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Chemistry Senior Thesis Presentations

Saturday, April 17
9:00 am- 12:00 pm

9:00	Opening Remarks by Dr. Hutchens, Chair	
	Beaker Room	Bunsen Room
9:10	Justin Blalock	Moriah Reed
9:25	Hannah Suszek	Brendan Lukomski
9:40	Carly Sanofsky	Kaitlyn Vogelaar
9:55	Miranda Kolatski	Ashley Mullings
10:10	Caleb Forbes	Courtney Simpson
10:25	Break	
10:40	Matthew Kurin	Kiara Hamilton
10:55	Mindy Mendkya	Jonathon Kloostra
11:10	Nick Rogers	Lucas Sheppard
11:25	Jocelyn Burtch	Jordan Vallad
11:40		Emily Miller



Justin Blalock
Chemistry, Cannabis Chemistry

Uptake of Per- and Polyfluoroalkyl Substances (PFAS) in Cannabis sativa

Abstract

Per- and polyfluoroalkyl substances (PFAS) are a diverse group of man-made aliphatic hydrocarbons where either some or all hydrogens have been replaced with fluorine. The strong C-F bond (bond energy of 485 kJ/mol) is responsible for their overall chemical inertness and molecular stability, being able to withstand temperatures of up to 900°C. This inertness has led to both their attraction for application, and why they are now considered a persistent organic pollutant (POP). Legacy perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) have been shown to wreak havoc on the ecosystem. This damage touches the plants and groundwater they are most commonly found in, as well as in humans. PFAS are bioaccumulative, storing in the liver and kidneys where they can cause thyroid disease, immunotoxicity, reproductive and developmental retardation, metabolic imbalances, and even cancer. Various herbaceous and woody vegetation are known to uptake PFAS into their roots, leaves, stems, and flowers, where they make their way into humans through ingestion. As cannabis becomes more widely accepted and legalized, it has become important to understand if PFAS is making its way into cannabis products. There are currently no peer-reviewed articles discussing the possible uptake of PFAS in cannabis plants. By collecting past research on PFAS contaminated agricultural products, patterns in uptake and translocation of PFAS were identified. The research herein demonstrates how chain length, functional group, pH, and soil organic matter (SOM) affects PFAS uptake in plants. These same findings were applied to cannabis. Gaps in previous PFAS research methodology are discussed, as well as opportunities moving forward, with an emphasis on more cannabis-focused research.

Jocelyn Burtch
Forensic Chemistry

The Effect of Cleaning Agents on Presumptive Blood Tests and DNA Extraction of Bloodstains

Abstract

After a crime has been committed, various traces of DNA from the offender and/or victim can be left behind at the crime scene. Blood is one of the most common types of physical evidence found at crime scenes involving physical violence such as murders and assaults. Crime scene investigators can use presumptive blood tests at a crime scene to examine suspicious stains or to detect the presence of blood. Most presumptive tests use fluorescence when reacted with hemoglobin in blood, which produces a color change, indicating the presence of blood.

In some instances, perpetrators will try to remove bloodstains with household cleaners in an attempt to remove any link connecting them to the crime. Sodium hypochlorite, a common ingredient in bleach, and sodium percarbonate, often found in laundry detergents, have been shown to affect the accuracy of different presumptive tests. This review studies the detectability of bloodstains using presumptive tests, as well as the effects of DNA analysis after stains are washed with different household cleaners.

Caleb Forbes
Chemistry

Comparison of Fingerprint Sequences on Physical Developer Quality

Abstract

Fingerprint identification is important and must always be improved because of how unique it is to a person. Fingerprints deposit eccrine sweat onto a surface, the constituents of eccrine sweat can be used in chemical enhancement tests so that they are visible. Some of these chemical enhancement tests include 1,2-indanedione with zinc chloride (IND-Zn), 1,8-diazafluoren-9-one (DFO), Ninhydrin, and Physical developer (PD). These chemical enhancement tests are usually used in a specific order with the PD as the last possible test used. This literature study focusses on the evaluation of two fingerprint sequences and which sequence will have a greater enhancing effect on the PD process.

Kiara Hamilton
Biochemistry

The Health Effects of Volatile Organic Compounds from Emission of Air Fresheners

Air fresheners are scented air systems that distribute fragrance containing volatile organic compounds (VOCs), throughout a room by connecting through a home's ventilation system. VOCs are harmful chemicals that are present in air fresheners used to mask the odour of an area. Air fresheners are used to fill the air with an aromatic or masking fragrance. The volatile components in air fresheners continue to pollute the air after the air freshener is removed from the setting it is placed in. Many health issues have been linked to the odor of laundry products coming from dryer vents, such as asthma attacks and migraines. On the labels of air fresheners, less than 10% of volatile ingredients are revealed. Acetone, ethanol, d-limonene, pinene, and acetate, are the most common VOCs listed as hazardous in fragranced air fresheners. There were various differences among unsaturated constituents, in addition to differences in ozone reactivity rates between unsaturated and saturated constituents. A portion of outside air is present in the mixed airstream and the ozone in the air can react with absorbed constituents, creating products that desorb into the air supply over time.

Jonathon Kloostra
Chemistry

Analysis for the presence of Cocaine and Tetrahydrocannabinol on Paper Currency

Abstract

The use of drugs such as tetrahydrocannabinol and cocaine can leave substances in trace amounts on paper currency. These, and other drugs can be detected by extracting the drugs from the currency. In order to extract THC and cocaine from the currency, a swabbing and HPLC methodology was developed using aspirin and acetaminophen. The findings of these methods were then used to swab currency from three different locations in Sault Ste. Marie, Michigan for THC and cocaine. The analytes of interest were not detected when using a different gradient method of HPLC. From analysis using LC-MS/MS, it was found that there were non-detectable levels of THC on all bills. The same analysis did find implied amounts of cocaine on six of the collected bills, all from the Marathon gas station, as well as one bill contaminated with the cocaine standard. These concentrations were found to be 0.343, 0.238, 0.184, 0.117, 0.149, 0.133, and 1.29 ppm for cocaine.

Miranda Kolatski
Forensic Chemistry

Chemical Changes in Soil Throughout the Process of Decomposition Using Cadavers

Abstract

In cases of suspicious deaths, an estimated time of death (TOD) is needed in order to begin forming a theoretical timeline. The TOD can be greatly influenced by a multitude of factors in the environment, such as temperature, microbial activity, and characteristics of the body itself, like size and injuries already on the body. There is, however, often errors in the determination of these times due to these factors. Recently there have been many studies focusing on the chemistry of the body and the environment in which it was discovered, and how these could lead towards a more accurate time of death. By simulating decomposing corpses in several different types of environments, more details about the rates at which these chemicals are excreted from the body can provide more accurate measurements for TOD. This paper aimed to examine three studies that analyzed these changes in soil and observed that there were increases in the pH levels, Further use with this could then allow for the development of more experiments to develop better PMI estimations.

Matthew Kurin
Biology

Detecting Heavy Metals in Nutritional Supplements

Abstract

Nutritional supplements have quickly grown to high levels of popularity over the last decade. Protein supplements specifically are seen as a necessity for athletes' diets across all age ranges. These products are also growing in popularity for patients recovering from surgeries and cancers who need extra nutrients in their diet. The Food and Drug Administration (FDA) does not currently require supplements to undergo testing by a third party for contaminants such as heavy metals, ions, and other foreign materials. To investigate the efficacy of these regulations, this project tested three nutritional supplement brands that are currently being used by a variety of patients requiring these types of supplements. The number of nutritional supplements tested was chosen as a representative sample to determine if further investigations should be done in the future utilizing a larger number of supplement brands. The samples were analyzed using inductively coupled plasma mass spectrometry (ICP-MS). Several of the average concentrations of the heavy metals of interest were found to be above the FDA accepted levels for bottled water. Bottled water limits were used as a comparison due to the similarity in use and the lack of any regulation for nutritional supplements.

Brendan Lukomski
Biochemistry, Mathematics

Nickel Contamination in Vaporizer Cartridges Used for Cannabis Concentrates

Abstract

As of July 1, 2020, Michigan mandated testing for copper and nickel in inhaled cannabis concentrates, setting the action limit to be less than or equal to 500 ppb. Initial testing of these cartridges determined failing levels of nickel in a significant number. Vaporizer cartridges from four major manufacturers/suppliers were tested according to Procedure 2 in the United States Pharmacopeia USP

233 and analyzed using inductively coupled plasma mass spectroscopy (ICP-MS). Analysis found that at least some cartridges from each of the four different manufacturers leached nickel at values greater than the action limit for inhaled concentrates. Additionally, cartridges that exceeded the nickel action limit found a contamination source in both ambient metallics within the cartridge and leached nickel from the cartridge itself. Temperature was also shown to be a factor in nickel leaching, with higher temperatures, on average, yielding greater nickel contamination. However, between all four manufacturers, there was no shared trend correlating time and level of Ni initially present or leached, indicating that contamination is random, yet significant, reaching as high as a 28% fail rate in one manufacturer.

Mindy Mendyka
Cannabis Chemistry

Moisture Content and Water Activity in Cannabis Plants

Abstract

People are looking to find more natural products like essential oils as an alternative for synthetic chemicals. Cannabis is an increasingly popular resource being used to make a variety of products such as oils, cannabis-infused foods or beverages, ropes, topicals and pills along with many more. In order for these products to be commercially marketed, there are certain standards that must be met, one of which is the water content in the cannabis plant. Water content refers to how much water a substance, in this case, a plant, contains typically displayed as a percentage. Water activity is often interchangeably used with water content but this is considered incorrect use of the terms. Water activity refers to how close the substance is to being water which is usually displayed on a scale of 0-1 with 1 representing pure water and 0 representing a substance that is nowhere close to being water.

Emily Miller
Forensic Chemistry

Spectrum of Antimicrobial Activity of 3,4-Dihydroquinazoline Compounds

3,4-Dihydroquinazoline compounds have been synthesized in the Mosey laboratory and some have shown growth inhibitory activity against *Staphylococcus aureus*. Ten compounds, which demonstrated, were shown to best inhibit the growth of *S. aureus* were chosen and tested for their ability to inhibit the growth of a range of Gram-positive and Gram-negative bacteria including *Escherichia coli*, *Enterococcus faecalis*, *Acinetobacter baumannii*, and *Pseudomonas aeruginosa*. The goal of this study is to determine whether these 3,4-dihydroquinazoline compounds exhibit broad spectrum activity or solely inhibit *S. aureus* growth, in hopes that the antibacterial properties of the compounds can be better understood and utilized in future treatments.

Ashley Mullings
Biochemistry

Peptoid Inhibition of Bacterial Growth

Abstract

Peptoids or N-substituted glycines are oligomers derivatives of peptides. Unlike peptides, they can withstand proteolytic degradation and thus can be more widely studied. Peptoid synthesis has become a remarkable invention that allows scientists to inhibit bacterial growth and study more effects that the peptoids have on the cells of these organisms. The objective of this research was to determine what structural combination of peptoids was most suitable to inhibit bacterial growth and it

was hypothesized that cyclic peptoids with fluorinated side chains would maximize inhibition. To establish this hypothesis, cyclic peptoids were compared against linear peptoids and their antibacterial activity measured using its minimum inhibitory concentration (MIC) values. The same procedure was followed to compare fluorinated peptoids to non-fluorinated peptoids. From these values, a correlation could be seen between these properties and an increased antimicrobial activity. To maximize these results for continued usage, it would be most efficient to use greater than six monomers for synthesis.

Moriah Reed
Biochemistry

Combinatorial treatment of HER2 positive breast cancer with trastuzumab

Abstract

Human epidermal growth factor receptor 2 (HER2) positive breast cancer is distinguished by an overexpression of the HER2 protein and makes up approximately 20-25% of breast cancers. Trastuzumab, an antibody that selectively targets HER2, is the leading treatment for HER2 positive breast cancer and can be used in combination with other treatments to increase the effectiveness against cancer progression. The progression free survival (PFS) increased when trastuzumab was used in combination with chemotherapy (61%), in an antibody drug conjugate (50%), and in combination with hormonal therapy (100%). There was an additional increase in PFS when pertuzumab, a monoclonal antibody, was added to treatment with trastuzumab/chemotherapy (49.2%) and trastuzumab/hormonal therapy combinations (19.6%). Using trastuzumab as a combination therapy offers a more targeted approach to treating HER2 positive breast cancer, prevents resistance to hormonal therapy, and overall increases the progression free survival for patients with HER2 positive breast cancer.

Nicolas Rogers
Cannabis Chemistry

Phytoremediation of Contaminated Soils Using Hemp

Abstract

Phytoremediation is growing more popular in the world as it is being used to decontaminate areas that were once thought of as places that could not be saved. The *Cannabis sativa* plant, or hemp, has been used in a wide variety of areas as a phytoremediator. The objective of this experiment was to grow hemp in contaminated soil and to analyze the concentration of heavy metals inside the plant after harvest. Feminized hemp seeds were grown in contaminated soil in a grow tent with automated lighting and watering setup for optimal growth. The plants were harvested and tested for heavy metal content. High levels of regulated heavy metals exceeding Michigan's Marijuana Regulatory Agency's action limit for cannabis products were found in both the roots and shoots sections of the plant. This experiment among others have found that the hemp plant works well as a phytoremediator to decontaminate and rid the soil of any heavy metal pollution.

Carly Sanofsky
Biochemistry

Heavy Metal Detection in Industrial Hemp using ICP-MS Analysis

Abstract

Marijuana for recreational and medicinal use has grown exceedingly popular and states have begun to legalize its use. Consequently, states have increased the various forms of cannabis research. This will allow a better understanding of the long-term exposure effects, especially when

there can be contaminants present. If these contaminants go unnoticed, users may be affected by various toxic, neurotoxic, carcinogenic, mutagenic, teratogenic effects or some may even experience internal organ damage. Most metal poisonings are also linked to various forms of cancers, respiratory diseases, and organ failure. Heavy metals in cannabis products must be monitored and regulated to ensure safety of the population. In this research, hemp samples will be analyzed for trace amounts of arsenic, mercury, lead, cadmium, chromium, and nickel using ICP-MS methods.

In order to perform analysis on the plant tissue, hemp samples were digested in acid and analyzed using ICP-MS. The ICP-MS data was used to gauge levels of heavy metal mass found within the original plant samples. The average of fifteen data samples showed that mercury, lead, arsenic, chromium, nickel and cadmium were present in levels of $>0.0017 \mu\text{g/g}$, $0.016 \mu\text{g/g}$, $0.073 \mu\text{g/g}$, $0.045 \mu\text{g/g}$, $0.072 \mu\text{g/g}$, and $0.0029 \mu\text{g/g}$, respectively. These levels were below the limits set forth by state governments, specifically focusing on Michigan action limits. The hemp samples used during the experiment would be suitable for any method of consumption if being sold for public usage. The data and findings of this research can be applied to the emerging marijuana industry the exposure impact on consumers. This research will provide necessary information to better understand the implications of heavy metal digestion in humans from cannabis products.

Lucas Sheppard
Biochemistry, Chemistry

Efficacy and Structural Properties of Peptoids Utilized for Combating Antimicrobial Drug Resistance

Abstract

Widespread overuse and misuse of antibiotics has exacerbated the rising issue of antibiotic resistance. Numerous types of bacteria have evolved resistance to one or multiple drug types, and this threatens to negate many of the advances made by modern medicine. To help combat this threat, many actions will be necessary, and one of those includes the discovery of new types of drugs which can be used to fight pathogenic microbes. One promising class of molecule is antimicrobial poly-N-substituted glycines, or peptoids. Peptoids have shown efficacy against gram positive and gram negative bacteria as well as drug resistant bacteria such as methicillin-resistant *Staphylococcus aureus*. Antimicrobial peptoids have displayed many mechanisms of actions, and there is a wide variety of peptoid sequences with good efficacy. Compared to peptides, peptoids also show much more favorable pharmacological properties such as protease resistance and slow elimination kinetics. This literature review will seek to examine and display structural properties which lead to the efficacy of antimicrobial peptoids.

Courtney Simpson
Integrated Science

Effectiveness of Inquiry-Based Learning and Virtual Laboratory Experiments in Traditional and Virtual Classroom Settings

Abstract

Inquiry-based activities are a form of teaching that spikes students' curiosity about a subject and prompts them to ask questions. These types of activities will often pose open-ended questions to students. This allows them to ask more questions about the subject before answering their questions through research. In laboratory settings, these activities also work well as students are given more

freedom to create their own questions and experimental design. Inquiry-based learning often has students in full-class discussions, working together to determine answers to questions, and making connections as they go. This learning is guided by the teacher as they prompt new questions, provide answers once students have discussed the question, and ask questions of the students to help them make the connections necessary to build and retain information.

Both traditional and virtual learning environments can include inquiry-based learning and virtual lab experiments. Virtual labs are becoming more widespread in schools that may not have the time or resources to set up full lab experiments in the classroom. These experiments give students an opportunity to experience the lab setting, dive deeper into their understanding of some more difficult topics, and test any scenario they could imagine with the use of inquiry-based learning, with less clean up at the end. Additionally, scores on tests that cover material taught through inquiry-based learning show higher understanding and retention of the material than the scores based solely upon lecture-based learning. Students that learn by doing, asking questions, researching answers, and reflecting on their learning are more likely to understand the material, instead of memorizing and forgetting. Memorization does not work in an inquiry-based learning classroom since the students are constantly building on information they have already discussed, and thinking back to what they know to start asking new questions.

This project will explore the differences between virtual and traditional learning, while determining the best approach for inquiry-based learning and virtual lab experiments in both settings. Exploration of these claims will be done through a review of current literature, observation, and teaching in a blended high school chemistry classroom.

Hannah Suszek
Forensic Chemistry

ICP-MS Analysis of Adhesive from Duct Tape

Abstract

Duct tape is a common piece of evidence found in a crime scene. Forensic laboratories can analyze duct tape recovered from scenes to determine color, compare backings and tears, and even examine latent prints found on the tape. While analyzing backings and tears can help determine a possible link to a specific roll of duct tape, or to a brand, there is not much that is known about duct tape adhesive comparison based on the chemical components. The objective of this study was to determine if trace chemicals in duct tape adhesive could be analyzed via Inductively Coupled Plasma Mass Spectrometry (ICP-MS) to compare various brands and batches. This could potentially allow recovered adhesive from a crime scene to be matched to a specific brand, batch, or even roll of duct tape using a single technique. Adhesive from 100 cm² of tape from three brands was scraped from the backing, microwave digested, and analyzed using ICP-MS. Although this method would need to be tested many times to determine accuracy, this research showed that this method was not the most reliable to compare duct tape adhesives to rolls, batches, but under some fine-tuning may be an acceptable method for identifying brands. The null hypothesis was that the value of trace elements in each brand was the same for the three brands. After running an ANOVA test it was found that this null hypothesis could be rejected for sodium, magnesium, aluminum, calcium, vanadium, chromium, manganese, iron, nickel, copper, zinc, molybdenum, cadmium, thallium, lead, and thorium. This means that the concentrations of these elements are statistically different between the three brands examined.

Jordan Vallad
Integrated Science

How to Successfully Motivate Students in a Science Classroom

Abstract

Educators are always trying to figure out how to best motivate their students. Many educators agree that there are some motivational methods that just work best. Those being visual arts, physical movement, relationship building, and relatable content. What methods for motivating students work best in a science classroom? Educators have turned to giving their students surveys asking them what motivates/engages them in lessons. Some educators have turned to doing hands on and culturally relevant laboratory work in their classes. The research done by these educators can be used in science classrooms across the country.

Kaitlyn Vogelaar
Forensic Chemistry

Comparison of Oral Fluid, Breathalyzer, and Blood Tests

Abstract

Since the 1935, United States police officers have been utilizing breathalyzer tests as a tool to aid in the officer's examination of a driver's inherent ability to maintain road safety during a stop. With the successful discovery of a quick, non-invasive test, another biological matrix has been introduced to aid in easy and non-invasive testing. Oral Fluids (OF) have been recognized as an alternative biological matrix used to detect the presence of drugs and alcohol. But is it as useful as a breathalyzer or blood test, which has been used for years? OF has been described as the combination of saliva that is secreted from the three major and several minor saliva glands with other constituents present in the mouth. A sample can be collected two different ways, by a roadside presumptive test or by a laboratory sanctioned test. All three tests can detect the presence of drugs or alcohol. This can be useful in the legal process for punishment upon the confirmation of an illegally impaired driver. Results of the initial tests can be used to obtain a search warrant for blood sample analysis rather than solely relying on reasonable suspicion, which would prolong the process. Between the concern of sensitivity, contamination, expense, sample size, and time constraints, the comparison of blood, breath, and OF will be provide a new topic discussion in the policing community that should be heavily explored.