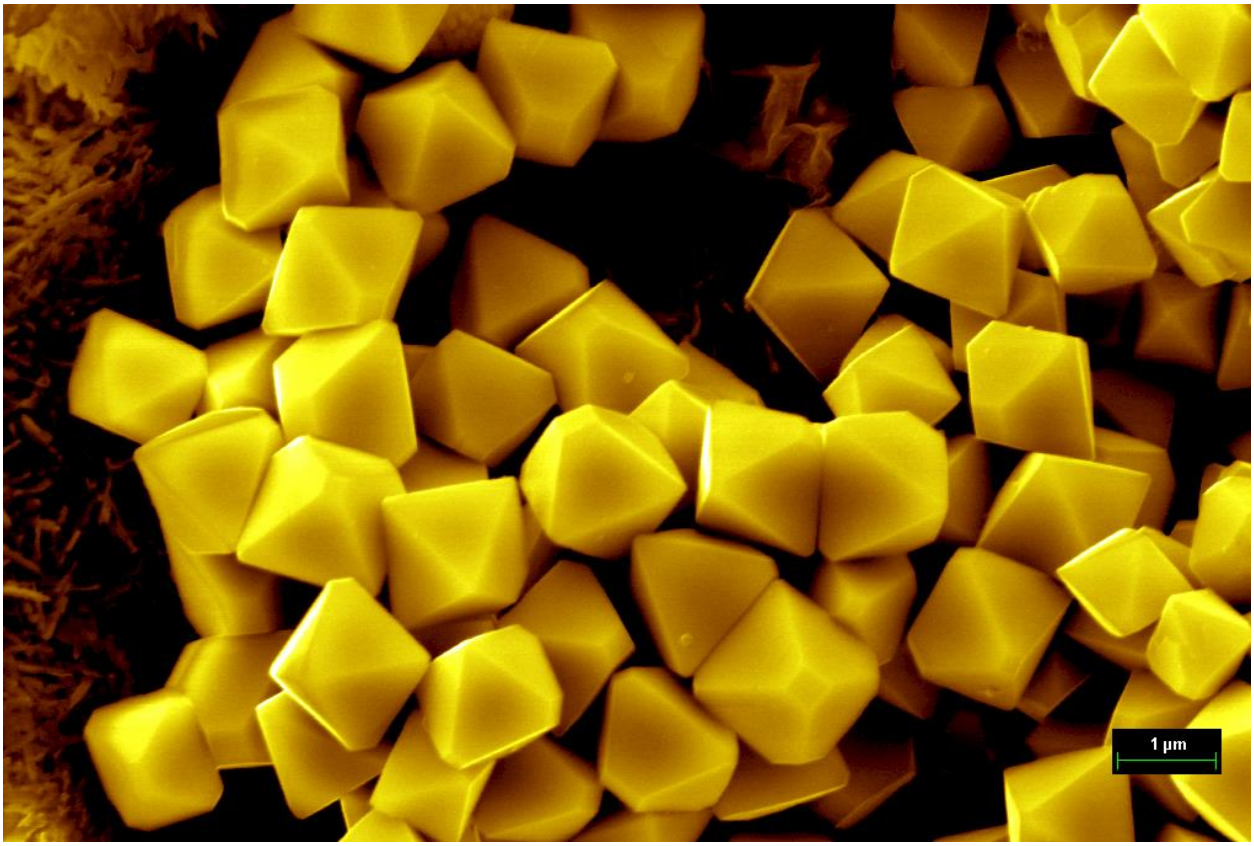


2016 Student Research Symposium

Tuesday, April 5th, 2016

Abstract Book

SOUTH DAKOTA
SCHOOL OF MINES
& TECHNOLOGY

Oral Presentations – Undergraduate Students

Session O-UG1: 8:00-10:15 AM Bump Lounge

(a) Analyzing Stomach Contents and Possible Diets of Mosasaurs in the Western Interior Seaway

James Mishoulam; Geology and Geological Engineering Department

Mentor/Advisor**:** Dr. Christina Belanger; Geology and Geological Engineering Department

Mosasaurs, extinct marine reptiles, are widely regarded as the most prominent predators of the Western Interior Seaway, the large epicontinental sea that covered most of North America during the Cretaceous. Examination of fossil mosasaur stomach contents has allowed reconstruction of general paleo-diet for mosasaurs. Previous studies have cataloged the stomach contents of individual mosasaurs, however analyses have not been done to see if diet varies among mosasaur genera or if different genera occupy different ecological niches. This study has compiled stomach-content data from eleven mosasaurs from seven genera. Four specimens were *Tylosaurus*, which were among the largest mosasaurs in the Western Interior Seaway. Here, I test the hypotheses that Tylosaurs had significantly different diets than other mosasaurs, and that Tylosaurs had more gut content specimens per individual than other mosasaurs. Using Chi-square and Mann-Whitney tests, the gut contents were analyzed, showing that Tylosaurs ingested significantly more marine squamates and sharks than the other mosasaurs did. The other mosasaurs ate fish, turtles and invertebrates, the latter two were not present in the Tylosaurs. The number of organisms per individual, however, is significantly different. The variation of diet could be due to the *Tylosaurus's* size, or possible higher levels of aggression. Future work to expand the data set would allow for more accurate testing of the above hypotheses. Preservation of stomach contents is rare, so the present sample size is small. With a larger sample size, further testing could confirm the above hypotheses, or provide more substantial evidence for their dismissal.

(b) A Simple Model for Chronic Wasting Disease in Moose

Rashyll Leonard; Mathematics and Computer Science Department

Mentor/Advisor: Dr. Martha Garlick; Mathematics and Computer Science Department

Chronic Wasting Disease (CWD) is a fatal prion disease that affects Cervids. Infections in deer and elk have been well documented since the mid 1900's, but it was not until 2005 that it was found in moose. Many models for CWD transmission within elk and deer exist, but the disease is not well modeled in moose. Previous CWD models may not apply to moose, because their social structure varies from that of dear and elk. In this presentation, we will examine the differences between moose and other Cervides in order to create a CWD model specific to moose. To do this, we start with a standard SI disease model for CWD in mule deer. We then explore variations on this model and discuss the feasibility of each model given empirical data on moose populations and CWD infection rates in Colorado.

(c) ***Determining the Base Preference for Intercalation of Tryptanthrins in DNA Using a Novel Assay for Drug: DNA Binding Interactionn***

Walker Hoolehan; Chemistry and Applied Biological Sciences Department

Mentor/Advisor: Dr. Mark Novak; Chemistry and Applied Biological Sciences Department and Dr. Richard Sinden; Chemistry and Applied Biological Sciences Department

DNA intercalation is the insertion of a molecule between contiguous base pairs in a double-stranded DNA helix. Typically, intercalators are planar aromatic hydrocarbons that can slide between adjacent nucleotides and pi-stack with DNA bases. DNA intercalators are an important class of cancer chemotherapeutic agents and antimicrobial agents. Indolo[2,1-b]quinazolin-6,12-dione (tryptanthrin) derivatives are a class of planar aromatic hydrocarbons with antimicrobial activity that can intercalate into DNA (Bandekar et al., 2010).

While tryptanthrin's antimicrobial activity at the cellular level has been studied, its molecular mechanism(s) of action are not known. Terryn III, et al. (2014) used a novel computational method to predict a significant G+C base pair intercalation preference for 4-aza-tryptanthrin. To test the theoretical/computational predictions, we have developed a novel assay based on the circularization of small DNA oligonucleotides for determining G+C vs A+T DNA binding preference. This assay provides an important means to analyze drug:DNA binding specificity and better understand their therapeutic potential.

Synthetic 21-mer DNA oligos with stably curved phased A-tracts at 10-bp periodicity were used to create small circular DNA molecules. Hybridization and subsequent sealing of the nicks by DNA ligase at their complementary overhangs yields a family of covalently closed circles with variable numbers of oligos. Since the intrinsic bending of DNA containing A-tracts is dependent upon 10-bp phasing, a topological alteration may compromise the efficacy of circularization thereby shifting the optimal circle length. To test for G+C or A+T DNA binding specificity, two unique duplex sequences were used: one containing phased A-tracts flanking an A+T rich element, and one containing phased A-tracts flanking a G+C rich element. Using gel electrophoresis, a shift in optimal circle size could be determined by analyzing the lane profiles for circularization in the presence of increasing concentrations of 4-aza-tryptanthrin.

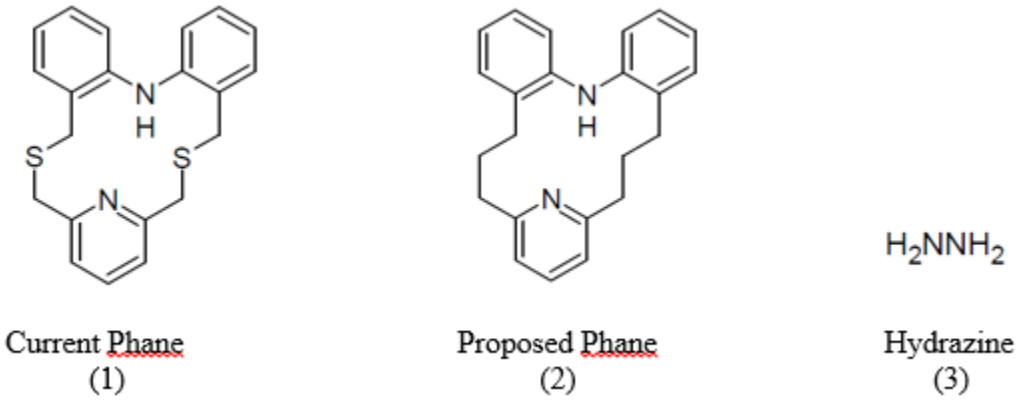
Our results confirmed the prediction of Terryn III, et al. (2014) that 4-aza-tryptanthrin binds preferentially to G+C rich DNA. Interestingly, the assay is also sensitive to groove binders. 3,3'-diaminodipropylamine demonstrated a shift in optimal circle length that was more pronounced in the A+T rich sequence. In addition to validating a novel computational method for analyzing intercalative DNA base pair specificity, we present a simple, cost efficient method for determining G+C vs A+T DNA binding preference. Moreover, we provide further insight into a potential mechanism of action for tryptanthrin's broad spectrum antimicrobial activity.

(d) Detection of Hydrazine via Fluorescence of Cyclophane

Nathaniel Chapman; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Mark Novak; Chemistry and Applied Biological Sciences Department

Hydrazine is a toxic compound which has a threshold limit value (TLV) of 40 ppb as determined by the current federal guidelines. Because of this, when handling hydrazine monitoring its levels is crucial. Modern methods of detecting hydrazine have been insufficient. Current dosimetry badges or electrochemical sensors are either disposable non-reusable, do not perform real-time, and have false positives. In order to address this problem, a new type solid state fluorescence detector has been proposed. This detector is based on a macrocyclic cyclophane containing carbazole and pyridine. These compounds do not fluoresce when subjected to UV due to pyridine quenching the fluorescence of carbazole. However, when the hydrogen bonding between the carbazole and pyridine is interrupted by a compound such as hydrazine, the compound fluoresces. This new detector has potential to be reusable by being incorporated in a polymer and would allow real-time monitoring of hydrazine.



Current Phane (1) | Proposed Phane (2) | Hydrazine (3)

Figure 1: Proposed Structures of Detectors and Hydrazine

Due to limitations of (1), we are proposing the synthesis of (2). This talk will focus on initial synthetic efforts.

(e) Spectral mapping of Muscovites in Low-Grade Metamorphic Rocks in the Black Hills, SD

Michael Day; Geology and Geological Engineering Department
Co-Presenter: Taran Bradley

Mentor/Advisor: Dr. Edward Duke; Geology and Geological Engineering Department

Previous studies have shown a correlation between the wavelength of the Al-OH absorption band in white micas and increasing degrees of metamorphism as measured by the appearance of metamorphic index minerals, metamorphic isograds and metamorphic zones.

The white micas, namely muscovite and phengite, have an absorption feature in the near-infrared. This feature is caused by vibrations in the bond between the octahedral cation and the hydroxyl. If the band is near 2200, the muscovite is aluminum rich; if it shifts to higher wavelengths, then the muscovite is more iron or magnesium rich.

This replacement of iron and magnesium with aluminum illustrates the Tschermak substitution which muscovite undergoes as the temperature of metamorphism increases. As the Black Hills metamorphism is driven almost entirely on temperature, with pressure remaining relatively constant, it makes for an excellent study area to test the relationship between temperature of metamorphism and the wavelength of the Al-OH absorption band.

Previous work done in similar areas has shown that this method is a possible way to quantify and better understand metamorphism. This study continues the previous work done by A. Leahy and E. Duke in the Black hills, adding to and analyzing the new and existing data in order to test this relationship.

A portable visible and near infrared handheld spectrometer was used in order to collect spectral data and GPS coordinates in the field. In addition to the field spectral data, certain rock samples were collected for later lab use. Using ENVI, the spectral data were viewed and analyzed in order to determine the Al-OH absorption feature wavelength. The data was then compiled into a spreadsheet and imported into a geodatabase in ArcMap, containing 716 data points. After testing various interpolation techniques, an Inverse Distance Weighted function was used in order to contour the variations of Al-OH wavelengths.

As a result, the variance in metamorphism suggested by the Al-OH wavelengths follows the general trend of the previous metamorphic isograd map of the Black Hills compiled by Redden and DeWitt in 2009. However, there are trends in the spectral data that suggest a possible northern extension of the staurolite isograd and a possible chlorite zone in the currently mapped biotite zone. These trends were not previously known and are currently being investigated.

The possible chlorite zone is being researched by T. Bradley. With this research, more data points are being collected and analyzed, with an emphasis on evaluating potential outliers due to hydrothermal alteration. In addition, thin sections are being studied by M. Day in order to find key index minerals and to test the composition of the muscovites present in the rock samples. Upon completion of both projects, the understanding of the metamorphism of the Black Hills will be improved, and the potential application of muscovite spectroscopy will be advanced.

(f) Green Roofs For a Sustainable Future

Jason Phillips; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. Jennifer Benning; Civil and Environmental Engineering Department

The City of Rapid City, South Dakota, recently implemented a storm water utility fee to help mitigate storm water runoff quantity and quality impacts to Rapid Creek. To maintain this valuable water resource for recreational use and wildlife habitat is essential for the community's quality of life. Along with this water resource protection, the community has recognized a need for the implementation of best management practices (BMP) and sustainable infrastructure in the city. This has given rise to research on green roofs, also known as living or eco roofs, at South Dakota School of Mines and Technology (SDSM&T). The overarching purpose of this on-going research is to provide a proof of concept for green roofs in this climatic region, which is characterized by hot summers, cold winters, high winds, record hail, and relatively low rainfalls. Other specific research objectives are to quantify: 1) the reduction in storm water runoff for green roofs compared to traditional roofs; 2) the pollutant loading reduction associated with storm water runoff from green roofs compared to traditional roofs; and 3) the thermal conductivity (or R-value) of green roofs compared to traditional roofs. To address these research objectives, three 4 foot by 8 foot sheds were built. One shed has a traditional asphalt shingled roof; one has an extensive green roof following the FLL German guide lines; and the other has an extensive green roof using GREEN GRID trays. The reason for having 2 types of green roofs is to monitor and compare their performances. This will provide a better proof of concept for design and future long-term performance research. While this research is on-going, to date, the water runoff from the roofs during two storm events were captured and analyzed in September and October of 2015. Hydrographs from both events showed that the green roofs reduced runoff volumes by 85% compared to the traditional roof. Water quality results met beneficial use criteria for cold water fisheries and domestic uses, but not for emersion or limited contact recreation due to high bacteria levels. However, the green roofs had a significant nutrient load reduction based on pollutant mass in the runoff with a relative percent reduction of 95%. Three storm events will be captured, in the spring of 2016, for additional water quality testing. Storm water reduction will continuously be monitored. This will allow for performance evaluation as the plants mature. Thermal conductivity testing is also in progress and will continue throughout the summer of 2016.

(g) Mechatronic Design of a Mixed Conventional/ Braking Actuation Mobile Robot

Jeremy W Simmons II; Mechanical Engineering Department

Mentor/Advisor:

The presentation will cover the design of a novel mixed conventional/ braking actuation mobile robot (MAMR), which replaces conventional actuators used for steering with controllable brakes. The mechatronic design of a novel electromechanical brake, its implementation in the MAMR, as well as the mechatronic design of the MAMR are presented.

The electromechanical brake presented is an omnidirectional caster that is electronically lockable, that when locked, generates a reactive friction force onto a dynamic system. The implementation of this electronic locking caster is such that the rolling element is completely locked and sliding occurs only between the rolling element and the rolling surface. This implementation effectively achieves two discrete states of the brake (i.e. on and off). The method used for approximating the necessary force generated by the locking mechanism to lock the rolling element in place will be covered. Applications for this concept of actuators have been proposed in other works, such as its use in distributed manipulation to control objects operating under action of uniform force fields [1] and on unconventional mobile robots like the MAMR. Practical applications might be found in package handling and object sorting.

The MAMR presented implements a novel platform for mobile robots and is composed of one non-steering omni-wheel, a wheel that is free to translate orthogonally to the drive direction, driven by an electric motor; two electromechanical brakes, whose design is presented; and the associated control hardware. This platform for mobile robots is an under-actuated system, having three degrees of freedom with only one true actuator, the driven omni-wheel. This work contributes to efforts being made on the control of such an under-actuated system.

[1] M. Bedillion, R. Hoover, and J. McGough, A distributed manipulation concept using selective braking, in American Control Conference(ACC), 2014. IEEE, 2014, pp. 3322-3328

(h) Swarm Bots

Doug Kadrmas; Electrical and Computer Engineering Department

Mentor/Advisor: Mr. Scott Rausch; Electrical and Computer Engineering Department and
Dr. Charles Tolle; Electrical and Computer Engineering Department

The purpose of this research is to coordinate movement between multiple aircrafts using an algorithm based off of RSS (Received Signal Strength) and already accessible onboard sensors. An algorithm to this problem is needed for real life situations such as busy airports and regions where ground control stations are not available such as overseas. The onboard sensors consist of Radio Frequency (RF) communication and IMU information such as heading and velocity. From this data a coordinate frame can be determined and populated with other drones. Once relative positions are determined, collision avoidance techniques can be used to coordinate movement.

One of the major hurdles is to construct a coordinate frame using these pieces of information. That is where the majority of the work lies. To build a general sense topology of the aircrafts, only the distance is needed, from RSS. From here the center of the group and basic angles of formation can be determined. To build a reference frame with respect to North, East, and Down (NED) more information is going to be needed. This is where the inertial measurement unit (IMU) comes in. With this, speed and heading can be utilized with cooperative aircraft to determine their location.

This problem is currently being solved on a 2D basis. Once this method is finalized, a 3D method will be looked into next. When moving to 3D more data and/or techniques will be needed such as antenna directivity. For the 2D solution, the directivity of the antennas being used is isometric, so differentiation in the azimuth direction is irrelevant. Although when you move to 3D, the directivity will need to be accounted for as antennas will not be isometric in both azimuth and elevation.

Overall, a solution for 2D is possible. 3D will be a future next step of this research and will take more time and detailed modeling to complete.

(i) A Novel Multi-touch Authentication Scheme for Mobile Devices

Dicheng Wu; Mathematics and Computer Science Department

Mentor/Advisor: Dr. Mengyu Qiao; Department of Mathematics and Computer Science Department

The enhanced performance and reduced cost have made mobile devices deeply penetrate into daily life and reform people's habits in modern society. While people enjoy the convenient services and diversified contents provided through mobile devices, the prosperity of mobile device also leads to serious security concerns in mobile devices. User authentication plays an indispensable role in protecting computer systems and applications from unauthorized access. Many user authentication methods have been proposed and implemented to protect desktop computer system, but do not provide optimal security and convenience for the new generation of touchscreen-equipped devices. Therefore, there is especially high demand for a new user authentication method, which achieve high accuracy, usability, compatibility, and low cost for mobile devices. In this paper, we present a novel touchscreen-based authentication scheme that utilizing both static and dynamic features generated by different hand's gestures. We collect raw data including position, size, pressure, time of each individual touch-point generated by fingertip movements which correspond to distinct characters of gestures of different users. Then, we convert raw data to static and dynamic features to achieve accurate pattern recognition. Several volunteers are invited to help experiment the proposed scheme and collect sample data by performing different gestures for multiple times on different touch-screen devices. Afterwards, we run statistical analysis to identify discriminative features to reduce the complexity and enhance accuracy for classification. In the end, we apply and compare various machine learning approaches with selected features to build stable and robust classification models. As a proof-of-concept, a mobile app is developed to implement the proposed scheme for android tablet due to its API and hardware supports. When a user uses this app at first time, the app will ask the user to sign up an account. Then, it leads the user to a sign-up screen and asks the user to enter a unique username and an email address. In the next step, the user is directed to another screen where he/she can select a preferred picture as the gesture background. Then, the app asks user to perform a gesture for three times to obtain initial gesture pattern data. In meantime, it also tests the similarities among the gestures. If an unstable pattern is detected, it will ask user to redo the gesture until the similarity meets pre-defined requirements. After successful registration, the user can sign in with the username and secret gesture. Each gesture will be evaluated by the classification model associated with the user account. Empirical research and experiments show that the proposed scheme overcome the drawbacks of the existing methods, and achieve high accuracy and usability for user authentication. Therefore, we believe it has great potentials to provide secure protection for systems, applications, and data in touch-screen equipped mobile devices.

[1] Qiao Mengyu, Suiyuan Zhang, Andrew H. Sung, and Qingzhong Liu. "A Novel Touchscreen-Based Authentication Scheme Using Static and Dynamic Hand Biometrics." 2015 IEEE 39th Annual Computer Software and Applications Conference (2015).

Oral Presentations – Graduate Students

Session O-G1: 8:00-10:20 AM McKeel Room

(a) Sensitivity of Black Hills Hydrology to Land-use Change Using WRF-Hydro.

Lucas Barrett; Atmospheric and Environmental Sciences Program

Mentor/Advisor**:** Dr. William Capehart; Civil and Environmental Engineering and Dr. Scott Kenner; Civil and Environmental Engineering

As time passes, environments begin to change due to a multitude of factors from climate change to species migration to anthropogenic forcings. The Black Hills region is one that could be on the verge of such change, due to the mountain pine beetle and human activity, and it's important to know the effects this may cause to those around the region, particularly related to hydrology.

The Weather Research and Forecasting model (WRF) has been a leading tool in research and prediction for the atmospheric sciences. Recently, the National Center for Atmospheric Research (NCAR) has released a new version of WRF that integrates terrestrial and stream hydrology into its predictive framework called WRF-Hydro. It was developed to be coupled to a dynamic atmospheric model or run uncoupled (driven with existing precipitation and evaporative forcings). It provides the ability to examine hydrologic impacts from events in a distributed (rasterized) framework at the same or higher resolution as the overlying atmospheric model or forcing dataset. WRF-Hydro also has the ability to analyze and model a variety of processes such as land-atmosphere energy budgets, evapotranspiration, soil moisture, subsurface flow, and surface runoff.

The objective of this study is to use the WRF-Hydro system to perform offline simulations, using National Weather Service (NWS) precipitation analyses and National Land Data Assimilation System (NLDAS) forcings, to test the hydrologic changes with land-use change in the Black Hills region. This will be enacted by analyzing scenarios that use the existing land cover and alternative regimes that incorporate potential long-term pine beetle damage, fire damage, and land-use change on hydrologic processes.

An analysis between the WRF-Hydro output from the 2013-2014 water year (not including a one year spin-up, to get the system into equilibrium) to actual observations will be used to assess whether WRF-Hydro can be used to evaluate the sensitivity of hydrologic parameters caused by land cover change within the Black Hills and Western South Dakota area (e.g., the Cheyenne River Basin). From there, an analysis will be done on the alterations of the land cover to simulate different scenarios in the Black Hills.

(b) In-situ Accumulation of Flowback Water Contaminants on the Corroded Pipeline Surfaces

Krishna Govinda Rajan Chilkoor Gopala; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. Venkataramana Gadhamshetty; Civil and Environmental Engineering Department

The hydraulically fractured oil fields generate significant amount of saline, flowback water on a daily basis. This flowback water is temporarily stored in the open impoundments before disposing it to class II wells. The flowback water storage in the impoundments has been reported to be associated with measurable environmental concerns. Therefore, the oil industries are evaluating the possibility of storing flowback water in steel tanks or piping it to gathering disposal network. Currently there is limited information about corrosion effects of flowback water on relevant pipeline materials such as carbon steel. We have used a series of electrochemical (Linear Polarization, EIS and Cyclic Polarization), microscopy (SEM/EDX, TEM), spectroscopy (ICP-MS and GC-MS) techniques to investigate the corrosion effects of flowback water on the mild steel. We present some interesting results. First, the flowback water is found to enhance corrosion rates (60 mills per year) in acidic condition (pH 4.5) by an order of magnitude compared to that in neutral pH condition. The flowback water induces pitting corrosion of the carbon steel under alkaline condition. Second, the high salinity and low pH conditions in the flowback water has promoted the formation of corrosion deposit (Akaganeite) on carbon steel surfaces; such corrosion deposits represent an ideal sink for metals and inorganic ions present in the flow back water (e.g., Sr, Zr, Ca, and Cl). In the event of a pipeline failure, the accumulated metal ions in pipe can discharge heavy doses of contaminants to soil and water resources. However, in our future study, we would like to take advantage of adsorbent and complex forming properties of Akaganeite in decontaminating flow back water of ions. To counter corrosive nature of flowback water in acidic condition, we would like to develop graphene based corrosion inhibiting nano-coatings.

(c) Change in Surface Water Balance Over the Past 36 Years

Cody Troop; Atmospheric and Environmental Sciences Program

Mentor/Advisor: Dr. William Capehart; Civil and Environmental Engineering Department

Global climate change is having an impact on many different industries and agriculture is one that is very directly affected. As climate changes, farming practices will as well. It is important to know not only what effects climate has on agriculture, but also the feedback that these changes can have on climate. The NLDAS reanalysis dataset, with a grid spacing of 1/8° over central North America and a one-hour time step, has a period of record going back through 1979. We will use this data to find changes in the water balance in the Corn Belt. Changes in both the timing and magnitude of seasonal potential evapotranspiration (PET) in response to changes in farming practices, and other climate forcings are expected. Results show a widespread increase in PET during the summer and fall months.

(d) Rock Snot and Nutrients: How are Didymosphenia geminata mats influencing nutrient cycling in streams?

Jaime Haueter; Atmospheric and Environmental Sciences Program

Mentor/Advisor: Dr. Lisa Kunza; Chemistry and Applied Biological Sciences Department

Didymosphenia geminata (aka Didymo or "rock snot") is a freshwater diatom which can produce copious amounts of algal mat material in low-nutrient streams. The mats consist of bifurcating extracellular stalk material, which the cell uses to attach to benthic substrate. Mats can cover entire stream beds, up to several cm thick. Although several studies have examined the environmental conditions necessary for mat development and persistence, few have investigated the effects on stream functions like nutrient cycling. We investigated the effects Didymo mats have on the nutrient cycling aspects of uptake and N_2-fixation in three lake outlet streams in Grand Teton National Park. Lake Creek had thick mats covering up to 95% of benthic substrate, Taggert Creek had patchy mats, and Bradley Creek had no mat presence. We measured N_2-fixation using *in situ* chambers, and phosphorus (P) and ammonium (NH_4^+) uptake via chambers and whole-stream pulses. N_2-fixation rates increased with increasing mat material, and mats removed significantly more P and NH_4^+-N than non-mat biofilms. With increased prevalence of Didymo nuisance mats worldwide, quantifying the effects mats have on stream functions will be essential to understanding the ecological impacts on these systems.

(e) Establishing Gene Fingerprints of Pathogenic Bacteria along Selected Reaches of Rapid Creek

Kelsey Murray; Biomedical Engineering Program

Mentor/Advisor: Dr. Linda DeVeaux; Chemistry and Applied Biological Sciences Department and Dr. Lisa Kunza; Chemistry and Applied Biological Sciences Department

Bacterial levels, particularly fecal coliforms such as *E. coli*, are standard water quality indicators of fecal contamination. According to the 2014 South Dakota Integrated Report for Surface Water Quality Assessment, sections of Rapid Creek are affected by unacceptably high levels of indicator bacteria. Routine coliform testing provides a snapshot of microbial abundance and content; however, such sampling does not take into account the pathogenic profile of the bacteria. Genes conferring harmful and invasive traits can be acquired by normally innocuous bacteria through "horizontal gene transfer," which has been observed in environments with high bacterial levels, especially where sewage or other waste is concentrated. Since the ability of a microbe to cause disease in humans is directly related to its genetic make-up, the more virulence genes a bacterium acquires, the higher the chance it will cause disease. For example, shiga-toxigenic *E. coli* variants (STEC) possess a gene that allows for production of a toxin that increases pathogenicity. Both municipal drinking water and water used recreationally have been shown to harbor STEC, which have the potential to transfer these genes to otherwise harmless bacteria, creating new pathogens.

We have developed and applied a new PCR-based pathogenicity metric to assay the disease-causing potential of organisms in impaired surface water. From total DNA isolates obtained from six sites Rapid Creek at two time points, genes encoding Shiga toxins and analogous verotoxins (*stx1/VT1*, *stx2*/*VT2*), in addition to an intimin-encoding gene (*eaeA*), an enteroinvasin-encoding gene (*einV*), and a serine protease-encoding gene (*espP*) were detected in water samples during the course of this study. The *stx1/VT1* and *einV* genes were detected in 100% of water samples, the *stx2/VT2* genes was detected in 72% of samples, the *eaeA* gene was detected in 64% of samples, and the *espP* gene was detected in 53% of samples. Fecal samples collected from domestic and wild sources near the creek were also tested for these genes. The *stx1*, *stx2*, *eaeA*, and *espP* genes were determined to be present in some of the samples, however the *einV* gene was absent from all feces tested, thus the source of *einV* contamination into water samples is unknown at this time.

Clearly, the presence of these genes within Rapid Creek indicates significant horizontal gene transfer among the resident bacteria, and their presence may indicate a potential risk to human health. While this study did not distinguish between one single bacterium carrying all the positive virulence gene versus each gene being carried by different organisms, the elevated levels of total *E. coli* in Rapid Creek indicates a significant potential to create new combinations of these genes through horizontal gene transfer, and thus, new human pathogens. In Rapid Creek, *einV* presence alone may be indicative of mild to moderate health risk, while the *stx1*, *stx2*, and

eaeA genes occur concurrently in many strains of pathogenic *E. coli*, and are all found in *E. coli* O157:H7, and thus their presence in Rapid Creek indicates a significant risk to human health.

(f) Geochemical Impact of Mountain Pine Beetles on Rapid Creek SD

Jesse Punsal; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. James Stone; Civil and Environmental Engineering Department

Mountain pine beetle (MPB) (*Dendroctonus ponderosae*) infestations in pine dominated watershed (*Pinus spp.*) forests may affect drinking water supplies through increased loading of organic carbon, due to increased tree mortality and decomposition. Both total organic carbon (TOC) and dissolved organic carbon (DOC) are precursors to the formation of toxic disinfection by-products (DBP) in municipal water supplies. Soil and water quality sample site selection was based on USFS management and remotely sensed historic land use data derived from Center for Earth Resources Observation and Science (EROS) Landsat algorithms. Preliminary results from the upper reaches of Rapid Creek and Castle Creek indicate that MPB infestation impacts stream DOC and water quality. Historic land use, forest management, and current stream flow affect the degree of impact of MPB. The Black Hills MPB outbreak may necessitate long-term changes to watershed management as both the quantity and quality of local and regional surface water and groundwater resources may be impacted due to the MPB outbreak.

(g) Integrated Crop and Livestock Production System- LCA analysis in Northern Great Plains of the USA

Prashansa Shrestha; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. James Stone; Civil and Environmental Engineering Department

Integrated crop and livestock farming endorses ecofriendly co-production of crop and livestock products focusing on maximum yield and minimum chemical use and soil disturbance. This study appraises alternative nutrient cycling and improved soil resilience by altering the microbial community structure and other soil properties with improved crop production. The impact of this innovative production method is quantified by using Life Cycle Assessment (LCA) methodologies. For the Northern Great Plains Region, corn, wheat, sunflower and dry peas will be the focus crops, with soybean, radish, and turnip as the cover crops. The rotations will involve sheep and cattle for grazing crop residue and cover crop for 6 months. LCA impacts to be investigated for these systems will be soil nitrification, greenhouse gas emission, eco-toxicity, water quality, energy efficiency and land use. Year-round management of cropping and grazing on residues and soil health are assessed. Model review inputs will include crop variety, crop rotation, cover crop, energy use, type and intensity of grazing, fertilization and pesticides application for the field sites. Field sites will include: i) University of Nebraska Agricultural Research & Development Center, Mead Nebraska; ii) USDA-ARS Northern Great Plains Research Laboratory's south station Mandan, ND; iii) Dickinson Research Extension Center site western North Dakota; and iv) South Dakota State University's Southeast Research Farm, Beresford.

Long-term LCA analysis of this project will provide critical information to producers enabling them to change their established agricultural practice by integrating crop-livestock system.

Session O-G2: 10:40-12:40 PM Bump Lounge

(a) Radon Mitigation for the SuperCDMS-SNOLAB Dark Matter Experiment

Joseph Street; Physics Department

Mentor/Advisor: Dr. Richard Schnee; Physics Department

Experiments that seek to detect very rare processes, such as interactions of the dark matter particles thought to make up 85% of the mass of the universe, may suffer background interactions from radon daughters that have plated out onto detector surfaces. To reduce these backgrounds, an ultralow-radon cleanroom was built at the South Dakota School of Mines & Technology. Cleanroom air is supplied by a vacuum-swing-adsorption radon mitigation system that has achieved a > 300× reduction from an input activity of 58.6 ± 0.7 Bq/m^3 to a cleanroom activity of 0.13 ± 0.06 Bq/m^3. A copy of this should provide sufficient radon reduction to meet requirements of the SuperCDMS SNOLAB dark matter experiment.

(b) The BetaCage: an Ultra-Sensitive Detector of Material Surfaces

Michael Bowles; Physics Department

Mentor/Advisor: Dr. Richard Schnee; Physics Department

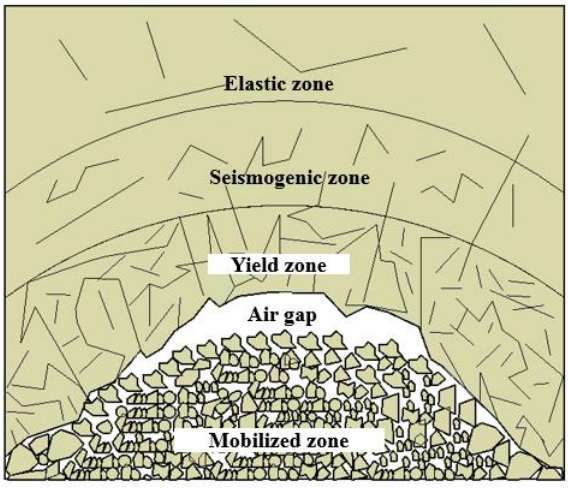
The BetaCage is a proposed ultra-sensitive (and nondestructive) detector for alpha- and beta-emitting isotopes on material surfaces, crucial for Dark Matter experiments and other rare-event searches. The BetaCage will boast alpha particle and low-energy electron sensitivity much better than is currently available from any instrument—commercial or otherwise. Isotope dating can be done with beta-emitters like Pb-210, and with the very long-lived isotopes Be-10 and Cl-36. I will describe the detector's design, expected sensitivity, and the progress of commissioning a prototype detector.

(c) Modeling of Radon Transport in Block cave Mines: A continuum and discrete approach

Kayode Ajayi; Mechanical Engineering Department

Mentor/Advisor: Dr. Khosro Shahbazi; Mechanical Engineering Department

Cave mining, an underground mining method, usually involves breaking and fracturing of orebody. In case of mines with uranium content, these could act as pathway for radon transport into the mine working environment which is dangerous for mine workers. At the propagating stage of the cave, the cave is classified into different notable zones as shown in the figure below with different properties such as porosity and permeability. Hence, prediction of radon migration in cave mines becomes complicated due to the dynamics associated with these zones. This research focused on the application of both discrete and continuum model for radon migration. The discrete approach focused on developing of a discrete fracture network (DFN) in MATLAB to predict radon flux and diffusivity in the fractured zones while the continuum approach focused on modelling of a propagating cave with a commercial computational fluid dynamic software (CFD), SC-Tetra. Results from the continuum modelling shows radon concentration at different zones of the mine and the effect of airflow on radon migration. Results from the developed discrete fracture network shows the contribution of the fractured zones to radon migration and the determination of certain macroscopic coefficient such as diffusivity and estimation of porosity which could be useful for future continuum models.



Regions of a propagating cave

(d) Deep Underground Study of 22Ne(a,n)25Mg

Tyler Borgwardt

Mentor/Advisor: Dr. Frank Strieder; Physics Department

This talk is devoted to describing the first experiment at the Sanford Underground Research Facility (SURF) by the CASPAR collaboration. The reaction of neon-22 with an alpha particle is an important reaction for the nucleosynthesis of elements beyond iron as it is a key source of neutrons. Current measurements are limited by low yields and high background. The future measurements at SURF will be underground to overcome this limit. The motivation for this reaction's importance will be described. The current state of the reaction will be discussed, while describing current issues that the present research hopes to resolve. In addition to this, the CASPAR collaboration will be described in detail. The equipment to be used will be discussed, as well as anticipated schedule and future work.

(e) Simulation of Radioactive Backgrounds and Calibration Sources for the Deep Underground Neutrino Experiment

Jason Stock; Physics Department

Mentor/Advisor: Dr. Juergen Reichenbacher; Physics Department

The far detector of the Long-Baseline Neutrino Facility (LBNF) will be sited underground at Sanford Underground Research Facility (SURF) in Lead/SD.Neutrinos were first postulated by Wolfgang Pauli in 1930, and were discovered in 1956. They are subatomic particles with no electric charge and extremely small masses that are the subject of intense study in particle physics. They occur in three known "flavors": electron-, muon- and tau-neutrinos . A neutrino that is produced in one flavor can be detected as any flavor. Understanding the parameters and mechanism governing these neutrino-oscillations is the primary goal of long-baseline neutrino physics. In order to ensure experimental success, radiological backgrounds have to be modeled in computer simulations in order to determine the radiological cleanliness requirements. In addition, man-made radioactive sources will contribute to the calibration of the low-energy regime, relevant for possible detection of extraterrestrial supernova neutrinos.The performed simulations will help characterize the optimal design of radioactive calibration sources, including deployment routes inside the LBNF detector, as well as the radiological cleanliness

requirements. In summer of 2016, data will be available from the 35 ton prototype at Fermilab/Chicago, allowing to test the performed computer simulations.

(f) Magnetic Polarons in Quantum Dots

Daniel Rederth; Physics Department

Mentor/Advisor: Dr. Rafal Oszwaldowski; Physics Department

Quantum dots based on dilute magnetic semiconductors are introduced. These magnetic quantum dots (QDs) indicate paths towards novel devices that could employ carrier spin [1]. I use a robust numerical method, based on the Luttinger-Kohn Hamiltonian and suitable for realistic self-assembled QD geometries [2], to study electronic structure and magnetism of p-type II-VI quantum dots doped with Mn magnetic ions. The theoretical and numerical approach for determining electronic and magnetic properties of magnetic quantum dots are discussed. The excellent agreement of preliminary results with published numerical results by other groups is shown. I demonstrate formation of the hole magnetic polarons, which manifests itself in self-induced splitting of the hole levels in absence of an external magnetic field [3]. In particular, the self-consistent approach to magnetic polaron formation in quantum dots is shown. The method will allow the study of this effect for a range of temperatures and confinement geometries.

[1] Semiconductor spintronics and quantum computation, D.D. Awschalom, D. Loss, and N. Samarth eds., (Springer, Berlin, 2002).

[2] H. Kirmse, R. Schneider, M. Rabe, et al., Appl. Phys. Lett. **72**, 1329 (1998).

[3] Seufert, J., Bacher, G., Scheibner, et al., Phys. Rev. Letters **88**, 27402 (2002).

Session O-G3: 10:40-12:40 PM McKeel Room

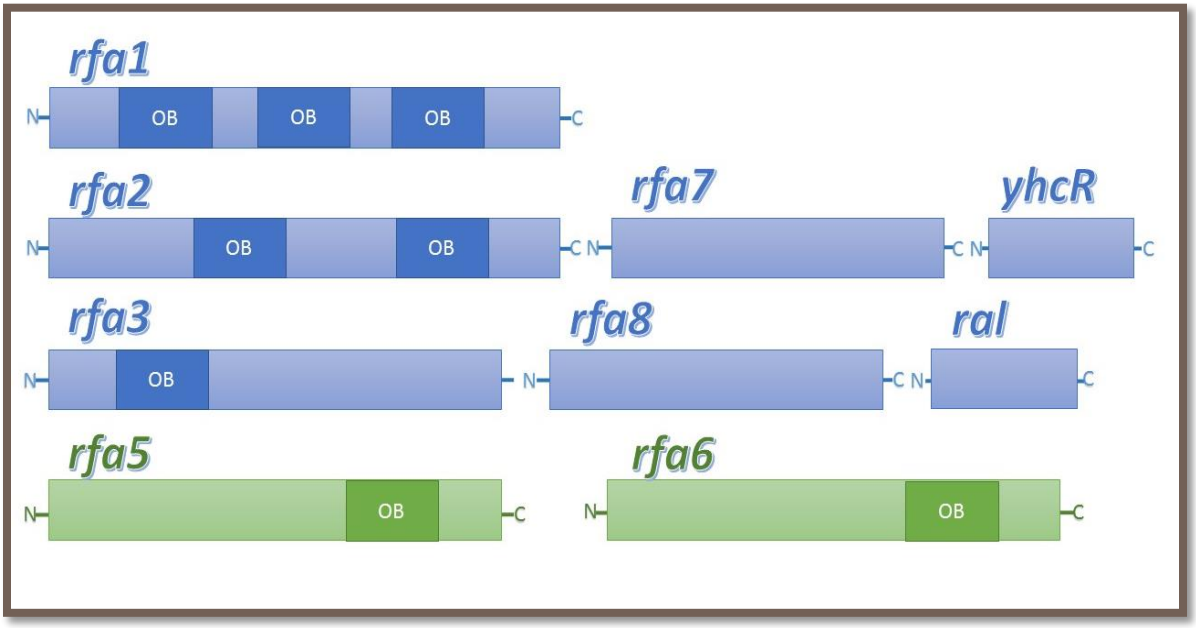
(a) The Role of Replication A Homologues in the DNA Damage Response of Halobacterium salinarum

Jessica Evans; Biomedical Engineering Program

Mentor/Advisor: Dr. Linda DeVeaux; Chemistry and Applied Biological Sciences Department

In order to maintain DNA sequence integrity, every living organism has developed methods to repair and accurately replicate their genomic information, preventing complications including mutation and cell death. Exogenous environmental stresses such as radiation, chemical damage, and desiccation cause an array of DNA damage that needs to be repaired. The archaeon *Halobacterium salinarum* has an LD_{50} of 12 kGy for ionizing radiation, while other bacteria such as *Escherichia coli* only have an LD_{50} of 500 Gy, and human cells more than a hundred times less than that. Unlike many other organisms, H. salinarum contains multiple Replication Protein A homologues, which are central to the protection of damaged DNA as well as the recruitment of other repair proteins and enzymes. Through deletion of these genes, it is possible to deduce the role of each gene in DNA repair by measuring the sensitivity to various DNA damaging agents. Strains containing deletions in three of the RPA genes—*rfa1, rfa3,* and *rfa8*—are extremely sensitive to ionizing radiation. Mitomycin C, a chemical DNA crosslinker, causes different type of damage than IR that still must be excised and repaired. These same three strains were significantly more sensitive to Mitomycin C than the wild type

strain. This indicates these genes are important for repair of multiples types of DNA damage.



(b) Reducing GAA Repeat Lengths Associated with Friedreich Ataxia using Coralyne as a DNA Intercalator

Roshan Thakuri; Biomedical Engineering Program

Mentor/Advisor: Dr. Richard Sinden; Chemistry and Applied Biological Sciences Department

Friedreich Ataxia is a progressively neurodegenerative triplet repeat expansion disease. It is an autosomal recessive genetic disorder caused by an expansion of $(GAA)_n$•$(TTC)_n$ repeats in intron 1 of the frataxin gene on chromosome 9 (Campuzano, Montermini et al. 1996). $(GAA)_n$•$(TTC)_n$ repeats have the potential to form a triplex DNA structure in in vitro leading to genomic instability (expansion or contraction of repeats) (Potaman, Oussatcheva et al. 2004). If these repeats could be deleted back to normal ranges, then the gene function could be restored in this disease. Our research tests the hypothesis that stabilization of a triplex structure using coralyne as a DNA intercalating chemical will increase the rate of deletion of $(GAA)_n$•$(TTC)_n$ repeats. To analyze the effect of coralyne, mutation rates for $(GAA)_n$•$(TTC)_n$ repeat deletions were determined in *E. coli* as a function of length and orientation when cloned into the chloramphenicol acetyltransferase gene in plasmid pBR325 derivatives. The chloramphenicol acetyltransferase gene in plasmid pBR325 derivatives provides a genetic selection system for measuring rates of repeat deletions using Luria and Delbrück fluctuation assays. In general, the rates of $(GAA)_n$•$(TTC)_n$ repeat deletion increased in different repeat lengths using coralyne. This increase was observed for both directions of DNA replication through the chloramphenicol acetyl transferase gene. In addition, the rates of repeat deletion were dependent on which repeat sequence (GAA or CTT) comprised the antisense strand. Complete deletions of $(GAA)_n$•$(TTC)_n$ repeats were the most common mutagenic event observed with, or without, the addition of

coralyne. Our results show that coralyne may have the potential to be applied as a therapeutic means for treating Friedreich Ataxia. The application of coralyne to delay or reverse the progression of disease could be a new therapy.

References:

Campuzano, V., L. Montermini, M. D. Molto, L. Pianese, M. Cossee, F. Cavalcanti, E. Monros, F. Rodius, F. Duclos, A. Monticelli, F. Zara, J. Canizares, H. Koutnikova, S. I. Bidichandani, C. Gellera, A. Brice, P. Trouillas, G. De Michele, A. Filla, R. De Frutos, F. Palau, P. I. Patel, S. Di Donato, J. L. Mandel, S. Cocozza, M. Koenig and M. Pandolfo (1996). "Friedreich's ataxia: autosomal recessive disease caused by an intronic GAA triplet repeat expansion." Science **271**(5254): 1423-1427.

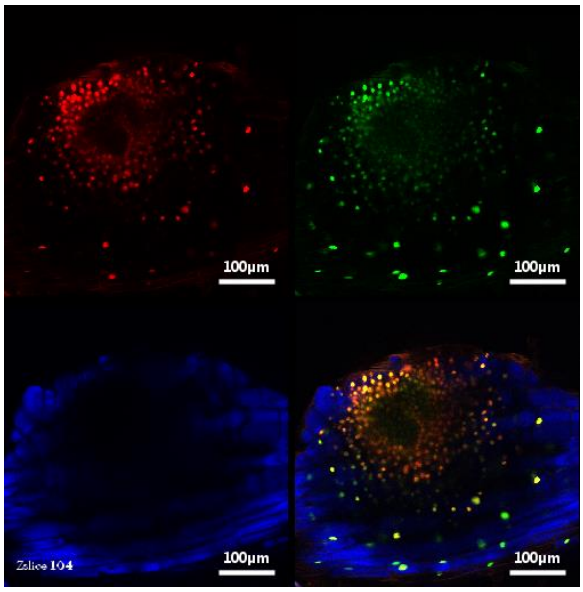
Potaman, V. N., E. A. Oussatcheva, Y. L. Lyubchenko, L. S. Shlyakhtenko, S. I. Bidichandani, T. Ashizawa and R. R. Sinden (2004). "Length-dependent structure formation in Friedreich ataxia (GAA)n.(TTC)n repeats at neutral pH." Nucleic Acids Res **32**: 12

(c) 3-Dimensional Imaging of Auxin and Cytokinin Localization in Transgenic Soybean and Medicago truncatula Root Organs via Two-Photon Induced Fluorescence Imaging

Jon Fisher; Nanoscience and Nanoengineering Program

Mentor/Advisor: Dr. Steve Smith; Nanoscience and Nanoengineering Program

Industrial nitrogen fertilizers account for nearly 50% of the fossil fuel costs in modern agriculture and contribute to soil and water pollution. Therefore, significant interest exists in understanding and characterizing nitrogen use efficiency of crops. Legume plant species exhibit a particularly efficient nitrogen uptake mechanism using root nodules which house nitrogen-fixing rhizobial bacteria. While the roles of the hormones auxin and cytokinin and of microRNA miR160 have been studied in detail, presently no work has produced 3-dimensional localization and quantification of these molecules throughout nodule development. In this work, soybean plants were transfected with a tri-color fluorescent vector with miR160-sensitive blue fluorescent protein (mTagBFP2), auxin-sensitive green fluorescent protein (GFP), and cytokinin-sensitive TdTomato. 3D images of soybean root nodules were captured using two-photon induced fluorescence microscopy. The resulting images were characterized based on their age and the concentration fluorophores for each sensor. 3D root tip images were also captured to compare the relative concentrations and localization to the previous findings.



Cross-sectional images of **Left.)** emerging soybean nodules and **Right.)** soybean lateral root tip. Each image shows 3 channels (red, green, and blue) and a composites image where yellow shows regions of overlap. The channels correspond to TdTomato (red, top left), GFP (green, top right), root autofluorescence (blue, bottom left), and composite (bottom right).

(d) Imaging cellular dynamics in cells by FLIM-FRET

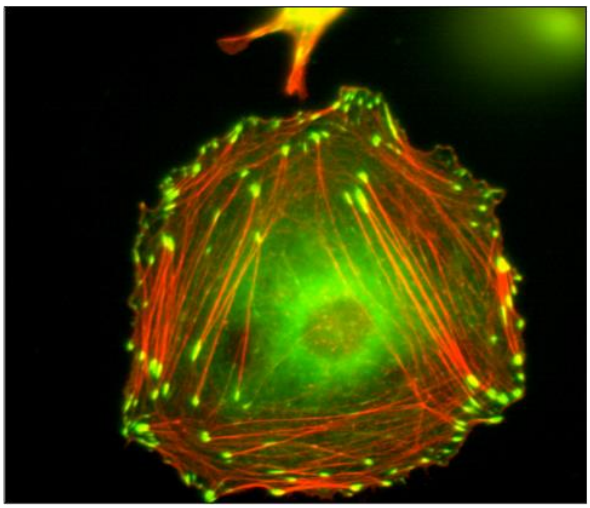
Divya Kota; Nanoscience and Nanoengineering Program

Mentor/Advisor: Dr. Jing Liu; Nanoscience and Nanoengineering Program

Measuring cellular dynamics in the live cells helps in understanding physiological, pathological and developmental processes which had been very difficult to achieve in previous years. Therefore, imaging research today is increasingly developing new methods for measuring these complex dynamics. Interacting proteins are assembled and control cellular dynamics within the cell but these processes can be difficult to monitor with chemistry-based screening methods. Alternatively, time-resolved single molecule microscopy is a non-invasive imaging technique which provides high spatial and temporal resolution from single living cells.

In this project, our goal is to measure the force transmission and tension generation in live cells by performing FLIM-FRET imaging, to analyze cytoskeletal dynamics and tension regulation and to illustrate their utility in addressing important problems in developmental systems by the help of two proteins- Nonmuscle Myosin MII and Lamins, which involves in cytoskeletal dynamics and tension regulation at various regions of the cell. The generated forces under various cellular conditions can be measured by the tension sensor module (TSMod). Characterization of cellular forces leads to a greater understanding of cell migration, cellular mechanosensing, tissue formation, disease progression etc.

Keywords: FLIM – Fluorescence Lifetime Imaging, FRET- Forster Resonance Energy Transfer



The picture shows vinculin (green) containing focal adhesions and actin stress fibres (red)- http://labs.medmicro.wisc.edu/huttenlocher/

References:

1. Horst Wallrabe and Ammasi Periasamy, Imaging protein molecules using FRET and FLIM microscopy, Elsevier, Current Opinion in Biotechnology 2005, 16:19–27
2. Chandrasekar, I., *et al.* Nonmuscle Myosin II is a Critical Regulator of Clathrin Mediated Endocytosis. *Traffic* (2014).
3. Chandrasekar, I., Huettner, J.E., Turney, S.G. & Bridgman, P.C. Myosin II regulates activity dependent compensatory endocytosis at central synapses. *The Journal of neuroscience: the official journal of the Society for Neuroscience* **33**, 16131-16145 (2013).

(e) Morphologic variation within a population of Stewartia floridana (Lucinidae: Bivalvia) from a coastal seagrass biome

Brooke Long; Geology and Geological Engineering Department

Mentor/Advisor: Dr. Laurie Anderson; Geology and Geological Engineering Department

Although the association of bivalve shell morphology with various environmental variables is well documented, intraspecific shell variation has not been studied within a population at a single location. This study uses geometric morphometrics to investigate morphologic variability in the shells of both living and dead representatives of the lucinid bivalve *Stewartia floridana* from a single 2500 m^2 site with varying seagrass patch stability near Bokeelia, Florida. Lucinids possess thiotrophic chemosymbiotic bacteria in their gills and appear to be critical in biogeochemical cycling in seagrass beds. The goal of this work is to test whether intraspecific morphology of living *S. floridana* is correlated with the presence of stable seagrass and if it is, whether those morphological differences are preserved in co-occurring death assemblages. If a morphologic signal is preserved, lucinid morphology could serve as a proxy for the presence of seagrass patches in the fossil record, as seagrass macrofossils and pollen have very low preservation potential. Estimated ages for live specimens were determined using sclerochronology calibrated

with stable oxygen isotope analyses. Seagrass and sand patch stability were determined in a geospatial analysis based on the maximum estimated lifespan of live *S. floridana*. Live specimens were assigned to categories (seagrass, sand, and transitional, where 'transitional' represents areas of fluctuating seagrass stability). Morphometric analyses of live *S. floridana* revealed that shape differs significantly (p-value < 0.01) between seagrass and sand specimens, and canonical variates analysis (CVA) indicates that the shape of transitional specimens falls between individuals from those two categories. Thin plate splines reveal that seagrass specimens have an expanded inhalant channel, a secondary respiratory surface in lucinids, which may be a response to high sulfide in seagrass-bed sediment, due to higher concentrations of detrital organic matter. Dead-articulated *S. floridana*, however, are morphologically distinct and display a distinct allometric trend from live specimens as supported by analysis of variance (ANOVA), CVA, and jack-knife cross-validation analyses. Therefore, although intraspecific variation in living individuals reflects fine-scale environmental differences, time-averaging and other biostratinomic processes may obscure those signals in death assemblages.

(f) Anatomically Linked Occurrence of Concretionary Preservation of Mosasaurs from the Pierre Shale of South Dakota

Alysia Korn; Geology and Geological Engineering Department

Mentor/Advisor: Dr. Christina Belanger; Geology and Geological Engineering Department

Fossils of mosasaurs, late Cretaceous (89-65 million years ago) marine reptiles are frequently found partially preserved in concretions, or hard mineral masses, but little is known about this mode of fossilization. This study examines if concretions preferentially form around specific anatomical regions. The presence of concretions was documented for four anatomical regions along with the type of concretion and the stratigraphic unit of provenance for mosasaur fossils found in the Pierre Shale of South Dakota. The frequency of occurrence of each anatomical region was different when looking at specimens preserved in shale versus concretions, suggesting that our view of the fossil record is different depending on the mode of preservation. The skull and torso were preserved more often in concretions than were limbs and tails suggesting that concretion growth preferentially begins in the core of the organism (skull and torso), where there is a higher volume of organic matter, and then successively precipitates further out toward the periphery. Concretionary fossils are hard to extract from the surrounding

rock, so are often ignored in the field and laboratory. The skull and torso contain many taxonomically diagnostic features; thus concretionary specimens should not be overlooked. Now that an anatomical preference for concretion formation has been established, further study can examine the effect of different types and quantities of organic matter on concretion growth so that a direct mechanism for concretionary preservation in marine vertebrates can be established.

Session O-G4: 1:00-2:40 PM Bump Lounge

(a) Policy Iteration for Optimal Switching with Continuous-time Dynamics

Tohid Sardarmehni; Mechanical Engineering Department

Mentor/Advisor: Dr. Ali Heydari; Mechanical Engineering Department

An approximate solution for optimal switching problems with continuous-time dynamics and infinite horizon cost functions is developed in this paper. The proposed solution is a Policy Iteration-based algorithm and provides a feedback scheduling policy with a negligible real-time computational burden. The convergence to the optimal solution and stability of the system under the proposed solution are studied. Both offline and online training methods for implementing the proposed algorithm are presented. Finally, effectiveness of the proposed algorithm is illustrated through numerical simulation.

(b) Parking Control of Mixed Conventional/Braking Actuation Mobile Robots Using Fuzzy Logic Control

Walelign Nikshi; Mechanical Engineering Department

Mentor/Advisor: Dr. Mark Bedillion; Mechanical Engineering Department

In this paper a new mobile robot system, the mixed conventional/braking actuator mobile robot (MAMR), is introduced. Various actuation systems exist for mobile robots such as differential drive with motor-driven wheels, legged mechanisms, and others. One common characteristic of all those actuation systems is the use of conventional motors to move each degree of freedom. Robots with such actuation systems are generally complex, heavy, and expensive. Furthermore, if one of the conventional actuators fails during operation, the system may lose its controllability. This paper uses brakes in combination with conventional actuators to tackle those drawbacks. The purpose of this paper is to study the dynamics of such a mobile robot system and parking control of such a robot along the x axis from any initial position and orientation in the workspace.

In this study, some of the conventional actuators are replaced by brakes resulting a new mobile robot platform. A three-wheeled mobile robot is converted to a mixed conventional/braking mobile robot by replacing the Ackerman steering wheels by two lockable caster wheels that are selectively

actuated to steer and brake the mobile robot, and the conventional drive wheel by a drive wheel that allows omni-directional motion but does not provide omni-directional force. Thus the mechanical complexity of the wheels is increased, but the actuation complexity is reduced by replacing the Ackerman drive with two brakes. Two states of brakes (i.e. on/off) which are obtained by assuming Coulomb friction at the braking points are considered. This system is closely related to a distributed manipulation system which was studied in prior work except the braking location is fixed relative to the local coordinate system[2]. In addition, this system has actuation force coming from the actuator instead of a constant force field. This system is also closely related to switching system[3] in which different combinations of the brakes result in subsystems that could be activated on a certain switching schedule.

Because of its effectiveness in the control of mechanical systems and ability to deal with analysis of complex processes with limited or uncertain information, a fuzzy logic controller (FLC) is proposed to control the parking problem of the MAMR. Of the three different fuzzy inference systems, the Tagaki-Sugeno approach is used because of its remarkable experimental results and a more systematic approach to FLC design. A number of Matlab/Simulink simulations with different initial conditions are done to show the effectiveness of the proposed controller. The desired objective is achieved by using three inputs with three membership functions which are used to formulate 26 *IF*/*THEN* rules. Although the main goal was to control the y position and orientation of the robot, we extended the problem to full parking in which the x position is also controlled by using a proportional controller. The convergence of the system is checked by running the simulation for different representative initial conditions and the robot converges regardless of its initial positions and orientations.

(c) A Machine Learning Approach to Android Malware Detection

Sumnima K.C.; Mathematics and Computer Science Department

Mentor/Advisor: Dr. Mengyu Qiao; Mathematics and Computer Science Department

With the booming of smart phone and high-speed wireless networks in recent years, applications and data have been shifting from desktop to mobile devices at a vigorous pace. Among various mobile operating systems, Android is on the majority of smartphones in most countries with a share of 82.8% according to recent IDC [1] report. Android is a privilege-separated operating system with security provided through a "permission" mechanism. Android apps need to request permissions to access sensitive personal data and system resources. However, empirical studies have found that various types of malicious software could obtain permissions and attack systems and applications by deceiving users and security mechanism. In order to protect Android smartphones, we propose a novel machine learning approach to detect malware by mining the patterns of permissions and API calls acquired and used by Android apps. We first investigated the mapping between API calls and the permissions, and then conducted a static analysis on

[2] M. Bedillion, R. Hoover, and J. McGough, "A distributed manipulation concept using selective braking," in American Control Conference (ACC), 2014. IEEE, 2014, pp. 3322–3328.

[3] D. Liberzon, Switching in systems and control. Springer Science & Business Media, 2012

source code. Binary and numerical features were extracted from permissions and API calls for qualitative and quantitative analysis. We downloaded more than 6000 normal and malicious apps from Google App Store and Android Malware Genome malware database [2] for experiments. Different supervised learning algorithms in Orange data mining toolbox [3], such as Support Vector Machines, Random Forest and Neural Networks, were applied and compared for classification. The experimental results show that the proposed approach delivers accurate detection of malware and thus has great potential to provide robust protection for Android smartphones.

1. http://www.idc.com/prodserv/smartphone-os-market-share.jsp
2. http://www.malgenomeproject.org/
3. http://orange.biolab.si/

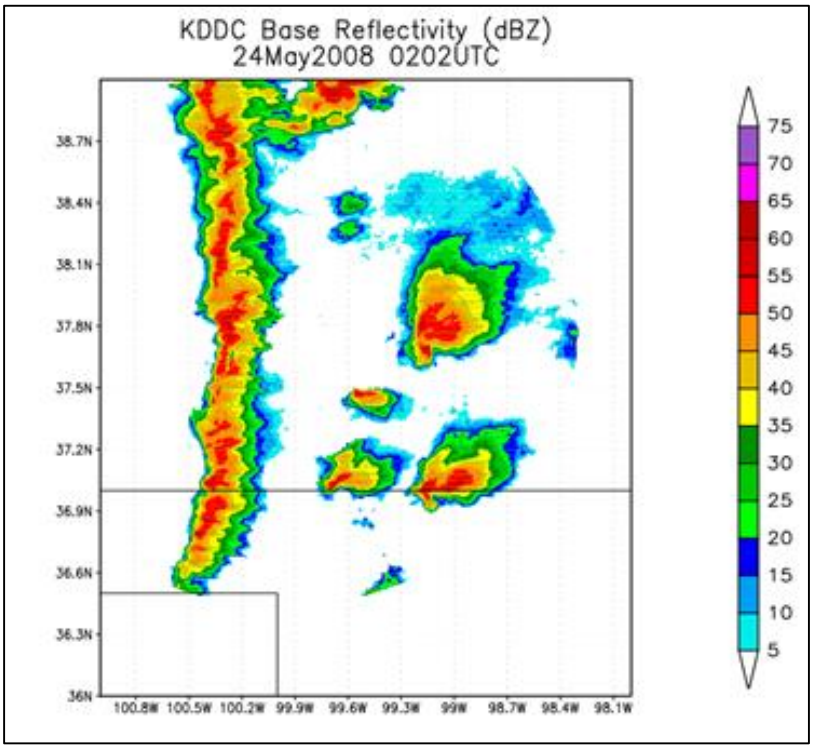
(d) An Observational Examination of Supercell and Squall Line Thunderstorm Interactions

Kevin Wagner; Atmospheric and Environmental Sciences Program

Mentor/Advisor: Dr. Adam French; Physics Department

Widespread severe weather outbreaks often contain multiple storm organizations, with supercells and squall lines generally producing most of the severe weather hazards (large hail, damaging winds, and tornadoes). Recent research has focused on cases where squall lines and supercell merged into a single system and noted some changes to storm structure in advance of the merger. This included changes in low-level rotation in supercells and anecdotal evidence that supercells in close proximity to a squall line produced longer-tracked tornadoes than other supercells in the same environment. The goal of this study is to further document changes in the storm structure and intensity of supercell and squall line storms when they are in close proximity to each other. Past research has shown that supercells and squall lines can both modify their local environments, including changes to the wind and thermodynamic profiles. The present study will use radar data from observed cases to determine if the two storms evolve consistently with expected changes to their local environments. This will be accomplished using archived WSR-88D data analyzed with the Warning Decision Support System -- Integrated Information (WDSS-II) software for multiple cases over a range of environments. By analyzing the evolution of radar parameters including

reflectivity factor, velocity, azimuthal shear, vertically integrated liquid (VIL), hail detection algorithms (HDA), and echo top heights, we plan to document any common changes to squall line and supercell intensity when the two are in close proximity. The results of this analysis will help to better define a conceptual model of how these two storm types interact when in close proximity, and provide observation-based "ground truth" with which to evaluate on-going numerical model simulations of similar interactions. Ultimately, the combined results of these projects are intended to aid in the development of future forecasting techniques to help enhance severe weather warnings during these types of complex weather events.



(e) Evaluation of Remediation Measures for Problems Caused due to Air Temperature Inversions in Surface Mines using CFD

Manoj Keerthipati; Mining Engineering and Management Department

Mentor/Advisor: Dr. Purushotham Tukkaraja; Mining Engineering and Management Department

An air temperature inversion is a deviation from normal change of temperature with altitude wherein temperature increases with increasing height. In surface mines, temperature inversions cause problems such as reflecting the sound waves from blasting back to earth's surface and trapping pollutants in the mine. In this study, a Computational Fluid Dynamics (CFD) model has been developed to simulate an air temperature inversion phenomena in a hypothetical mine. The model is used to run a series of simulations to evaluate a variety of remedial measures to mitigate

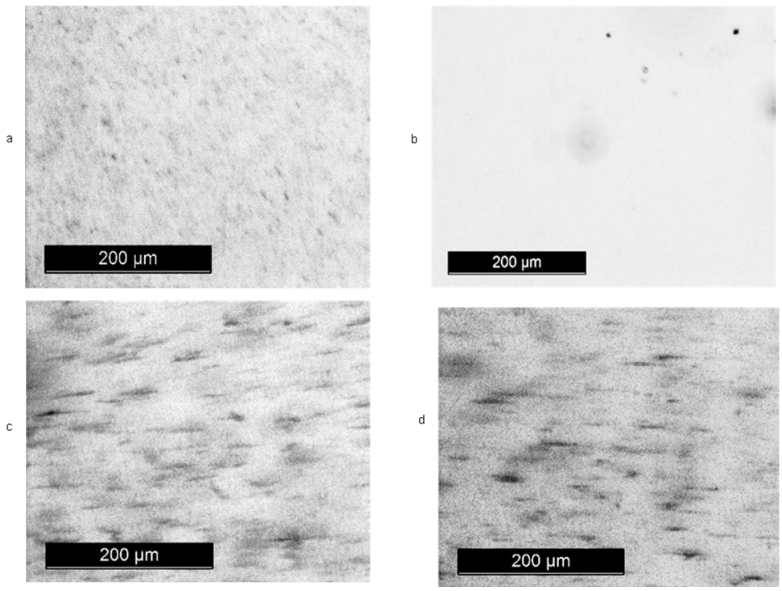
the problems caused due to air temperature inversions. The effect of the various techniques to dissipate the thermal inversion has been evaluated in this model.

Session O-G5: 1:00-2:40 PM McKeel Room

(a) Effects of solvent hydrogen bonding, viscosity, and polarity on the dispersion and alignment of nanofluids containing Fe2O3 nanoparticles

Greg Christensen; Nanoscience and Nanoengineering Program

Mentor/Advisor: Dr. Haiping Hong; Materials and Metallurgical Engineering Department



Optical Microscope images of: a: Fe_2O_3 in ethylene glycol, b: Fe_2O_3 in glycerol, c: Fe_2O_3 in 50% vol. ethylene glycol 50% vol. water, d: Fe_2O_3 in 50% vol. ethylene glycol 50% vol. water under 0.042 KG magnetic field

It has been shown that the alignment of Iron (III) oxide (Fe_2O_3) nanoparticles in water (H_2O) can enhance the thermal conductivity of nanofluids. To better understand solvent effects such as hydrogen bonding, viscosity, and polarity, nanofluids were prepared by mixing Fe_2O_3 nanoparticles and various solvents (water, ethanol, 1-propanol, isopropanol, 2-propanone, hexane, cyclohexane, ethylene glycol, glycerol, etc), and the dispersions and alignments of the Fe_2O_3 nanoparticles in these solvents with and without an applied magnetic field were investigated using an optical microscope. The microscope images indicated that inter-molecule hydrogen bonding of the solvents with one OH group (water, ethanol, 1-propanol, and isopropanol) could help to disperse and align the Fe_2O_3 nanoparticles. The intra-molecular hydrogen bonding causes a dramatic increase in viscosity for fluids with multiple OH groups, such as ethylene glycol ($C_2H_6O_2$) and glycerol ($C_3H_8O_3$), and makes the Fe_2O_3 nanoparticles dispersion and alignment difficult. Adding water to those fluids could lead to significantly reduced viscosity and make the particles disperse and align well. Polarity studies indicated that higher polarity yields better dispersion and alignment of the Fe_2O_3 nanoparticles. Thermal studies showed that thermal conductivity of nanofluids containing metal oxide particles with hydrogen bonding in base fluids is enhanced compared to the theoretically calculated data. Intermolecular hydrogen bonding between water and ethylene glycol increases the thermal conductivity of nanofluids while decreasing the fluid viscosity. The results also well explain why 50 wt% water 50 wt% ethylene glycol is an excellent commercial coolant. Since high thermal conductivity enhancement with minimal viscosity increase is the primary goal of heat transfer nanofluids, this current research may open new doors to better understanding of the fundamental nature of nanofluids.

(b) Combustion Characteristics of Calcium Iodate Based Biocidal Formulations

Fidel D.Ruz-Nuglo; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Lori Groven; Chemical and Biological Engineering Department

Biocidal formulations have been well explored by a number of researchers over the years and typically include a metal fuel such as Aluminum and iodates such as I_2O_5 or KIO_3. However, these

formulations are plagued by aging and degradation of the iodate and/or the aluminum (fuel), which in turn reduces their efficacy. To overcome this, some type of protective agent for the iodates and for the aluminum is necessary. In this effort, fluoropolymers serve as i) the protective agent for both the iodates and the aluminum within the formulations, and ii) as a polymer binder for the development of a printable biocidal. In this study, the fluoropolymer (THV) is found to be effective in protecting both the calcium iodate and the aluminum powder under accelerated aging conditions (70 °C, 30% RH). Simultaneous differential scanning calorimetry (DSC) and thermo-gravimetric (TG) analyses were performed to elucidate the complex interactions between the fluoropolymer, iodate, and aluminum. Inks were formulated with THF or DMF serving as the solvent and printed using a Nordson EFD system. The combustion characteristics are presented as a function of polymer loading and line width. Combustion velocities on the order of 150 mm/s were observed when nanoscale aluminum is used as the fuel. The necessary rheological characteristics and the associated safety characteristics of the printed formulations will also be detailed.

(*c*) ***Solvent Extraction of Lanthanum (III) Using PC88A Extractant Diluted in Kerosene***

Vivek Agarwal; Materials and Metallurgical Engineering Department

Mentor/Advisor: Dr. Mohammad Sadegh Safarzadeh; Materials and Metallurgical Engineering Department

Lanthanum (La) occurs in nature with other rare earth elements in numerous minerals such as bastnäsite ($(Ce,La,Y)CO_3F$) and monazite ($(Ce,La,Nd,Th)PO_4$) and has several industrial applications.[1] Recently, domestic production of rare earth elements has been promoted due to potential supply risk, economic benefits and environmental concerns. Therefore it is highly desirable to develop highly efficient extraction techniques which are cost effective and environmental friendly.

In this investigation, the solvent extraction of La from aqueous media was studied. The effects of aqueous equilibrium pH, various acid media (H_2SO_4, HCl and HNO_3), extractant (PC88A) concentration, initial lanthanum concentration and temperature on solvent extraction of La were systematically investigated. The most promising experimental conditions were identified. A molecular modeling approach was also used to understand the metal ion-organic extractant interaction.

The extractant used was 2-ethylhexyl 2-ethylhexyphosphonic acid (PC88A). Reagent grade kerosene was used as the diluent for the organic extractant. Lanthanum oxide (La_2O_3) of 99.99% purity; was used for preparation of stock solutions of La (III) in different acids.

At initial pH of 7, almost complete extraction from all three acids (~98% for H_2SO_4 and HNO_3 and ~92% for HCl) was obtained. Modeling results show that three molecules of PC88A interacts with one molecule of lanthanum which was confirmed by slope analysis method from experimental data.

Based on the experimental results, HNO_3 and HCl were found to be the preferred aqueous media for solvent extraction of La. Experimental results were in complete agreement with the molecular modeling results.

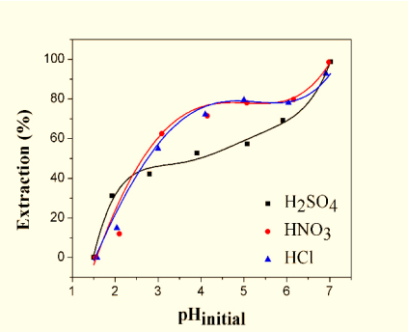


Figure 1. Effect of initial pH on extraction of La (III)

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(d) Solvent Extraction of Metals from Low Grade Manganese Deposits

Aarthi Gunasekaran; Materials Engineering and Science Program

Mentor/Advisor: Dr. William Cross; Materials and Metallurgical Engineering Department

Manganese is a silvery metallic metal, often found in combination with iron. This is a major component in steels and certain type of bronzes. South Dakota has considerable low grade

manganese deposits, primarily from sea nodules deposited millions of years ago. The deposits primarily consist of mixed manganese, iron, calcium and magnesium carbonates. In this work, solvent extraction techniques for separation and recovery of metal ions are discussed. This technique is applicable for both manganese stock solution and pregnant leach solutions. Solvent extraction of calcium, magnesium, manganese and iron was performed using extractants di-(2-ethylhexyle)phosphoric acid (D2EHPA) and Cyanex 272. The extractants were soluble in kerosene. An aqueous solution with the metal ion to be characterized and an organic solution of diluted extractant were prepared and mixed at 1:1 volume ratio. The solutions were separated after equilibrium and the aqueous phase was analysed with Atomic Absorption Spectroscopy. The extraction procedure was done on pregnant leach solution and compared with the results of stock solution.

(e) Bio-electrochemical approaches for treatment of flowback water from hydraulically fractured oil fields

Namita Shrestha; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. Venkataramana Gadhamshetty; Civil and Environmental Engineering Department

Unconventional extraction techniques (hydraulic fracturing and horizontal drilling) are being used to extract oil from impermeable shales in the upper great plain region. The fracturing process consumes significant volumes of freshwater, and generates significant volumes of saline wastewater (produced water and flowback water). For instance, hydraulic fracturing process is used to extract oil from Bakken shale; in this process, it transforms 33% of the incoming fresh water into flowback water. Conventional technologies (reverse osmosis, membrane and thermal processes) are not viable for treating flowback water characterized with high total dissolved solids (TDS) (60,000-200,000 mg/L) and chemical oxygen demand (COD) (70000 mg/L) and several unknown contaminants. The flowback water from fractured oil fields is currently being injected into class II injection wells. Our goal is to develop an inexpensive technology for treating flowback water and enabling its reuse in the oil fields. We propose a multi-stage treatment technique. First, the flowback water is treated with freeze-and-thaw extraction (FTE) for TDS removal. FTE is chosen based on fact that ND region is characterized with cold and frequent freezing temperatures. Second, flowback water effluent from FTE is treated in microbial capacitive deionization to achieve simultaneous desalination and COD removal. We have obtained promising preliminary results (44% TDS removal and 90% COD removal) from the Bakken flowback water.

Session O-G6: 3:00-4:40 PM Bump Lounge

(a) Structure and Properties of High Entropy Alloy of AlCrCuNiTi Deposited by Direct Current Magnetron Sputtering

Lukmon Aminu; Materials Engineering and Science Program

Mentor/Advisor: Dr. Bharat Jasthi; Materials and Metallurgical Engineering Department

High Entropy Alloy often referred to as HEA is a form of alloy system that has multiple principal elements with equimolar or near equimolar ratios. Earlier researches have shown that HEA show improved wear and better properties as compared to conventional alloy system and this has prompted researches into the possibility of application as thin-films for better protective layer for corrosion resistant, and wear resistant coatings for various applications. The present research is aimed at investigating the corrosion and nano-mechanical properties of an equiatomic high entropy alloy of AlCrCuNiTi. Surface films of 2 µm thick were deposited on a 304-stainless steel using a magnetron sputtering deposition technique. Microstructural characterization of the specimens were performed using X-ray and electron microscopic analysis.

(b) Corrosion-Resistant Crystalline-Oxide Coatings on Steel Substrates by an Immersion Anodizing Process

Sushma Priyanka Karanam; Materials and Metallurgical Engineering Department

Mentor/Advisor: Dr. Bharat Jasthi; Materials and Metallurgical Engineering Department

The main objective of this work is to investigate the feasibility of depositing an aluminum oxide (Al_2O_3) layer on steel substrate using Plasma Electrolytic Oxidation (PEO) technique. PEO process is a deposition technique carried out in an alkaline electrolyte system which is environment friendly. PEO process is characterized by applying high voltage in a cyclic manner (cathodic and anodic) to the substrate immersed in an electrolyte solution. This results in the migration of charged ions onto the anodic substrate resulting in the formation of crystalline oxide coatings on the substrate. Al_2O_3 coating can be fabricated on steel substrate with attractive properties such as corrosion resistance, abrasion resistance, mechanical strength, interfacial adhesion and thermal properties which can be useful for many engineered applications. Electrochemical testing of the coatings is performed in 3.5% NaCl solution to understand the effect of PEO process parameters on the resultant corrosion properties. Microstructure and phase composition of these coatings are examined by using Scanning Electron Microscope (SEM) and X-ray Diffraction (XRD) techniques. The effect of post deposition heat treatment on the microstructure and phase transformation of the coatings were also evaluated and reported.

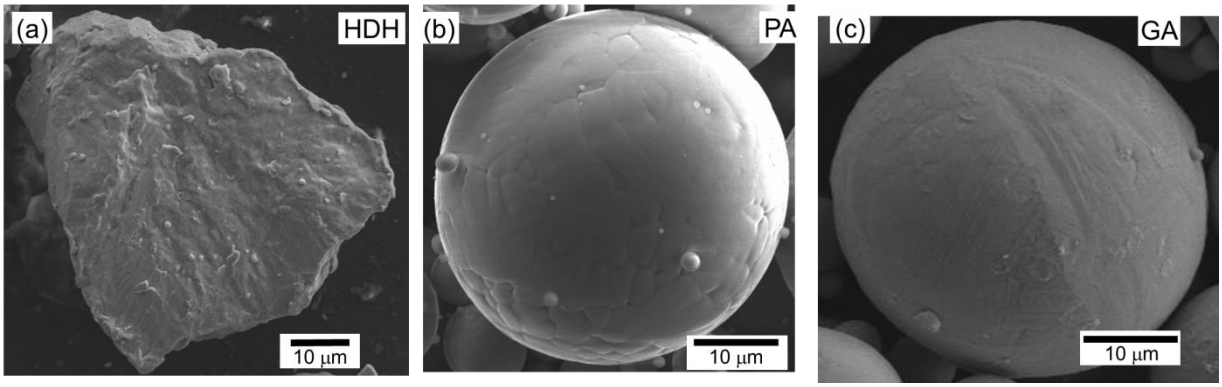
(c) Characterization of Pre Alloyed Ti-6Al-4V Powders for Effective Cold Spray Deposition

Venkata Bhattiprolu; Materials Engineering and Science Program

Mentor/Advisor: Dr. Grant Crawford; Materials and Metallurgical Engineering Department

Cold spray is a solid state deposition process which is attractive for a variety of applications including repair of metallic components. The process, however, relies on significant plastic

deformation of the metal powder to achieve a dense coating. Consequently, depositing high strength materials, such as titanium alloys, is challenging. Feedstock powder microstructure is known to strongly influence cold spray deposition quality. This talk will present an in-depth microstructural analysis of commercially available Ti-6Al-4V feedstock powders to identify the ideal powder microstructure for cold spray processing. Microstructural characterization for several feedstock powders (i.e. gas atomized, plasma atomized, hydride-dehydride) was carried out in as-received condition using optical microscopy, scanning electron microscopy, x-ray diffraction and electron backscatter diffraction (EBSD). Local mechanical properties were characterized by Nanoindentation. Results showed that atomized powders were characterized by predominantly acicular and martensitic α grain structures with some presence of equiaxed α grains. Hydride-dehydride (HDH) powders were characterized by equiaxed α and intergranular β grain structures. Results indicated that the grain sizes of hydride-dehydride powders on average were larger than atomized powders. EBSD revealed multiple phases for plasma atomized (PA) and hydride-dehydride powders. Nanoindentation results showed that plasma atomized powders were hardest followed by hydride-dehydride and gas atomized (GA) powders.



SEM micrographs showing powder morphology of (a) Hydride-dehydride, (b) Plasma atomized, and, (c) Gas atomized powders

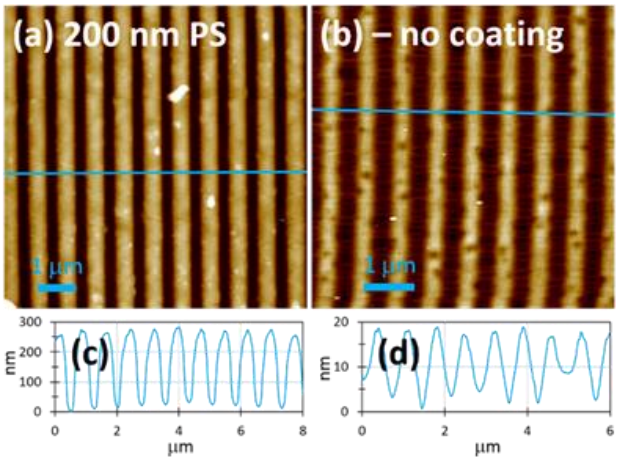
(d) ***Enhancing Laser Ablation of Silicon by Polymer Confinement Regime***

Anahita Haghizadeh; Nanoscience and Nanoengineering Program

Mentor/Advisor: Dr. Haeyeon Yang; Nanoscience and Nanoengineering Program

Pulsed-laser ablation of semiconductors has attracted a great interest in surface micro processing. Difficulties of silicon micro processing has been a challenge for scientists and limited its

applications in industry. We have studied enhancing interferential laser ablation of silicon by confinement polystyrene regime. This approach allows us to reach higher ablation rate and well defined features on the silicon surface. For this purpose silicon substrates were covered by polystyrene film at different thicknesses. We have assumed new geometry of laser induced plume and high pressure and temperature of confined plasma under the polystyrene film leads to having deeper trenches at the interference maxima compare to the resultant trenches by ablation in water and air. Theoretical calculation has agreed with these assumptions and showed much greater induced pressure of confined plasma under the polystyrene film. Polystyrene film thickness, laser wavelength and intensity impacts have been studied as well.



Impact of Polystyrene film Thickness on Nano-wires depth profile

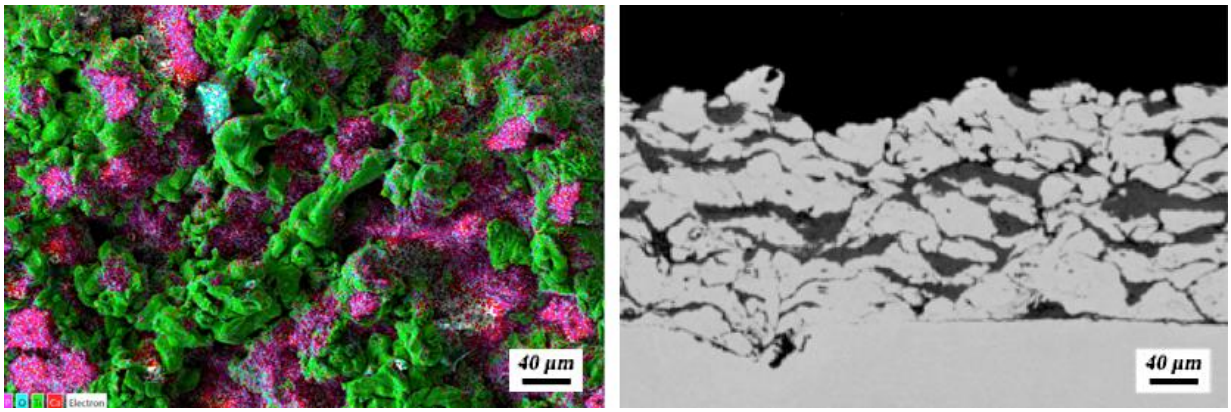
(e) Processing, Microstructure Characterization and Biological Response of Cold Sprayed Biocomposite Coatings

Eden Bhatta; Biomedical Engineering Program

Mentor/Advisor: Dr. Grant Crawford; Materials and Metallurgical Engineering Department

Cold spray processing is a solid-state deposition process commonly used to deposit dense metal coatings. Next generation surface coatings for titanium implants must exhibit both rapid

osseointegration behavior and good mechanical stability to ensure a prolonged implant lifespan. We report on the relationship between processing, microstructure characterization, and biological performance of functionally graded biocomposite cold spray coatings. Coatings with varying composition of hydroxyapatite and titanium (20% HA, 50% HA, 80% HA, and functionally graded) were fabricated using high-pressure cold spray deposition. The similarity in structure of hydroxyapatite and bone mineral allows bone tissues to integrate into the surface of implant resulting in a strong biological fixation. As-processed coatings were characterized using optical microscopy, scanning electron microscopy, x-ray diffraction, and contact angle goniometry. Adhesion strength of the coatings was measured using a tensile pull-off adhesion test. Biological performance of the as-deposited coatings was characterized via in vitro cell culture using mouse osteoblasts. Osteoblast viability, differentiation, and mineral deposition were investigated.



Top-down EDS image of 50%HA-50%Ti composite coating (Green-Ti, Red-HA) and cross section SEM image.

Session O-G7: 3:00-4:40 PM McKeel Room

(a) ***Potential of Mean Force Study of CO Chemisorption on Co (0001) in Presence of Supercritical Fluid Solvent***

Alireza Asiaee; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Kenneth Benjamin; Chemical and Biological Engineering Department

Utilization of supercritical fluid (SCF) solvents in heterogeneous catalytic processes is a breakthrough across a range of chemistries such as oxidation, pyrolysis, amination, and Fischer-Tropsch synthesis (FTS). Despite numerous experimental investigations about the effect(s) of implementing SCF phase on these processes, there are not too many theoretical studies probing the role of SCF solvent from a molecular-level viewpoint. In the current work, we applied molecular dynamics (MD) simulations toward modeling of CO chemisorption on Co(0001) catalyst surface, as the first step in the mechanism of FTS. The free energy landscape has been considered at various bulk hexane densities, ranging from ideal gas conditions to near- and super-critical hexane densities. Using the potential of mean force (PMF) calculations and comparing the free energy variations resulted from the weighted histogram analysis method (WHAM), it is shown that CO chemisorption on catalyst surface would be enhanced in in the presence of supercritical hexane within the reduced pressure range of 1.0-1.5 at constant temperature of 523 K. This improvement in CO stability in adsorbed state coincides with the variations in the isothermal compressibility of bulk hexane at similar temperature and pressure ranges.

(b) ***Electrospun Carbon Nanofiber Membranes for Water Treatment Applications***

Rika Beck; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Todd Menkhaus; Chemical and Biological Engineering Department

Fresh water scarcity has become a significant problem in both the developing and developed worlds. Therefore, the need for efficient and cost-effective water treatment methods is increasingly critical. Additionally, wastewater reuse is a growing technology that will likely revolutionize

municipal and industrial water supply. Wastewater reuse often requires more specific treatment methods to remove industrial contaminants. Activated carbon in both granular and powder form is a highly effective adsorbent that is currently used for many water treatment applications, including the removal of disinfection by-products, mercury, cadmium, natural organic substances, and radionuclides. The adsorption performance of the carbon largely depends on its physical and chemical properties, such as the activation method, pore size distribution, surface area, and the material used to make the carbon. Activated carbon formed into nanofiber mats/membranes has the potential to improve the performance of traditional activated carbon adsorption. For this study, electrospun carbon nanofiber membranes were prepared/derived from their precursors of lignin or polyacrylonitrile (PAN). Then the carbon samples, including PAN- and lignin-based carbon nanofiber membranes, PAN microfiber mats, and a commercially available granulated activated carbon, were characterized/evaluated by determining methylene blue adsorption capacity and kinetics of adsorption, iodine number, and permeability. Further tests were conducted to determine if the material had any efficacy in removing organic acids and other common groundwater contaminants. Results suggest that the electrospun nanofiber membranes offer 4-10-times higher adsorption capacity, faster adsorption kinetics (half the time needed to reach equilibrium), and comparable permeability to granular activated carbon and microfiber mats. An energy and economic evaluation for implementation of the carbon nanofiber media into a hypothetical water treatment process showed that the nanofibers could reduce energy consumption by 87%, from a combination of lower pressure pumping and less frequent thermal regeneration.

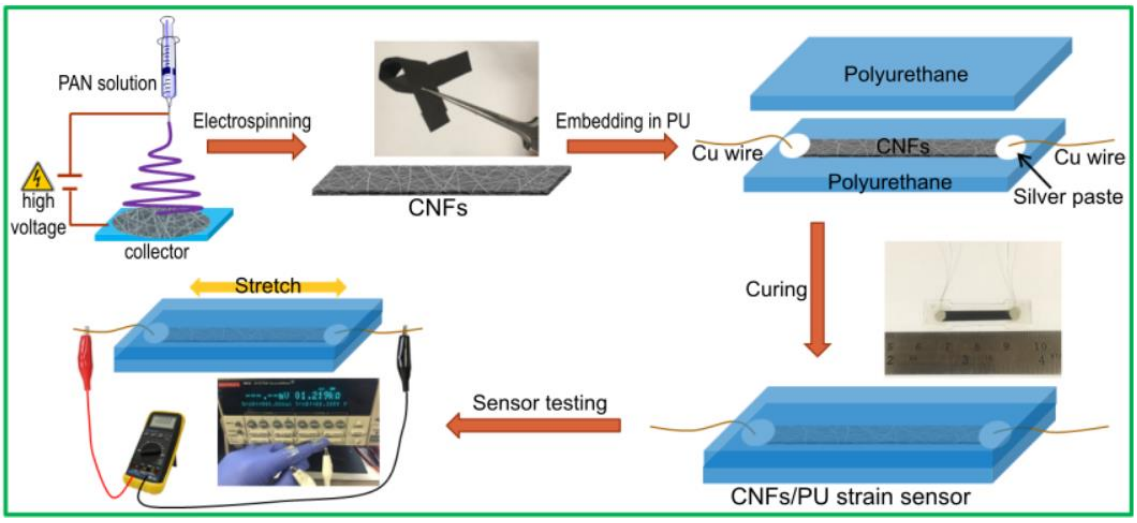
(c) ***Highly Stretchable Strain Sensor Based on Electrospun Carbon Nanofibers for Human Motion Monitoring***

Yichun Ding; Chemistry and Applied Biological Sciences Department

Mentor/Advisor: Dr. Zhengtao Zhu; Chemistry and Applied Biological Sciences Department

Highly stretchable and sensitive strain sensors are in great demand for human motion monitoring. This work reports a strain sensor based on electrospun carbon nanofibers (CNFs)

embedded in polyurathane (PU) matrix. The piezoresistive properties and the strain sensing mechanism of the CNFs/PU sensor were investigated. The results showed that the CNFs/PU sensor had high stretchability of strain up to 300%, high sensitivity of gauge factor as large as 72.5, and superior stability and reproducibility during the 8000 stretch/release cycles. Furthermore, the CNFs/PU sensors were used for monitoring the movements of finger, wrist, and elbow bending, demonstrating that the strain sensor based on the CNFs/PU could be promising for flexible and wearable devices for human motion monitoring.

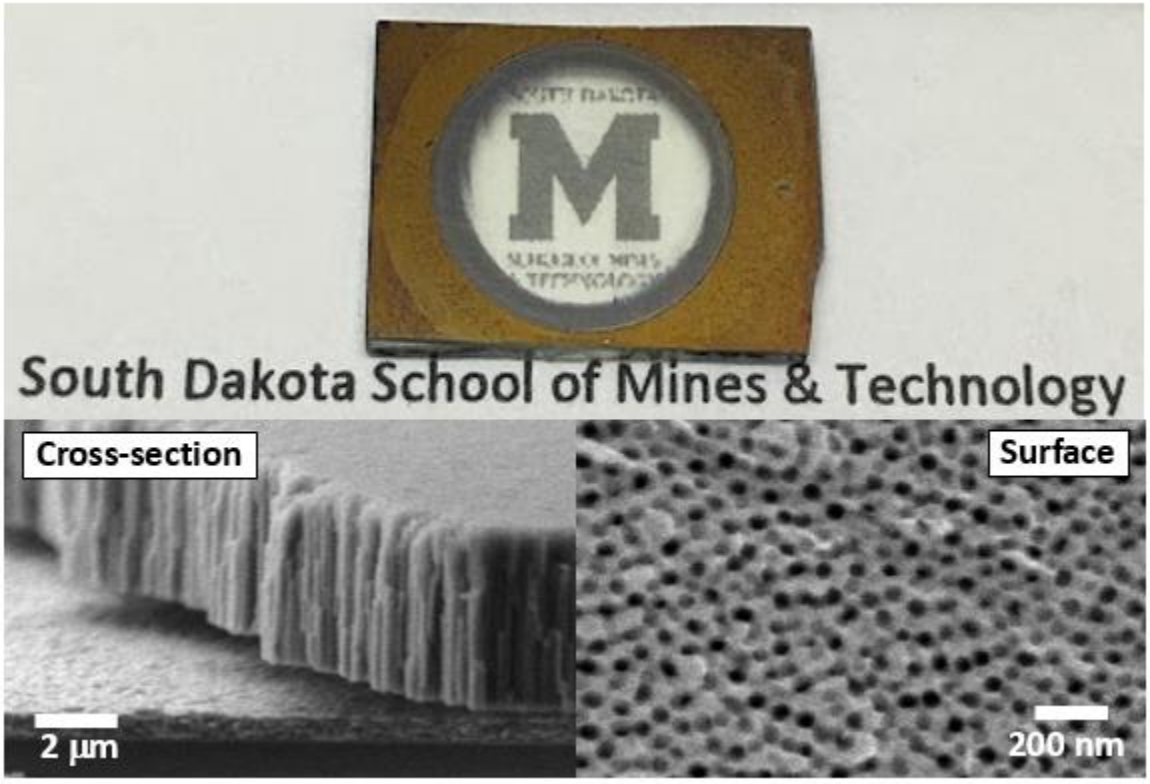


(d) ***Transparent TiO_2 Nanotube: Development and Application in Establishing the Mechanism for Macrophage Response***

Jevin Meyerink; Biomedical Engineering Program

Mentor/Advisor: Dr. Grant Crawford; Materials and Metallurgical Engineering Department

The macrophage is the first and most important cell to interact with implanted materials and, consequently, controls the onset of an inflammatory or reparative response. To improve bone regeneration, understanding macrophage-nanotube interaction is of great interest. However, a better understanding of the largely unknown mechanism by which resident cells interact with the nanostructured surface is needed.



Our current work has resulted in transparent TiO_2 nanotube platforms which allow *in situ* imaging of cellular adhesion via conventional imaging techniques. These techniques expose a "new angle" of imaging the macrophage-nanotube interaction site. With this new approach, unknown factors that dictate cell morphology, communication, attachment, and inflammation may be revealed.

(e) ***Solution Combustion Synthesized Lithium Cobalt Oxide as a Catalytic Precursor for the Hydrolysis of Sodium Borohydride***

Matthew Wilcox; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Lori Groven; Chemical and Biological Engineering Department

Solution Combustion Synthesis (SCS) has recently been explored as one method to synthesize metal oxides (e.g., Co_3O_4) that can serve as catalytic precursors for the hydrolysis of sodium borohydride ($NaBH_4$). In this paper solution combustion synthesis was used to produce the mixed metal oxide lithium cobalt oxide ($LiCo_2O_4$) from a solution of cobalt nitrate, lithium acetate, and glycine. The subsequent use as an effective catalyst precursor for $NaBH_4$ hydrolysis was characterized. The catalytic activity results show that the hydrogen generation rate (HGR) at room temperature was much higher for the solution combustion synthesized material than for commercial Lithium Cobalt Oxide, even though the specific surface area of the commercial material was much higher. Using a 0.6 wt.% aqueous solution of NaBH4 at 25 °C and a 5 wt.% catalyst precursor loading, a HGR of 2.09 L min^{-1} g_{cat}^{-1} was achieved for solution combustion synthesized Lithium Cobalt Oxide. In contrast, at the same conditions, for commercial material generated a HGR of 0.29 L min^{-1} g_{cat}^{-1}. Optimization of solution combustion synthesized catalyst material to remove undesired compounds was found though varying heat treatment temperatures.

Poster Presentations – Undergraduate Students

Session P-UG1: 8:00-10:00 AM Posters #1-8 Ballroom

#1 A Case Study in Medical Geology: Investigation of the Geologic Controls on Black Hills Radon Rates

Laura Rochlitz; Geology and Geological Engineering Department

Mentor/Advisor: Dr. Zeynep Baran; Geology and Geological Engineering Department

The presence of excessive radon in the Black Hills homes is a well-established fact. Through the process of GIS interpolation and field work, the main cause of radon in homes built on non-uranium bearing formations (whether faulting and other structural deformation or proximity to radium/uranium bearing formations) can be inferred. Maps of the Black Hills area showing radon potential is a main product of this research, and these maps can provide residents of the area with information about their individual potential exposure.

#2 Investigation of the Occurrence of Erionite and Potential Enrichment Zones at Reva Gap in Harding County, SD

Tait Earney; Geology and Geological Engineering Department

Mentor/Advisor: Dr. Zeynep Baran; Geology and Geological Engineering Department

Erionite, a naturally occurring zeolite mineral, was classified as a Group 1 known respiratory carcinogen by the World Health Organization in 1987 after a series of studies confirmed a link between exposure to fibrous erionite and high incidences of malignant mesothelioma in villages in the Cappadocia region of central Turkey. Since then, many deposits of erionite throughout the western United States have been studied to determine their potential risk to public health and safety. In South Dakota, erionite was discovered within Tertiary strata at several locations, including at Reva Gap in the Slim Buttes Unit of Custer National Forest in Harding County. While erionite is known to occur at this location, until now no research has been conducted to try and identify if or where an erionite enrichment zone occurs. Utilizing a bulk sampling method, rock samples were gathered from each formation (Arikaree, Brule, and Chadron) and their sub-members. The samples were then processed and subsequently examined under a microscope to determine erionite content. Preliminary results of the study indicate that erionite is present in each formation, with the Arikaree Formation containing the highest concentration, followed by the Brule Formation, and Chadron Formation. Understanding the distribution of erionite at this site, and other locations, is very important when it comes to ensuring public health and safety.

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#3 ***Potential to Formally Name a New Sedimentary Unit in Southwestern South Dakota***

Tyler Rust; Geology and Geological Engineering Department

Mentor/Advisor: Dr. Foster Sawyer; Geology and Geological Engineering Department

Recent research efforts have been made to investigate post-Laramide faulting and generate an updated geologic map in southwestern Oglala Lakota County, South Dakota. During these investigations a sedimentary unit was encountered which has not been described in any previous literature. An appropriate map label must be assigned to this unit in order to complete the geologic map of the area. Further evaluation of the deposit will determine whether this unit should be formally named or assigned a more generic label such as "quaternary loess". The unit will be evaluated with respect to the North American Stratigraphic Code for formally named units. Field reconnaissance in the surrounding area will attempt to locate additional occurrences of the deposit and a mineral analysis will be carried out to determine the compositional and textural properties. The results of these studies will determine whether this sedimentary unit meets the criteria for formal name designation.

#4 ***Differences in Phytoplankton in Lake Kampeska and the Nutrient Removal Facility Affect Nutrient Removal***

Taylor Clemmons; Chemistry and Applied Biological Sciences Department

Mentor/Advisor: Dr. Lisa Kunza; Chemistry and Applied Biological Sciences Department

Nutrient loading has been a problem in Lake Kampeska near Watertown, SD for more than a decade. Lake Kampeska receives nutrients and sediment, from the Big Sioux River watershed, and the elevated nutrient loads can alter the ecosystem of the lake. Increased N and P loading leads to eutrophic and anoxic conditions which may lead to fish kills. To manage the nutrient input into Lake Kampeska, a retired water treatment facility was re-purposed in Watertown, SD into an algal growth facility. The goal of this facility is to remove nutrients biologically through the use of algae from the lake. We are examining the proportion of blue green algae (cyanobacteria), green algae, and diatoms with in both the lake and the growth chamber within the facility. Diatoms and green algae dominated in the lake and the nutrient removal facility phytoplankton year round, while cyanobacteria were observed in the lake and nutrient removal facility, only in late summer and early fall. The increase in temperature also led to an increase in algal cells per mL. Total phosphorous decreased when there was more algae present. Understanding the seasonal distribution of algae in the lake and how that compares to the facility will provide the data needed for management of the nutrient removal facility as they strive to become more efficient. Average removal of nutrients from the facility throughout 2015 was 3.13% P and 18.15% N, however adjustments to the facility may increase efficiency of nutrient removal in the future.

#5 Pathogenicity Potential of Fundamental Regions of the Big Sioux River

Sydney Sayler; Chemistry and Applied Biological Sciences Department

Mentor/Advisor: Dr. Linda DeVeaux; Chemistry and Applied Biological Sciences Department

Certain strains of *Escherichia coli* (*E. coli*) are considered to be highly pathogenic bacteria strain linked with outbreaks of severe diarrhea and hemolytic uremic syndrome (HUS), an often-lethal disease in children. An important infectious strain of *E. coli* is the Shiga-toxigenic *E. coli (STEC)* serotype O157:H7, which accounts for more than 73,000 HUS cases reported annually. In addition to harboring genes for Shiga toxin (stx), *E. coli* O157:H7 is also classified as Enterohaemorrhagic *E. coli* (EHEC) for its possession of additional virulence factors that intensify the symptoms of HUS. As a bacterium acquires more potentially pathogenic genes, the likelihood of causing disease in humans rises. In the environment, bacteria undergo Horizontal Gene Transfer (HGT), the process by which bacteria acquire genes from other members of the microbial community, regardless of species; this can cause an increase in the pathogenicity of any individual. Areas of high bacterial load, such as fecally impaired bodies of water, tend to see a greater occurrence of HGT. The current water-quality testing procedures comprise: temperature, transparency, pH, dissolved oxygen, and total fecal coliforms. These procedures, however, do not distinguish the potential health risks caused by the presence of pathogenic bacteria. In order to understand the potential pathogenicity of contaminating bacteria in a waterway, our team in the Chemistry and Applied Biological Sciences Department at South Dakota School of Mines and Technology created a novel pathogenicity metric that tests for the presence of approximately 30 known virulence genes. This metric allows for extensive characterization of any sample that we received. Collaborative efforts between our team and the East Dakota Water Development District of Sioux Falls allowed for ten samplings in triplicate over a 17-week period in the spring and fall of 2015. Our samples were taken from six separate sites along the Big Sioux River and Skunk Creek. Once samples were received, the DNA was extracted, amplified via PCR, and separated based on its molecular weight. Of the approximately 30 genes in our panel, six pathogenicity genes were recurrently detected: *stx1*, *stx2*, *VT1*, *VT2*, *eaeA*, and *ehxA*. With these results, we were able to conclude that, based on the abundance, distribution and persistence of these pathogenic genes, the aquatic environments within our sampling area of the Big Sioux Water Basin are contenders for human health risks and cause for disease contraction concern.

#6 Which Macroinvertebrates Consume Didymosphenia Geminata in Rapid Creek?

Matthew Davalos; Chemistry and Applied Biological Sciences Department

Co-Presenter: Russell Marlow; Atmospheric and Environmental Sciences Department

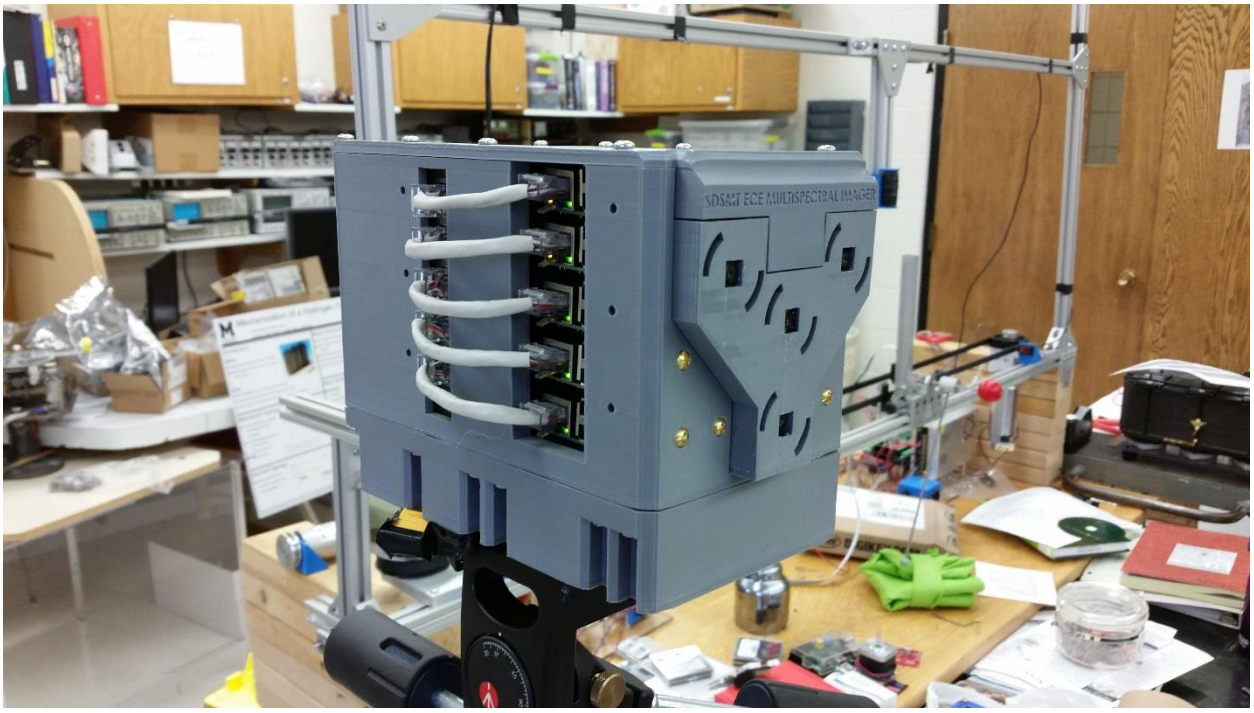
Mentor/Advisor: Dr. Lisa Kunza; Chemistry and Applied Biological Sciences Department

Macroinvertebrate diet selection is an important factor when examining food web dynamics within aquatic ecosystems. *Didymosphenia geminata* is a nuisance alga that creates thick benthic mats that may alter food webs. We sampled macroinvertebrates from Rapid Creek below Pactola Dam in August 2014, and examined the gut contents of the ten families of macroinvertebrates present. *D. geminata* cells were identified in 97 percent of macroinvertebrate gut contents. In a common mayfly, *Baetis*, we found that other benthic resources were preferentially chosen over *D. geminata*, including other diatoms. Mats of *D. geminata* can alter the diet selection of some macroinvertebrates leading to changes within food-web dynamics.

#7 Development of a Low-Cost Multispectral Imager

Conrad Farnsworth; Electrical and Computer Engineering Department

Mentor/Advisor: Dr. Charles Tolle; Electrical and Computer Engineering Department



The need for an imager that is low cost, 3D Printable, and open source has been previously unknown until this project came along. A modular unit capable of being reconfigured on the fly to take images in the near infrared, long wave infrared, visible, and UV spectra has obvious advantages in both agricultural and medical fields. The low cost aspect of this imager would mean that the unit would proliferate to the point where its usefulness would encompass a much larger populous than the general scientific community. Now any location with 3D printers can own a professionally designed unit and use it to further advance their community. The unit was designed, manufactured, and tested within a three month time period and the results were proven to be very successful. The device was able to take images in all four spectra and functioned exceptionally well. Furthermore, much planning was done with this unit that allows it to be upgraded in further revisions as I continue development. The fact that this project is open source (featured on thingiverse.com) means that others can even upgrade this unit for their own use.

#8 Understanding the Effects of Radon Daughter Plate Out on Dark Matter Detectors

Therese Frels; Physics Department

Mentor/Advisor: Dr. Richard Schnee; Physics Department

Radon progeny that have deposited onto sensitive material in a dark matter detector can cause a false positive. Understanding how to minimize radon therefore would benefit dark matter detection.

The Jacobi model predicts radon deposition as functions of environmental parameters. However, there are limitations to the model. This research uses small samples of material to measure the amount of deposition, through the subsequent alpha decays under different conditions. Some of the changes include: changing the position of the sample, changing the air flow, and adding a charge to the sample. A faster air flow causes less radon progeny to plate out. Adding an electric charge to the plate causes a large amount of plate out. Results from this study and their implications for assembly of dark matter detectors will be discussed.

Session P-UG2: 10:15 -12:30 PM Posters #9-17 Ballroom

#9 Solvent Extraction of Thorium and Europium with DEHPA and PC88A

Kathryn Hines; Materials Engineering and Science Program

Mentor/Advisor: Dr. William Cross; Materials and Metallurgical Engineering Department

The object of this research is to study the ion-ligand bond during the solvent extraction process. Specifically, how many molecules of extractant bond to each ion to form the coordination complex. What – and how do – molecules interfere with or change the bonding process. This will lead to a broadening of the understanding of the bond between the extractant and the metal ions, and possibly future development of new extractants. To this end Job's Method of Continuous Variation was applied. All other parameters were kept constant. This will lead to finding the empirical formula of the coordination complex.

At low concentrations of bis-2-ethylhexyl-phosphoric acid (referred to hereafter as DEHPA) and 2-ethylhexyl hydrogen-ethyl hexyl phosphonate (or PC-88A) to Thorium, a white precipitate as a third phase was formed. More trials at lower total molar concentration were performed and no precipitates were formed. However, almost all samples showed 99.99% extraction. Europium samples remained clear with no precipitates. Using Job's Method of Continuous Variation, and because of previous work shown by Annette Hein, a previous REU student, an estimate of 3.3 ligand molecules per europium ion was established. However, more experiments should be performed to verify this number.

#10 Practical Method to Examine the Dynamics of a Three Atom System for a Physical Chemistry Curriculum

Zachery Crandall; Chemistry and Applied Biological Sciences Department

Mentor/Advisor: Dr. Justin Meyer; Chemistry and Applied Biological Sciences Department

A practical method for Physical Chemistry students to examine the dynamics of a three atom system is proposed. This method uses Gaussian chemical modelling software coupled with the WebMO interface to conduct a two variable scan of the bonds in a three atom system, such as Ha – Hb + Hc → Ha + Hb - Hc. The scans are plotted on a 3D surface plot of bond energy in Microsoft Excel. The 3D plots created portray local minima and attractive and unattractive potential energy surfaces that help visualize product formation. Systems can also give insight into the relative strengths of small functional groups, such as thiol and disulfide bonds in the S-S-H system. Students will also learn how to use Excel on a more advanced level, writing Excel or Visual Basic code to manipulate data and immersing themselves in the 3D plot through its extensive plot manipulation tools.

#11 Characterization of Precursor Powders using Microwave Measurements

Nicole Thompson; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. Christopher Shearer; Civil and Environmental Engineering Department

Supplementary cementitious materials (SCMs) are powders commonly used to react with ordinary Portland cement to produce stronger and more durable concrete. SCMs can also be used to react with alkaline solutions to form a hardened structural binder known as a geopolymer. This research seeks to better characterize certain material properties of SCMs, which will allow for better understanding of the mechanisms that occur during the formation reaction of geopolymers. Cement and cementitious replacement materials including slag, silica fume, fly ash, metakaolin, natural zeolites, and lime are analyzed using X-ray fluorescence and X-ray diffraction to determine their elemental and crystalline mineral compositions, respectively. The size and spatial distribution of particles in these powders heavily influence the hydration and mechanisms of reactions, therefore samples are sent for particle size distributions to gain further insight as to the role of porosity within these reactions. Additionally, SCM samples are also characterized using microwave measurements via the filled waveguide technique to determine their dielectric properties including permittivity and loss factor (Bois et al. 1999). The relationships between the chemical and physical properties of the SCMs and their dielectric properties are examined. This information will be useful in developing a model of the geopolymer reaction process, which is the goal of the broader study using microwave materials characterization.

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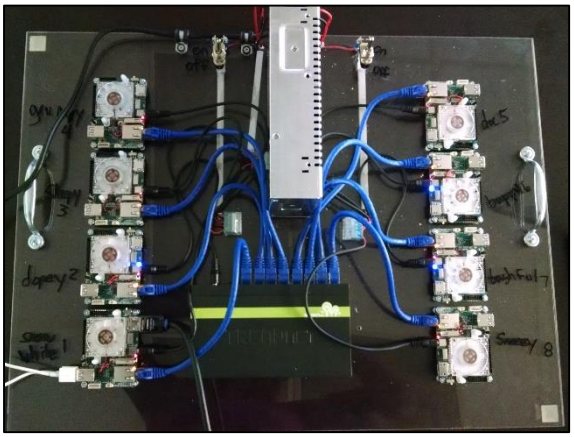
#12 ARM Cluster: The Research Tool

Christine Sorensen; Mathematics and Computer Science Department
Co-presenter: Andrew Hoover

Mentor/Advisor: Dr. Christer Karlsson; Mathematics and Computer Science Department



A common trend in computing over the last few years has been to create more computational power by connecting cheap, less powerful computing platforms into cluster. The initial purpose of this project was to build an ARM cluster of 6-12 homogeneous single board computers to make it the fastest and most efficient in cost and energy with the intention to show a proof of concept.

We decided that the metric to measure efficiency in cost and energy would be the number of floating-point operations per dollar per unit of power. Three types of single board computers were tested: Raspberry Pi 2B, PcDuino, and ODROID XU4. PcDuino was immediately dropped due to problems with the operating system.

An Open Multi-Processing (OpenMP) benchmark was installed on each of the computers running on all cores. In the results of the benchmark, the Raspberry Pi performed best with 0.000217 Gigaflops/Dollar/Watt compared to ODROID's 0.000203 Gigaflops/Dollar/Watt. However, the ODROID XU4 was chosen because bandwidth potential was higher and it ran 7.4 times faster. Eight ODROIDs were purchased and connected in a star topology using an unmanaged switch. To benchmark the cluster, LINPACK, a software that performs numerical linear algebra that is commonly used for cluster benchmarking, was used.

LINPACK utilized Message Passing Interface (MPI) software to run on all cores and computers, testing every combination of number of cores and matrices. The results of the initial benchmarking with communication over Ethernet was 13.38 GFLOPS using all eight cores on all eight devices. This was compared to a standard i7 desktop which benchmarks to 47.5 GFLOPS.

The next stage of this project is to compare the results using Ethernet connection against connections using the other means of communications: Universal Serial Bus (USB) and General-Purpose Input/Output (GPIO). Also, the results of the star network topology the cluster was initially connected in is being compared to the speed of other topologies: ring and hypercube.

The purpose of this project has over time drifted into using the cluster as an education tool. Answering questions such as how computers work, how do we build and setup networks, and how can we communicate between the computers and benchmark the performance? Also, how can we make this a cost efficient educational tool for teaching parallel computing, networks, or assembly, for institutions and organizations that normally do not have access to clusters?

#13 How Does the Difference in Stream Gradient Affect Macroinvertebrate Consumption of Didymosphenia Geminata?

Jack Storm; Chemistry and Applied Biological Sciences Department

Co-presenters: Matt Davalos and Jaime Haueter

Mentor/Advisor: Dr. Lisa Kunza; Chemistry and Applied Biological Sciences Department

Didymosphenia geminata is a freshwater diatom that can produce thick benthic mats of algal biomass in low nutrient rivers. The mats are known to alter diet selection of some macroinvertebrates, which may have ramifications on food web dynamics. Yet little is known about the correlation between gradient and benthic resource availability, and how these might be altered by mats. Lake Creek, the outlet of Phelps Lake in Grand Teton National Park, WY, has *D. geminata* mats which cover up to 95% of the substrate. Lake Creek starts as a high gradient stream, then levels out as it leaves the mountains to become a low gradient stream. We collected samples of macroinvertebrates from both the high and low gradient portions of Lake Creek in July 2014. We identified the macroinvertebrates to the family level and dissected the organisms to examine the gut contents. Comparing benthic resources available and gut contents of macroinvertebrates in each of the stream sections will give insight into the influence *D. geminata* mats have on benthic resource availability and food web dynamics.

#14 Accuracy of Measurements Collected from 3D Virtual Models of Fossils

Madigan Cochran-Bjerke; Geology and Geological Engineering Department

Mentor/Advisor: Dr. Maribeth Price; Geology and Geological Engineering Department

Although 3D virtual modeling has been used with accuracy within the field of archeology, it has not yet been widely implemented within the field of paleontology. There are many benefits of accurately digitizing fossil collections, including the ability to digitally reconstruct damaged specimens, the ability to preserve specimen data in perpetuity, and the ease of sharing rare or fragile specimens. The purpose of this study is to test the accuracy of measurements collected from 3D digital models of fossil specimens. Eight fossils were selected for this project. A high-resolution camera was used to photograph each specimen from multiple angles. Enough photographs were taken of each specimen to create a 3D virtual model of the specimen using AGISoft Photoscan Professional (AGISoft, St. Petersburg, Russia) software. After the models were created, diagrams of the fossils were drawn, showing where to take the measurements. Three measurements will be obtained three separate times from each fossil and each model by at least eight volunteers. One measurement will be based on clearly defined characteristics, one will be based less defined characteristics, and one will be based on poorly defined characteristics. Training on how to take the measurements was provided at each measurement collection session. Each volunteer took the three different measurements three separate times on each original fossil and on the corresponding models. The physical measurements were collected via digital calipers, the model measurements collected via Adobe Acrobat Reader DC (Adobe Systems Incorporated, San Jose, C.A., United States). Rather than taking each measurement three times in a row, each volunteer took the clearly defined measurement, then the measurement based on less defined characteristics, then the measurement based on poorly defined characteristics. They then repeated this sequence until all measurements have been collected three times. This process was chosen to remove the bias of trying to make measurements match. The averages and standard deviations from the 3D models are now being compared to those from the physical specimens. The measurements will be split into different groups and graphed in order to compare:

- Differences in model-measured versus physically-measure values
- Differences in precision between model and physical measurements
- Differences in accuracy and precision for clearly defined versus less defined characteristics
- Repeatability of measurements across volunteers
- Repeatability of measurements for individual volunteers

The differences between the measurements from each group will be examined for patterns to determine if the measurements from the models and the original fossils are statistically indistinguishable. The presence of patterns may identify biases or issues that are unique to model or physical measurements, or are endemic to both.

#15 Electronic HF Signal Adding for Newly-Developed Alpha-Beta-Radiation-Screener

Benjamin Lynch; Physics Department

Mentor/Advisor: Dr. Juergen Reichenbacher

A large volume alpha-beta-radiation-screener built with new ultra-low background assembly techniques will allow for a sensitivity 100 times better than the current world record. Moreover, surface scans of large objects of various sizes and shapes can be performed, bypassing the common practice of damaging the objects in order to alter their shape and size to fit small flat bed screeners. The large two feet cubed vacuum chamber is equipped with multiple silicon wafer detectors with joint electronic read-out to save costs. The design of the new screening system is optimized to monitor surface deposition of critical long-lived radon daughters. These inevitably come from natural radon in the ambient air during the construction of large detectors for neutrino and dark matter searches. Since the sensitivity of commercialized alpha-screeners, usually used for monitoring radon daughter deposition, is lower than that required for dark matter and neutrino experiments by orders of magnitude, a new system has to be developed. The new alpha-beta-radiation-screener is ideally suited for quickly measuring large samples of various sizes and shapes, a 100 times better sensitivity and implementing new innovative background suppression techniques that will push the limit on lowest achieved backgrounds for dark matter and neutrino experiments. Electronic signal amplifying units and data acquisition channels are very expensive. Using only one unit by adding the signals of each silicon wafer detector such that only one amplifying unit and only one data acquisition channel are required, will provide very substantial savings. The necessary signal adding box are constructed within the framework of this physics design project. Necessary test circuits are probed and Spice simulations are conducted in order to identify the optimal circuit configuration.

#16 Caspar

Lucas Lindholm; Physics Department
Co-presenter: John Harrison; Physics Department

Mentor/Advisor: Dr. Frank Strieder; Physics Department

Where do elements come from? Why are some rarer or more common than others? The Compact Accelerator System Performing Astrophysical Research, CASPAR, will help answer these questions. Throughout the known universe, the relative rareness of elements that we see in our solar system holds true. This rarity is too consistent to be a coincidence, it must be explained by our models concerning the origin of matter. First, there was the big bang. As it cooled down, protons and eventually hydrogen formed. This hydrogen then formed stars, and those stars formed heavier elements in their cores through fusion. Heavier elements could not form by fusion though. CASPAR will study the stellar production, or nucleosynthesis, of these heavier elements.

About half of the elements beyond Iron are formed around stars larger than our sun in the s-process (slow neutron process). The neutron sources for the s-process are Neon-22 and Carbon-13. In order to fully understand the origin and rarity of heavier elements, such as copper and gold, we need to understand the s-process, and thus, the decay of Neon-22 and Carbon-13.

The study of these reactions at actual stellar energies has proved problematic. Because of the cosmic ray induced background, we have not yet been able to directly measure the reaction rates in this energy range and rely instead on extrapolations and theoretical predictions.

By going deep underground, CASPAR can escape this background noise. A one mega electronvolt accelerator that was hauled 4850 feet underground will fire alpha particles first at Neon-22 and later at Carbon-13. These alpha particles will cause the release of neutrons just like stellar s-process reactions. We will then capture the reaction products and find the energies and probability of the reaction. The data we gather will account for the current distribution of elements in the universe, will give us better insight into the origin of the elements, and will in turn be an important piece of our understanding of the history of the universe.

Currently, CASPAR is still being set up with an operational goal of late Spring 2016. The windowless gas target has been tested on the SD Mines campus, and is currently being transported underground. Once underground, the target will be integrated to the accelerator and beam line, shown in the subsequent image. Following successful testing and calibration, CASPAR will begin to uncover the details in the stellar origin of heavy elements.

Downstream CASPAR's beamline at 4850 ft - Sanford Underground Research Facility

#17 Presence and Abundance of Didymosphenia Geminata in Grand Teton National Park

Emily Stickney; Chemistry and Applied Biological Sciences Department

Mentor/Advisor: Dr. Lisa Kunza; Chemistry and Applied Biological Sciences Department

Didymosphenia geminata is a nuisance alga that is altering some of the most low nutrient streams and rivers in the world. In 2008, we surveyed and sampled 24 streams within Grand Teton National Park, WY and surrounding areas, and 7 had cellular presence of D. geminata. Many of these streams are found in areas that see high levels of foot traffic. However, cells alone have not made this diatom a nuisance, it is the thick benthic mats of stalk material that it secretes. Lake Creek exhibited the presence of visible D. geminata mats, Taggert Creek had minimal mat buildup, while Flat and Fish Creeks had just a few tufts of mat material. We re-sampled 20 streams in 2015 and found D. geminata mat material in 9 streams. D. geminata mat prevalence increasing within Grand Teton National Park may lead to further research on shifting land use and environmental conditions in the area.

Poster Presentations – Graduate Students

Session P-G1: 8:00-9:30 AM Posters #30-35 Ballroom

#30 Combustion Characteristics of W/MnO_2 as an Environmentally Friendly Time Delay System

Joshua Koenig; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Lori Groven; Chemical and Biological Engineering Department

Current fielded delay formulations face increased scrutiny due to their environmentally hazardous components (i.e., $BaCrO_4$, $PbCrO_4$, and $KClO_4$) and there is an immediate need for viable replacements. Previous work in this area has explored various alternate compositions such as metal/metal oxide systems, intermetallics, or metalloid/metal oxide. However, in many cases these alternate systems could not serve as a true replacement due to gas production and or lack of tailorable burn times. In this work, the W/MnO_2 system is explored based on our previous promising results for Mn/MnO_2 system. The delay performance and reaction kinetics parameters are examined at similar diameters to common delay housings. For example, for 0.635 mm diameter pellets inverse burn rates ranging from 6.06 s/cm to 15.03 s/cm have been observed for 70/30 wt% W/MnO_2 and 40/60 wt% W/MnO_2 formulations respectively.

#31 A Review on Ionic Liquids in Extractive Metallurgy

Jennifer Galvin; Materials Engineering and Science Program

Mentor/Advisor: Dr. M. Sadegh Safarzadeh; Materials and Metallurgical Engineering Department

The extraction of many non-ferrous metals from ores, including oxides, sulfides, and silicates, traditionally involves the leaching of minerals in acid or alkali reagents, often followed by solvent extraction to selectively recover the valuable metals. However, the waste from these processes is hazardous and causes damage to the environment. Recently, environmentally-friendly alternatives have been explored, with one of the most promising methods appearing to be extraction using ionic liquids (ILs). ILs are made up of an organic cation and either an organic or inorganic anion. These can be individually selected to create unique, specialized ILs for specific tasks. Imidazolium ILs have been investigated for leaching of metals such as gold, silver, and base metals [1]. The cation of this type of IL has a ring of three carbons and two nitrogens, with an alkyl group attached to each of the two nitrogen atoms [2]. These could potentially serve as a replacement for cyanide, which is highly toxic and creates many potential hazards for health and environmental safety. Results for both oxidic ores and sulfidic ores have shown this IL to be a promising alternative [1]. The method of solvent extraction to separate and concentrate metals involves the use of organic solvents and extractants that are toxic, flammable, and damaging to the environment. ILs, on the other hand, are typically non-flammable, non-volatile, and have been found to be effective in many solvent extraction applications [2]. ILs have also been studied for recycling processes that are traditionally performed through acid leaching followed by solvent extraction. Because phosphates are not readily leached by the majority of ILs, these can be used to selectively extract valuable oxides. One practical application of this is the recycling of fluorescent lamps, where the valuable rare earth oxides could be extracted, leaving behind the much less valuable halophosphates [3]. While more research is needed into the practical implementation of ILs in extraction of non-ferrous metals, ILs appear to be a promising environmentally-friendly alternative to several processes that are in use currently. Their low flammability, high-thermal stability, and low vapor pressure make ILs a likely candidate for a “greener” future in extractive metallurgy.

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2. Han D, & Row KH. (2010). Recent applications of ionic liquids in separation technology. *Molecules (Basel, Switzerland)*, *15*(4), 2405-26.

3. Dupont, D., & Binnemans, K. (2015). Rare-earth recycling using a functionalized ionic liquid for the selective dissolution and revalorization of Y2O3:Eu3+from lamp phosphor waste. *Green Chem*, *17*(2), 856-868.

#32 Nanoparticle Synthesis for the Treatment of Lung Cancer

Amber Jerke; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Timothy Brenza; Chemical and Biological Engineering Department

Lung cancer remains the leading cause of cancer deaths in the United States. The overall five-year survival rate is only 18.0 percent regardless of stage at diagnosis[1]. For comparison, the overall five-year survival rate for breast cancer and prostate are 89.6 percent and 98.9 percent, respectively. Treatment for this disease includes surgery, radiation therapy, chemotherapy, or a combination of the three with chemotherapy being the most common. Unfortunately, these treatments have had little to no impact on relative survival as rates have only increased a mere 6.2 percent since 1975. Additionally, the drugs used in chemotherapy require frequent bolus doses and the systemic administration of these drugs results in many off-target effects such as hair loss, nausea, and fatigue.

Nanoparticles delivered intravenously have been shown to enhance efficacy of chemotherapeutic treatment in some forms of cancer[2]. Due to their small size, nanoparticles less than 200 nm are able to preferentially accumulate in cancer tissue via the enhanced permeability and retention (EPR) effect[2]. This allows the cancer to be treated locally versus systemically thereby minimizing interaction with healthy tissue and reducing off-target effects. Nanoparticles can be further tailored by altering targeting moieties, material, and drug payload. Targeting ligands attached to the particle surface allow for further localization and potential enhancement of cellular uptake. Whereas the drug release characteristics can be controlled by modifying the material composition allowing for sustained drug release over time versus a bolus dose once a week to several times a week.

Despite these promising benefits, nanoparticle based drug delivery devices are typically produced in small batches to ensure consistency in biological behavior and pharmacological profiles. This research will show the characterization and optimization of flash precipitation nanoparticle preparation. Optimization factors investigated include solvent to anti-solvent ratio, stir rate, and injection flow rate. Response measurements include dynamic light scattering (DLS) and scanning electron microscopy (SEM) for nanoparticle characterization, and therapeutic encapsulation efficiency and therapeutic release profiles by ultraviolet/visible light absorption (UV/Vis). To take advantage of pulmonary access to the lungs, future work will include developing this technology into an inhalable formula.

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#33 Development of an in Vitro Model of the Respiratory System

Jordan Hoops; Biomedical Engineering Program

Mentor/Advisor: Dr. Timothy Brenza; Chemical and Biological Engineering Department

Lung disease is a major burden on the United States and global community. Diseases such as asthma, chronic obstructive pulmonary disease, pneumonia, and lung cancer are major causes of death and economic loss. In the US alone, 39.5 million people suffer from asthma and 12.7 million from COPD. Respiratory diseases have direct costs of $97.7 billion in hospital stays, medications, and primary doctor visits. Therapeutics by pulmonary administration offer targeted treatment for these illnesses with advantages not present in other routes of administration. Pulmonary administration avoids first-pass metabolism, eliminating distribution to unnecessary tissues and consequent side effects. Certified caregivers and needles are not required to administer the therapeutics, resulting in increasing patient compliance and reducing costs of treatment.

However, current methods of studying particle interactions with the respiratory system utilize *in vitro* and *in vivo* animal models, which are difficult to extrapolate into predictions of response in the human respiratory system. Typical preclinical models involve rats, mice, guinea pigs, and nonhuman primates, which have different modes of breathing and species-specific airway geometry. Thus, there is a need to develop a more physiologically-relevant *in vitro* model of the human respiratory system to be used in improved drug delivery development. In this work, we are developing models of the respiratory system using multiple human cell types. To mimic airway epithelial and alveolar epithelial cells, CALU-3 and A549 cell lines will be utilized. Culturing conditions of the epithelial cells will be optimized to obtain confluent polarized monolayers of cells. Characterization of cell lines include formation of functional tight junctions, by both florescence microscopy and transepithelial electrical resistance (TEER), secretion of mucus and surface proteins and diffusion of substances across these epithelial barriers.

Once developed, we can monitor these parameters for applications in drug delivery, occupational and environmental hazard studies, and reconstruction of the respiratory system in tissue engineering.

#34 The Influence of Particle Size on Particle/Air Partitioning of Phthalates

Kristen O'Connor; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. Jennifer Benning; Civil and Environmental Engineering Department

Semi volatile organic compounds (SVOCs) are widely utilized in manufactured products intended for homes and other indoor environments. Biomonitoring has indicated a high incidence of human exposure to these chemicals in indoor environments. High exposures combined with evidence of links between SVOCs and health disorders, such as asthma, allergies, endocrine disrupting behaviors, and even neurological diseases, have raised concerns in the scientific community. However, the nature of the transport of SVOCs from sources to human uptake are still not well characterized. Literature indicates that SVOC-particle interactions play a critical role in the transport of SVOCs from sources to humans. In this investigation, the influence of particle size on the emissions and partitioning of di-2-ethylhexyl-phthalate (DEHP) will be measured in coiled tubular chambers saturated with DEHP. Ammonium sulfate monodisperse particles will be introduced into the chamber at diameters of 10, 15, 20, 25, 30, and 35 nm using an electrospray aerosol generator. The inflow and outflow of particles will be measured intermittently using a nano particle sizer. The outflow from the chamber are sampled and analyzed using a thermal desorber and gas chromatography mass spectrometer system. Particle interactions will be quantified as the partitioning coefficient, which was calculated using the gas phase DEHP concentration, the particle phase DEHP concentration, and the total particulate mass concentration. The results of these investigations will further understanding of the role of particles on the emissions and transport of SVOCs and will improve comprehensive exposure assessments.

#35 The Effect of Organic and Inorganic Particle Type on Diethylhexyl Phthalate Emission Rate

Kimberly De Boer; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. Jennifer Benning; Civil and Environmental Engineering Department

Reducing the air exchange rate in homes benefits the environment, as it increases the energy efficiency of homes. Unfortunately, homes with low air exchange rates have higher concentrations of hazardous chemicals such as semivolatile organic compounds (SVOCs) like diethylhexyl phthalate (DEHP), emitted from products in the indoor environment, to the air [1]. In one study, Benning et al. [2] finds that DEHP is emitted at higher rates in the presence of particles than when there are no particles present. A later study found a correlation between the amount of SVOCs in the air in homes with a higher concentration of particles in the air [3].

In order to more precisely characterize the relationship between DEHP emissions and the presence of particles, experiments will be run using parallel tubes laden with DEHP. To measure the difference between gas-phase and particle-phase DEHP emitted from the tubes, one tube will have a filter before sampling to prevent collection of particle-phase DEHP. The other tube will have no filtering before sample collection and collect both gas-phase and particle-phase DEHP emissions. A TSI Model 3480 electrospray aerosol generator will be used to introduce particles into the tubes with nitrogen gas added to create sufficient flow. Particle type will be varied between organic and inorganic particles and normalized by surface area of particles. The DEHP emissions will be collected with Tenax tubes and measured with thermal desorption coupled with a gas chromatograph/mass spectrometer (GC/MS). Because DEHP is an organic material, organic particles are expected create higher DEHP emissions.

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Session P-G2: 9:30-11:00 AM Posters #36-41 Ballroom

#36 Development of Pyrotechnic Formulations for Deep Bore Well Plugging

Kuanysh Kuramyssova; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Lori Groven; Chemical and Biological Engineering Department

Current interest in deep borehole CO_2 sequestration and nuclear waste disposal challenges the traditional plug and abandonment technology due to high hydrostatic and lithostatic pressures, high mineral content water, and geothermal gradient. In this work, we explore the development of pyrotechnic formulations to serve as a potential well sealing technology that would offer high corrosion resistance, service temperature, low permeability, and mechanical strength unattainable with the conventional methods. The stoichiometric Al/Fe_2O_3 thermite system was diluted 20-50 wt.% with silica, soda-lime glass, wollastonite, and albite in the starting mixture. Average propagation velocities for silica and soda-lime glass diluted systems varied from 0.8 - 32.9 mm/sec and 0.5 - 14.9 mm/sec, respectively. Average peak temperatures for silica diluted systems were 1354 - 2380 K. For soda-lime glass systems average peak temperatures were 1853 – 2358 K, excluding the 50 wt.% soda-lime glass formulation. The microstructure of self-propagating high-temperature synthesis products varied with the type of additive in the starting mixture and combustion peak temperature. The reaction kinetics of each diluted Al/Fe_2O_3 system were determined using the Boddington method.

#37 Smart Energetics: Harnessing Piezoelectric Behavior

Sara Row; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Lori Groven; Chemical and Biological Engineering Department

Switchable or smart materials generally incorporate the manipulation of the piezoelectric properties present in many polymers [1]. Polymers such as polystyrene, Dyneon THV (tetrafluoroethylene hexafluoropropylene vinylidene fluoride) and Kynar Flex PVDF (poly vinylidene fluoride) are examples of such materials, with the addition of a current the polymer can be activated or "turned on" [1,3]. This technology is currently used in devices such as nano-generators and nano-sensors. In this work, such materials are explored with the addition of micron and nanoscale aluminum to form an energetic material that can be switched or sensitized. Using a thin film configuration (spin coated) capacitance was measured over a range of applied force demonstrating clear piezoelectric behavior for these energetic films. The effect is most strongly observed in materials where β-PVDF is observed via X-ray diffraction or that have a relative high level of amorphous structure. In our data this corresponds to formulations where Dyneon THV is used. The ability to sensitize these materials electrically and mechanically will be discussed in more detail.

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#38 Development of Optimal Fiber-Reinforced Shotcrete Mix Design for Use in Sanford Underground Research Facility

Nicholas Claggett; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. Christopher Shearer; Civil and Environmental Engineering Department

Shotcrete, a process by which concrete is pneumatically applied to a surface, has been used extensively in the mining industry for both underground and surface applications for nearly a century, but emerging technologies, including the development of macrosynthetic fibers, are enabling revolutionary changes in the performance and application of shotcrete mixtures (Clements and Bernard 2004). The Sanford Underground Research Facility (SURF) in Lead, SD has encountered several problems with their use of conventionally reinforced shotcrete and is interested in the development of a superior shotcrete mixture. This research aims to develop an optimal shotcrete mixture design which will perform satisfactorily without the need for steel wire mesh. The research has examined the effect of supplementary cementitious materials including fly ash and silica fume, aggregate ratios, admixtures, and fiber lengths on compressive strength and permeability (as measured indirectly by resistivity) of the concrete. Future research will examine the effect of varying fiber lengths and fiber dosages on shotcrete characteristics including flexural and compressive strength and shrinkage. Specifically, the mix design process seeks to address a gap in the current body of knowledge of fiber reinforced shotcrete (FRS) by characterizing the mechanical behavior of FRS with lengths of fibers ranging from 0.75 inches to 2.25 inches. The research will culminate with the creation of a field test site at Homestake Mine which will evaluate the performance of the shotcrete by comparing it to a conventionally reinforced mix using in situ characteristics including rebound, displacement over time, and crack development. A computer modeling program *Phase*^{2} will be used to simulate the performance of the rock and shotcrete using information obtained from the test site and lab data.

Works Cited:

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#39 Accurate Specimen Placement for Dielectric Measurements in a TM0n0 Cylindrical Cavity

Colen Kling; Electrical and Computer Engineering Department

Mentor/Advisor: Dr. Lori Groven; Chemical and Biological Engineering Department and Dr. Keith Whites; Electrical and Computer Engineering Department

The use of a specimen holder in a TM0n0 cylindrical resonant cavity for measuring the complex permittivity of materials is explored. This method uses a foam form to accurately place potentially small sized specimens inside of a cavity. The effects of using the specimen holder for measurements and permittivity extraction are examined. Measurements of a well known dielectric material are presented to show that accurate results can be obtained with the specimen holder.

This research seeks to achieve accurate specimen placement without negatively affecting measurement accuracy. Resonant methods are used to measure low loss materials because these systems can obtain high Q values [1]. The loss tangent resolution of a resonant system depends on the Q value: typically the larger the Q value, the higher the resolution [2]. The introduction of a material to the resonator will usually lower the Q value compared to when there is no material present, and this change in Q along with the resonant frequency can be used to calculate the complex permittivity of the material [3]. The additional loading due to the specimen holder, as shown here, can be taken into account when calculating the complex permittivity allowing the material properties of only the specimen to be found. The applicability of the specimen holder reviewed here is validated through the measurement of a pressed Teflon powder specimen. An important application of this method is measuring different low loss dielectric materials where a small specimen size is required; for example, this research group used it to measure the electromagnetic properties of energetic materials.

#40 Development of a Novel Soil-Foundation-Structure Interaction Modeling Approach for Large Diameter Piles Subject to Fault Displacement

Omololu Ogunseye; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. Bret Lingwall; Civil and Environmental Engineering Department

Surface fault rupture imposes large displacement hazard upon structures that straddle them, resulting in damage to structures and utilities in active fault zones. Structures behaved differently in response to fault rupture displacement from evidence obtained by field observations of earthquake events; both satisfactory and unsatisfactory performances (Bray, 2001). Figure 1 is an example of a structural displacement imposed by fault rupture. The satisfactory performances, which is resistance to damage provided the motivation for further research on fault rupture propagation and structural response to the imposed displacement. Although surface fault rupture has been modeled successfully in the past by others (Oettle *et. al*, 2013), there are uncertainties with the interaction of fault rupture, foundation and structure, especially with large diameter pile foundations which are common in bridges, tall buildings and towers carrying high power transmission lines. Case histories data available are post-earthquake event data (Gazetas and Anastapoulos 2008).

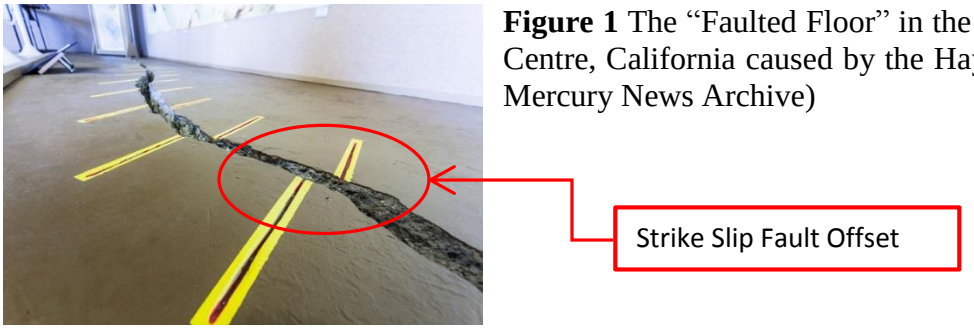

Figure 1 The "Faulted Floor" in the Fremont Community Centre, California caused by the Hayward Fault (**Source**: Mercury News Archive)

For this research, the goal is to develop a soil-foundation-structure interaction modeling approach for large diameter pile foundations which are subjected to large displacements. Fault rupture propagation through soil and foundation interaction will be modeled using a continuum approach and validated by comparing observed behaviour of large diameter reinforced and/or cased concrete piles with experimental and full-scale field data available in the engineering literature. The selection of the constitutive model and input parameters will be discussed. In addition, soil-pile interaction will be modeled and validated by available experimental p-y data for different soil types. Severe nonlinearity is expected in the soil and the structural pile. Finally, the synthesis of the distinct model attributes will produce a representative "cohesive" model that can show correctly the interaction between surface fault rupture and large diameter pile foundations.

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#41 Development of Sustainable Materials Using Paper Mill By-product

Hyo in Lee; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. Soonkie Nam; Civil and Environmental Engineering Department

As the world becomes more environmentally aware, sustainable engineering is of ever growing importance. One important area that has a large potential to be impacted by this increased demand is the construction market. Sustainable, or more environmentally friendly construction materials would find a large market demand if they could maintain the strength and reliability of current materials while maintaining a comparable cost.

The aim of the present research is to find a sustainable replacement for concrete. Total replacement is likely impossible, so for the time being, the focus will be on aggregate materials that can be added to concrete. One such material that is being considered is paper mill byproduct. This product currently has no uses. To turn this waste into a potentially useful material, it will be added to concrete in concentrations of 5%, 10%, and 15% by composition. The compressive strength of these mixtures will be compared to 100% concrete through the use of a load test. In addition to this, since this byproduct is an organic material, it will decompose, consequently the compressive strength of the materials will be measured every six months for 24 months to determine the effect of the decomposition of the byproduct on the compressive strength of the concrete.

As this work has not been done yet, the results can only be speculated. It is possible that any significant amount of paper mill byproduct that is added to concrete may critically affect the strength, making it unsuitable for typical construction projects. It is also possible that some percentage compositions are above the minimum strength required for typical uses of concrete, making it suitable for replacement of concrete. If this is the case, the strength may deteriorate over time, causing the material to be unsuitable for permanent structures, but it may find a use in temporary structures.

Session P-G3: 11:15-12:45 PM Posters #42-47 Ballroom

#42 Identification of Bacterial Genes that Encode Antibiotic Resistance in Selected Areas of the Big Sioux River

Ashley Preston; Biomedical Engineering Program

Mentor/Advisor: Dr. Linda DeVeaux; Chemistry and Applied Biological Science Department and Dr. Lisa Kunza; Chemistry and Applied Biological Science Department

Bacteria have many innate as well as acquired mechanisms that enable survival to antimicrobials. Selective pressures, such as antimicrobial use in human health treatment and animal production, lead to increased levels of resistance in bacterial communities. This raises particular concern in environments with high levels of bacteria where ingestion by humans is a possibility, such as in recreational waters.

Many waterways across the U.S. are listed as impaired for fecal coliform and *E. coli;* it is important to understand the risk to human health from exposure to these waters. Bacteria are the cause of this public health concern as some harbor genes for human disease. The more "virulence factors" a single bacterium contains, the higher the potential for causing severe illness. Adding to this concern is the ability of bacteria to share genes across species through "horizontal gene transfer". Pathogenic bacteria also expressing antimicrobial resistance are an even greater threat, as infections are harder to treat with commonly used antibiotics.

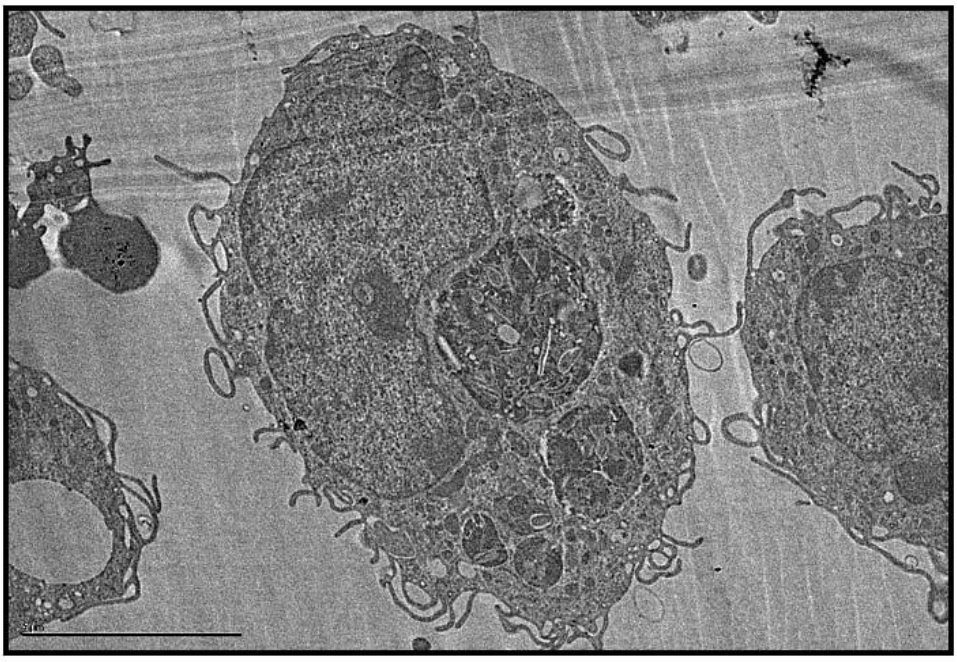
Many sections of the Big Sioux River, in eastern SD, are listed as "impaired" for fecal coliforms and *E. coli*. We have developed a method to screen the entire bacterial population present in water for potentially harmful genes, and have found that many genes common to enterohemorraghic *E. coli* are present in these waters (See Murray, DeVeaux, and Kunza research). The presence of antibiotic resistance genes in these same populations would increase the potential for creating a "superbug" resistant to eradication efforts. We will be extending our current panel to include families of antibiotic-resistance genes to further examine the human health risk associated with the entire bacteria community in this particular body of water. Understanding the source of antibiotic resistant bacteria and associated health risks may lead to improved monitoring and remediation efforts for bacteria in the future.

#43 TEM Imaging and Tomography on Phagocytosis of Macrophages

Ishara Ratnayake; Nanoscience and Nanoengineering Program

Mentor/Advisor: Dr. Phil Ahrenkiel; Nanoscience and Nanoengineering Program and Dr. Steve Smith; Nanoscience and Nanoengineering Program

Macrophages are a type of white blood cell that engulf and digest foreign substances, microbes, and cancer cells in a process called endocytosis, so macrophages act like scavengers. They are constantly roaming around, searching for and destroying dead cells and foreign particles that don't belong in the body. The first part of my research will be focused on TEM imaging and tomography of macrophages. Our research group focuses on understanding the clathrin-mediated endocytosis process of macrophages. The TEM tomography of macrophages would give a clear idea about the endocytosis process as well as the structure of the cell. In order to get a sound knowledge about the TEM specimen preparation and TEM imaging, currently I am working on liquid macrophage samples prepared by our collaborators at South Dakota State University. Starting from fixed macrophages in PBS buffer, my plans is to investigate the most suitable procedure for making TEM thin specimens and successively obtaining high-quality TEM images. After gaining some experience, I am planning to apply this procedure to conduct the TEM tomography of macrophages.



#44 Optimization of Lactic Acid Production Through Strain Improvement of Enterococcus faecalis CBRD01

Bikram Upadhyaya; Biomedical Engineering Program

Mentor/Advisor: Dr. Linda Deveaux; Chemistry and Applied Biological Sciences Department

Currently, lactic acid is the most promising starting material for chemical synthesis and transformations due to the presence of adjacent and highly reactive carboxylic and hydroxyl groups. Lactic acid in food products usually serves as either a pH regulator or a flavoring agent, and is used in a wide range of food applications such as yogurt, bakery products, beverages, meat products, confectionery, dairy products, salads, dressings, ready meals, etc. Traditionally, the industrial lactic acid production has been performed by fastidious lactic acid bacteria such as *Lactobacillus* that require expensive nutritional components for lactic acid metabolism. In addition, the neutral pH requirement for growth and lactic acid production by *Lactobacillus* sp. results in additional costs for lactic acid recovery related to environmental concerns. Therefore, there is a growing need for development of acid-tolerant microorganisms that are capable of lactic acid production at rates and yields similar to those of the traditional, neutral-pH lactic acid processes, and without the need of neutralization and acidification. This would contribute to lower costs and significantly reduce the environmental footprint of lactic acid and products made from it.

Although lactic acid production has been well documented, improved production parameters that lead to reduced production costs are always of interest in industrial developments. A novel homolactic acid fermentative, non-fastidious and robust bacterium was recently isolated that is capable of producing increased levels of high-purity lactic acid at high yields, titers, and productivity rates. The isolate was identified as *Enterococcus faecalis*, deposited with the American Type Culture Collection, its full genome was sequenced, and the isolate *E. faecalis* CBRD01 was deposited with the American Type Culture Collection (ATCC) with a patent deposition designation PTA-12846. The objective of this work was to lower the optimal pH for growth for the organism closer to the pK_a of lactic acid of 3.8 using "directed evolution" while retaining the ability of the strain to produce high levels of lactic acid. We used strain improvement through directed evolution as an efficient approach for creation of industrial strains as productivity is often limited by strain's inability to tolerate extreme environmental conditions such as acidity, temperature and metabolite concentration.

In this work, error-prone whole genome amplification (EP-WGA) of *E. faecalis* CBRD01 is being employed to generate populations with subtle improvements in pH tolerance. In WGA, short, random oligonucleotide primers are used to prime PCR with the genome of the organism as the template. By using a non-proofreading polymerase, fragments are generated with random nucleotide changes introduced. These fragments are then re-introduced into the organism to be modified using electroporation, with subsequent selection or high-throughput screening for the desired traits. Major findings will be presented and discussed.

#45 Methane production from CRUDE Residue

Aditi David; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Rajesh Sani; Chemical and Biological Engineering Department

Global warming and related environmental concerns have compelled us to develop a robust green technology for eliminating the utilization of conventional fossil fuels. Replacement of conventional fuels is possible only by producing the energy through alternative eco-friendly methodologies. Thermophilic anaerobic digestion (TAD) of waste disposal is one such option which fulfills most of the sought after criteria. Complex mixture of gases (mainly composed of methane; CH_4) generated through TAD can be used directly (*viz*. for heating and burning) and also act as precursor for other commercially viable energy products (*viz*. methanol, butanol *etc*.). Production of liquid biofuels through anaerobic fermentation (AF) technology is also a reliable classical approach. However, emergence of zero organic waste concept, instigated us to combine the AF process with TAD step for CH_4 production.

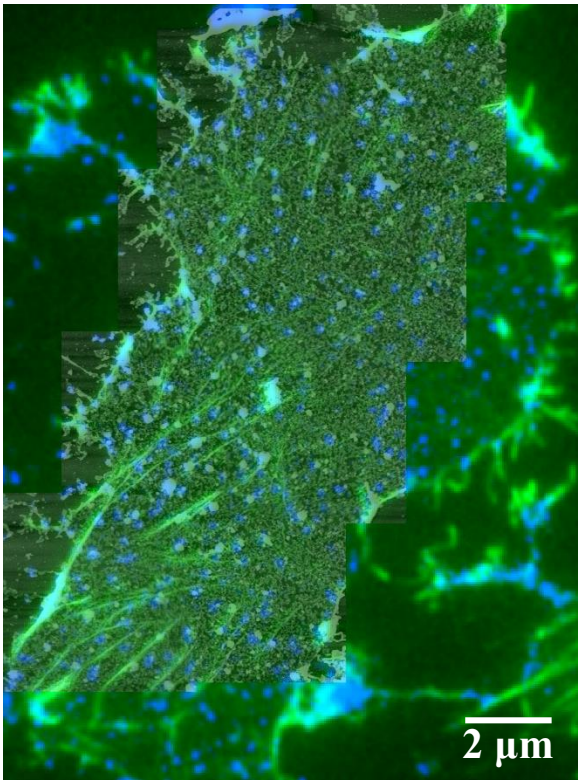
By following zero organic waste concept, we have combined the in-house optimized TAD process (novel thermophilic methanogenic consortia) with in-house developed CRUDE (Conversion of Raw and Untreated Disposal into Ethanol) process (using *Thermoanaerobacter* spp.) for CH_4 production from food & paper waste. The inoculum for TAD was obtained from Waste Water Reclamation Facility. Organic residue of CRUDE process generated ~60mL CH_4 well within 20 days (60^oC; 150 rpm; pH). These data suggest that secondary wastes from the ethanol production process (CRUDE process) do have lots of organic carbon, which could be digested by our thermophilic methanogenic consortia to produce methane. Further optimization of TAD of the CRUDE residue is being done to for higher methane levels and more complete volatile organics utilization.

#46 Correlated Fluorescence-Atomic Force Microscopy Studies of the Clathrin Mediated Endocytosis in SKMEL Cells

Amy Hor; Nanoscience and Nanoengineering Program

Mentor/Advisor: Dr. Steve Smith; Nanoscience and Nanoengineering Program

Clathrin-mediated endocytosis is one of the central pathways for cargo transport into cells, and plays a major role in the maintenance of cellular functions, such as intercellular signaling, nutrients intake, and turnover of plasma membrane in cells. The clathrin-mediated endocytosis process involves invagination and formation of clathrin-coated vesicles. However, the biophysical mechanisms of vesicle formations are still debated. Currently, there are two competing models describing the membrane bending during the formation of clathrin cages: one involves the deposition of all clathrin molecules to the plasma membrane, forming a flat lattice prior to membrane bending to form clathrin vesicles, whereas in the second model, membrane bending happens simultaneously as the clathrin arrives to the site to form a clathrin-coated cage. We investigate clathrin vesicle formation mechanisms through the utilization of atomic force microscopy for high resolution topographical imaging, combined with fluorescence imaging to definitively label intracellular constituents with specific fluorescent fusion proteins (actin filaments labeled with green phalloidin-antibody and clathrin with the fusion protein Tq2) Results from our work are compared against dynamical polarized total internal fluorescence (TIRF) and transmission electron microscopy (TEM) to draw conclusions regarding the prominent model of vesicle formation in clathrin-mediated endocytosis.



#47 The Growing Dead: Zombies and Persistence

Elizabeth Jensen; Biomedical Engineering Program

Mentor/Advisor: Dr. Linda DeVeaux; Chemistry and Applied Biological Sciences Department

Persistence is defined as a small fraction of bacterial cells in a population that have the ability to survive treatment from several types of antibiotics without undergoing genetic change to do so. Contrary to antibiotic resistance, which allows the resistant cells to grow despite the presence of antibiotics; persisters appear to enter a "zombie" like state and not grow in the presence of antibiotics. When an antibiotic resistant culture is inoculated into fresh media with the resistant antibiotic, the culture will grow as before. However, when a persister culture is inoculated into fresh media, the same cells that were persistent in the first culture may not be in the second. Persistence is a transient state and persister cells have the ability to "switch" back to wild type growth when conditions are favorable. Persistent cells are known to have altered cellular metabolism. In this way persister cells have been compared to zombies. They are not dead but are performing the minimal cellular processes necessary to stay alive in this altered state. An altered metabolism combined with altered levels of the normal toxin-antitoxin genes are known to contribute to persister formation. If the cell has an increased toxin to antitoxin ratio, the cell will enter the persistent state. If the antitoxin does not neutralize the increased toxin levels, the cell will remain in the persistent state and ultimately die. However, increased antitoxin levels have proven to prevent the cell from entering the persistent state, leaving them susceptible to antibiotics. I am working to understand how persistence affects growth cycles and then alter the amount of persisters that form in *Deinococcus radiodurans*. *D. radiodurans* is a non-pathogenic extremophile whose persister cells can be viewed after exposure to ionizing radiation as well as antibiotic exposure. Using plasmids containing solely the antitoxin or the toxin, over-production of one or the other can be induced and the amount of persisters that form can be quantified. Plotting growth curves of these plasmids separately can confer an understanding of how persisters affect the growth rate of the organism. One way that the toxin to antitoxin ratio gets out of balance is through increased degradation of the antitoxin by the Lon proteases. The Lon family of proteases are ubiquitous in nature, having been found in both prokaryotes and eukaryotes. In prokaryotes, they are regulatory proteases that degrade short lived proteins. One such protein they degrade is the antitoxin protein that contributes to persistence formation. In *D. radiodurans*, two genes code for the Lon homolog. Using overlap extension PCR, these genes can be deleted and the effect of this deletion on persister formation can be measured

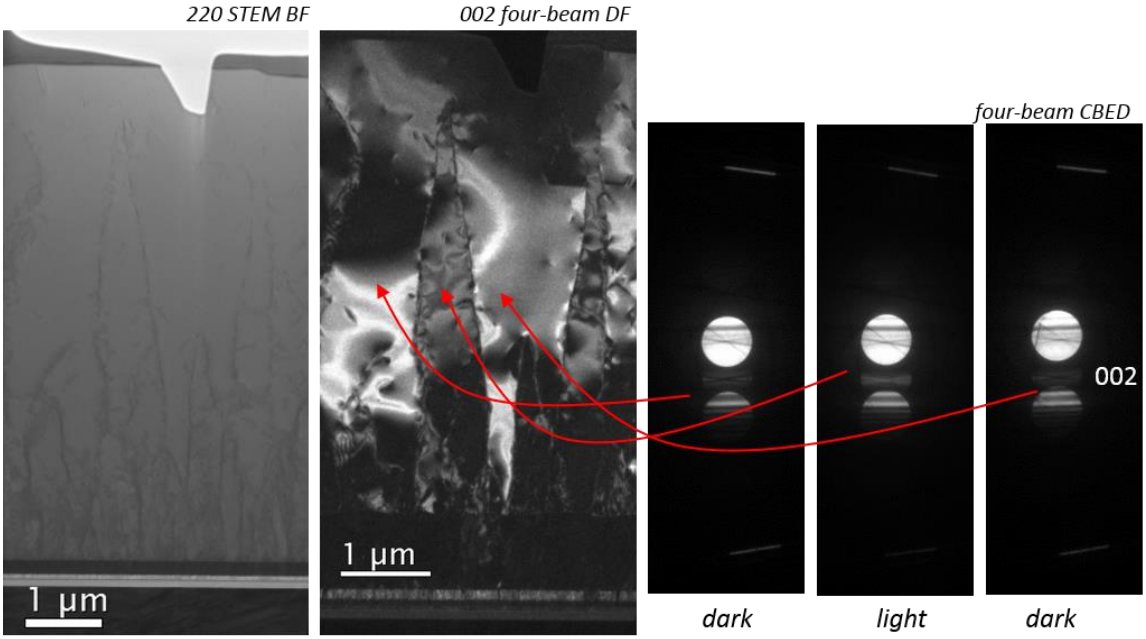
Session P-G4: 1:00-2:30 PM Posters #18-23 Ballroom

#18 Antiphase Domains in GaAs Thin Films Grown on Low-Cost, Flexible Substrates by Metalorganic Chemical Vapor Deposition

Nan Zheng; Nanoscience and Nanoengineering Program

Mentor/Advisor: Dr. Phil Ahrenkiel; Nanoscience and Nanoengineering Program

Continued research on photovoltaic materials is needed to increase energy-conversion efficiencies and reduce manufacturing costs. Polar GaAs can grow on a non-polar Ge single-crystalline substrate with two different configurations, which results in antiphase domains (APDs) and antiphase boundaries (APBs) [1]. APDs in GaAs thin films grown on low-cost, flexible substrates is more complicated because of the nearly single-crystalline, (001)-oriented Ge layers formed on metal ribbons. Here we report on APDs in semiconducting GaAs thin films grown on both Ge single crystalline substrate and on low-cost, flexible substrates. Transmission electron microscopy (TEM) results show that APBs in textured GaAs films grown on flex-Ge also tend to be low-angle grain boundaries.



Cross-sectional images of multilayer GaAs/flex-Ge film deposited at UH. Changes in local phase occurred across low-angle grain boundaries.

References:

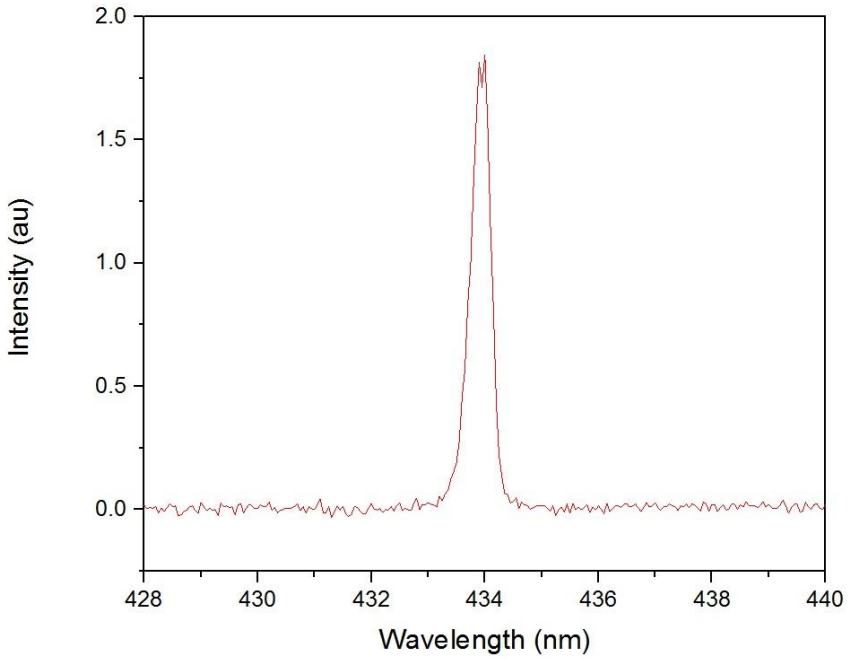
[1] Applied Physics Letters **47**, 879 (1985)

#19 Study of InAs/GaAs Nanostructures by Photoluminescence Spectroscopy

Nikhil Pokharel; Nanoscience and Nanoengineering Program

Mentor/Advisor: Dr. Haeyeon Yang; Nanoscience and Nanoengineering Program

We intend to examine the electronic state of InAs/GaAs nanostructures using photoluminescence spectroscopy. When photo excited electrons in material return to their equilibrium state, the excess energy released in the form of radiation is detected by photo detector. The wavelength of luminescence is related to difference in energy levels between excited state and equilibrium state of the material. A 403 nm diode laser with variable power up to 104 mW can be used to excite the sample and the radiation from sample is detected by InGaAs photodetector of near-IR region. A lock in amplifier using phase sensitive detection can measure even this small signal obscured in noisy environment. The effect of slit size of entrance and exit slits in the emission spectra of illuminating source was also studied.



#20 Neutron Calibration of the LUX/LZ Dark Matter Experiment

Madan Sharma Timalsina; Physics Department

Mentor/Advisor: Dr. Juergen Reichenbacher; Physics Department

The LUX Dark Matter Experiment has performed the most sensitive direct search for weakly-interacting massive dark matter particles (so-called WIMPs). The successor experiment LZ will also be located underground at SURF (Sanford Underground Research Facility) in Lead/SD. The LZ central detector will not only be an order of magnitude larger than the existing LUX inner detector, but its sensitivity for direct dark matter searches will be even 100 times better than LUX. If WIMPs exist, they could interact in the cryogenic liquid xenon of the detector's core by bouncing into a xenon nucleus, which will then recoil and produce scintillation light and electric charge. The ratio of the directly detected scintillation light and the delayed charge detection is characteristic for such a nuclear recoil, and differs significantly from an electron recoil produced by undesired background reactions. However, the precise knowledge of the critical ratio value, for which the electron recoil dominated regime transitions into the nuclear recoil dominated regime, is key.

Dedicated neutron calibration sources such as a DD-generator gun, AmLi and AmBe neutron sources, as well as a new mono-energetic Y/Be neutron source are essential tools to precisely map the nuclear recoil region. That way it can be demonstrated what a possible WIMP detection would look like in the LUX/LZ detectors.

The precise neutron fluxes of the various neutron calibration sources have to be measured before the actual deployments of the sources will be performed, in order to assess the detection efficiency in the detector.

A new neutron monitor system, utilizing He-3 proportional counter tubes, is being developed within the framework of the LUX/LZ project.

#21 Phenonomenological Analysis of Phase Transitions in Single-Domain Barium Titanate

Tyler Liebsch; Physics Department

Mentor/Advisor: Dr. Vladimir Sobolev; Physics Department

An analysis of phase transitions in a single-domain crystal of $BaTiO_3$ has been carried out in the framework of the Landau-Ginzburg-Devonshire phenomenological approach. One of the goals of our study was to select the best set of phenomenological coefficients for the thermodynamic potential expression which gave the closest values of transition temperatures for all three phase transitions observed in $BaTiO_3$.

Using selected sets of values for these coefficients, we planned to achieve another goal of our study, namely, to analyze the conditions for existence of an intermediate monoclinic phase; since, it was recently suggested that the phase transition from the high temperature tetragonal phase to the lower temperature orthorhombic phase has to take place through an intermediate monoclinic phase.

In our calculations, we compared the free energies for the cubic, tetragonal and orthorhombic phases to determine the transition temperatures for different sets of values of thermodynamic parameters. The parameters that gave the best agreement with recent experimental results were used to analyze the temperature intervals of stability for each phase. We also compared the temperature dependences of the free energy for an intermediate monoclinic (M_C-type) phase with those for the tetragonal and orthorhombic phases. It was shown that the monoclinic phase had a higher free energy than both the tetragonal and orthorhombic phases for a single-domain $BaTiO_3$ crystal. We determined that the metastable monoclinic phase would appear in the vicinity of the phase transition, under the application of a properly orientated electric field or external stress.

The phase transition sequence involving the monoclinic phase would demand two individual 2^{nd} order phase transitions, resulting in the tetragonal and orthorhombic phases losing stability at the transition temperatures. The experimentally-observed monoclinic phase is theorized to act as a bridging-mechanism between the tetragonal and orthorhombic phases since it belongs to both symmetry groups. The M_C phase would appear from a rotation of the polarization vector from the tetragonal phase towards the orthorhombic phase through the (101) plane. However, our results confirm that both the tetragonal and orthorhombic phases remain stable and the spontaneous polarization changes discontinuously, characterizing a 1^{st} order phase transition.

#22 Optimization of Polyacrylonitrile Nanofiber Mats for Sterile Filtration Applications

Caitlin Crandall; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Todd Menkhaus; Chemical and Biological Engineering Department

Clean water is essential for human life, and millions of people around the world lack consistent access to it. From underdeveloped areas, to disaster zones, to major cities in our own country, access to safe drinking water is a pressing need. Current membranes, fabricated from ceramics, metals, or polymers, have begun to provide a solution to the clean water problem, but they suffer from high expense, low permeability, high fouling, and high flux decline. These problems severely limit their applications and useful life. Nanofiber membranes have highly interconnected pores, which provides large effective surface areas and porosities. As a result, fouling and the associated flux decline occur much more slowly than with current membranes, making these membranes more cost-effective, energy-efficient, and long-lasting than current membranes.

Here, polyacrylonitrile (PAN) membranes were prepared and investigated to determine the effects of membrane thickness (1, 2, and 3 layers of stacked membranes, compressed together), fiber diameter (200, 500, and 800 nm), and compression (0.025, 0.1, and 0.2 MPa) on filtration performance including particle rejection and flux. Membrane separation performance was tested by measuring rejection 0.1 μm and 0.2 μm diameter particles (mimicking large viruses and microbial impurities, respectively), along with determination of water flux at relatively low operating pressures (10 psi). The results indicated that rejection performance improved as thickness increased, as fiber diameter decreased, and as compression increased. For 0.2 μm diameter particle rejections, over 1500 $L/m^2/h$ pure water flux was achieved with 92-100% rejection by membranes with 200 nm fiber diameters, 0.1 MPa compression, and 2 layers. For 0.1 μm particles, 950 $L/m^2/h$ pure water flux was achieved by membranes with 200 nm fiber diameters, 0.2 MPa compression, and 2 layers.

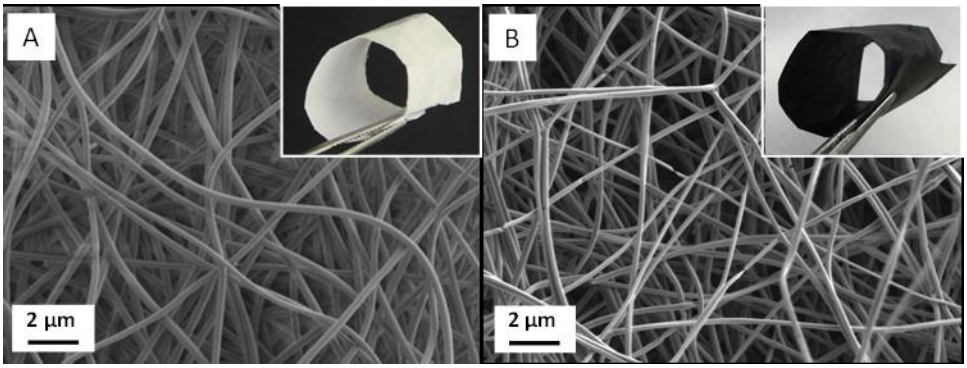
#23 Electrospun Materials for Flexible Dye-Sensitized Solar Cell

Fan Zheng; Nanoscience and Nanoengineering Program

Mentor/Advisor: Dr. Zhengtao Zhu; Chemistry and Applied Biological Sciences Department

Dye-sensitized solar cells (DSSCs) have attracted growing interests as an alternative to conventional silicon-based solar cells due to their cost effectiveness, simple fabrication process, and relatively high energy conversion efficiency. Among all types of DSSCs, the DSSCs consisted of flexible components usually exhibits excellent flexibility, which enables the potential applications of DSSCs in portable and wearable power supplies.

This project focuses on the application of electrospun materials in flexible DSSCs. In specifc, the flexible electrospun SiO_2 nanofibrous mat is adopted as a supporting substrate, into which the binder-free TiO_2 paste will partially penetrate; subsequently, the side of SiO_2 nanofibrous mat filled with TiO_2 nanoparticles can work as the photoanode in DSSCs, while the other side of the fibrous mat without TiO_2 nanoparticles can work as the spacer between the photoanode and the counter electrode. Furthermore, flexible electrospun carbon nanofibrous mat or flexible electrospun SiO_2 nanofibrous mat squeezed with commercial conducting carbon paste is investigated as flexible counter electrode for DSSCs. This project suggests that the application of electrospun materials in flexible DSSCs could simplify the procedure and provide a promising approach to fabricate the high efficient flexible DSSCs.



Session P-G5: 1:30-2:45 PM Posters #48-52 Ballroom

#48 Life Cycle Assessment of Polymerization Processes based on Renewable Resources

Claudia Isola; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. James Stone; Civil and Environmental Engineering Department

Bio-based polymers are increasing in popularity as the chemical industry shows considerable efforts to identify and develop alternatives for traditional petroleum-based plastics. The development of these polymers has impacts on energy consumption and the environment. To evaluate these impacts it is necessary to have a comparison base between the products, processes, and pathways for each production scenario. Life Cycle Assessment (LCA) is a tool that quantifies the environmental sustainability of bio-based polymers from "cradle to grave", which means analyzing production, use, and disposal of a product or process. It is a useful way to make this comparison related to environmental impacts resulting from the production of each product or process. This study evaluates the energy consumption and environmental impacts of polymerization processes based on renewable resources, using different scenarios and scales such as: identifying convenient raw material and sourcing with a clear insight into their ecological footprint (e.g. amount of water and energy used), the energy demand for concentrating, separating and processing the reagents from product, and exploring alternatives in a completely sustainable process. SimaPro modeling software will be used to evaluate the sustainability for each product, process, and pathway scenario. Through this analysis, it will be possible to recognize the process areas that are significant environmental impact contributors and then suggest possible alternatives to optimize the process and decrease those impacts.

#49 Ionospheric Plasma Coupling to Low-Frequency Electromagnetic Radiation: A Mechanism for Monitoring Earthquake Precursors Using the Existing Global Navigation Satellite System

Kelsey Kramer; Atmospheric and Environmental Sciences Program

Mentor/Advisor: Dr. Donna Kliche; Mathematics and Computer Science Department

It is fairly well established in scientific literature that the ionosphere responds to a variety of geophysical activity and that a connection exists between processes in the Earth's lithosphere and subsequent disturbances observed in the upper atmosphere and ionosphere. Additionally, published analysis of geomagnetic field fluctuations reveal a correlation to future seismic events. Various techniques have been applied to monitor ionospheric changes; however, a new detection method for identifying earthquake precursors is possible through identification of low-frequency electromagnetic signatures in continuously monitored and corrected Global Navigation Satellite and GPS signals. The method applies statistical analysis of geomagnetic field fluctuations at the earth's surface and ionospheric total electron content (TEC) to identify precursive geomagnetic field fluctuations and corresponding ionospheric response that signify impending earthquake activity.

The present study involved the simultaneous monitoring of collocated seismic, geomagnetic, and ionospheric activity for the 2008 Wenchuan earthquake. An anomalous enhancement of TEC in southern China was found three days prior to the earthquake. Because the solar-terrestrial condition was quiet that day, it was improbable that the elevated TEC was caused by a geomagnetic storm. The spatial distribution was very local, which is likely associated with the seismo-ionospheric coupling process. Our subsequent analysis of vertical geomagnetic field data in the same region showed a corresponding geomagnetic field deviation from the four-week average preceding the earthquake. The data suggest anomalous changes in ionospheric TEC occur as a result of changes in the magnitude of geomagnetic fields. The data indicate a strong correlation from both the spatial and temporal perspective.

This work was done by National Security Technologies, LLC, under Contract No. DE-AC52-06NA25946 with the U.S. Department of Energy and supported by the Site-Directed Research and Development Program.

#50 Assessing Groundwater Vulnerability on the Pine Ridge Reservation in Southwestern South Dakota

Lilly Jones; Geology and Geological Engineering Department

Mentor/Advisor: Dr. Foster Sawyer; Geology and Geological Engineering Department

Groundwater is used as a domestic water supply by about one-half of the US population (Alley and others, 1999). The U.S. Environmental Protection Agency (USEPA) requires assessment of groundwater vulnerability to contamination for all public water-supply systems as part of the Safe Drinking Water Act (1996).

Groundwater vulnerability assessment is a tool used by scientists, and federal, state, and local water-resource managers to guide management of water resources. Science objectives with regard to a vulnerability assessment involve reproducible, objective approaches that provide scientifically defensible data to water resource managers, regulators, and decision makers.

Assessment parameters include proximity of point source and non-point source contaminants to the groundwater system, contaminant load, factors which could increase contaminant load, geochemical properties of contaminants, and fate/transport of contaminants in a groundwater system. Objective assessments combine statistical or process-based methods such as modeling, regression equations, and map overlay to determine relationships between explanatory variables or processes that could cause aquifer contamination.

Most source water wells on the Pine Ridge Indian Reservation are completed in the Arikaree aquifer. Aquifer characteristics have been investigated by the U.S. Geological Survey but as of this date, a comprehensive source-water assessment for the Pine Ridge Reservation has not been completed.

The goal of this proposed vulnerability assessment is to produce scientifically defensible results that can be shared with stakeholders. A process-based model published by the US Geological Survey in 2014 will provide the basis for assessment. Contaminant and water quality data will be added to the model to complete the assessment. Combining a process-based model with measured water quality data and contaminant-specific parameters in a map-overlay process will produce source water assessment products with objective measures of aquifer vulnerability for the Pine Ridge Reservation.

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#51 Creation of a Material-Handling Risk-Modeling Program

Nick Kelly; Engineering Management

Mentor/Advisor: Dr. Adam Piper; Industrial Engineering Department

Work-related musculoskeletal disorders (WMSDs) are a leading cause of ergonomic concern. As seen in **Figure 1**, transportation and warehousing is significantly riskier than other industries. Ergonomic programs attempt to train manual material handlers to lift and set material in their ergonomic power zone, which is above the knees and below the shoulders. [1]

This study aims to create a model that can be used to evaluate risky lifting in the beverage distribution industry.

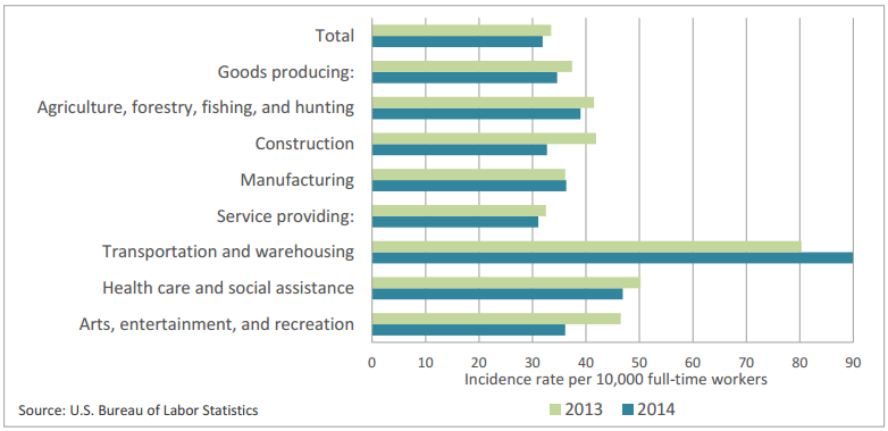

Figure 1: WMSD incidence rates for selected private sector industries, 2013-2014 [2]

A routine of lifting twelve cases of soda and water each and setting them onto a cart was designed. Twenty-six student volunteers did the routine twice and one student did the routine thrice. The beverages were picked from approximately eight inches, twenty-nine inches, and fifty-four inches off of the ground onto a cart that started approximately eleven inches and, as stacked, became up to forty-six inches off of the ground. The muscles observed with electromyography (EMG) sensors were the upper and middle trapezius, the middle deltoid, the latissimus dorsi, and the erector spinae, in the thoracic and lumbar region. Both left and right sides of each muscle were measured. Body angles were measured at base of neck and lower back in the sagittal plane and the coronal plane.

After all observations, a fuzzy c-means clustering tool in MATLAB was used to create three clusters, one for each Powerzone. The clusters were averaged across all participants and then put into a fuzzy inference system that attempted to output the posture during the routine. The system was accurate fifty-eight percent of the time.

The system can be improved by taking anthropomorphic measurements of the individuals and then making different systems for different categories, such as stature. Also, the model can be used to ascribe an estimated dollar amount in worker's compensation prevention.

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#52 Modeling the Hydrological Impact of Land Cover Change Over Time

Patrick Shaw; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. Scott Kenner; Civil and Environmental Engineering Department

With the mountain pine beetle infestation spreading across the Black Hills in western South Dakota, the response of streamflow characteristics to the constantly changing land cover is being studied. The United States Geological Survey (USGS) Earth Resources Observation Systems Data Center (EROS) published land cover change over time in 2001, 2001, 2006, and 2011 as the National Land Cover Dataset (NLCD). The upper Rapid Creek basin in the Black Hills, a sub-basin of the Cheyenne River basin, is the study area using the land cover change database. The upper Rapid Creek watershed experiences rainfall dominated precipitation and changing land uses of mountain pine beetle (MPB) (*Dendroctonus* ponderosae) infestation, burned vegetation, and managed forest. Upper Rapid Creek watershed includes three USGS stream gage stations with data for the past forty years. This study examines streamflow variation with precipitation and land cover change over time in upper Rapid Creek watershed in both wet and dry years. Converting the continuous land cover change characterization into dynamic parameters for input into the Hydrological Simulation Program – Fortran (HSPF) will result in a hydrologic simulation for the land-use change over an extended time period. The result provides a modeling tool to aide in the time-variable hydrologic parameterization of land cover change for input into HSPF as well as determining the influence of land cover change over time on stream flow characteristics.

Session P-G6: 2:45-4:15 PM Posters #24-29 Ballroom

#24 **Characterization of Patterned, Surface Tethered, Environmentally Responsive Polymer Brushes For Improved Bioseparation Applications**

Vanessa Wood Braband; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Todd Menkhaus; Chemical and Biological Engineering Department

A variety of surface tethered polymer brush surfaces were developed with various adsorptive chemistries, surface configurations, and ligand densities (shown schematically in *Figure 1)*. Adsorptive behavior of proteins at the interface between the different surfaces and the surrounding fluid, including both targeted and non-targeted molecular species, in various environments, was probed by utilizing surface plasmon resonance (SPR) spectroscopy. In addition to SPR measurements, the surface chemistries and morphologies of these samples were characterized by standard experimental techniques, specifically Fourier transform infrared spectroscopy (FT-IR) and atomic force microscopy (AFM), to further provide insight into the surface characteristics adsorption phenomena. Two molar ratios of mixed poly(acrylic acid) (PAA) with hydroxyl (OH) or methyl (CH_3) alkanethiols were examined and characterized. AFM images illustrated that the surface tethered PAA brushes were successfully dispersed/patterned by the inclusion of an additional chemical species. The findings indicated that patterned PAA brushes (surface tethered PAA brushes that were dispersed by the inclusion of small surface tethered alkanethiols) utilizing the hydroxyl terminated alkanethiol as the "inert" spacer had enhanced properties (e.g., an enhanced capacity for the targeted species, a larger resistance to nonspecific adsorption, a larger capacity, faster kinetics, and greater control of the desorption/release and capture of the targeted protein) over both pure PAA and patterned PAA utilizing a methyl terminated alkanethiol spacer. Compared to pure, densely packed PAA brushes, SPR measurements indicated that preparation of an 80% initiator and 20% hydroxyl terminated alkanethiol mixture enabled patterned PAA to be synthesized with an enhanced adsorption capacity (10.1% larger) and an enhanced adsorptive rate (30.9% faster). The dispersed surface tethered PAA brushes (with a reduced surface density) enabled the capacity to be more fully and the rate of adsorption to be enhanced utilized (reduced transport limitations deep within the polymer brush surface enhancing molecular access to the vacant adsorptive sites. The enhanced capacity resulted from In addition; the patterned PAA and OH surfaces retained the specificity for the targeted species over the non-targeted species, and had negligible irreversible adsorption (which was undesirable as it could not be controlled nor efficiently desorbed from the surface, as was experienced with the CH_3 spacer). The findings of this work will aid the improvement of bioseparation materials by specifically tailoring the material properties of these types of adsorptive surfaces such that they have an enhanced capacity and faster adsorption kinetics.

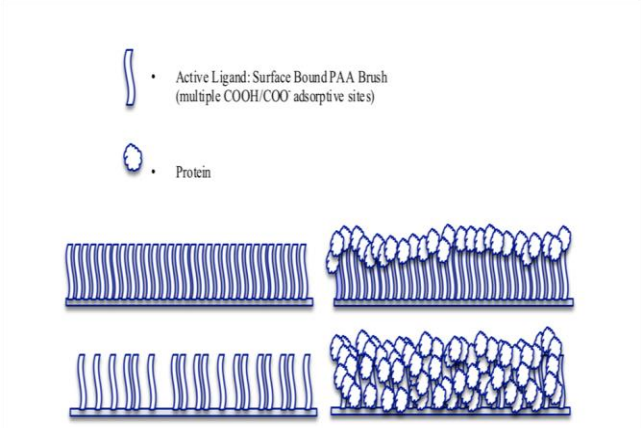
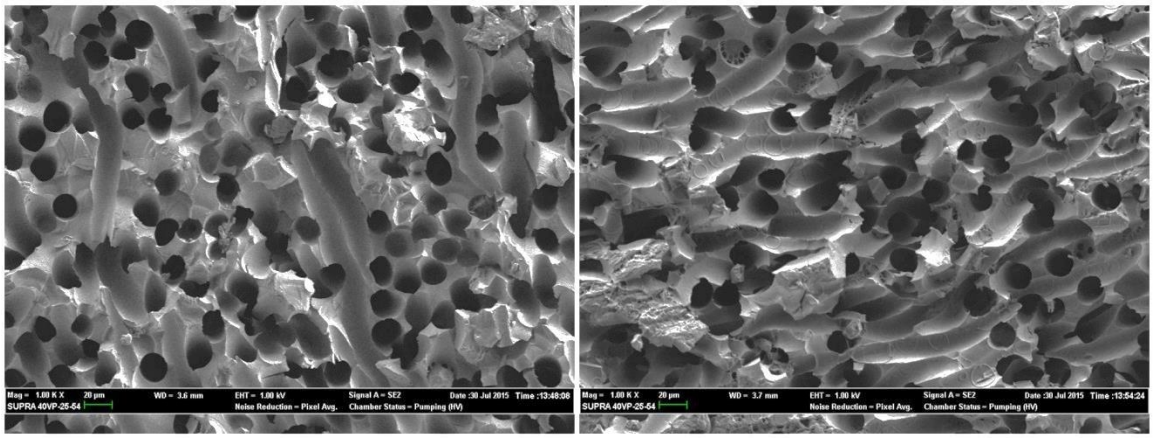


Figure 1: Schematic representation polymer brush adsorptive surfaces of densely packed polymer brushes (top) and patterned polymer brushes (bottom) before protein adsorption (left) and after protein adsorption (right)

#25 Mechanical Properties of Reinforced Polymer Foams

Eric Schmid; Nanoscience and Nanoengineering Program

Mentor/Advisor: Dr. William Cross; Materials and Metallurgical Engineering Department and Dr. Marc Robinson; Civil and Environmental Engineering Department and Dr. David Salem; Materials and Metallurgical Engineering Department



Polymer foams are typically manufactured using gas nucleation, whereby a saturated gas is allowed to expand and create voids inside a softened polymer. These voids are typically spherical, or polyhedral when tightly packed, and are relatively monodisperse in size. In most cases, these similarly sized, uniformly shaped foam cells result in isotropic polymer foam properties. Furthermore, as the foam becomes more porous, the mechanical properties suffer exponentially, typically retaining less than five percent of the strength and modulus of the neat, non-porous polymer[1]. Therefore, it is of great interest to develop foams with better mechanical properties but without increasing their bulk density. Reports of reinforced micro- and nanocomposite polymer foams have demonstrated varying degrees of success, using materials such as cellulose, carbon nanomaterials, and clays[2]. Similar reinforcement strategies are currently being utilized to reinforce the thermally insulating polymer foam composites (image shown) developed in the CAPE Lab. These foams contain hollow-channel shaped voids rather than spherical pores, and have been fabricated using a technique which allows for excellent control over the void shape and size[3]. Using this fabrication method, highly engineered, multi-functional foam materials can be produced for high performance applications, such as cryogenic pressure vessels and outer-space habitats.

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#26 Electrospun Carbon Nano-Felt Derived from Alkali Lignin for Cost-Effective Counter Electrodes of Dye-Sensitized Solar Cells

Xiaojing Ma; Nanoscience and Nanoengineering Program

Mentor/Advisor: Dr. Hao Fong; Chemistry and Applied Biological Sciences Department

In this study, freestanding and mechanically flexible nano-felt consisting of electrospun carbon nanofibers (ECNFs) derived from alkali lignin with BET specific surface area of ~583 $cm^2 \cdot g^{-1}$ and average pore size of ~3.5 nm was prepared and then surface-deposited with Pt nanoparticles (Pt NPs). Both nano-felts of ECNFs and ECNFs-Pt were studied as cost-effective counter electrodes of dye-sensitized solar cells (DSSCs). The energy-dispersive X-ray spectroscopy (EDS) results showed that the amount of Pt NPs in ECNFs-Pt nano-felt was ~9.9 wt.%, and the scanning electron microscopy (SEM), transmission electron microscopy (TEM), and X-ray diffraction (XRD) results indicated that the Pt NPs with small sizes in the range of 2–20 nm were randomly distributed on the surface of ECNFs. The electrochemical impedance spectroscopy (EIS) tests revealed that the ECNFs-based counter electrode had low charge transfer resistance (R_{ct} = 1.94 $\Omega \cdot cm^2$), and the R_{ct} value was reduced to 1.2 $\Omega \cdot cm^2$ upon surface-deposition of Pt NPs. The prototype DSSCs based on ECNFs and ECNFs-Pt counter electrodes exhibited comparable performances to the DSSC based on conventional Pt counter electrode in terms of short circuit density (J_{sc}), open circuit voltage (V_{oc}), fill factor (FF), and energy conversion efficiency (η).

#27 Electrospun Polycaprolactone Three-Dimensional Nanofibrous Scaffold with Interconnected and Hierarchically Structured Pores for Bone Tissue Engineering

Tao Xu; Chemistry and Applied Biological Sciences Department

Mentor/Advisor: Dr. Hao Fong; Chemistry and Applied Biological Sciences Department

For the first time, electrospun PCL 3D nanofibrous scaffold has been developed by an innovative and convenient approach (*i.e.*, thermally induced nanofiber self-agglomeration followed by freeze drying), and the scaffold possesses interconnected and hierarchically structured pores including macropores with sizes up to ~300 μm. The novel PCL 3D scaffold is soft and elastic with very high porosity of ~96.4%, thus it is morphologically/structurally similar to natural ECM and well-suited for cell functions and tissue formation. The *in vitro* studies reveal that the scaffold can lead to high cell viability; more importantly, it is able to promote more potent BMP2-induced chondrogenic than osteogenic differentiation of mouse bone marrow mesenchymal stem cells. Consistent to the *in vitro* findings, the *in vivo* results indicate that the electrospun PCL 3D scaffold acts as a favorable synthetic ECM for functional bone regeneration through the physiological endochondral ossification process.

#28 Molecular Simulation of Ionic Liquid/Co-Solvent Structure and Thermodynamics

Santosh Bandlamudi; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Kenneth Benjamin; Chemical and Biological Engineering Department

The extensive use of ionic liquids (ILs) is a significant achievement in extracting lipids and proteins from biomass for bio-fuel production from algae and other bio-based feedstocks. The particular effectiveness of ionic liquids combined with polar-covalent molecules (PCM), such as methanol, as an extraction solvent mixture in extracting bio-oils from micro-algae has been demonstrated successfully, the main highlight being auto-partitioning of extracted lipids into a separate phase.[1] While the efficacy of these IL/PCM mixtures has been demonstrated experimentally, there is no current molecular-level understanding of the structural and thermodynamic properties of these mixtures.

The thermodynamic and structural properties of IL/PCM mixtures are explored using molecular simulation. Molecular dynamics (MD) simulations are conducted to predict mixture volumetric, thermal, and structural properties. MD simulations of thermodynamic mixing properties for IL/PCM binary mixtures show virtually ideal mixing behavior, while various excess heat of mixing behaviors are predicted. In addition, MD predictions of cation-anion clustering and structural properties like radial distribution functions (*rdfs*) and structure factors provide information on local fluid structure and interactions between ionic liquid and polar-covalent molecules, including the change in ion aggregation with mixture composition. Also, the free energy of cation-anion aggregation is determined with umbrella sampling[2] and the weighted histogram analysis method (WHAM)[3], and reveals the increase in ion aggregation with PCM composition. These simulation predictions are compared to small angle X-ray scattering (SAXS), light scattering, and polarization data for model validation.

The aggregation behavior of triolein, a model lipid, in IL/co-solvent mixtures was also explored. From the MD generated *rdfs* and potentials of mean force, we observe a clear correlation between the extent of triolein aggregation and the experimental extraction yields as a function of methanol composition. This indicates that the lipids are aggregating in these IL/co-solvent mixtures, a simulation finding that is supported by light scattering experiments and correlates well with overall extraction (auto-partitioning) yields.

These efforts provide an improved understanding between the molecular-level behavior and macroscopic thermodynamic properties of IL/PCM mixtures, to characterize these new tailored solvent mixtures for bioprocessing separation applications.

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[2] G. M. Torrie and J. P. Valleau, "Nonphysical sampling distributions in Monte Carlo free- energy estimation: Umbrella sampling", Journal of Computational Physics, **1977**, 23, 187.
[3] A. M. Ferrenberg and R. H. Swendsen, "Optimized Monte Carlo Data Analysis", Physical Review Letters, **1989**, 63, 1195.

#29 Biodegradable Block Copolymeric Materials for Biomedical Applications

Eswar Arunkumar Kalaga; Chemical and Biological Engineering Department

Mentor/Advisor: Dr. Timothy Brenza; Chemical and Biological Engineering Department

Controlled drug delivery systems have become the research interest to many scientists around the world; these systems have included non-degradable as well as biodegradable polymer nanoparticles as drug delivery vehicles. Based on the method of preparation, nanoparticles, nanospheres, and nanocapsules can be obtained. These polymer based nanoparticles have been shown to effectively delivery drugs, proteins and DNA to the targeted sites. However many of these polymeric nanoparticle based devices have difficulty in achieving consistent product with the same biological behavior and pharmacological profiles.

In this project we look to overcome some of these limitations by starting with di-block (AB), tri-block (ABA) copolymers. For the individual blocks of the copolymer we have synthesized poly(lactic acid) (PLA) and poly(sebacic acid) (PSA). These represent polymers from two distinct classes (polyester and polyanhydride) of biodegradable polymers used in biomedical applications. In addition to these polymer classes having different physical properties (hydrophobicity, thermal stability), they also undergo different methods of polymer degradation (bulk vs surface erosion). In this project we will modulate the structure of the block copolymer to design self-assembling nanoparticles with improved control of drug release. By synthesizing a library of PLA-PSA di-block and tri-block copolymers we will demonstrate the influence of different block molecular weights and structure on nanoparticle self assembly. Future work will look at the encapsulation efficiency of therapeutics within the nanoparticles and release of therapeutics from the nanoparticles in physiological conditions.

2016 Student Research Symposium
List of presenters, alphabetical by last name:

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P=Poster Presentations G=Graduate

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Ajayi, Kayode; O-G2 (c)
Aminu, Lukmo; O-G6 (a)
Asiaee, Alireza; O-G7 (a)
Bandlamudi, Santosh; P-G6 #28
Barrett, Lucas, O-G1 (a)
Beck, Rika; O-G7 (b)
Bhatta, Eden; O-G6 (e)
Bhattiprolu, Venkata; O-G6 (c)
Borgwardt, Tyler; O-G2 (d)
Bowles, Michael; O-G2 (b)
Chapman, Nathaniel; O-UG1 (d)
Chilkoor Gopala, Krishna Govinda Rajan; O-G1 (b)
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Fisher, Jon; O-G3 (c)
Frels, Therese; P-UG1 #8
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