UNIVERSITY OF MICHIGAN-DEARBORN

32nd Annual Poster Session

Abstract Booklet

Department of Natural Sciences
College of Arts, Sciences, and Letters

April 19, 2024

Poster Session Committee:
Bushra Hussain
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Ogie Stewart
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Biochemistry

Understanding, Cultivation and the Practice of Extraction and Characterization of Essential Oils of Aromatic Plants

Hawraa Najaf

Faculty Sponsor: Marilee Ann Benore

Abstract

Riboflavin, also known as vitamin B2, is an important nutrient, the precursor for coenzymes FMN and FAD that performs metabolic functions. As a water-soluble nutrient it is necessary to consume B2 regularly to maintain optimal levels. Researchers are interested in studying the correlation between riboflavin and other nutrients, especially iron. Iron deficiency is one of the most common nutritional deficiencies worldwide and can result in various health problems, such as anemia. Studies suggest that riboflavin may help in enhancing iron absorption and utilization in the body, potentially reducing the risk of iron deficiency anemia. The potentially synergistic roles of iron and B2, both involved in redox reactions, is intriguing. Further research is needed to determine the most effective dietary approaches for reducing iron and riboflavin deficiencies, particularly among low socioeconomic populations.

Stability Studies Of Riboflavin Binding Protein

Students: Desara Muska

Faculty Sponsors: Marilee Benore, Simona Marincean

Abstract

The significance of Riboflavin (vitamin B2) in human metabolism is critical for metabolic reactions and homeostasis. The research involved refining the purification process of the B2 transport protein Riboflavin Binding Proteins (RBP). Analyses, including gel electrophoresis, provided insights into the stability characteristics of RBP, such as its degradation products, and accurate molecular weight.

Synthesis and Characterization of Novel Chemical Analogues to Detect Riboflavin (B2) Deficiency

Student: Travis Branscum

Faculty Sponsor: Marilee Benore and Simona Marincean

Abstract

Riboflavin, vitamin B2, is a precursor to the coenzymes FMN and FAD, and a required daily nutrient. Flavins are essential to metabolic processes due to their roles in redox reactions critical to energy production and synthesis of new molecules. While riboflavin deficiency was thought to be rare, recent evidence suggests that several diseases, including cancer and metabolic syndromes, can be ascribed to insufficient riboflavin. Assessing individuals for vitamin status is difficult for riboflavin, as no simple and inexpensive test is available. This research demonstrates the potential of a novel molecule that can be used in research and detection. A series of riboflavin derivatives have been synthesized with the intention of observing their binding capabilities, particularly to riboflavin-binding protein. It has been demonstrated that the analogs retain their ability to bind to riboflavin-binding protein. This opens the applications of these derivatives to be further explored.

Purification and Characterization of Mountain Mint (Pycnanthemum muticum) Essential Oil and its Potential Use in Medicine and Food

Students: Samantha Kuszynski and Jaafar Harb

Faculty Sponsors: Marilee Benore, Simona Marincean

Abstract

The Lamiaceae (mint) family is an important medicinal group of over 7000 species, including spearmint, lavender, and rosemary. The Pycnanthemum genus represents a diverse group of herbaceous plants known as the “mountain mints”, which are native to eastern North America and have a characteristic minty aroma. These mints, also known as clustered mountain mints, are less invasive than plants in the Mentha genus, such as peppermint, and support native pollinators. Various mountain mints have been used medicinally by Native Americans to treat chills and fever, coughs, and upset stomach. P. muticum has not been as well characterized as other varieties but shows potential for medicinal and flavoring use as part of the mint family. A concern is the level of pulegone, which has been both positively and negatively linked to its role in attractiveness as a pollinator plant and its toxicity. Synthetic pulegone use is regulated by the FDA. Mountain mint leaves, buds, and stems were studied. Harvest, extraction by distillation, and characterization of essential oil were conducted. Essential oil constituents were characterized and yields compared using GC/MS and tested for antibiotic activity.

Aromatic and Medicinal Plants Course – Extraction, Characterization, and Product Development of Essential Oils of Specific Aromatic Plants

Students: Travis Branscum, Daniel Broadwater, Brennon Egan, Aaron Engelhardt, Kayla Leonard, Desara Muska, Draic Mullin, Hawraa Najaf, Elizabeth Schmidt, Tommy Smith, Alex Zaborski

Faculty Sponsors: Marilee Ann Benore and Simona Marincean

Abstract

Aromatic and medicinal plants contain chemical components proven to be beneficial for health, and highly utilized in medical, food and industry applications. While used for centuries, the detailed biochemistry of aromatic and medicinal compounds is only now being determined: metabolic synthetic paths unveiled, impact on cellular, metabolic and neuronal paths determined, and potential for use (and abuse) the focus of research globally. The chemical components induce anti-inflammatory, anti-microbial, and physiological influence, as well as induce behavioral and sensory experience that are employed in medical and wellness therapies.

Aromatic and Medicinal Plants Course – Extraction, Characterization, and Product Development of Essential Oils of Specific Aromatic Plants

Students: Travis Branscum, Daniel Broadwater, Brennon Egan, Brennon Egan, Aaron Engelhardt, Kayla Leonard, Draic Muska, Draic Mullin, Desara Muska, Hawraa Najaf, Elizabeth Schmidt, Tommy Smith, Alex Zaborski

Faculty Sponsors: Drs. Marilee Ann Benore and Simona Marincean

Abstract

Aromatic and medicinal plants contain chemical components proven to be beneficial for health, and highly utilized in medical, food and industry applications. While used for centuries, the detailed biochemistry of aromatic and medicinal compounds is only now being determined: metabolic synthetic paths unveiled, impact on cellular, metabolic and neuronal paths determined, and potential for use (and abuse) the focus of research globally. The chemical components induce anti-inflammatory, anti-microbial, and physiological influence, as well as induce behavioral and sensory experience that are employed in medical and wellness therapies.

To explore the chemistry and biochemistry of the medical uses of aromatic and medicinal plants, students at the University of Michigan-Dearborn performed biochemical techniques to extract and characterize essential oils of aromatic plants. In this class the specific use of essential oils was explored, students learned to grow plants, and extract and identify specific components (often terpenes) from the extractions. In individual projects students researched, via literature and experiment, a specific aromatic plant to extract the essential oil and characterize its chemical components. The essential oils were extracted via solvent extraction or steam distillation and characterized using Gas Chromatography/Mass Spectroscopy, bacterial contamination, and potential bacterial resistance.

For the final PBL project the students used their chosen essential oils (purchased for safety) to produce commercial products.

Transcriptional Regulation of Ethanol O-Acyltransferase in *S. cerevisiae* Compensates for Genetically Reduced Phospholipid Synthesis

Students: Daniel Ehrheart* and Hussein Alshuhani

Faculty Sponsor: Peter Oelkers, PhD

Abstract

In order to maintain control over its environment, a cell must maintain the composition of its phospholipid membrane. When alterations to the composition of lipids that make up the membrane are detected by the cell, it can initiate a variety of physiological adjustments through the expression of genes to compensate for the changes. One previously observed response by cells with impaired ability to synthesize phospholipids was the significant increase in mRNA abundance of certain genes in the cytosol. This project sought to investigate if there was a link between the translation of a protein compared to the abundance of its mRNA in the cytosol following these alterations to membrane composition. In order to accomplish this, the promoter region of EEB1, one of the upregulated genes, was amplified via PCR and ligated into a yeast integrating plasmid contiguous to the LacZ reporter gene. The relative activity of the LacZ gene could then be monitored through colorimetric assays. Comparing the relative activities between wild type and lipid-compromised cells indicated a possible link between mRNA abundance to corresponding protein and activity. This is of particular importance in *S. cerevisiae* as a regulatory mechanism linking phospholipid composition and ethanol esterification has not been previously described. This relationship offers possible insights into physiological adjustments made by all eukaryotes to compensate for altered membrane composition and function.

* Presenting student

In vitro Analysis of Substrate Specificity of the Human 1-acylglycerol-3-phosphate acyltransferase 4: Implications on Neuronal Membranes

Student: Shadi Kaddah

Faculty Sponsor: Peter Oelkers

Abstract

Lipid metabolism plays a pivotal role in maintaining cellular integrity and function, serving as a foundation for the development and maintenance of neuronal membranes essential for cognitive processes. In the heart of this metabolic pathway, 1-acylglycerol-3-phosphate acyltransferases (AGPATs) emerge as critical enzymes, facilitating the biosynthesis of phospholipids by acylating lysophosphatidic acid into phosphatidic acid, a pivotal step for the generation of cellular membranes and lipid signaling molecules. This project aimed to dissect the specific activities of Lpt1, Slc1, and human AGPAT enzymes under varying conditions, with a special focus on AGPAT4 due to its high expression in neurons. Employing in-vitro lysophospholipid acyltransferase assays, we evaluated enzyme sensitivity to buffer composition and Mg2+ dependency alongside substrate acyl-CoA specificity assays with AGPAT4 expressed in yeast. Preliminary findings reveal that Lpt1 exhibits a robust resistance to changes in buffer conditions, in stark contrast to Slc1, which is significantly inhibited by MOPS buffer. Additionally, Lpt1 activity is diminished in the presence of Mg2+, unlike Slc1, which was not sensitive to Mg2+. Previously, Slc1 showed distinct Mg2+ dependence. AGPAT4 showed higher reaction velocity towards unsaturated lysophosphatidic acids over saturated ones, which suggests a critical role in modulating neuronal membrane dynamics through the selective incorporation of unsaturated fatty acids. Preliminary data on AGPAT3 indicate similar reaction velocities for saturated and unsaturated substrates, though further investigation is required. These results contribute to a deeper understanding of lipid metabolism's impact on neuronal membrane composition, with future potential for novel therapeutic avenues.

Biological Sciences

Difference in Natural Selection Pressure on the Tooth Enamel Genes of Chameleons and Dragon Lizards

Student: Hannah Khansa

Faculty Sponsor: John Abramyan

Abstract

While teeth are ubiquitous across all vertebrates, their development and patterning vary across different groups. In most fishes, amphibians, and reptiles, teeth are replaced continuously throughout life, while mammals have reduced replacement to only one or two generations. Interestingly, members of the Families Chamaeleonidae (chameleons) and Agamidae (dragon lizards) have lost lifelong tooth replacement, instead developing “acrodont” teeth that have no root and instead fuse to the jawbone to be used for the lifetime of the animal. This as opposed to “pleurodont” reptile teeth, which sit in sockets like mammals, but are continuously replaced. In addition to differences in replacement patterns, mammals have also evolved prismatic enamel, which is thought to strengthen the enamel covering their permanent teeth. Knowing this, we hypothesized that the enamel structure genes in acrodont lizards may have also changed to facilitate lifelong tooth retention. Here we analyze the coding DNA and amino acid sequences of six enamel-specific genes (AMBN, AMEL, AMTN, ACP4, ENAM, and MMP20) from acrodont lizards, in comparison to pleurodont lizards and mammals. Supporting our hypothesis, we found that genes that code for enamel structure did indeed exhibit change in their selection pressure, while those that were involved in enamel protein processing did not.

Asymmetrical positioning of cell organelles reflects the cell chirality of mouse myoblast cells

Students: Zeina Hachem *, Courtney Hadrian, Lina Aldbaisi, Muslim Alkaabi

Faculty Sponsor: Jie Fan

Abstract

Cell chirality is crucial for the chiral morphogenesis of biological tissues, yet its underlying mechanism remains unclear. Cell organelle polarization along multiple axes in a cell body, namely, apical-basal, front-rear, and left-right, is known to direct cell behavior such as orientation, rotation, and migration. Among these axes, the left-right bias holds significant sway in determining the chiral directionality of these behaviors. Normally, mouse myoblast (C2C12) cells exhibit a strong counterclockwise chirality on a ring-shaped micropattern, whereas they display a clockwise dominant chirality under Latrunculin A treatment. To investigate the relationship between multicellular chirality and organelle positioning in single cells, we studied the left-right positioning of cell organelles under distinct cell chirality in single cells via micropatterning technique, fluorescent microscopy, and imaging analysis. We found that on a "T"-shaped micropattern, a C2C12 cell adopts a triangular shape, with its nucleus-centrosome axis pointing towards the top-right direction of the "T". Several other organelles, including the Golgi apparatus, lysosomes, actin filaments, and microtubules, showed a preference to polarize on one side of the axis, indicating the universality of the left-right asymmetrical organelle positioning. Interestingly, upon reversing cell chirality with Latrunculin A, the organelles correspondingly reversed their left-right positioning bias, as suggested by the consistently biased metabolism and contractile properties at the leading edge. This left-right asymmetry in organelle positioning may help predict cell migration direction and serve as a potential marker for identifying cell chirality in biological models.

* Presenting student

Interacting with tumor cells weakens the intrinsic clockwise chirality of endothelial cells

Students: Benson Hang *, Eman Jassem, Hanan Mohammed

Faculty Sponsor: Jie Fan

Abstract

Endothelial cells (ECs) possess a strong intrinsic clockwise (CW, or rightward) chirality under normal conditions. Enervating this chirality of ECs significantly impairs the function of the endothelial barrier. Malignant tumor cells (TCs) undergo metastasis by playing upon the abnormal leakage of blood vessels. However, the impact of TCs on EC chirality is still poorly understood. Using a transwell model, we co-cultured the human umbilical vein endothelial cells (hUVECs) or human lung microvascular endothelial cells (hLMVECs) and breast epithelial tumor cell lines to simulate the TC-EC interaction. Using a micropatterning method, we assessed the EC chirality changes induced by paracrine signaling of and physical contact with TCs. We found that the intrinsic clockwise chirality of ECs was significantly compromised by the TC's physical contact, while the paracrine signaling (i.e., without physical contact) of TCs causes minimal changes. In addition, ECs neighboring TCs tend to possess a left bias, while ECs spaced apart from TCs are more likely to preserve the intrinsic right bias. Finally, we found the chirality change of ECs could result from physical binding between CD44 and E-selectin, which activates PKCα and induces pseudopodial movement of EC towards TC. Our findings together suggest the crucial role of EC-TC physical interaction in EC chirality, and that weakening the EC chirality could potentially compromise the overall endothelial integrity which increases the probability of metastatic cancer spread.

* Presenting student

Acidification of the Phagosome Orchestrates the Motor Forces Directing its Transport

Students: Habiba Shamroukh, Perla Fares*, Zeinab Bezih, and Muaaz Akhtar

Faculty Sponsors: Suvranta K. Tripathy and Kalyan C. Kondapalli

Abstract

Phagosomes are dynamic organelles formed by macrophages to capture and destroy microbial pathogens. Phagosome transport from the cell periphery to the perinuclear region, is essential for fusion with lysosomes and the elimination of pathogens. Molecular motors, kinesin and dynein, generate opposing forces, transporting the phagosome away from and towards the lysosome, respectively. Luminal acidification plays a crucial role in determining the net directional movement of the phagosome. The mechanics of this regulation are not known. In this study, we used the sodium proton exchanger NHE9 to selectively modulate phagosomal acidification in macrophages and investigated its impact on the mechanical properties of kinesin and dynein motors through optical trapping experiments. We observed a negative correlation between the tenacity of dynein motors and pH under high resistive forces. Reduced phagosomal acidification impaired generation of dynein cooperative forces, which are crucial for transport to the lysosome. Conversely, the kinesin-powered motility of phagosomes is enabled by a decrease in acidification. Given the various methods pathogens employ to limit phagosomal acidification, our findings are highly significant in the context of host-pathogen interactions.

* Presenting student

Exploration of Probiotic Lactobacilli

Students: Thikra Shagir *

Faculty Sponsor: Jolie Stepaniak

Henry Ford College

Abstract

Lactobacilli are a group of lactic acid bacteria that have many health benefits, particularly in the context of probiotics. Probiotics contain live microbes that are introduced into or onto the body to exert beneficial effects. The aims of this study were to evaluate the presence and viability of lactobacilli in a commercial probiotic capsule, investigate their antagonistic effects on the fungus Candida albicans, and explore the inhibitory effects of chemicals produced by lactobacilli on Candida albicans. The research methods involved three main steps: enumeration of viable lactobacilli in the probiotic product through a standard plate count, conducting spot tests to assess microbial antagonism between lactobacilli and Candida albicans, and analyzing the inhibitory effects of cell-free supernatants from lactobacilli cultures on Candida albicans. The results showed that between 1.9 and 3.6 x 106 CFUs (colony forming units) of lactobacilli could be obtained from each probiotic capsule, which fell short of the number claimed by the manufacturer. While the spot tests suggested that lactobacilli may exert some inhibitory activity against Candida albicans, the results were not consistent. The cell-free supernatant experiment showed varying degrees of inhibition against Candida albicans. Additional experiments are needed to further investigate these actions of lactobacilli.

* Presenting student

Effects of Seed Size, Number and Position on Wind Dispersal of Artificial Fruits of Eastern Redbud (*Cercis canadensis*)

Students: Breckan Myers* and Asma Jamil

Faculty Sponsor: David Susko

Abstract

A number of intrinsic factors influence the quantity and quality of seed dispersal of wind-dispersed fruits and seeds (ie. fruit and seed diaspores, respectively). Intrinsic fruit dispersal traits regulated by maternal plants include fruit mass, length, width, area, wing loading (ie., the ratio of fruit mass: fruit surface area), morphology, and the presence and types of appendages. Within fruits, seed traits that influence dispersal include seed mass and number, and, in the case of multi-seeded fruits, the respective positions of seeds within one or more carpels. In general, attributes of diaspore size, weight, and morphology are correlated with their dispersal potential, the latter of which is typically estimated by measuring diaspore rates of descent or terminal velocities, horizontal dispersal distances, and/or dispersal areas. In the flattened, elongated wind-dispersed leguminous fruits of eastern redbud, *Cercis canadensis*, trees, we hypothesized that differences in the distribution of seeds within fruits, and, hence, the relative location of the center of mass within fruits, were responsible for differences in flight behaviors. In this study, we created artificial fruits that mimicked the natural fruits of eastern redbud which typically contain 1-6 seeds. This allowed us to manipulate how variability in several fruit and seed characteristics, such as seed number and location within fruits, fruit size and mass, and fruit morphology, influences the aerodynamic behavior, and, thus, the dispersal potential of these fruits measured in terms of their rates of descent and dispersal distances. We found that fruits could be separated into two aerodynamic types: Type I, tight-spiraling rolling autogyros or Type II, broad-spiraling rolling autogyros. In general, Type I fruits exhibited high rates of descent and short dispersal distances since they descended primarily along a vertical axis. Type I fruits included single-seeded or two-seeded fruits in which the seed(s) were situated close to either the basal or distal end, as well as multi-seeded (3-5 seeded) fruits in which seeds were asymmetrically distributed. Type II fruits exhibited comparatively slow rates of descent and large dispersal distances since they descended in broad helical spirals with a diameter of 1 m or more. They included single-seeded or two-seeded fruits in which the seeds were situated in the center of a fruit, as well as six-seeded fruits in which seeds were symmetrically distributed. The effects of differences in seed number and location within fruits resulted in similar trends in dispersal rates and distances for both small- and large-sized fruits. We conclude that the approximate location of the center of mass of eastern redbud fruits determines the coning angles and spin rates of their fruits. Fruits with a centrally-located center of mass generate more aerodynamic lift which slows their rate of descent in comparison to fruits with a center of mass situated towards their basal or distal ends. Future studies of multi-seeded fruit diaspores will need to account for within-fruit variation in the number, sizes, and locations of seeds, and their potential effects on diaspore flight behavior and distribution.

BIOL – 6 (Susko)

Impact of Fluorene-9-bisphenol (BHPF) Exposure on Embryonic Stem Cell Function and Developmental Gene Expression

Student: Yazan Almahdi*, Eva Schwark

Faculty Sponsor: Besa Xhabija, Ph.D.

Abstract

Fluorene-9-bisphenol (BHPF), a prevalent substitute for Bisphenol A (BPA) in the production of "BPA-free" plastic products, has raised concerns due to its potential cytotoxic effects. This comprehensive study explores the impact of BHPF on mouse embryonic stem cells (mESCs) and embryonic bodies (EBs), focusing on gene expression changes, morphogenesis, and differentiation. Our investigation reveals that BHPF exposure disrupts mESC morphology, indicating a loss of self-renewal and pluripotency, and adversely affects EB formation and growth dynamics. Through RNA-Seq analysis, we identified alterations in gene expression related to heart morphogenesis, cellular components, RNA transcription, and pathways crucial for stem cell pluripotency and differentiation. Notably, BHPF exposure increased expression of the inflammatory gene Il6 and modulated the expression of 16 genes associated with various cell types, suggesting a complex impact on cellular stress responses and terminal differentiation. Our findings highlight significant pathways affected by BHPF exposure. The results underline the urgency for further research into the molecular mechanisms underlying BHPF's effects on embryonic and stem cell biology, aiming to elucidate the potential health implications of environmental exposure to BHPF. This study lays the groundwork for future investigations into the developmental and neurodegenerative disorders linked to BHPF, offering new perspectives on the biological effects of synthetic bisphenols.

* Presenting student

Spinosyn A, a Potential Anticancer Agent, Inhibits Growth of ERα-positive Breast Cancer Cells Through the Regulation of Various Signaling Pathways

Student: Aidan McLaughlin *

Faculty Sponsor: Besa Xhabija, Ph.D.

Abstract

Breast cancer remains a leading cause of worldwide cancer-related mortality. Current breast cancer treatments are limited by toxicity, developed resistance, and side effects, necessitating the exploration of novel therapeutics with improved efficacy and reduced toxicity. Spinosyn A (SPA) is a natural product synthesized from the soil bacteria, *Saccharopolyspora spinosa*. SPA is known for its traditional use as an insecticide but has emerged as a promising candidate in the pursuit of improved breast cancer treatments. This study aims to elucidate the comprehensive anticancer effects of SPA on T47-D, estrogen receptor α positive (ERα-positive) breast cancer cells, through evaluations of cytotoxicity, cell migration, proliferation, induction of oxidative stress, DNA damage, and genome-wide transcriptional alterations. Our findings demonstrate that SPA significantly inhibits cell proliferation, migration, and induces apoptosis in a dose-dependent manner. Furthermore, flow cytometry and holographic imaging microscopy revealed that treatment with SPA led to cell cycle arrest in the G0/G1 phase, activation of the MAPK and PI3K signaling pathways, increased oxidative stress, and substantial DNA damage, as indicated by the activation of the ATM-CHK2 signaling pathway and upregulation of pBRCA1. Analysis of both Annexin V and 7-AAD markers and the morphological features of SPA-treated T47-D cells revealed the initiation of apoptosis. Transcriptomic analysis also identified significant changes in gene expression, further highlighting the effect of SPA on various cellular processes and signaling pathways. The results of our study provide insights into the molecular mechanisms and pathways for SPA's potential as an anticancer agent. This research paves the way for further exploration into SPA's clinical applications in breast cancer treatment, potentially contributing to the development of more targeted and less toxic therapeutic options.

* Presenting student

Blood–brain barrier dysfunction after pediatric traumatic brain injury

Students: Tia Atoui*, Yara Mashal*, Stefanie Tasevski, Amanda Ghannam

Faculty Sponsor: Zhi (Elena) Zhang

Abstract

Traumatic brain injury (TBI) results from external forces that hinder normal brain development and function in children. Blood-brain barrier (BBB) disruption is a major consequence of TBI. BBB maintains brain homeostasis by suppressing entry of peripheral immune cells, promoting toxic substance removal, and providing nutrient delivery. Although studies have investigated BBB dysfunction after TBI in adults, multifaceted role of the BBB following pediatric TBI remain poorly understood. In this study, we evaluated the BBB integrity and function at the acute phase post-injury in a mouse model of pediatric TBI. Our results indicate that TBI resulted in enhanced BBB permeability and derangement of tight junction proteins within hours following injury, which is associated with poorer outcomes. Therefore, BBB disruption in pediatric TBI holds significant promise for diagnosis and treatment.

* Presenting students

BIOL – 9 (Zhang)

Gold nanoparticle-4-Phenylbutyric acid conjugates ameliorate ER stress and improved behavioral outcomes after pediatric traumatic brain injury

Students: Nazik Ebrahem*, Alaina Small*, Amy Nkrumah*, Mauda Abdullah

Faculty Sponsor: Zhi (Elena) Zhang, Krisanu Bandyopadhyay

Abstract

Traumatic brain injury (TBI) remains a leading cause of morbidity and mortality in children. Dysregulation of ER stress following TBI contributes to abnormal protein accumulation, cell loss, and cognitive deficits. 4-Phenyl butyric acid (4-PBA) has been used in decreasing ER stress, however, poor bio-availability hinders it effectiveness. Here, we evaluated gold nanoparticle (GNP)-4-PBA brain bio-distribution and therapeutic efficacy in a mouse model of pediatric TBI. We found that GNP-4-PBA crossed blood-brain-barrier and localized with neurons and microglia at the site of injury. A single dose of GNP-4-PBA significantly improved sensorimotor functions, decreased ER stress and neuro-inflammation in both males and females. Moreover, at the same dose, GNP-4-PBA exhibited a significantly higher effectiveness, compared with the 4-PBA free drug. In conclusion, GNP-4-PBA achived targeted delivery, decreased ER stress and neuro-inflammation, and improved behavioral outcomes after pediatric TBI.

* Presenting students

Differential regulation of ER stress and neuroinflammation after pediatric traumatic brain injury

Students: Amanda Ghannam*, Victoria Hahn*, Stefanie Tasevski, Sara Moughni

Faculty Sponsor: Zhi (Elena) Zhang, Jie Fan

Abstract

Endoplasmic reticulum (ER) stress and neuroinflammation play an important role in secondary brain damage after traumatic brain injury (TBI). Due to the complex brain cytoarchitecture, multiple cell types, including neurons and glial cells, are affected by TBI. However, cell type-specific and sex-specific responses to ER stress and neuroinflammatory after brain trauma remain unclear. Here we investigated differential regulation of ER stress and neuroinflammatory pathways in neurons and microglia during the acute phase post-injury in a mouse model of impact acceleration TBI in both males and females. We found that TBI resulted in significant weight loss only in males, and sensorimotor impairment and depressive-like behaviors in both males and females at acute phase post-injury. By simultaneously evaluating the responses in neurons and microglia towards ER stress and neuroinflammation in both males and females, we discovered that the ER stress and anti-inflammatory responses were significantly stronger in microglia, especially in female microglia, compared with the male and female neurons. Whereas the degree of phosphorylated-tau (pTau) accumulation was significantly higher in neurons, compared with the microglia. In conclusion, TBI resulted in behavioral deficits and cell type-specific and sex-specific responses to ER stress and neuroinflammation, and abnormal protein accumulation at the acute phase after pediatric TBI.

* Presenting students

Cerebellar impairment in a mouse model of infantile hypophosphatasia

Students: Stefanie Tasevski*, Sara Moughni*, Amanda Ghannam, Victoria Hahn

Faculty Sponsor: Zhi (Elena) Zhang

Abstract

Mutations in the tissue-nonspecific alkaline phosphatase (TNAP) gene can result in hypophosphatasia (HPP) that is characterized by skeletal and dental hypomineralization. Growing evidence indicates that neurological symptoms are prevalent in patients with HPP. The cerebellum plays an important role in sensorimotor coordination and cognition. However, the impact of TNAP mutation on the cerebellar circuitry development and function remain poorly understood, especially in children with HPP. In this study we investigated the roles of TNAP in the cerebellum. Male and female wild type (WT) and TNAP knockout (KO) mice underwent behavioral testing on postnatal day 13-14 (P13-14), and were euthanized after completion of behavioral tests. Brain tissues were harvested for gene expression and immunohistochemistry analyses. We found that TNAP deficiency resulted in developmental delays and impaired sensorimotor functions in both male and female KO mice. These developmental and behavioral deficits were accompanied with Purkinje cell dysfunction, indicated by abnormal Purkinje cell morphology, and dysregulation of genes that are involved in cell functions and survival. In conclusion, TNAP deficiency causes maldevelopment of cerebellum, impaired cerebellar functions and Purkinje cell abnormalities. These results shed light on a new perspective of cerebellar contribution, especially Purkinje cell dysfunction, to the sensorimotor deficits in hypophosphatasia.

* Presenting students

BIOL – 12 (Zhang)

Chemistry

Generation of two-dimensional arrays of copper nanoparticles on functionalized surfaces

Yakeen Aljaber*, and Evelyn Diakiw

Faculty Sponsor: Krisanu Bandyopadhyay

Abstract

Synthesis of metal nanoparticles immobilized on solid support has seen remarkable growth due to their unusual catalytic properties. As a result, there is considerable interest for investigating a general preparative route to engineer aggregation-resistant metal nanoparticles for catalytic applications. The present work deals with the organized assemblies of the N-(trimethoxysilylpropyl)ethylenediamine triacetic acid to generate copper (Cu) nanoparticles for electro-catalytic oxidation of methanol. Self-assembly of N-(trimethoxysilylpropyl) ethylenediamine triacetic acid (TETA) on silicon and glass substrates is used to functionalize the surface and adsorb Cu(II) ions through electrostatic interactions between surface functional group and Cu^{2+} ions in solution. Reduction of surface bound ions by appropriate reducing agent leads to a nanoparticle size restricted by the TETA template. Structural characterization of the generated nanoparticles is obtained through Atomic Force Microscopy (AFM) and Ultraviolet-Visible (UV-Vis) Spectroscopy is used to determine the optical properties of the nanoparticle arrays.

Bridging the Gap in Pre-Medical Mentorship: The Michigan Medical School Series (MMSS)

Students: Wasey Rehman[1]*, Nadia Aboumourad BS[2], Zahra Patni[1], Zahra Tanana[1], Asil Khanafer[1], Nada Sedrati[1], Yousif Kaakarli[3], Zade Abou-Rass[4], Manas Ponnam[4], Hadi Fayad[5], and Ammar Khan[5]

Faculty Sponsor: Dr. Krisanu Bandyopadhyay

[1] University of Michigan-Dearborn
[2] University of Michigan Medical School
[3] Oakland University
[4] Wayne State University
[5] University of Michigan

Abstract

Knowledge and familiarity with the medical school application process can significantly ease its daunting aspects. Support for pre-medical students has notoriously come from mentorship and guidance from upperclassmen and alumni, particularly at primary undergraduate or regional institutions. However, access to information for navigating the medical school journey remains restricted, often disproportionately affecting students without mentors or immediate connections to medical academia. A hybrid four-part series over four weeks featured medical student panelists from five SouthEast Michigan medical schools (University of Michigan, Wayne State University, Michigan State University (COM/CHM), Oakland University) as part of a collaboration between 17 pre-health and natural science organizations from four SouthEast Michigan universities. Over 200 registrants from nine nationwide undergraduate institutions attended, spanning all class standings. Panelists shared high-yield, school-specific recommendations. Panelists discussed data-based evidence on admissions, class data, demographics, and match rates—overviews of pre-clinical curriculum, clerkships, medical student experience, and access to financial aid. After the panel, students had the opportunity to pose questions and connect with the panelists as potential mentors and felt better equipped to tackle their journey to medical school and the medical school application. Students felt empowered and better skilled in navigating their undergraduate and admission journeys. They were provided with mentors to bridge their undergraduate institution to various medical schools. The event sparked an interest to continue to amplify access to information.

* Presenting student

Magneto-Structural Correlations in New Derivatives of Benzo[*e*][1,2,4]triazinyls

Students: Gabriel Harbauer, Brayden Early, Thomas Smith,

Faculty Sponsor: Christos P. Constantinides

Abstract

Stable organic radicals, with their unique physical properties, stand out as promising building blocks for multifunctional molecular materials. These materials have the ability to amalgamate optical, transport, and magnetic properties, and they can be finely tuned at the molecular level by introducing minor structural alterations in their molecular backbone. Ensuring control of their solid-state packing is crucial to custom tailoring their macroscopic properties, necessitating the development of structure-activity relationships. Recently, we have developed a variety of synthetic routes to air- and moisture-stable Benzo[e][1,2,4]triazinyl radicals (also known as Blatter radicals), aiming to identify correlations between structure and magnetism. Presented herein is a magneto-structural correlation study of newly synthesized Blatter-type radicals.

The Preparation of the Blatter Radical via the Azaphilic Addition of Phenyl lithium to Benzo[e][1,2,4]triazine

Students: B. Early, N. Medawar, K. Chicosky, Y. Aljaber, S. Sheynkop, A. Ahmad

Faculty Sponsor: Christos P. Constantinides

Abstract

A simple, one-pot method for the preparation of 1-aryl-3-phenyl-1,4-dihydrobenzo[*e*][1,2,4]triazin-4-yl radicals by addition of aryllithium to the readily available 3-phenylbenzo[*e*][1,2,4]triazine followed by aerial oxidation is described. The Blatter radical is characterized by solution EPR spectroscopy.

Evaluating Seasonal Variations of Sodium, Chloride, Calcium and Magnesium in Water Samples from Rouge River and Fairlane Lake: Effects of De-icing Salt Use on Water Quality

Students: Slater Stanton*, Ashley Benson, Hayden Allie*, Samantha Brunell* and Andrea Sanchez*

Faculty Sponsor: Yiwei Deng

Abstract

The aim of this investigation is to assess the seasonal variability of sodium, chloride, calcium, and magnesium concentrations in water samples collected from Fairlane Lake and the Rouge River, situated adjacent to the Henry Ford Estate. Flame atomic absorption spectrometry (FAAS) was utilized for sodium and magnesium determination, complexometric titration for calcium analysis, and potentiometry with a chloride ion selective electrode (Cl-ISE) for chloride quantitation. The findings reveal significant seasonal fluctuations in sodium and chloride levels within the river samples, exhibiting lower concentrations during summer and autumn, and higher concentrations in winter. However, levels of these elements might decrease compared to those in summer and autumn due to significant dilution resulting from snow and ice melting. While seasonal trends for calcium and magnesium were notable, they were not as pronounced as those observed for chloride and sodium. Interestingly, concentrations of these elements in the lake water remained relatively consistent across seasons. The stable concentrations found in Fairlane Lake are probably due to its geographical location. Situated away from roadways and draining into the Rouge River at a higher latitude, Fairlane Lake is less prone to contamination from runoff associated with human activities. A comparison of the two water systems indicates that elevated levels of sodium and chloride found in the river samples are likely due to widespread use of road salt during winter months. These findings offer crucial insights into how anthropogenic activities, particularly salt application, impact the seasonal dynamics of these elements, consequently influencing the ecosystem of the Rouge River.

* Presenting students

CHEM – 5 (Deng)

A system-orientated concept map extension (SOCME) for sulfuric acid

Students: Culp, Faith; Hoover, Lauryn; Nagy, Devon

Faculty Sponsor: Craig J. Donahue

Abstract

This poster presents a system-oriented concept map extension (SOCME) describing the manufacture and uses of sulfuric acid (H_2SO_4). This map originated as a student group project in a junior-level course in inorganic chemistry focused on main group chemistry. The map includes relevant subsystems that connect the core reactions/processes to broader earth, environmental, and societal subsystems. The map is modeled after the work of P. G. Mahaffy, *et. al.* that appeared in a Special Issue of the *Journal of Chemical Education*, in December 2019 (pages 2730-2741) devoted to *Reimaging Chemistry Education: Systems Thinking, and Green and Sustainable Chemistry*.

A system-orientated concept map extension (SOCME) for primary aluminum production

Students: Aaron Engelhardt, Tyler Stewart, and Noah Zain

Faculty Sponsor: Craig J. Donahue

Abstract

This poster presents a system-oriented concept map extension (SOCME) describing the manufacture and uses of primary aluminum, aluminum obtained from bauxite. This map originated as a student group project in a junior-level course in inorganic chemistry focused on main group chemistry. The map includes relevant subsystems that connect the core reactions/processes to broader earth, environmental, and societal subsystems. The map is modeled after the work of P. G. Mahaffy, *et. al.* that appeared in a Special Issue of the *Journal of Chemical Education*, in December 2019 (pages 2730-2741) devoted to *Reimaging Chemistry Education: Systems Thinking, and Green and Sustainable Chemistry*.

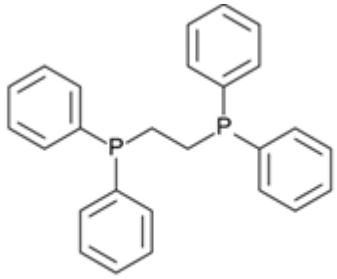
Synthesis of 1,2-bis(diphenylphosphino)ethane (dppe) and the complex $NiCl_2$(dppe) and use of the complex as a catalyst

Students: Yakeen Aljaber, Katherine Chicosky, Sofiya Skeynhop, Ahsan Ahman, Brayden Early, and Nathan Medawar

Faculty Sponsor: Craig J. Donahue

Abstract

1,2-Bis(diphenylphosphino)ethane (dppe) was prepared in a sodium-liquid NH_3 solution. Addition of triphenylphosphine to this solution gave $Na^+PPh_2^-$, which upon addition of 1,2-dichloroethane gave the title compound. 1,2-Bis(diphenylphosphino)ethane was recovered by liquid-liquid extraction (dichloromethane/water) and recrystallized from a 95% ethanol-dichloromethane mixture to give a white, air-stable solid. Reaction of dppe with $NiCl_2 \cdot 6H_2O$ in ethanol gave $NiCl_2$(dppe), a neutral, air-stable, orange, square planar complex, where dppe functions as a bidentate ligand forming a five-membered chelate ring. The $NiCl_2$(dppe) complex was used as a catalyst in a Suzuki cross-coupling reaction of 1-bromo-4-X-benzene with phenylboronic acid in the presence of K_3PO_4 in refluxing *tert*-amyl alcohol. This reaction produced 4-X-biphenyl species, characterized by ^1H NMR.



1,2-Bis(diphenylphosphino)ethane (dppe)

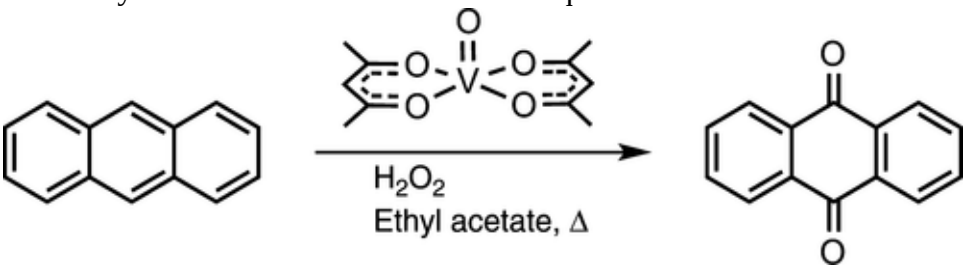
Preparation and characterization of a series of bis(bidentate) and tetradentate vanadyl complexes and their use as a catalyst

Students: Brayden Early, Nathan Medawar, Katherine Chicosky, Sofiya Skeynhop, Yakeen Aljaber, and Ahsan Ahman,

Faculty Sponsor: Craig J. Donahue

Abstract

A two-step process was used to prepare a series of VO(bidentate)$_2$ complexes. In the first step, orange V_2O_5 was reduced to blue vanadyl sulfate, $VOSO_4$, in a hot solution containing a mixture of sulfuric acid and ethanol. In the second step, the bidentate ligand (e.g., acetylacetone or 2,4-pentanedione) was added to the $VOSO_4$ solution and then anhydrous sodium carbonate was added until the evolution of CO_2 ceased. The insoluble VO(bidentate)$_2$ complexes were collected by filtration and recrystallized from chloroform. The VO(salen) complex, where salen^{2-} is a tetradentate ligand containing a pair of N and a pair of O donor atoms, was prepared in an analogous fashion. These blue-green, neutral, paramagnetic, five-coordinate complexes were characterized using several techniques (magnetic moment measurements, electronic spectra, IR spectroscopy, and electron spin resonance spectroscopy (esr)). VO(acac)$_2$ was subsequently used as a catalyst to oxidize anthracene to anthraquinone – see below.



Unlocking the Secrets of Aspirin Expiration Date

Students: Manar Mawri *

Faculty Sponsor: Charles Irish

Henry Ford College

Abstract

This study investigates the impact of the expiration date on acetylsalicylic acid (ASA), the active ingredient in commercial aspirin tablets. In this study, we employed spectrophotometry, direct titration, and back titration. The initial results from the spectrophotometer tests were poor due to binders and other insoluble ingredients in the aspirin. Therefore, we put most of our efforts into the titration methods. For the titration methods, a NaOH solution was standardized using 0.25 g samples of Potassium Acid Phthalate (KHP; KHC8H4O4). In the direct titration of aspirin tablets, the mass of three tablets from each sample was recorded. Subsequently, each group of aspirin samples was sufficiently crushed using a mortar and pestle. Next, three samples, each weighing 0.3 g of the crushed tablet, were transferred into 250 mL Erlenmeyer flasks. To this, 20 mL of ethanol and three drops of phenolphthalein indicator were added. Using the prepared NaOH solution, each sample was titrated until the first permanent cloudy pink color appeared, and the initial and final volumes of the base were then recorded. In the back titration of aspirin tablets, after reaching the first permanent cloudy pink color, the same amount of base, along with an additional 10 mL, was added to each sample. Subsequently, the samples were heated in a water bath for 15 minutes and cooled for 5 minutes. Following this, a standardized HCl solution was used to back titrate the excess NaOH added until the pink color disappeared, and a cloudy white color was observed. The initial and final volumes of the acid were recorded. Our scatter plots show reproducible percent change for each particular year, as seen by how close the data points are for a given year. The same pattern of data was found by both direct and back titration, giving us confidence in the observed pattern. However, the pattern of data is different from what we expected. We anticipated that the percent change of ASA would increase with the age of the aspirin. Contrary to our expectations, our data shows that the percent ASA decreased the most for the 2016 aspirin, while the 2014 aspirin did not experience as significant a decrease, despite being older than the 2016 aspirin. We hypothesize that each aspirin bottle's history of storage influenced its rate of deterioration, with a belief that the 2016 aspirin was exposed to more moisture than the 2014 aspirin.

* Presenting student

The Significance of the Aromatic Stabilization of the Blatter Radical

Students: David Doty

Faculty Sponsor: Daniel Lawson

Abstract

The Blatter radical distinguishes itself as an exceptionally stable radical molecule that has been receiving increased attention in contemporary research. This molecule features three unpaired electrons on its nitrogen atoms; of these, two are spin-paired while the third is delocalized over the molecule. The radical nature of the molecule is thought to be stabilized by resonance delocalization of 3 phenyl rings that effectively surround the radical. In our study, we aim to examine the importance of the aromatic character of each benzenoid ring by substituting them with either non-aromatic rings, such as cyclohexane, or with antiaromatic rings, for instance, cyclopentadiene. By probing into the roots of the Blatter radical's stability, we anticipate uncovering more refined methods to adjust and control the properties of the Blatter radical.

Cyclopropylmethylidene as a Versatile Protecting Group for Carbohydrate Synthesis

Nasma Ibrahim*, Zahraa Jaber, Sara Ali, and Isha Masood

Faculty Sponsor: Xiaohua Shannon Li

Abstract

Complex carbohydrate synthesis requires the availability of diverse and orthogonal protecting strategies for common functional groups, such as hydroxyl, amino and carboxyl groups. Besides masking necessary functional groups, it is well-known that protecting groups also greatly impact the reactivity of glycosyl donors and acceptors and the stereoselectivity of glycosylation reactions. We recently developed cyclopropylmethylidene (CPMD) as a versatile protecting group for carbohydrate synthesis. It can be formed by acid-catalyzed acetalization between cyclopropanecarboxaldehyde and 1,3-diols of sugar molecules. Selective reductive opening of the 4,6-*O*-cyclopropylmethylidene can be achieved to afford a C4 free hydroxyl group and a C6-cyclopropylmethyl (CPM) ether or vice versa. The cyclopropylmethylidene was found to be less stable than benzylidene under acidic conditions. In addition, cyclopropylmethyl (CPM) ether may be deprotected using trifluoracetic acid in dichloromethane.

* Presenting student

The nature of riboflavin protein interactions probed via flavin derivatives: the role of ribityl tail

Student: Nathan Medawar

Faculty Sponsors: Simona Marincean, Marilee Benore

Abstract

Flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) are two essential co-enzymes that participate in metabolic processes involving electron, proton, and hydride transfer via their flavin moiety. Riboflavin, an essential water-soluble vitamin, is the precursor for both FAD and FMN even though humans do not have the ability to synthesize it and must obtain it from their diet. The link between riboflavin deficiency and development problems as well as presence of overexpressed riboflavin receptors in several cancer types has generated interest for potential applications in drug therapeutics. Thus, understanding the nature of the vitamin-protein interactions is critical for these endeavors.

Early X-ray studies of chicken isolated riboflavin binding protein (chicken-RBP) reported close contacts in the binding pocket between amino acid residues, tyrosine and tryptophan, on one side, and vitamin's flavin moiety, on the other side. However, there is little information on the role of the ribityl, a sugar-like, tail in the vitamin-chicken RBP interactions. Preliminary results in our group have shown that a riboflavin derivative with a longer, modified tail lacking hydroxyl groups, has a similar behavior as riboflavin with respect to chicken-RBP. We report here the synthesis and characterization of a novel derivative that will be used to explore the impact of the tail's carbon backbone on the vitamin-protein binding.

CHEM – 13 (Marincean)

Earth and Environment

Exploring the Conservation Dynamics and Habitat Ecology of Antillean Manatees in Belize

Student: Christian Cannon *

Faculty Sponsor: Ulrich Kamp

Abstract

Antillean manatees (*Trichechus manatus manatus*) are globally acknowledged as an endangered species and serve as a vital role to the aquatic ecosystem of Belize in Central America. Despite their ecological significance, Antillean manatees face numerous conservation challenges, including habitat degradation, anthropogenic threats, and the impacts of climate change. In this study, we conducted a comprehensive investigation into the conservation dynamics and habitat ecology of Antillean manatees in Belize. Through a multidisciplinary approach, we utilized scientific literature, satellite imagery, and data analysis techniques. Our findings highlight the importance of understanding habitat preferences, identifying anthropogenic threats, and assessing the impacts of environmental changes on manatee populations. Additionally, we draw parallels with the manatee conservation efforts in Florida, U.S., emphasizing the global relevance of conservation challenges and their consequences for manatee management worldwide. We discuss the implications of our research for the proactive management and conservation of Antillean manatees, proposing recommendations for future conservation strategies and research directions. By enhancing our understanding of the conservation dynamics and habitat ecology of Antillean manatees, this study contributed to ongoing efforts to protect and preserve this charismatic species in Belize and throughout the world.

Preliminary Density Functional Theory Study of Organophosphorus Compounds and the Reactivity with Serine Amino Acids

Students: Sumaiyya Mujawar*

Faculty Sponsor: Prof. D. Lawson

Abstract

Acetylcholine is a key neurotransmitter involved in various physiological processes, including muscle contraction, regulation of heart rate, and modulation of cognitive functions. Acetylcholinesterase is present at the cholinergic sites refer to specific locations in the body where the neurotransmitter acetylcholine (ACh) exerts its effects by binding to receptors. Acetylcholinesterase (AChE) belongs to a category or group of enzymes known as serine hydrolases. The primary role of AChE is to terminate neuronal transmission and signaling between synapses to prevent ACh dispersal and activation of nearby receptors. Organophosphates for a group of mostly synthetic compounds that inhibit AChE and form are an economically important component of pesticides and nerve agents for the agriculture industry. Whereas, organophosphates are synthetically derived, little is known about how they inhibit nerve reception.

This work uses Density Functional Theory to examine the nature of a group of organophosphates to assist in elucidating the reaction mechanism between organophosphorus (OP) insecticides and the serine amino acid. The aim is to gain insights into the molecular mechanisms underlying the possible interactions between OP and the biological active sights, focusing on properties such as dipole moment, electrostatic potential, Highest Occupied Molecular Orbital (HOMO), and Lowest Unoccupied Molecular Orbital (LUMO) values. By employing quantum mechanical computational methods of DFT, we elucidate how OP insecticides interact with serine at the molecular level. Our findings reveal significant variations in dipole moments among the studied compounds, indicating differences in polarity and charge distribution. Overall, our analysis provides valuable information for understanding the behavior and reactivity of organophosphorus compounds, with implications for pesticide development, environmental monitoring, and pharmaceutical research.

Microbiology

Swarming Motility Facilitates *Proteus mirabilis* Biofilm Fouling of Foley Catheters

Student: Molly Lesko

Faculty Sponsor: Christopher Alteri

Abstract

Urinary tract infection (UTI) is the second most common bacterial infection. *Proteus mirabilis* is a leading cause of catheter-associated UTIs (caUTI). UTIs and caUTIs are a burden on the healthcare system. *P. mirabilis* is a facultative, Gram-negative pathogen characterized by its robust swarming motility. Work in our lab previously found that prototype *P. mirabilis* strain HI4320 swarms onto and colonizes a sample of five different commercially available Foley catheters. We next aimed to investigate if other strains or clinical isolates of *P. mirabilis* were similarly able to colonize catheters during swarming because different *P. mirabilis* strains have distinct swarming phenotypes, some are vigorous swarmers while others are weak swarmers. We found that a collection of five *P. mirabilis* clinical isolates all colonized three catheters to similar levels as strain HI4320 including two catheters marketed as antimicrobial. Weak swarmers, such as isolates DE120 and HA139 were able to not only access the catheter via swarming but their subsequent growth on the catheter was not inhibited by antimicrobial treatments. Our findings have important implications for the use of antimicrobial catheters as infection control measures in the clinic.

The Use of Attenuated Total Reflectance Fourier Transform Infrared (ATR-FTIR) Spectroscopy to Analyze Pb-Induced Changes in Bacterial Strains

Students: Amin Kassem, Somie Opara
Faculty Sponsors: Shannon Li and Sonia M. Tiquia-Arashiro

Abstract

Microorganisms can effectively remove Pb from aqueous solutions through biosorption and the functional groups in their cell walls are responsible for the binding tasks. However, the success of biosorption relies on the diversity of cell wall structures. ATR-FTIR spectroscopy was used to identify the functional groups involved in Pb uptake of four bacterial strains (R3, R19, L2, and L30) grown in different concentrations of Pb (0, 10, 100, and 500 mg/L of Pb). FT-IR profile of Pb-free bacterial strains displayed various peaks corresponding to functional groups. When the cells were treated with Pb, some functional groups shifted, and some new peaks appeared. The number of IR shifts varied between strains. More shifts were observed for R2 and R19 (10-14 IR shifts) than L2 and L30 (8 IR shifts). These functional groups include: $(RCO)_2O$, C-C, $R_2C=O$, RCOOH, C≡C, RCHO, C−H, RO−H free, C_2HR_3, monosubstituted, and 1-3 disubstituted aromatic compounds. The appearance of new IR peaks was more evident when cells were grown at 100 mg/L Pb. These IR peaks correspond to functional groups such as $C_2H_2R_2$, C_2H_3R, R-OH, RCOCl, R-OH hydrogen bonded, $R_2C=NR$, $R_2C=NH$, C=C, C=C−H, C≡C−H, P−NH, P−NH_2, P=N, Ar-H, 1-2 and 1-4 disubstituted aromatic compounds. This study showed significant changes in the functional groups when exposed to Pb which might be responsible for the biosorption of Pb by the strains.

SEM-EDS and TEM-EDS Analysis of Zn Biosorption Characteristics of *Klebsiella* sp. and *Raoultella* sp.

Students: Claudia Shuler, Grace Pagnucco, Somie Opara, Amin Kassem

Faculty Sponsor: Sonia M. Tiquia-Arashiro

Department of Natural Sciences, University of Michigan-Dearborn, Dearborn MI 48128

Abstract

This study investigates the biosorption characteristics of zinc (Zn) by two bacterial strains, *Klebsiella* sp. and *Raoultella* sp., using Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (SEM-EDS) and Transmission Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (TEM-EDS). The biosorption potential of these bacterial strains is of particular interest due to their potential application in bioremediation and environmental sustainability. The experimental procedure involved the cultivation of the strains in media enriched Zn-enriched growth media, followed by harvesting and preparation of the biomass samples. SEM-EDS was utilized to examine the surface morphology and elemental composition of the bacterial cells before and after Zn biosorption, enabling visualization of the binding sites and distribution of the adsorbed Zn. TEM-EDS analysis provided further insights into the cellular internalization of Zn and its intracellular distribution. Preliminary results indicate that both *Klebsiella* sp. and *Raoultella* sp. exhibited significant Zn biosorption capabilities, with variations observed in their biosorption mechanisms and patterns. The SEM-EDS analysis revealed the Zn precipitates on the bacterial cell surface, while TEM-EDS uncovered evidence of intracellular Zn localization within distinct organelles. This study contributes to better understanding of the Zn biosorption process, shedding light on the potential mechanisms involved in their interaction with Zn. These results have important implications for the development of eco-friendly bioremediation strategies and open avenues for further exploration of the biotechnological applications of these bacterial strains in environmental remediation. However, more comprehensive investigations are warranted to elucidate the underlying molecular and cellular processes driving the observed biosorption characteristics.

Copper Biosorption by Siderophore-producing Bacterial Strains

Students: Diana Kasperek, Claudia Shuler, Grace Pagnucco, Amin Kassem, Hawraa Najaf, Somie Opara, Oliver Coutinho, Lana Abbas.

Faculty Sponsor: Sonia M. Tiquia-Arashiro

Department of Natural Sciences, University of Michigan - Dearborn, Dearborn, MI 48128, USA

Abstract

Copper (Cu) is one of the most commonly selected heavy metals for industrial and agricultural applications for centuries. The accumulation of Cu in the environment has led bacteria to develop mechanisms for biosorption or resistance to Cu if levels reach toxicity. Albeit, bacteria require Cu as micronutrient to act as electron carriers, catalysts for redox reactions, and constitute an important feature of cofactor enzymes. Our research focuses on the biosorption effects of Cu on the four bacteria strains R3, R19, L2, and L30 through siderophore production. Various experiments conducted in Luria-Bertani (LB) broth or plates mixed with differing concentrations of Cu were performed to observe these effects and characteristics, such as siderophore assay, minimum inhibition concentration (MIC), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy/transmission electron microscopy (SEM/TEM). 16S rRNA gene PCR amplification was performed to conduct species identification as well. There was a positive presence of siderophores and visible traces of Cu both within and outside cells, and MIC tests showed the optimal Cu concentrations for growth. FTIR described the interaction between the cell wall and Cu. Overall, these strains have shown that these bacterial strains have the capability to adapt to Cu toxicity.

Biosorption mechanisms of metal removal by bacterial strains

Student: Grace Pagnucco

Faculty Sponsor: Sonia Tiquia-Arashiro

Abstract

Rapid industrialization and urbanization have resulted in widespread contamination of metals in aquatic ecosystems. In view of this, the present study examines the metal tolerance and biosorption characteristics of four bacterial strains isolated from Saint Clair River sediments. These strains were found to remove metals (As^{3+}, Pb^{2+}, Cu^{2+}, Mn^{2+}, Zn^{2+}, Cd^{2+}, Cr^{6+} and Ni^{2+}) in mono- and multi-metal solutions. While *Klebsiella* sp. R3 and *Klebsiella* sp. R19 were less tolerant to metals than *Serratia* sp. L2 and *Raoultella* sp. L30, they demonstrated the ability to efficiently remove more metals. This result suggests that the efficiency of metal removal does not rely solely on metal tolerance but also on the cation binding ability of the strain. Metal resistance was found to be associated with decreased uptake and/or impermeability, which reduced the overall metal uptake of strains L2 and L30. FT-IR analyses indicated that strains R3 and R19 strains possess more accessible carboxyl and amide functional groups than L2 and L30, which are the most important metal binding sites. SEM analysis showed reduction in size and changes in cell morphology demonstrating the toxic effects of the metal. The cells were also aggregated together. STEM results indicated that the metals were fixed at the cell surface and in the cytoplasm. This study confirms that the simultaneous presence of an aqueous solution may cause a mutual inhibition in the adsorption of each metal to the EPS resulting in reduced metal uptake emphasizing the need to select specific bacterial strains for a given metal-containing effluent.

Mechanism Cd Absorption and Removal by *Klebsiella* sp. and *Raoultella* sp. in Aqueous Solutions

Students: Hawraa Najaf, Claudia Shuler, Grace Pagnucco, Amin Kassem, Somie Opara, Diana Kasperek, Oliver Coutinho, and Lana Abbas.

Faculty Sponsor: Sonia M. Tiquia-Arashiro

Department of Natural Sciences, University of Michigan - Dearborn, Dearborn, MI 48128, USA

Abstract

Due to urbanization and pollution, cadmium (Cd) is widely present in aquatic environments and is causing toxicity to aquatic organisms. Microorganisms have developed resistance to Cd and mechanisms remove Cd through the absorption process. However, the mechanism of Cd biosorption by bacteria in aqueous solutions is still not well understood. Thus, the goal of this study was to better understand the mechanism and how bacteria play a role in the removal of this metal from aqueous solutions. Experiments such as minimum inhibitory concentration (MIC) to Cd, siderophore production in the presence of Cd, SEM (scanning electron microscopy), and TEM (transmission electron microscopy) was performed on four bacterial strains (R3, R19, L30, and L2). The MIC of the R3 and R19 strains were lower (20 mg/L) than the L2 and L30 strains (75 mg/L). Siderophore production was observed at 20 mg/L for strain L30, at 50 mg/L for L2, L30, and R19, and at 10 mg/L for R3. No siderophores were produced in strain R3 in the presence of Cd at any given concentration. TEM showed images that demonstrated that among the eight metals examined, Cd is the most dominant metal found not just on the cell wall but also in the cytoplasm, suggesting that the strains have mechanisms to transport Cd within the cell. The study provides a comprehensive understanding of Cd-bacteria sorption reactions as well as practical applications in the remediation of heavy metals.

FT-IR Spectroscopy for the Identification of Binding Sites for Cr absorption in Bacterial Strains

Students: Lana Abbas, Amin Kassem, Oliver Coutinho, and Hawraa Najaf.

Faculty Sponsors: Shannon Li and Sonia M. Tiquia-Arashiro

Abstract

Chromium (Cr) contamination presents significant environmental and health hazards, necessitating a thorough understanding of its interaction with bacterial strains for effective remediation approaches. In this investigation, Fourier-transform infrared (FT-IR) spectroscopy was used to examine the binding sites responsible for Cr absorption in four bacterial strains (R3, R19, L2, and L30). The primary objective was to identify the functional groups involved in the binding process, thereby offering valuable insights into the mechanisms of Cr uptake. The bacterial cultures were exposed to 10 mg/L of Cr and FT-IR spectroscopy was utilized to record their spectra. The acquired spectrum underwent meticulous data analysis, encompassing peak identification and analysis. The FT-IR spectra of the bacterial strains exhibited changes in the intensity and position of specific absorption bands following Cr exposure. By means of peak identification and reference spectrum comparison, functional groups such as 1,3-disubstituted and 1,2-disubstituted aromatic Compound, alkenes ($C_2H_2R_2$) alkynes (C≡C), hydroxyls (R-CHO, R-OH), amines (C-C), and N- and P-containing functional groups (P-NH_2, P=N, P-NH), were identified as plausible binding sites for Cr absorption across all bacteria strains. This study collectively shows the effectiveness of FT-IR spectroscopy in the binding sites accountable for Cr absorption in bacterial strains. The integration of peak identification shows an analysis of the underlying mechanisms proceeding with Cr uptake. The identified functional groups hold valuable presenting information for further exploration in the development of efficient bioremediation strategies tailored for Cr-contaminated environments.

Changes in bacterial cell's functional groups in response to Cd exposure using FT-IR Spectroscopy

Students: Oliver Coutinho, Amin Kassem, and Lana Abbas.

Faculty Sponsors: Shannon Li and Sonia M. Tiquia-Arashiro

Department of Natural Sciences, University of Michigan - Dearborn, Dearborn, MI 48128, USA

Abstract

Fourier Transform Infrared (FT-IR) Spectroscopy can be employed to observe changes in the chemical structure of the bacterial cells when exposed to varying concentrations of cadmium (Cd). In this study, four bacterial samples R3, R19, L2, and L30 were grown on media containing varying concentrations (0, 10, 20, and 50 mg/L) of Cd. FTIR assays were performed using 2 to 6 individual colonies per strain. The FT-IR spectra highlighted the presence of significant peaks corresponding to functional groups present in the bacterial strains. When the cells were exposed to increasing concentrations of Cd, a shift in absorption bands and appearance of new peaks were observed. These changes suggest that the functional groups are involved in the binding of Cd on the cell wall. functional groups. The R3 and R19 strains contained more shifts compared to the L2 and L30 strains. Additionally, the R19 strain shifts around 3000 cm^{-1} decreased in intensity as the concentration of Cd increased. Functional groups common to all four strains include $C_2H_2R_2$, aromatic compounds, C_2HR_3, P-NH_2, $(RCO)_2O$, R-OH, P=N, C-C, P-NH_2, R_2C=NR or R_2C=NH, C≡C, RCHO, C-H, and P-NH. Conversely, the functional groups that were not shared by all strains include: 1,4-Disubstituted aromatic compounds, Ar-H, and R2C=O or RCOOH. To conclude, the FTIR technique proves to be an efficient tool for detecting structural changes and probable binding sites induced by the presence of Cd. The changes to functional groups can lead to significant effects, namely altering the mechanisms of a bacteria in how it interacts with Cd.

Electron Microscopy Techniques and Energy Dispersive X-ray Spectrometry as Tools to Characterize Biosorption of Lead by Bacterial Strains from an Urban Watershed

Students: Somie Opara, Grace Pagnucco, Claudia Shuler, and Hawraa Najaf

Faculty Sponsor: Sonia M. Tiquia-Arashiro

Abstract

For many bacteria, biosorption is a mechanism that allows heavy metals like lead (Pb) to be removed from bodies of water. To understand the mechanism of this process, this study was conducted to determine the biosorption capacity of Pb uptake of two bacterial strains, *Klebsiella sp.* (R19) and *Raoultella planticola* (L30), isolated from the St. Clair Lake. Multiple techniques were employed to understand the biosorption process and the structural and biochemical characteristics of the strains, including: FTIR spectroscopy, STEM-EDS assay, MIC assay, and siderophore assay. The FTIR analysis indicated that biosorption of Pb is achieved through binding on the cell wall's functional groups. The STEM-EDS analysis showed that biosorption of Pb can also occur via extracellular polymeric substances (EPS) secreted from microbes as well as intracellularly. Both of the strains were resistant to Pb as both required a relatively high concentration of Pb before showing signs of growth inhibition (MIC = 800 mg/L) and were also observed to produce more siderophores with increasing Pb concentrations. The EPS and cell wall facilitated ion exchange and metal chelation-complexation by virtue of the existence of ionizable functional groups such as carboxyl, sulfate, and phosphate present in the protein and polysaccharides on the cell surface. The siderophores facilitated the accumulation of Pb in the cytoplasm. This highlights the potential application of bacteria for bioremediation of Pb from multiple metals through biosorption and the use of STEM-EDS as a powerful tool to determine the location of Pb in the cell during Pb uptake.

Transformation of *Escherichia coli* HB101 K-12 with a high-copy number plasmid (pGLO) encoding the green fluorescent protein

Students: Sufyan Abdalla and Vaughn Karaim

Faculty Sponsor: Sonia M Tiquia-Arashiro

Abstract

One of the core methods applied in molecular biology is the transformation of bacteria with plasmid DNA. In this study, the pGLO plasmid, which codes for green fluorescent protein (GFP) and ampicillin resistance was utilized to transform *Escherichia coli* HB101 K-12. Two transformation reactions were prepared: one with pGLO plasmid and one without it. Following transformation, *E. coli* was grown on LB, LB+ampicillin, and LB+ampicillin+arabinose agar. As expected, the control (no plasmid) showed no transformants on the LB/ampicillin plate, but grew as lawn of *E. coli* cells on LB. The transformation efficiency of the GFP cells ranged from $2.5x10^1$ to $1.71x10^4$ transformants/µg of plasmid on LB/ampicillin/arabinose plate and $3.8x10^1$ and $1.23x10^4$ transformants/µg of plasmid on LB/ampicillin plate. The non-GFP cells transformation efficiency ranged from $3.78x10^2$ to $2.21x10^4$ transformants/ug on LB/ampicillin plate. The range of data may be so widely spread due to uneven spreading of bacteria, heat shock for too long or too short, or for not having enough bacteria for successful transformations. The majority of the transformation efficiency data were lower than the generally accepted optimal range ($1x10^4$ to $1x10^8$ transformants/ug plasmid), and only three data points ($1.23x10^4$, $1.71x10^4$ and $2.21x10^4$ transformants/ug) out of the entire class data were within the optimal range. None of the data points present in the set were higher than the generally accepted range. Overall, this work demonstrates the pGLO plasmid's usefulness for gene expression and genetic modification in *E. coli* HB101 K-12, offering valuable insights for microbial research, genetic engineering, and biotechnology.

Chemotaxis Behavior in *E. coli* in Response to Different Chemical Stimuli

Students: Reeghan Book, Zainab Nassereddine and Erica Parmenter

Faculty Sponsor: Sonia Tiquia-Arashiro

Abstract

Chemotaxis, which allows bacteria to detect and move in response to chemical gradients, is fundamental for their survival and behavior. In this study, we investigated *E. coli*'s chemotactic behavior in response to various chemoeffectors. Capillaries containing these chemoeffectors were placed in chemotaxis chambers containing *E. coli* and incubated for 1.5 hours at 30°C. After incubation, cell migration into the capillary tubes was compared with the control (chemotaxis buffer) using serial dilution and spread plate techniques. Overall, our group's findings revealed distinct responses in chemotaxis assays. Glycerol and aspartate were identified as repellents with migration percentages of 0.044% and 0.018%, respectively. In contrast, galactose, leucine, and the chemotaxis buffer acted as attractants with migration percentages of 1.698%, 4.341%, and 1.045%, respectively. This deviates from the expected results described in the literature where galactose, glycerol, leucine, and aspartate, are typically regarded as attractants. However, their effects can vary with chemoeffector concentration and cell population density. We suspect the deviation in our results is due to experimental errors. Potential issues include incomplete submersion of the capillary tubes containing the effector or expulsion of *E. coli* cells during extraction. Variable skill levels in serial dilution techniques could also introduce error. Consistent findings across all groups suggest leucine's repellent effect on *E. coli*, which the literature supports. These findings underscore the complexity of bacterial responses to chemical stimuli and emphasize the need to understand the mechanisms underlying these responses. Specifically, further testing is necessary to confirm whether aspartate and galactose attract or repel *E. coli*.

Streptomycin and Tetracycline Resistance Acquisition in *Serratia marcescens* and *Micrococcus luteus* via Spontaneous and Induced Mutations

Students: Nazik Ebrahem and Florent Qyteti

Faculty Sponsor: Sonia M. Tiquia-Arashiro

Abstract

Bacteria can experience induced and spontaneous mutations. Induced mutations occur when bacteria are intentionally exposed to harmful conditions, such as ultraviolet (UV) light. On the other hand, spontaneous mutations occur naturally and are difficult to detect unless a selecting agent is present, like an antibiotic. We aim to investigate the effect of induced mutations on pigment production in *Serratia marcescens,* and to examine spontaneous mutations affecting tetracycline-sensitive (Tet^s) *Micrococcus luteus* and streptomycin-sensitive (Str^s) *S. marcescens*. To assess the impact of induced mutations, we exposed *S. marcescens* plates to 254 nm UV light for durations ranging from 0 to 20 seconds. The gradient plate technique was used to assess spontaneous mutations in *M. luteus* and *S. marcescens* using tetracycline and streptomycin, respectively. Analysis of *S. marcescens* plates reveals significant decrease in pigmentation and colony count with increasing UV light exposure. This suggests that UV light-induced mutations result in pigment loss and prolonged exposure causes cell death. The slants cultures revealed that mutations were permanent in mutants (white colonies) but not in colonies displaying characteristics of both mutated and non-mutated cells (hybrid colonies). Minimum inhibitory concentration (MIC) values for streptomycin and tetracycline were 19.22 µg/mL and 0.39 µg/mL for the *S. marcescens* and *M. luteus* strains, respectively. These results indicate microbial growth despite antibiotic presence, highlighting the development of advantageous spontaneous mutations. In conclusion, our findings shed light on how bacterial mutations respond to both intentional environmental stresses and natural selective pressures like antibiotics, offering insights into mutation mechanisms and microbial adaptation.

Physics

Role of Ellipticity on Spin Dynamics of Ferromagnetic Nanorings

Students: Yassin Elmeligi *

Faculty Sponsor: Bushra Hussain

Abstract

Ferromagnetic nanorings are of great interest within condensed matter physics due to the presence of two stable states within them-the vortex state and a mediating onion state. The low-field vortex and higher-field onion states are additionally denoted by an abrupt change in spin wave (SW) frequencies at the transition field between the two orientations. The accommodation of these states within ferromagnetic nanorings allows for their application within a range of fields such as biomedicine, materials engineering, computer science, and computer engineering. Beyond the existence of the vortex and onion states, the SW spectra and transition fields between the two states can be controlled by factors such as geometry and applied field. Elliptical nanorings have been fabricated and studied for their effect on SWs through methods such as Brillouin light scattering.

Our computations modify a Hamiltonian based formalism developed for circular nanorings to elliptical permalloy nanorings. We study the influence varying the ellipticity of a nanoring has on the spin dynamics of the nanoring. In addition, we analyze the influence of rotating the nanoring with relation to the applied field has on its SWs and transition field between the vortex and the onion states. Our results find a strong dependence on nanoring orientation in relation to the applied field for the SW frequencies in an elliptical geometry. Additionally, we find that SW frequencies exhibit a dependence on the ellipticity of the nanoring.

* Presenting student

Spin Dynamics of Ferromagnetic Nanorings

Students: Aishwarya Seetharaman * and Musada Algaithi

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Abstract

Ferromagnetic finite structures of nano-size scale have been extensively studied due to their wide range of applications, such as bio(sensors), data storage devices, signal-processing and logic systems, microwave devices and spintronics. Of such structures, circular nanorings are of particular interest in part due to their circular symmetry, which is advantageous in high-frequency switching, logic and storage devices. A distinct feature of these nanorings is the existence of two stable magnetization states, the low-field vortex state and the high-field onion state [1]. The abrupt switching of these states occurs at a defined external field. The transition field and spin dynamics of these structures may depend on the size of the rings, the ratio of their inner and outer radius, as well as on the magnetic material used [2].

Here, a computational analysis is presented for the spin waves (or magnetic fluctuations) in single-layered ferromagnetic nanorings using a microscopic, or Hamiltonian-based, approach. In this work we study and compare the static and dynamic properties of circular nanorings for two ferromagnetic materials, cobalt (Co) and nickel (Ni). The calculations for Co and Ni produce unique frequencies and spatially-dependent intensities of the quantized spin waves as well as distinctive transition fields causing an abrupt switching from vortex to the onion state.

[1] C. A. F. Vaz et al., Journal of Physics: Condensed Matter 19, 255207 (2007).
[2] B. Hussain and M. G. Cottam, Journal of Physics D 54, 165002 (2021).

* Presenting student

Approaches to Analyzing Movement of Intracellular Organelles

Students: Emily Leich*

Faculty Sponsor: Dr. Nicholas A. Licata

Abstract

Analyzing the in-vivo motion of intracellular organelles presents a number of significant challenges. Molecular cargo is subject to both thermal motion inside the cell, as well as directed motion caused by the processive walking of molecular motors to which it is tethered. The molecular motors walk along a cross-linked microtubule network, which plays the role of an intracellular organelle highway. We consider methods for analyzing intracellular transport when only the position of a bead acting as cargo within the cell can be seen. In this experimental assay, the microtubules and motors cannot be seen or tracked, so the focus of the method described here is to analyze the motion of the cargo. The position of the bead was tracked within two different cell types, both wild type cells and cells with a modification to the expression level of the NHE9 protein. A maximum likelihood approach based on changepoint theory is able to parse an individual trajectory into statistically similar segments, for which cargo velocities and diffusion coefficients are calculated. The choice of changepoint algorithm parameters is made based on an analysis of simulated data generated from the Langevin equation. The approach is applied to in-vivo experimental data from both wild type and mutant cells. The resulting distributions characterizing the statistics of cargo transport between the two cell types were compared. The results of this research show that the motion of intracellular organelles is empirically different in cells with modified NHE9 expression levels as compared to wild type cells.

* Presenting student

Mechanical regulation of kinesin at varying pH

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Faculty Sponsors: Suvranta K. Tripathy

Abstract

Kinesin-1, a plus-end microtubule-based motor, converts chemical energy into work through its nucleotide hydrolysis cycle. Electrostatic interactions between kinesin head domains and microtubule govern the mechanics of kinesin motors. The interaction energy between kinesin and microtubules can be modulated varying the pH level. Increasing pH of the motility buffer increases the heterogeneity of kinesin motor by increasing its velocity. However, no detailed studies currently exist elucidating the effect of pH on chemomechanical cycle of kinesin. To address this, we examined the mechanism of kinesin function under different pH conditions using a single-molecule motility assay at varying nucleotide concentrations. Our analysis, employing Michaelis-Menten kinetics, reveals that pH variation significantly alters the catalytic turnover rate of kinesin. Notably, kinesin exhibits an optimal travel distance at pH 6.8-7, while its speed increases with rising pH levels. Additionally, through optical trapping experiments, we studied the detachment kinetics of kinesin at different pH levels. We found that increasing pH enhances the detachment of kinesin under load. Overall, our work provides an in-depth analysis of the multi-modal function of the kinesin motor as regulated by environmental pH. This is further supported by Monte Carlo simulations. The outcomes of this research are anticipated to enhance our understanding of the walking mechanism of the kinesin motor and can shed light on the regulation of intracellular transport.

* Presenting students

Stabilized magnetic spin dimer entanglement using a genetic algorithm

Student: Julie Krause

Faculty Sponsor: Jin Wang

Abstract

Genetic algorithm optimized time varying magnetic field functions for stabilizing and maximizing entanglement in a decoherence-free Heisenberg spin dimer are presented. The oscillation in entanglement in a decoherence free magnetic spin dimer is presented. The effect on the coherence and population terms in the density matrix due to the time-varying magnetic field functions is discussed and viewed using two dimensional time varying plots of entanglement and three-dimensional Bloch sphere diagrams. This work shows that it is possible to remove the natural oscillatory nature of decoherence free entanglement and maximize entanglement using time varying transient magnetic field stabilizing functions.