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UNDERGRADUATE RESEARCH SYMPOSIUM

ABSTRACTS

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Development of Silver Tipped Capillaries for Controlled Electrospray Ionization Mass Spectrometry

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The Badu-Tawiah Research group aims to make mass spectrometry easier to use for non-experts. Our research focuses on the ionization source specifically with contained electrospray ionization. We have been using silver coated capillaries to increase intensity and the signal to noise ratio. Additionally, we have optimized the reduction reaction to plate the silver on the capillaries. Our technique has shown success with ionizing nonpolar aromatic molecules with varying functional groups. It has also been used with condensation reactions through the use of a dual tip spray mechanism. Our next focus is on optimizing our technique and finding more applications that will succeed with the silver tipped capillaries. Our goal is to be able to see intensity in the ionization of otherwise difficult to detect molecules and mechanisms.

Site Selective Chlorination of Arenes and Heteroarenes Using Hypervalent Iodine Catalysis via the use of Microdroplet Chemistry

Owen L. Looker, Rebekah E. Strong, Abraham K. Badu-Tawiah

This presentation will showcase the use of charged microdroplets to accelerate selective chlorination of aromatic compounds. Site-selective methods are a valuable tool in the synthesis of industrially relevant compounds, particularly within medicinal chemistry. Simple late-stage synthesis allows chemists to make necessary conversions to near-complete pharmaceutical agents. However, direct reactions that are regioselective are limited. Available reactions are currently limited to reactions relying on hazardous and expensive heavy metal catalysts that are environmentally detrimental. Typically, organic reactions are multi-step, and time consuming, taking hours or even days. Herein, we describe a contained electrospray ionization (cESI) reaction platform, utilizing etched silica capillaries for the generation of non-thermal plasma during the generation of charged microdroplets that facilitate chemical reactions in a single step, and run at the time scale of microseconds. Products ensuing from the plasma-microdroplet fusion platform are analyzed in real-time using a proximal mass spectrometer. We have taken advantage of the green catalytic nature of hypervalent iodanes (e.g., phenyliodine(III) diacetate) to probe selective chlorination of heteroarenes (isoquinoline), using acetyl chloride as our chlorine source. All compounds were analyzed using negative-ion mode and tandem MS has been used for structural characterization of products and intermediates. We will show NMR data that validate the regioselectivity of reactions. Radical scavengers will be used to further probe the mechanism, which is currently believed to proceed via an arene radical cation.

Determination of Bio-Specificity and Cross Reactivity of Cytokines and their Antibodies for the Early Prediction of Severe Acute Pancreatitis using Mass Spectrometry

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A paper-substrate device for the early prediction of severe acute pancreatitis is being developed using paper-based immunoassay followed by on-chip paper spray mass spectrometry. Acute pancreatitis (AP) accounts for over 300,000 hospital admissions in the U.S. annually. Approximately 15% of AP subjects develop severe AP (SAP), defined by the presence of persistent organ failure. The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) reported a critical knowledge gap to advance clinical care is the establishment of an early prediction tool to identify which patients will develop SAP during hospitalization. Recently, some cytokines, proteins associated with immune response, have been linked to SAP. Here, we use a pH-sensitive ionic molecule as a probe for a paper substrate sandwich immunoassay to detect biomarkers. After the immunoassay, we are able to cleave the probe and analyze via ambient paper spray mass spectrometry. This allows for the qualitative and quantitative identification of biomarkers. Monoclonal antibodies are pitched to be highly selective for proteins of interest, and we hypothesize that using the paper substrate immunoassay we can determine the specificity of the antibodies and the cross reactivity of the proteins. Data will be presented for manual immunoassay in two-dimensional wax-printed paper substrates for the cytokines that have been linked to SAP: angiopoietin-2, hepatocyte growth factor, interleukin-8, resistin, and soluble tumor necrosis factor receptor. Data will also show the antibody selectivity for these cytokines and the level of cross reactivity that may limit multiplexing capabilities of developed tests.

Development of a Conductive Emitter for Dynamic Spray Mass Spectrometry

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Mass spectrometry relies heavily on the initial ionization step which influences metabolic coverage and detection limits in complex mixtures. Existing ionization methods struggle with samples that have diverse physicochemical properties (polar/non-polar and high/low molecular weight) using a single source. To overcome this, we present a novel single ionization source capable of sequential ionization across a wide molecular range without requiring sample preparation or chromatography. This is accomplished through dynamic voltage ramping, which allows different analytes to be ionized atspecific voltages. Our dynamic spray source features an electrodeless design with a single emitter made of disposable silver-coated borosilicate glass capillaries, operating within a DC voltage range of 0 to ±8 kV. The voltage waveform increases or decreases linearly over time, enabling conventional nanoelectrospray ionization (nESI) at initial voltages (1-2 kV) and transitioning to microdroplet/gas- phase ionization for APCI. This method works in both positive- and negative-ion modes, allowing for the sequential detection of diverse analytes in complex mixtures and biofluids. At higher voltages (>4 kV), corona discharge is initiated at the pointed tips of the borosilicate glass capillaries, generating nonthermal plasma. Initially, commercially available conductively coated PicoTips were used, but their high cost and limited capillary size variation prompted the development of a more cost-effective and customizable solution. We successfully coated sharp borosilicate glass capillaries with a conductive silver layer using a silver nitrate solution in ethanol and butyl amine, yielding an even silver deposit. Detection of wide range of molecules (steroids, lipids, proteins, sugars, vitamins, and nucleotides) in a complex mixture without any manual voltage tuning has been accomplished. The application of this Dynamic Spray ionization source, coupled with a single conductive emitter, shows significant promise for the analysis of complex mixtures and biofluids, making it a versatile and robust method with potential applications in translational and biomedical research.

Site-Directed Mutagenesis & Structural Studies of "Thg1-like Proteins in *Dictyostelium Discoideum* (DdiTLP3)"

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It has been long thought in textbooks and in many other academic papers that DNA and all other nucleic acids can only be synthesized in the 5'-3' direction. However, tRNA His guanylyl transferase (Thg1) invalidates this long-standing idea as the enzyme can add nucleotides to truncated tRNA molecules in the unconventional 3'-5' direction. Site-Directed Mutagenesis on new groups of Thg1 proteins called "Thg1-like Proteins in Dictyostelium Discoideum (DdiTLP3)" is being done to understand how these unique enzymes can recognize different types of tRNA substrates unlike Thg1 which can only recognize its one substrate which is tRNA-His. So, to understand what kind of molecular dynamics allowed for DdiTLP3 enzymes to recognize and act on several types of substrates, we designed primers of a desired point mutation that were targeted at the 176 residues of the DdiTLP3 encoding protein i.e. D176A, D176L, D176R, D176F. Mutant protein DNA was cloned into XL-1 Blue Escherichia coli (E. coli) cells followed by performing a serious of expression, protein assays as well as sequence alignment studies with AVA421+DdiTLP3 Wild Type plasmid and DdiTLP3 mutant plasmid DNA.

The Biochemical Characterization of Congenital Diaphragmatic Hernia Plastin-3 variants

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Congenital Diaphragmatic Hernia (CDH) is a severe congenital disease characterized by an incomplete formation of the diaphragmatic septum leading to mislocalization of the abdominal organs (e.g., the liver, stomach, and bowel) to the chest cavity. Through a combination of clinical and genetic analysis, eight novel mutations in plastin-3 (PLS3), an actin-binding and bundling protein, were linked to CDH. PLS3 has two actin-binding domains, ABD1 and ABD2, which determine how the protein binds and bundles actin filaments (F-actin). The successful binding and bundling of F-actin are essential for the cell's normal functions. If PLS3 ability to bind and/or bundle F-actin is impaired by pathological mutations, the cell's morphological features and critical functions will be severely altered. The CDH-linked PLS3 mutations studied in this project are localized at different domains of the protein, and their effects on the protein structure and function are currently being characterized through high- and low-speed cosedimentation assays, fluorescence anisotropy, and differential scanning fluorimetry.

Probing DNA and RNA G-quadruplex folding and dimerization with 2-aminopurine

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The presence of guanine (G)-rich sequences in both DNA and RNA can allow for the formation of non-canonical tetrahelical structures known as quadruplexes. One of the most stable quadruplex structures is formed by the sequence GGGTGGGTGGGTGGG and its RNA analog. Both sequences fold into an intramolecular quadruplex with three G-quartets connected to each other by chain-reversal or propeller loops. Quadruplexes are capable of stacking with each other, forming dimers or multimeric complexes. Here, we developed a novel fluorescence assay to characterize the self-assembly modes of quadruplexes. We constructed two sequences with five GGG segments and 2-aminopurines (2AP) inserted in the terminal loop positions. 2AP is a fluorescent analog of adenine with almost identical thermodynamic and base-pairing properties. When positioned in the folded quadruplex, 2AP emits maximum light. When positioned in the overhang position, the adjacent guanines interact with the fluorophore and quench it. Since the quadruplex uses only four sequential GGG segments, these substrates would be expected to adopt one of two conformations (structural isomers) with 4-nt overhangs at either end. As a result, depending on the dimerization mode, the quadruplexes either emit light or will be quenched. This method was used to analyze both DNA and RNA G-quadruplexes. DNA quadruplexes were found to dimerize at the 5'-5' interface, while RNA quadruplexes dimerize at the 5'-3' interface. DNA quadruplexes also showed no folding preferences in 50 mM NaCl buffer, while RNA quadruplexes exhibited a preference towards folding from the 3' end in 1 mM NaCl buffer. Taken together, these data reveal new insights into differences between DNA and RNA quadruplex folding and association.

Peptide nanotubes grafted with 3E8 scFv for enhanced delivery of Camptothecin drug to adenocarcinoma cells

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Antibody drug conjugates (ADC) are utilized within the realm of therapeutics to optimize the delivery of various medications, mostly cytotoxic agents used to treat cancers. The antibody of the ADC allows for direct targeting, and thus, improved drug delivery to the infected area and decreased cytotoxicity to healthy cells. The exciting new field of antibody-nanoparticle conjugates (ACNP) provides the same targeting benefits while also introducing enhanced stability and versatility of payload. The purpose of this research is to create an ACNP for improved delivery of Camptothecin (CPT), an anticancer drug. CPT is insoluble and unstable in physiological conditions. To overcome these drawbacks, CPT is sequestered inside a peptide nanotube via solid phase synthesis and coated with polydopamine (PDA). 3E8 single-chain variable fragment (scFv) is utilized as the targeting agent for TAG72, an aberrant mucin found in adenocarcinomas. For bioconjugation, 3E8 is synthesized with a free cysteine at the C-terminus which is believed to undergo a Michael addition with polydopamine. The binding was studied using fluorescence and structured illumination microscopy (SIM) imaging. In the cell line expressing TAG72, the ACNP has higher cytotoxicity than just the nanotubes alone. These results are promising as the purpose was to create a more stable compound with improved cytotoxicity. Further research will include improvement of bioconjugation using enzymes to catalyze more specific covalent binding.

Synthesis and Characterization of Ruthenium Complexes of a Novel Tetradentate P_2N_2 Ligand

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Transition metal hydride complexes are important in a range of applications, including catalysis and small molecule activation. Recently, our lab has been investigating new phosphine ligand platforms for the design of transition metal hydride pre-catalysts for C–H functionalization reactions. This presentation will discuss the synthesis and characterization of ruthenium complexes supported by a novel tetradentate P_2N_2 ligand and their catalytic screening for C–H borylation of arenes. The new P_2N_2 ligand is based on a 1,5-diaza-3,7-diphosphacyclooctane framework with pyridyl and cyclohexylphosphine donor groups. Complexation of the P_2N_2 ligand with $RuCl_2$(dmso) 4 generates $(P_2N_2)RuCl_2$, which adopts a C_{2v} geometry. Subsequent reaction of $(P_2N_2)RuCl_2$ with $MBHEt_3$ reagents (M = Li, Na, K) yields tetranuclear Ru_2M_2 complexes with bridging hydride ligands. Treatment of the Ru_2Li_2 complex with excess TMEDA results in abstraction of 2 equiv. of lithium hydride, leading to a symmetric Ru_2 hydride dimer. The new complexes have been characterized by single crystal X-ray diffraction and multinuclear NMR. Ongoing work is focused on reactivity and catalytic screening studies.

Probing σ-donation character of a PPP-ligand scaffold via synthesis of a phosphorous (V) selenide

Hanan Muhammad, Matthew C. Fitzsimmons, Christine M. Thomas*

Department of Chemistry and Biochemistry: The Thomas Laboratory

Catalysts describe a broad range of compounds that increase the rate of a chemical reaction by providing an alternative, lower-energy reaction pathway while remaining unchanged. Thus, catalysts are essential in industry – their application ranges from catalytic converters in motor vehicles to ammonia production for fertilizer. Generally, catalysts utilize scarce, thereby expensive precious metals. However, the Thomas lab has utilized environmentally benign and abundant first-row transition metal complexes, such as cobalt, nickel, and iron for sustainable catalysis. A series of tris-phosphine pincer ligands (PP^RP) have been shown to provide chemical and thermal stability to a series of cobalt diiodide complexes, $(PP^RP)CoI_2$. In addition to increased stability, these phosphine-ligated complexes are easily activated *in-situ* to produce highly active hydrofunctionalization catalysts. The central component of the pincer ligands is a central N-heterocyclic phosphine component, which acts as a neutral ligand. It shows that donor/acceptor properties can be electronically tuned by varying the third substituent. In order to investigate the donor properties of the central N-heterocyclic phosphine as the substituent is modified, we are generating a series of phosphorous (V) selenide derivatives. These selenides have been shown to be effective reporters of the σ-donating properties of the phosphine lone-pair, as the $J_{P\text{-}Se}$ coupling constant, measured using ^{31}P nuclear magnetic resonance (NMR) spectroscopy, increases as the phosphine's basicity decreases. Herein, the synthesis of a series of phosphine selenides will be described, using measured $J_{P\text{-}Se}$ values to draw conclusions about methods to tune the donor properties of the PPP-tridentate ligand system for use in catalyst optimization.

Novel Quinone Methide Precursors for the Resurrection of Organophosphorus-aged Butyrylcholinesterase

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Acetylcholinesterase (AChE) is an important enzyme for human health. AChE relaxes nerve impulses through hydrolysis of the neurotransmitter acetylcholine. Organophosphorus (OP) compounds are toxic due to their ability to inhibit and age AChE, which induces a cholinergic crisis. Inhibition occurs when the catalytic serine residue is phosphylated, and aging occurs when the OP-inhibited form of the enzyme undergoes a spontaneous *O*-dealkylation over time – and that time depends on the structure of the OP compound. Reactivation is the process to reverse the effects of OP inhibition, while recovery of the OP-aged form is termed resurrection. Butyrylcholinesterase (BChE) is an important and endogenous cholinesterase enzyme that metabolizes anesthesia agents. BChE has many similar catalytic features as AChE and is inhibited by OP compounds through a similar mechanism. BChE is found in high concentrations in human blood, and BChE can act as a stoichiometric bioscavenger of OP compounds. Quinone methide precursors (QMPs) have been shown to reactivate OP-inhibited BChE from *in vitro* studies, but there have not been any reported compounds that resurrect OP-aged BChE. When aged BChE is resurrected, it could be a possible pseudo-catalytic bioscavenger of OP compounds to protect AChE. By resurrecting OP-aged BChE, the treatment plan for OP exposure could be improved since the fastest aging half-life of an OP compound in BChE is as short as 9 minutes. A previously synthesized 6-benzyloxypyridin-3-ol QMP with a dimethylamine leaving group resurrects OP-aged BChE, and a diverse library of substituted 6-benzyloxypyridin-3-ol derivatives have been explored to investigate improvements in resurrection. Such novel 6-benzyloxypyridin-3-ol QMP derivatives have been synthesized with different substituents on the phenyl ring and different chain lengths to explore the relationship of QMP structure to BChE resurrection. These QMPs were synthesized via an alkylation reaction with 5-bromopyridin-2-ol, followed by hydroxylation and Mannich reactions to install the amine leaving group of the QMP. For this library, many novel QMPs with electron-withdrawing and electron-donating substituents on the phenyl rings, along with various amine leaving groups, were synthesized and fully characterized. The *in vitro* biochemical screening results and the synthetic processes will be presented.

Synthesis of PAS-linked, phenol-based quinone methide precursors as potential resurrectors and reactivators of organophosphorus-aged and organophosphorus-inhibited acetylcholinesterase

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Organophosphorus (OP) compounds inhibit the enzyme acetylcholinesterase (AChE), a cholinergic enzyme that hydrolyzes acetylcholine into acetic acid and choline. The inhibition of AChE results in the accumulation of acetylcholine in the synaptic cleft, which results in symptoms including nausea, vomiting, muscle tremors, and confusion. Left untreated, AChE inhibition can result in death. There are several current therapeutics for OP-inhibited AChE that can reactivate OP-inhibited AChE and return AChE to its native state; however, OP-inhibited AChE can also undergo a spontaneous *O*-dealkylation event called aging. The rate of aging for OP compounds can range from minutes to days, depending on the identity of the compound. There is currently no FDA-approved therapeutic capable of returning OP-aged AChE to its native state. The primary goal of our research is to develop novel treatments capable of resurrecting OP-aged AChE and to increase the number of available treatments for reactivating OP-inhibited AChE. Our lab has previously identified and established an expansive library of quinone methide precursors (QMPs) that have demonstrated the ability to reactivate OP-inhibited AChE. To reactivate OP-inhibited AChE, these QMPs must reach the catalytic active site of AChE, which is buried at the bottom of a 20 Å gorge. Atop this gorge lies the peripheral anionic site (PAS) of AChE, which is densely lined with aromatic residues. The compounds presented here have been synthesized featuring aromatic PAS-binding elements, as it is hypothesized that these compounds will exhibit a higher binding affinity for AChE due to their aromatic PAS linkers. This presentation will demonstrate the synthesis and purification of QMPs and evaluate, by *in vitro* biochemical studies, the resurrection and reactivation capabilities of these compounds.

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Iron Carbene-Mediated Methylation of Carboxylic Acids

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Esters are the 15th most common functional group found in drug molecules and are found in many natural products including amino acids, steroids, and fatty acids. The two most common methods used to methylate carboxylic acids include Fischer Esterification, utilizing strong acid and methanol, and diazomethane, utilizing a high energy (and often explosive) diazo intermediate. These harsh methods leave little room for functional group tolerance and selectivity. Additionally, these methods require significant safety precautions if done on scale. We have developed an iron mediated methylation of carboxylic acids using dibromomethane. Our method shows excellent functional group tolerance while using mild and cheap reagents. Methylation can be done on a wide range of carboxylic acids to form ester products with alkyl, benzyl, allyl, halide, and heteroatom substituents, as well as on common drug molecules and amino acid motifs. In conclusion, we developed a robust, mild, and cost-effective methylation of carboxylic acids with high functional group tolerance.

Positionality Effects of Methoxy Substituted Aryl Donors on NIR Emission

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Near-infrared imaging (NIR imaging) is a newly emerging, noninvasive approach to bioimaging. Our research builds on previous work that has deduced the benefits of a donor-acceptor-donor (D-A-D) structure because of high intramolecular charge transfer and conjugation that lowers the HOMO-LUMO gap to produce NIR emission. This project assesses the optical and electronic differences between ortho, meta, and para positions of methoxy substituents on aryl donors attached to the acceptor core of thienothiadiazole (TTD)-based dyes. The series of aryl donors were attached to TTD using the Suzuki Coupling reaction, and then analyzed for absorption and emission with UV-Vis spectrometry. Our findings show that the para-positioned methoxy donor emitted at a wavelength further into the NIR region, whereas the ortho-positioned donor was relatively unstable and demonstrated rapid degradation. These observations will significantly influence future D-A-D moieties that are researched and will advance the progression of NIR emissive dyes in this rapidly growing field, providing a strong foundation for further research and development.

Low Molecular Weight HEX-PAMAM Scaffolded Ionogels for Transdermal Drug Delivery

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Limitations related to traditional drug delivery methods have shown to be successfully overcome using a wide variety of polymer-templated nanocarrier systems. Ionogels are a combination of an ionic liquid (IL), which is an organic salt, and a branched organic framework. Ionogels as a drug delivery method have gained interest recently due to effective drug localization in vivo as well as transdermal cargo delivery abilities. Dendritic polymers as an organic framework for ionogel production have been shown to be an excellent choice due to inherent internal cavities for cargo loading, tunable terminal functional groups, and inherent synthetic controls on size, symmetry, and shape. Low molecular weight poly(amidoamide) (PAMAM) dendritic polymers have been studied for many applications including catalysis, drug delivery, and gene transfection due to their exceptional biocompatibility. Here, PAMAM was modified by replacing the central ethylene diamine core with hexamethylenediamine (HEX-PAMAM) and tuning the terminal groups via either amine or hydroxyl functionalization. Each HEX-PAMAM dendritic polymer was then synthesized, amine or hydroxyl-terminated, and investigated for the formation of a 3D HEX-PAMAM network upon combination with choline lactate-based IL. These ionogels were then explored for mechanical, viscoelastic, vibrational, and thermal behavior to determine their applicability as an efficient transdermal drug delivery vehicle. In addition, Rhodamine B was introduced as a small molecule cargo loading model to investigate effects on ionogel viscoelastic properties. Preliminary results showed the introduction of Rhodamine B did not have any adverse effects on the viscoelastic profile or the shear thinning behavior. In addition, hydroxyl-terminated HEX-PAMAM was shown through rheological studies to have a greater viscosity than the amine-terminated HEX-PAMAM due to stronger intermolecular electrostatic interactions. Cell viability and porcine skin diffusion studies are underway to elucidate the premier ionogel for transdermal cargo delivery and biocompatibility. These ionogels show great promise in transdermal drug delivery for therapeutic purposes.

Deoxygenative Reduction of Aliphatic Aldehydes via *gem*-Dichromium Intermediates

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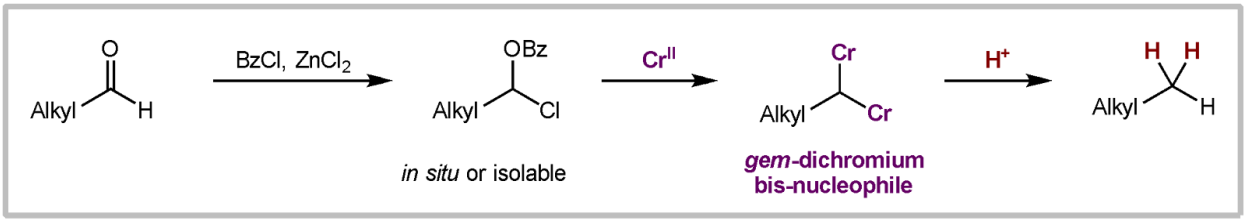
Deoxygenative reduction of carbonyls to methylenes are useful transformations to defunctionalize organic functional groups in organic synthesis. Traditional deoxygenation methods for these defunctionalizations have been well-developed for benzylic, allylic, and aliphatic ketones, such as the Clemmensen reduction and Wolff-Kishner reduction. However, deoxygenation of aliphatic aldehydes is underdeveloped and requires harsh conditions such as the use of strong acids, toxic reagents, and dry hydrazine (explosive). Furthermore, traditional deoxygenative methods lack chemoselectivity, in which, deoxygenation between aldehydes and ketones can't be controlled. Herein, we have developed a mild, safe, practical, and efficient method to deoxygenate aliphatic aldehydes over ketones to methylenes via *gem*-dichromium intermediates.



Association between urine biomarker profile and kidney molecular phenotype in recurrent cisplatin injury model

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Cisplatin is a platinum-based chemotherapy drug used in pediatrics to treat various cancers by targeting and killing fast-dividing cells like cancer. Cisplatin has side effects that cause damage to the kidney. Cisplatin is cleared through the kidney where it can be reabsorbed by tubular cells which induces oxidative stress, DNA damage and cell death. Endogenous biomarkers used in the clinic evaluated kidney function based on measured GFR or BUN level but did not detect damage/injury in the tubular cells. This research explores the use of urinary EGF, serum BUN, transdermic GFR, and uKIM-1 to detect kidney damage earlier and more sensitively than endogenous biomarkers in a recurrent cisplatin injury model. The study also investigates the impact of tumors/matrigel on cisplatin kidney injury, with the aim of improving early detection and management of nephrotoxicity.

An Inquiry of the Effects of the Earth's Magnetotail on the Lunar Surface

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Kasim Memon, Franklin University

The Great Lunar Expedition for Everyone (GLEE) is a collaborative effort between the Colorado Space Grant Consortium and the NASA Artemis Program, engaging students globally in lunar exploration. The Ohio State University GLEE project investigates the effects of Earth's magnetotail on the lunar surface, focusing on the relationship between the lunar regolith's dielectric constant and magnetic field strength. Previous research has largely focused on the solar wind impacts on the lunar atmosphere, accounting for surface weathering; however, the effects of the Earth's magnetotail on the Moon remains underexplored.

Understanding the Earth's magnetotail and its significant influences on the lunar regolith's properties is vital to learning how potential water forms beneath the surface. To test this, two Arduino-based microcontrollers, LunaSats, equipped with a magnetometer and a capacitance sensor, are being utilized to understand the change in dielectric constant of the lunar regolith and magnetic flux density. A 3D printed solenoid with current flowing in all three cartesian directions allows for magnetic field manipulation to validate LunaSat magnetometer readings. Moreover, measuring the dielectric constant through a capacitance sensor and using its numerical relationship to soil moisture content allows for an understanding of sample hydro formation. By using lunar regolith stimulant and other resources at the George Washington Carver Space Park, the Ohio State University GLEE team aims to acquire proof of concept prior to lunar data collection. The results of this study will have important implications for future lunar robotic missions, particularly in hydro-fuel production and magnetic-based systems.

This research is crucial for advancing our understanding of the Moon's interaction with Earth's magnetosphere and the broader impacts of solar wind on lunar conditions, contributing to the development of sustainable lunar exploration strategies.

Keywords: LunaSats, Earth's Magnetotail, Lunar Regolith, Magnetic Field Strength

Regulation of 5-deoxy sugar utilization for growth by extraintestinal pathogenic E. coli

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Extraintestinal pathogenic E. coli (ExPEC) is a growing health concern due to their prevalence in urinary tract and blood infections. We recently identified a metabolic pathway in ExPEC strains called the Dihydroxyacetone phosphate shunt that allows for the utilization of 5-deoxpentose sugars as carbon substrates for growth. This includes 5-deoxyribose and 5-methylthioribose, which cannot be used by commensal strains. E. coli utilizes an expressional hierarchy of carbon assimilation pathways based on the preference of available sugars, with glucose typically being the most preferred. We hypothesized that the DHAP shunt in ExPEC strain ATCC 25922 is transcriptionally regulated based on available carbon substrates. To test this, we constructed a LacZ reporter plasmid in which fragments of the putative promoter region of the DHAP shunt gene cluster were cloned onto the 5' end of lacZ. ExPEC strain ATCC 25922 was transformed with the plasmids and grown in defined media with glucose or 5-deoxyribose as the carbon source. The resulting LacZ activity was measured in cell lysates spectrophotometrically. We observe that in the presence of glucose, LacZ activity and hence DHAP shunt expression from the putative DHAP shunt promoter is repressed. Conversely, when cells were grown in the presence of 5-deoxyriobse alone, LacZ activity and hence DHAP shunt expression was robust. Furthermore, deletion of a likely transcription regulatory protein located near the DHAP shunt gene cluster on the E. coli genome partially alleviated the repressive effects of glucose on DHAP shunt transcription. This work suggests that the DHAP shunt for 5-deoxypentose sugar utilization in ExPEC strains is transcriptionally repressed by glucose and is seemingly regulated in part by a transcriptional repressor protein. Future experiments will target potential transcription factor binding sites for pathway regulation using this LacZ reporter system and directed mutagenesis.

Dual Drug Delivery System with In-Vitro Tracking Capabilities

Bingxun Li, Taneja, Sagarika

Parquette Group (Dr. Jon R. Parquette)
The Ohio State University

In this project, we are making a dual drug delivery system with in-vitro tracking capabilities. We are attaching two Rhodamine-dipeptide conjugates RhB-KK and RhB-KE with 5-Fluorouracil, an anti-cancer drug via succinic acid linkage using solid phase peptide synthesis (SPPS) to get RhB-KK-Fu and RhB-KE-Fu. Both RhB-KK and RhB-KE have been shown to self-assemble as nanotubes in previous studies. The self-assembly process is pH sensitive as they exist in a nanotubular state at pH >4.6, and in a monomeric non-fluorescent state at pH<4.6. In the prior studies, they have demonstrated to possess the potential of being utilized as a cellular tracking agent as both assembly states emit fluorescence at two different wavelengths (460nm and 580nm). Attachment of an anti-cancer drug would further enhance the application of this system by imparting it therapeutic properties. The succinic acid linkage chosen is susceptible to cleavage by the intracellular enzymes, which enables the free drug to be released selectively inside the cancer cells.

Mechanism underlying Astrocytic Uptake of Sulforhodamine 101 (SR101)

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Sulforhodamine 101 (SR101) is a commonly used chemical marker for astrocytes and is particularly useful in functional in vivo and in situ studies. However, the mechanism underlying the astrocytic uptake of SR101 remains elusive. Serendipitously, we found that SR101 uptake can be fully inhibited by meclofenamic acid (MFA). The MFA-mediated SR101 uptake inhibition is characterized by a non-competitive binding of MFA to the SR101 uptake pathway, a rapid inhibitory time course (T_{50}, 0.4925 min), and high efficacy (IC_{50}, 4.428 μM). Therefore, MFA emerges as a useful inhibitor to further explore the mechanism of SR101 uptake in astrocytes. In a transcriptome study, the slco1c1 mRNAs, a gene encoding L-thyroxine (T4) transporter (OATP1C1), showed high astrocyte expression. To explore slco1c1 as a potential SR101 uptake pathway, we pre-incubated acute hippocampal slices with 10 μM T4 for 20 min. This resulted in a 95% inhibition of SR101 uptake. Inhibition of OATP1C1 should lead to a buildup of ambient T4. To examine if T4 could affect neuronal excitability, we examine the electrophysiological responses of CA1 pyramidal neurons to 10 μM T4. Elevated ambient T4 appeared to attenuate the excitability of CA1 pyramidal neurons. Thus, our study has identified MFA as a potent SR101 uptake inhibitor in astrocytes. Additionally, we show that L-thyroxine competitively inhibits SR101 uptake in astrocytes, implying that slco1c1 is likely the transporter that mediates the SR101 uptake in astrocytes. Potentially, inhibition of OATP1C1 has an inhibitory impact on the excitability of CA1 pyramidal neurons.

Investigating Melanin-Indole Interactions using Fluorescence Spectroscopy

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Melanin's elusive structure and uncontrolled rapid autooxidation continues to hinder the development of melanin-like synthetic materials and prevents the application of its wide array of electronic, optical, and mechanical properties in catalysis systems, bioelectronics, and energy conversion/storage developments. A prevalent biopolymer, Melanin provides pigmentation, photo protection, and the ability to eliminate and paradoxically generate toxic radical oxygen species within many life forms. Within fluorescence studies, melanin's fluctuating oxidation state, its potential to quench probe fluorescence, and its broadband absorption, makes quantitative study of these nanoparticles difficult. In this study, Stern Volmer experiments were used to determine the extent and mechanism of interaction between melanin's nanoparticle surface and the fluorescent probe, hydroxy terephthalic acid (hTA). Furthermore, the inner filter effect was corrected using absorbance and Raman scattering intensity from the solvent. After correction, melanin Stern-Volmer experiments showed minimal quenching between the fluorescent probe hTA and synthetic DOPA melanin, likely due to hTA's negative charge, which inhibits binding to the negatively charged melanin nanoparticles. This approach successfully accounted for several properties that hinder accurate fluorescence results. In the future, the techniques applied in this study can ensure that the quantitative results determined in melanin research have been effectively corrected for and are therefore reproducible.