism, zinc serves as a reductant to form the tert-butoxy radical via a single electron transfer (SET) to the oxidant di-tert-butyl-peroxide (DTBP). The tert-butoxy radical serves as a hydrogen atom transfer (HAT) agent and selectively abstracts the aldehydic C-H bond due to bond dissociation energy (BDE) considerations. The resulting acyl radical is then cross-coupled with an alkyl electrophile to form the ketone product. Work is also currently underway exploring the potential utility of silane-based XAT agents for promoting alkyl electrophile activation. Both methods show promise as redox-economic alternatives for accessing ketones from aldehydes and alkyl halides.

## Poster #45

### Supramolecular Compounds as Potential Detectors for Adenine in Kidney Disease

Lourd Lazar, Abena Asabea Adjei , Frank Boateng Osei & Ngong Kodiah Beyeh

Resorcinarenes are a multifaceted and a fast-growing research field through their distinctive cavity-like shape that permits them to bind to various guests via non-covalent interactions to afford molecular recognition and sensing of the guests. These are cyclic tetramers consisting of a 1,3-dihydroxybenzene and an aldehyde joined at the meta position forming bridged aromatic compounds. Adenine, a purine nucleobase, is a byproduct from the metabolism of adenosine triphosphate (ATP) that is essential for catalytic reactions and biochemical processes. The metabolite adenine has been reported to be increased in kidney diseases. The current available detection methods involve sensing protein albumin, urea, and creatinine using expensive techniques such as mass spectroscopy and presents with poor sensitivity and low detection levels in early kidney disease. In this research, we aim to develop a resorcinarene-based model for the detection of adenine in biological samples using fluorescence spectroscopy. A water soluble resorcinarene C3-OH N-naphthylmethyl chloride salt was synthesized using established protocols and analyzed for binding to adenine using nuclear magnetic resonance spectroscopy (NMR) and isothermal titrations calorimetric (ITC). The NMR and ITC results showed weaker binding interactions between the C3-OH N-naphthyl resorcinarene chloride receptor and adenine, which may not afford better detection in the presence of competitive analytes.

## Poster #46

### New Materials for Thermally Controlled Release of Inhalable Nitric Oxide

Matthew T. Maliskey, Shuxiao Li & James R. Bour

Nitric oxide (NO) has recently been an FDA-approved inhalable therapeutic that dilates blood vessels and is a neurotransmitter in the human body. This treatment is versatile in combatting foreign bacteria and pathogens when administered as dilute gas. However, concentrated nitric oxide is extremely reactive, toxic, and expensive to purify. Likewise, conventional inhalable nitric oxide (iNO) treatments are inaccessible outside of major hospitals. Modern iNO treatments run the risk of uncontrolled NO(g) release, high toxicity of potential byproducts, and the required expenses for purifying NO for suitable release. Herein, we have developed an acquiescent approach to onsite iNO generation from organic mediated reactions, extending the shelf-life of NO(g) containing inorganic/organic solids, and safer transportation and storage. The objective is to design new materials that can expand the scope of suitable feverish temperature nitric oxide organic reactions that release or purify medically valid NO(g). The idea is to integrate rudimentary thermodynamic elements to control NO concentration. As a result, these NO releasing polymers will decompose at elevated temperatures, which will serve as a baseline to increase shelf-life, utilize cheaper reagents, and lower transportation costs. Overall, these ideas are vital to advance the basis of more accessible iNO delivery systems, costs, and synthetic materials that are vastly safer alternatives to conventional iNO(g).

## Poster #47

### Visible-light mediated [2+2]-cycloadditions between alkenes and hydrazones to form azetidines

Timothy Nagel, Yu-Cheng Yeh, Kyle Chong & Corinna Schindler

Azetidines are saturated four-membered heterocycles containing one nitrogen atom. These and other nitrogen-containing heterocycles are of great interest for medicinal chemistry and other applications, as a very high number of FDA-approved drugs and compounds contain at least one nitrogen heterocycle. However, compared to their five- and six-membered counterparts, azetidines are very underexplored in this area due to the challenges in synthesizing them, particularly when attempting to vary substitution at the 2- and 4- positions. In order to synthesize these challenging compounds, we have developed a method utilizing visible light to catalyze a [2+2]-cycloaddition between the alkene and hydrazone components, known as an aza Paternò-Büchi reaction. This reaction has been shown to work with a wide variety of activated alkenes and hydrazones, including alkenes derived from biologically relevant molecules, which demonstrates its utility in the synthesis of novel pharmaceuticals.



## Poster #48

### Progress Towards the Enantioselective Total Synthesis of Tronocarpine

Natasha Perry, Esther Oko & Dr. Pavel Nagorny

Enantioselective synthesis of natural products allows for a more direct analysis of their biological applications. Described herein are recent efforts for the enantioselective total synthesis of tronocarpine during early-stage synthesis of the natural product. Desymmetrization following a non-stereospecific Diels alder reaction and subsequent catalytic dehydrogenation will be attempted to install chirality at the quaternary stereocenter. Kinetic resolution using a chiral Cu(I)-based catalyst will also be attempted to separate the two enantiomers of tronocarpine.

## Poster #49

### Synthesis of 1,5-Benzodiazepine with an Acidic Proton

Rohit Rajala & Dr. Roman Dembinski

Benzodiazepines are a heterocyclic class of compounds that are actively used as pharmaceutical ingredients in medication to treat anxiety, insomnia, and a variety of other conditions caused by an overactive central nervous system. They do so by increasing the effectiveness of GABA, a neurotransmitter responsible for creating a depressing, sedative effect. The common benzodiazepines on the market have a structure with nitrogens at the 1,4-positions, with 1,5-nitrogen structures being under-researched despite their potential ability to chelate, or bond, with metals. Our group has been working on creating such compounds decorated with various alkyl and aromatic substituents, yet the isopropyl group displayed synthetic challenges due to the alpha proton's acidic properties. Despite initial failures, as of today, the synthesis of precursor alkynone has achieved yields from 16-20%. The alkynone was then reacted with o-phenylenediamine to successfully synthesize 1,5-benzodiazepine with an isopropyl group at a yield of 60-78%, and used to produce a metal complex. These efforts help us better understand and mitigate the effect caused by the presence of an acidic proton on the benzodiazepine synthesis and may further contribute to the synthesis of metallo drugs.

## Poster #50

### Functionalizing commercially-available Pyrazolopyrimidines

Andrew Robles & Annika Tharp

Pyrazolopyrimidines are a family of heterocyclic compounds characterized by a pyrazole ring fused with a pyrimidine moiety. Notably, numerous kinase inhibitors contain this scaffold at the core of the drug. Kinase inhibitors represent a major class of pharmaceuticals used to treat various cancers. Additionally, due to their unique structure, which is similar to that of adenine, pyrazolopyrimidines can function as adenosine receptor antagonists on their own. Thus, developing a modular, 2-step method to rapidly synthesize heavily functionalized pyrazolopyrimidines would be welcomed by the medicinal chemistry community. In our lab, we are in the process of investigating methods to functionalize commercially-available pyrazolopyrimidines utilizing subsequent Suzuki and Buchwald-Hartwig couplings.

## Poster #51

### **Pulling Carbene–Copper–Carbazolide Complexes Into Next Generation Photoactive Materials**

Noah Schepke, Evan Sadler, Jonathan Meyer & Zacharias Kinney

Organic light-emitting diodes (OLEDs) comprise most of the display market, accounting for nearly half of all smartphone screens in 2023. Structurally, OLEDs contain  $\pi$ -conjugated organic molecules that work synergistically with inorganic components to yield vibrant luminescence. Even with the progress that has been made with these 'hybrid materials', blue luminescent materials have lagged behind due to high energy involved with blue emitting materials. Recently, carbene-metal-amido (CMA) complexes have been elevated to the forefront of emissive materials due to their synthetic versatility, low raw materials costs, and the tunability of their luminescence. Specifically of interest with these CMA systems are utilizing (1) robust carbenes that are inherently stable monotopic ligands, (2) Earth abundant and cost-effective two-coordinate metals, and (3) carbazolides with tunable emission. To improve the efficiency of these CMA complexes, we have chosen two general routes: (1) modify the carbazolide moiety with electron-withdrawing and electron-donating groups in either the 3,6- (in resonance) or 2,7- (purely inductive) positions to enhance its emission and (2) alternate between two different imidazyliene-based carbenes with variable levels of steric hindrance surrounding the metal center. This work seeks to expand our understanding of the structure-property relationships of CMA complexes through remote modulation of the complex's luminescence. Current synthetic, spectroscopic, and crystallographic results will be discussed.

## Poster #52

### **Increasing the Energy Density of Redox Flow Batteries Using Pyridinium Compounds Displaying Two Reversible Reductions**

Sophia Valdivia, Madison Shaffer & Dr. Tom Guarr

Redox flow batteries (RFBs) are gaining interest to make energy storage more affordable and efficient. RFB's are an energy storage device that relies on the oxidation and reduction of soluble electroactive chemical species for charging, storing, and discharging energy. Redox-active organic molecules (ROMs) are promising electroactive materials due to their low production costs, low molecular weights, and the ability to achieve significant electrochemical potential differences between the anolyte and catholyte. Previous research has shown that pyridiniums with 1-electron systems provide reduction potentials between -1.5 V and -1.8 V, but they were not sufficiently stable. This work aims to increase the battery's energy density by synthesizing a pyridinium with a 2-electron system while stabilizing the first reduction. Using cyclic voltammetry, the reduction potential is determined, and insight is gained about the stability of the radical.

## Poster #53

### **Exploration of binding efficiency of asciminib to c-Abl with varying kinase global conformation**

Brian Cavanaugh, Evelyn Peterson, Chyenne Igunbor, Christopher Bingham, Jennalisse Ellis & Matthew Soellner

c-Abl, a nonreceptor tyrosine kinase implicated in chronic myeloid leukemia (CML), results from its fusion with the housekeeping gene BCR, leading to cellular overexpression. Known inhibitors targeting c-Abl, such as dasatinib and imatinib, act by binding to its ATP-binding site, a canonical active site. However, their efficacy is compromised by mutations within this site. To address this challenge, asciminib was developed as an alternative, allosteric inhibitor that binds to a distinct allosteric pocket on c-Abl inducing a closed global conformation of the kinase. In the closed conformation, c-Abl is inactive, unable to phosphorylate substrates within the cell. Herein, we explore the binding of asciminib to c-Abl locked in both open and closed conformations to show increased efficacy of asciminib in the closed conformation compared to the open conformation. 3D-Abl was expressed with a polyhistidine-tag and ligated with conformationally selective dasatinib-based irreversible inhibitors to induce the closed and open conformations of the kinase. The dissociation constant,  $K_D$ , of asciminib is determined via the biolayer interferometry (BLI) optical technique, utilizing the polyhistidine-tag present in the 3D-Abl constructs.

## Poster #54

### Identification of Native Redox Partners of CYP121 from *Mycobacterium tuberculosis* to enhance Non-Native Biocatalytic oxidations

Stephanie K. Reyes Vargas, Hannah Boesger, Dr. Sean Newmister, Ph.D & Dr. David H. Sherman, Ph.D

Cytochrome P450s (P450s) catalyze a variety of oxidations on complex substrates with the help of redox partner-associated electron delivery system. Even though model redox partners from *Spinacia oleracea* are commonly used as an effective electron source, they can often reduce the catalytic efficiency of non-native P450 reactions due to electron decoupling. To overcome these challenges, we have identified a novel non-native oxidation reaction catalyzed by the P450 CYP121, isolated from *Mycobacterium tuberculosis* (MtB). While this reaction yields a promising anticancer medicine, the yield is too low for further development. We hypothesize that the use of *Spinacia oleracea* redox partners, as opposed to the native CYP121 redox partners, contributes to the low yield of this oxidation reaction. Thus, our study aims to discover the native redox partners of CYP121 to enhance the yield of this non-native biocatalytic reaction through the employment of molecular cloning, protein expression, and a total of seven potential redox partners from MtB. Following purification, these MtB redox partners were evaluated in terms of their ability to enhance the catalytic activity of CYP121 in its native reaction: C-C coupling of cyclo-dityrosine (cYY) to mycocyclosin. Moving forward, our objective shifts to the exploration of CYP121's potential in performing our desired oxidation of a promising antibody-drug conjugate (ADC) payload with potent cytotoxicity and reduced cardiotoxicity. This study underscores the crucial role of electron transfer mechanism in P450 biocatalysts as an approach for natural product synthesis and anticancer therapeutic development. Overall, this work highlights the importance of electron delivery in P450 biocatalysis for the development of anticancer therapies.

## Poster #55

### Shape-Controlled Synthesis of Copper Nanoparticles for the Electrocatalytic Reduction of Nitrate

Amanda Browne, Dimple Rani, Charles C. L. McCrory

Nitrate pollution due to industrial waste and agricultural fertilizers has severely impacted aquatic ecosystems and is a threat to both these ecosystems and human health. Current treatment methods, however, are limited by external reducing agents and high costs. The electrocatalytic reduction of nitrate ( $\text{NO}_3^-$ ) into usable resources such as ammonia and nitrogen is an effective, low cost, and environmentally friendly method of treating nitrogen contaminated wastewater. Copper (Cu)-based electrocatalysts are reported to actively reduce nitrate due to their good affinity to adsorb nitrate. Additionally, Cu nanoparticles are more favorable than other active metals, such as rhodium, due to their lower cost. Nanoparticles with different morphologies (sphere, cube and octahedral) effectively modify the adsorption strength of different intermediates, which possibly affects the selectivity of the electrocatalysts. To understand this, herein, Cu nanoparticles of different morphologies are synthesized using a two step process. In the first step, cuprous oxide ( $\text{Cu}_2\text{O}$ ) nanoparticles (sizes: 200-250 nm) are synthesized using a surfactant-free wet chemical method and characterized using scanning electron microscopy (SEM) and x-ray diffraction (XRD) techniques. In the second step, these are reduced to copper nanoparticles using thermal reduction and chemical reduction methods. A textured surface is observed in the thermal reduction process while the chemical reduction maintains the smooth surface of the nanoparticles, as noticed in the SEM images. Further, these copper-based electrocatalysts are studied for the electrochemical nitrate reduction reaction.



## Poster #56

### Shining a Light on the Photoactive Mechanism of Vitamin B12 Olefin Formation

Alivia Mukherjee, David Cooper, Summer Wu, Nicolai Lehnert, Roseanne Sension, and James

Penner-Hahn

Vitamin B12 is the most chemically and structurally complex vitamin. Its crystal structure elucidation earned Dorothy Hodgkin the 1964 Nobel Prize in Chemistry. For decades, the unique photoactive property of the molecule has been known, notably the dissociation of the upper axial Co-C bond upon irradiation with light. Biology takes full advantage of this, evidenced by the CarH protein of certain non-photosynthetic bacteria, which utilizes it for gene regulation. However, the mechanism of this photochemistry is not yet fully understood. To help elucidate this mechanism, we have been studying the formation of olefins in alkylcobalamin derivatives using time-resolved continuous beam spectroscopy – a method we developed based on the commonly used pump-probe technique. Through our investigation, we have demonstrated that the formation of the alkene product is not dependent on the presence of a weak base in solution as previously proposed. Spectroscopic monitoring of varying redox states during continuous beam photolysis, combined with our studies of the organic product formed, provides crucial information for understanding the alkene formation.

## Poster #57

### Quantum Master Equation Formalism for Quantum Systems Coupled to Multiple Thermal Baths

Philip Mancino, Eitan Geva, Callie Wilson

It is well known that the cost of solving the Schrödinger Equation for molecular systems scales exponentially with system complexity. This is an inherent problem in any application of quantum mechanics to chemistry, given that the typical chemical problem will incur a significant computational cost. It is often the case that not all the information pertaining to the total system is needed to compute desired observables. The Quantum Master Equation (QME) formalism is an elegant solution to the complexity problem that utilizes this fact. Here, we present an overview of the QME formalism given a suitable projection operator as input, and review the common application of the formalism to the relaxation of an open quantum system by modeling the system of interest as coupled to an equilibrated thermal bath. We also provide an overview of recent work done by the Geva group to extend the QME formalism to an open quantum system coupled to two or more thermal baths. We show that the model reveals  $n^2$  memory kernels in the case of  $n$  thermal baths. We also show how the memory kernels reduce in the case of weak system-bath coupling, as well as the  $n$ -bath equivalent of the Redfield Equations. We thereby obtain a rate equation in the system density matrix populations by applying the secular approximation. These results are readily applicable to the study of quantum transport and heat flow between baths through a quantum system.