2017 Student Research Symposium

Tuesday, April 4, 2017

Abstract Book
Undergraduate Oral Presentations

Session O-UG1 8:00 – 8:40 AM Dorr Room (Surbeck Center)

(a) Understanding the Effects of Radon Daughter Plate Out on Dark Matter Detection

Therese Frels; Physics Department
Mentor/Advisor; Dr. Richard Schnee; Physics Department (PHYS)

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. Dark matter detectors are made of many different types of materials, such as steel and Teflon. These materials are sampled in various arrangements to determine plate out rate and effectiveness of measures to reduce plate out. Results from this study and their implications for assembly of dark matter detectors will be discussed.
Polycarbonate resins are produced using bisphenols as a monomer and are commonly used as engineering plastics in many fields, some examples being: automotive parts, medical parts, building materials, sheets, bottles, optical recording media, lenses, etc. Bisphenol A polycarbonate (BPA-PC) obtained from 2,2-bis(4-hydroxyphenyl)propane has high transparency, heat resistance, and mechanical strength. Over the past few years, new transparent amorphous polycarbonates from bis[4-(4-hydroxyphenyl)-phenyl]alkanes have been synthesized with higher glass transition temperatures (from 190°C to 350°C vs. 150°C) have been reported [1].

The synthesis of polymeric materials based on monomers from renewable resources is a growing field of interest stimulated by the rising concern for the environment. In recent years there has been an increasing demand for the application of natural products to address problems in the environment, in waste disposal, and in the depletion of non-renewable resources. 1,4:3,6-Dianhydrohexitol stereoisomers (isomannide, isoidide, and isosorbide) are sustainable intermediates that have attracted substantial attention in the field of polymer materials.

Synthetic efforts in our group have been directed toward the synthesis of novel bio-based polycarbonates, which may have potential in higher performance applications. As a result of our interest in bisphenol monomer development for new polycarbonate applications, we thought it would be worthwhile to explore how incorporation of 1,4:3,6-dianhydro-D-mannitol (isomannide) moiety might affect the properties of synthesized copolycarbonates.

Isomannide is obtained from D-mannose and is linked to its rigidity, chirality, and non-toxicity. Furthermore, isomannide is expected to theoretically improve the light resistance of the polycarbonates. When incorporated in polycarbonate, this rigid secondary diol imparts high chain stiffness, which could result in an increased glass transition temperature \( T_g \). Solution polycondensation of isomannide with both a 50/50 and a 75/25 molar ratio of isomannide and 2,2-bis-(4-(4-hydroxyphenyl)phenyl)propane monomers was performed using triphosgene and pyridine. Preliminary results indicate that polymers formed are soluble in chlorinated solvents. Results related to the synthesis of the novel bio-polycarbonates, with highlights put on the difficulties encountered to polymerize isomannide-based materials, were reported. The molecular structure of the synthesized isomannide-based homocopoly carbonates was analyzed by \(^1\)H NMR and FTIR spectroscopy. \( T_g \) was investigated by means of differential scanning calorimetry.

Graduate Oral Presentations

Session O-G1 9:00 – 10:20 AM Dorr Room (Surbeck Center)

(a) Nonlinear Control Synthesis for Parking Control of Mixed Conventional/Braking Actuation Mobile Robots

Walelign Nikshi; Mechanical Engineering Department
Mentor/Advisor: Dr. Randy Hoover; Electrical and Computer Engineering Department

In this paper, a nonlinear control synthesis for a mixed conventional/braking actuation mobile robot (MAMR) is presented. The MAMR is thought to be one of the possible solutions to tackle the common drawbacks of conventional mobile robots such as complexity, weight, and cost. This paper proposes a sliding mode control approach to control the parking of the MAMR along the x axis from any initial position and orientation. The dynamics of the MAMR are studied for later use in controller design. Different controllers are designed for different parts of the switching surfaces based on the dynamics of that particular region and the stability proof of each controller is given. The effectiveness of the proposed control algorithm is tested by simulation.
(b) Layered Image Grouping for Outlier Rejection and Feature Clustering

Daniel Nix; Mathematics and Computer Science Department
Mentor/Advisor: Dr. Jeffrey McGough; Mathematics and Computer Science Department

Feature based computer vision algorithms attempt to match image features from one image to the next. It is generally accepted that the initial matching stage will produce incorrect matches. Accurate matching required by post-processing algorithms is typically achieved using Sample and Consensus algorithms like Random Sample and Consensus[1]. These algorithms tend to perform poorly in environments with large proportions of outliers or with substantial image noise. Sampling methods also have issues with repeatability since samples are drawn at random[2].

Presented is an alternative algorithm leveraging symmetries of spatial inversion to quickly reject outliers and cluster features with similar velocities which is resilient to large outlier ratios and noise.

![Layered Image Grouping](image.png)

**Fig. 1.** Layered Image Grouping matching two groups of points moving different amounts between images. Each group maps to a different point on the $z = 0$ plane.


A Secure QR Code Scheme
Julian Brackins; Mathematics and Computer Science Department
Mentor/Advisor: Dr. Mengyu Qiao; Mathematics and Computer Science Department

Abstract

Quick Response code, an industrial standard originated from manufacturing informatization, has been getting growing attention and utilization in the past few years, due to the deep penetration of smartphones and the advancement of wireless networks. QR codes outperform other barcode standards because of their high capacity, fast readability, strong error tolerance, and flexible encoding options, all of which enable QR codes to be used as a convenient method of information sharing and storage for various computer and mobile applications including URL sharing, mobile app installation, social networks, electronic payment, ticketing and shipping services. The increasing popularity also make QR codes a potential target of traditional and emerging threats. One of the security risks present with QR codes is the existence of phishing schemes where attackers direct users to fake pages with the intention to intercept secret information. This can be translated into the QR code realm when hackers modify or print new QR codes present on posters, business cards, or other medium, allowing the scanned QR codes to redirect a user to a dangerous web page. Since security has always been a critical issue for mobile computing and communications, authentication methods are needed in order to protect the data and origin integrity of QR codes.

The aim of this project is to develop a scheme along with a proof of concept prototype of a security countermeasure that authenticates QR codes using build-in security features. This scheme involves the modification of QR code generation to embed message authentication code. Upon scanning a secure QR code, the user will receive the encoded message on the barcode as usual. However, there will also be an added message validation layer involving the use of cryptographic systems. This implementation is expected to be non-intrusive and additive to existing QR code applications. This means that if the scanning device were to be used on an old QR code without the digital signature information, the scanner would still return the intended payload. Meanwhile, the scanner would inform the user that the particular QR code lacks the security feature. The finalized prototype is expected to be deployed to popular mobile platforms to exemplify the anticipated functionalities.
(d) A Sliding Time Window Heuristic to Solve Large Underground Mine Production Scheduling Problems

Tacio Vinicius Ferreira Lopes; Mining Engineering and Management Department

Mentor/Advisor: Dr. Andrea Brickey; Mining Engineering and Management Department

Underground mine production schedule optimization has advanced in recent years with the application of new algorithms and improvements in computational capabilities, yet many problems remain difficult to solve. We present a sliding time window heuristic (STWH) to solve an underground mine production scheduling problem that results in faster solution times for longer time horizons and without a loss in fidelity when compared to global solutions. The STWH is used in conjunction with OMP Solver, which solves the linear relaxation of an integer formulation, and the TopoSort heuristic, which converts the linear relaxation solution to an integer solution. The STWH algorithm recursively solves sequential subproblems, retaining a “window” of each subproblem solution, and honoring delays and activities that span between multiple windows. We present results achieved for a large-scale underground gold mine. These results show improvements in computational speed and provide solutions that better reflect operational realities.
(a) Hydrothermal Liquefaction of Lignocellulosic Biomass for Fuel Production – Aspen Plus Simulation and Modeling

Max Lampert; Chemical and Biological Engineering Department

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

The growing demand for alternative fuels has drawn a great attention from all over the world. Hydrothermal liquefaction (HTL) is a biomass conversion process that has generated strong interest because various wet feedstocks can be directly used without drying. Through this process, bio-oil are produced from thermal decomposition of biomass at sub- or super critical water condition (250 °C– 374 °C, 6 MPa– 25 MPa). There have been many studies dealing with HTL of biomass in batch reactor. In our laboratory, homogenous catalysts such Ni(NO$_3$)$_2$, Ca(NO$_3$)$_2$, and Co(NO$_3$)$_2$ were tested for HTL of pinewood, cardboard and several other substrates. The highest biocrude yield of 55% along with 20 wt% of bio-oil was obtained at 300 °C in the presence of Ni(NO$_3$)$_2$. The higher heating value (HHV) of bio-oil was found to be 32 MJ/kg. Although few studies have been done by PNNL on large scale algae HTL system, there is no continuous lignocellulosic HTL system commercially available. Due to the challenges for processing of lignocellulosic biomass such as feedstock handling and multiple phase separation, Aspen Plus simulation and modeling was performed to simulate HTL process in order to understand correlation between experimental conditions and the products distribution to address issues such as equipment sizing, and capital and operation costs. The simulation studies were performed with the system capable of processing lignocellulosic biomass at a rate of 10 t/day. Hydrodeoxygenation (HDO) was also integrated in the system to obtained hydrocarbon fuels. Major equipment includes HTL reactor, heat exchanger, solid/aqueous phase separator and HDO reactor. Simulation and modeling results will be presented.

(b) Effectiveness of Multi-layer Graphene coated Copper Foil against Microbial Induced Corrosion of Desulfovibrio Alaskensis G20

Govind Chilkooor; Civil and Environmental Engineering Department

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

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The National Association of Corrosion Engineers (NACE) estimates that the United States of America (US) spends $4-$6 Billion/year to combat Microbial induced corrosion (MIC) due to sulfate reducing bacteria (SRB). The commercial polymer coatings have failed to protect base metals due to aggressive action of bacteria in inducing pin-hole defects leading to degradation, embrittlement and subsequent failure of base metal. Recent studies have shown nano-scale graphene coating can effectively combat MIC of metals such as Copper and Nickel. Here, we compare the corrosion resistance of single layer (SLG-Cu) with Multi-layer graphene (MLG-Cu) synthesized via Chemical Vapor Deposition (CVD) on copper foil using Desulfovibrio alaskensis G20 as a representative SRB. Transmission electron microscopy (TEM) and Raman spectrum confirmed the presence of single layer and multi-layer (6-8 layers) of graphene on SLG-Cu and MLG-Cu respectively. Scanning electron microscopy (SEM) images revealed higher defect regions for SLG-Cu compared to MLG-Cu. Electrochemical analysis in a three-electrode corrosion cell revealed MLG-Cu has superior performance than that of SLG-Cu. The corrosion rate of Cu foil were found to be at least 20 times lower for MLG-Cu (0.1 mills per year (mpy)) than that of SLG-Cu (2.5 mpy) after 7 days of exposure. Electrochemical impedance spectroscopy (EIS) revealed 2 times higher resistance to corrosion for MLG-Cu (7 kΩ/cm²) compared to SLG-Cu (2.5 kΩ/cm²). Transmission electron microscopy (TEM) images indicated severe localized pitting for SLG-Cu compared to that of MLG-Cu. Scanning electron microscopy (SEM) & X-ray powder diffraction (XRD) analysis of corrosion products for MLG & SLG-Cu indicates the presence of sulfide peaks and the formation of Chalcocite (Cu₂S) respectively. Presence of Chalcocite confirms SRB induced corrosion of copper in the areas where the graphene layers had surface defects. The study attributes the better corrosion barrier of MLG-Cu to lower defect density regions which provides a robust physical barrier against MIC.
Flexible dye-sensitized solar cell (DSSC) is a promising technology for portable and wearable power supplies. This talk presents our recent research efforts in electrospun materials for flexible DSSCs. In the first project, electrospun SiO$_2$ nanofibrous mat is adopted as a flexible and thermal-stable supporting substrate, into which the binder-free TiO$_2$ nanoparticles are impregnated partially; subsequently, the side of the SiO$_2$ nanofibrous mat filled with TiO$_2$ nanoparticles works as the photoanode of DSSCs, while the other side of the mat without TiO$_2$ nanoparticles works as a spacer between the photoanode and the counter electrode. In the second project, electrospun carbon nanofibrous mat is investigated as a flexible counter electrode for Pt-free DSSCs. The flexibility of the electrospun films is demonstrated by resistance measurement under various bending radii. The catalytic activity of the flexible carbon nanofibrous mat upon I$^{-}$/I$_3^-$ electrolyte is evaluated. Additionally, the effect of the thickness of the nanofibrous mat on device performance is studied. The results demonstrate the enormous potential of electrospun materials in scalable production and commercialization of low-cost and efficient flexible DSSCs.
(d) Electrospun Polycaprolactone-based 3D Nanofibrous Scaffolds with Interconnected and Hierarchically Structured Pores for Bone Tissue Engineering

Tao Xu; Biomedical Engineering Program

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

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Nanofibrous scaffolds that are morphologically/structurally similar to natural ECM are highly interested for tissue engineering; however, the electrospinning technique has the difficulty in directly producing the clinically relevant 3D nanofibrous scaffolds with desired morphological structures. To address this challenge, for the first time, electrospun polycaprolactone (PCL) 3D nanofibrous scaffolds has been developed by an innovative and convenient approach (i.e., thermally induced nanofiber self-agglomeration followed by freeze drying), and the scaffolds possessed interconnected and hierarchically structured pores including macropores with sizes up to ~300 μm. The novel PCL 3D scaffolds were soft and elastic with very high porosity of ~96.4%, thus they were morphologically/structurally similar to natural ECM and well-suited for cell functions and tissue formation. The in vitro studies revealed that the scaffolds would lead to high cell viability and promote more potent BMP2-induced chondrogenic than osteogenic differentiation of mouse bone marrow mesenchymal stem cells. The in vivo results indicated that the electrospun PCL 3D scaffolds could act as a favorable synthetic ECM for functional bone regeneration through the physiological endochondral ossification process. In the follow-up study, we fabricated (also via the TISA technique) and evaluated 3D electrospun PCL/PLA blend (mass ratio: 4/1) nanofibrous scaffolds. Compared to PCL-3D scaffolds, PCL/PLA-3D blend scaffolds had higher mechanical properties and in vitro bioactivity; as a result, they not only enhanced the cell viability of hMSCs but also promoted the osteogenic differentiation. Furthermore, the in vivo studies revealed that PCL/PLA-3D scaffolds would considerably facilitate new bone formation in a critical-sized cranial bone defect mouse model. In addition, further studies on electrospun 3D nanofibrous scaffolds with varied PCL/PLA ratios for bone tissue engineering are in progress.
(a) Comparisons Between EROS Continuous Change Detection Classification System and USFS Forest Health Technology Mapping for the Current Mountain Pine Beetle Outbreak

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

The United States Geological Survey (USGS) Earth Resources Observation Systems Data Systems (EROS) Data Center currently is developing a Continuous Change Detection Classification (CCDC) land cover tool to assess temporal surface changes from 1984 to present based on Landsat images. Tiled images are geographically stacked and calibrated to allow users to temporally analyze the remotely sensed data on a pixel-by-pixel (30m by 30m) basis within the Landsat library. The CCDC incorporates mathematical models to produce a raster file of the changed pixels called ChangeMAP. The “change” occurs when the pixel value is outside of two standard deviations of the mathematical model’s fitted trend line for three consecutive images. A tile encompassing the upper Rapid Creek watershed in the Black Hills of western South Dakota have been chosen as a ‘learning’ area for the tool’s land use classification algorithm. The region often experiences multi-year periods of drought and flooding as well as land surface change from forest fires, forest management practices, and mountain pine beetle (MPB) (*Dendroctonus ponderosae*) infestation. The forest fires, management practices, and MPB infested areas have been mapped digitally by the United States Forest Service (USFS). A regression analysis was performed on twelve subbasins within the upper Rapid Creek watershed with similar MPB stage, management, soils, geology, aspect, and slope. Results demonstrated a significant correlation between the CCDC ChangeMAP to the USFS shapefiles for MPB and managed areas. The CCDC model detects forest changes from mechanical and natural elements, and therefore in the future can be used to create maps for the changed forested areas.
For years, the Black Hills streams, including Rapid Creek, have been a primary salmonid fishery for wild brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*). Recently, a steady decline in the brown trout population has been observed in Pactola Basin amongst fish ranging in size from 150mm to 250mm. HEC-RAS and RIVER2D will be used for hydraulic and habitat analysis to evaluate an existing habitat restoration project. The results from this research will be used to guide future habitat restoration by providing a more accurate input on how stream morphology will impact existing habitats within the Black Hills. The modeling study focuses on stretch of Rapid Creek, just downstream of Pactola Reservoir. This stretch of Rapid Creek has experienced high water flows from releases from Pactola Reservoir which washed away banks and affected fish habitat. To address the problem of discharge, erosion and subsequent reduction in hiding spots and spawning areas for brown trout and other fish, an extensive habitat project has been carried out by Game Fish and Parks involving placing and burying dozens of wind-fallen trees along the bank to encourage the productivity of trout fisheries in this section of Rapid Creek. The pre-construction stream characteristics will be modeled and compared to post-construction stream characteristics to evaluate the effects on stream morphologic parameters and stream habitat. Thus, the objectives for this project are; (1) Collect pre-and post-development stream cross-section data through surveying. (2) Develop a pre-and-post development 2D HEC-RAS hydraulic model based on the surveyed data, accounting for velocities, water depth, temperature, substrate, and water quality. (3) Develop a River2D model to analyze instream habitat characterization based on hydraulic analysis. (4) Identify data that has been collected on water quality, substrate, temperature, and fish distribution in space and time and use the data to calibrate the models. (5) Use modeling results and filed observation to guide future fish habitat restoration projects.
Respiratory disease is the single most important factor limiting bighorn sheep (*Ovis canadensis*) populations across western North America. Bighorn sheep are susceptible to diseases carried by domestic sheep, and their numbers experienced a precipitous decline from 2 million in the year 1800 to about 80,000 individuals today. Recent research determined that the pathogen *Mycoplasma ovipneumoniae* (**Mo**) is responsible for large-scale epizootics in bighorn sheep, resulting in as high as 90% mortality in adults. The remaining ewes produce lambs that also experience up to 90% mortality in years following initial population infection, leading to an aging population with limited or no annual recruitment. Field observations and captive studies suggest that some adults that survive the initial outbreak act as “chronic shedders” of **Mo** pathogens and have a role in the subsequent lamb mortalities. Preliminary data collected in a captive setting indicate that the removal of surviving chronic shedders may increase lamb recruitment in a population. However, this theory was developed based on a small sample size and is yet untested in wild herds. Our study builds on this theory by testing it in free-ranging populations.

To document the presence of chronic shedders, we serially collected samples for **Mo** presence in the Rapid City and Custer State Park herds of bighorn sheep in the Black Hills of South Dakota and built disease histories for each individual. Through these disease histories, we classified the chronic shedders and removed them from the Custer State Park herd, while leaving the Rapid City herd unmanipulated to serve as a control population. We then monitored adult and lamb survival in both populations and documented causes of mortality. Subsequent disease tests indicate that **Mo** is no longer persistent in the experimental population, while prevalence of **Mo** in the control population has increased over the course of the study. Additionally, the control population experienced 26% lamb mortality and 13% adult mortality due to pneumonia, while the experimental population experienced none. Although an additional year of data will be collected, these preliminary findings suggest that selective removal of chronically shedding bighorns significantly reduces pneumonia incidence and mortality in wild populations.

The expected final outcome of this research is a recovered bighorn sheep population in Custer State Park and a science-based blueprint for how to remove **Mo** from a wild population of bighorn sheep that can be applied on a national scale. Urgency is warranted in developing techniques to manage disease in bighorn sheep, as several bighorn subspecies are listed as endangered. The study gives managers a chance to save unique subspecies and populations, which provide biological value to the ecosystems they inhabit.
Morphologically Distinct Populations of Ctena orbiculata (Bivalvia, Lucinidae) from Marine Lakes on San Salvador Island, Bahamas

Broc Kokesh; Geology and Geological Engineering Department

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

Island-like habitats that pose geographic barriers for populations are useful for observing ongoing biological evolution as well as demonstrating potential consequences of future habitat fragmentation. In this study, I tested whether intraspecific shell shape differed between two isolated populations of the lucinid Ctena orbiculata (Bivalvia). Specimens were collected from Crescent Pond and Moon Rock Pond, two marine lakes on San Salvador Island, Bahamas. Shell shape was quantified by means of geometric morphometrics using a landmark configuration for homologous features on the interior of the left valve for each specimen (Figure 1A). Results indicated that mean shape differed significantly between populations. A classification accuracy of 70% was found along a shape-change axis that maximally separates each population, indicating that most specimens can be accurately classified by which lake they were collected from (Figure 1E). Thin plate splines representing shape change along this axis demonstrated that specimens from Moon Rock Pond tend to have a dorsally-shifted anterior adductor muscle scar, elongated posterior adductor muscle scar, and a larger inhalant channel (Figure 1B-D). Further analyses were conducted to determine if shape was related to a specimen’s size. Size measurements derived from geometric (centroid) and traditional (length and height) morphometrics all indicated that specimens from Crescent Pond were on average larger than those from Moon Rock Pond with little overlap in size range. Shape also varied with size, although this relationship did not differ between populations, suggesting that allometry can explain differences in shape between populations.

Figure 1. A) Landmark and semilandmark curve configuration over photographed Ctena orbiculata shell. (B) TPS for shape change in the negative direction from the mean along the DF axis. (C) Mean shape for all specimens. (D) TPS for shape change in the positive direction from the mean along the DF axis. (E) Discriminant function analysis showing the distribution of specimens from Crescent Pond (orange) and Moon Rock Pond (blue).
Bacterial levels, particularly fecal coliforms such as *E. coli*, are standard water quality indicators of fecal contamination, and segments of the Big Sioux River are affected by unacceptably high levels of fecal indicator bacteria. Such routine coliform testing provides a snapshot of microbial abundance and content; however, it 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. 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. In order to assess the disease-causing potential of organisms in impaired surface water, we have developed and applied a new PCR-based pathogenicity tool to assay the disease-causing potential of total bacteria in impaired surface water. Bacterial isolates were further characterized for their disease-causing potential by determining whether a single organism carried multiple pathogenicity genes, 16S sequencing was used to identify human pathogens within surface waters, and terminal restriction fragment length polymorphism (T-RFLP) was used to evaluate the diversity of the microbial communities. From total DNA isolates obtained from six sites along the Big Sioux River, genes encoding Shiga toxins (*stx1, stx2*), in addition to an intimin-encoding gene (*eaeA*), an enteroinvasin-encoding gene (*einV*), a enterohemolysin (*ehxA*), a epithelial cell adherence gene (*toxB*), and a serine protease-encoding gene (*espP*) were detected in water samples during the course of this study. Of the bacterial isolates subjected to pathogenicity gene profiling, 81% carried the *stx1* gene, and 25% also carried the *eaeA* gene, indicating a higher human health risk. 16S sequencing of isolates led to identification of several human pathogens including *Pseudomonas stutzeri, Serratia marcescens, Rhanella aquatilis, Aeromonas veronii*, and *Pseudomonas putida*. T-RFLP analysis generated unique fingerprints of microbial communities at various sites that exhibit temporal changes. T-RFLP results will be compared to a 16S gene clone library for further analysis. Clearly, the presence of several pathogenicity genes within the Big Sioux River indicates the potential for significant horizontal gene transfer among the resident bacteria, and their presence may indicate a potential risk to human health.
(a) Hydrophilic to Hydrophobic Transition of Melamine Sponge – A Facile Approach toward High-Efficient Oil Absorbent Material

Yichun Ding; Biomedical Engineering Program

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

Development of oil absorbent materials with high selectivity and efficiency has attracted wide attention in recent years for applications in pollutant removal from oil spills and other accidental pollution. In this work, we report a facile, cost-effective, and scalable approach to prepare hydrophobic melamine resin sponge via a one-step solution immersion process. The commercial melamine resin sponge (intrinsically superhydrophilic with a contact angle ≈ 0°) is immersed in a salt solution (e.g., FeCl₃, NaCl, Ni(NO₃)₂, and Fe(NO₃)₃) for a few minutes and then dried at ambient temperature or at 100 °C in an oven. After the treatment, the melamine sponge becomes hydrophobic (contact angle ≈ 130°). The hydrophobic melamine sponge exhibits excellent absorption capability of 71 to 157 times its own weight for a wide range of oil and organic solvents. The mechanism of the hydrophilic to hydrophobic transition in melamine sponge is investigated. Our work offers a simple and economical approach to high-efficient oil absorbent melamine resin sponge for potential applications in oil (or organic solvents) spill recovery and environmental remediation.
(b) 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

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ABSTRACT

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 the Mn/MnO$_2$ system. The delay performance and aging characteristics are examined at similar diameters to common delay housings and the role of heat loss investigated. 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. The formation of benign combustion products, level of gas production, and reaction kinetic parameters will also be discussed.
Additive manufacturing using 3D printing technologies has sparked interest in improving manufacturing techniques for energetic materials. Current methods rely heavily on unautomated labor intensive work, which increases costs and manufacturing time. A specific energetic material of interest is the classical solid rocket propellant used extensively in commercial and military applications. Solid composite rocket fuel is currently cast into grains which can be time consuming and costly. Transition to a fully printable solid rocket fuel formulation would allow for ease of manufacture on large and small scale. In this research, the development of a printable solid rocket fuel has been explored along with required methods for printing highly solids loaded materials. In this study, the classical solid rocket fuel formulation was modified to allow for flow properties conducive to 3D printing. Optimization of the formulation to reduce slumping and allow for proper structural integrity, along with keeping the material at the classical solids loading of 85 weight percent was a primary goal. Printing of structured rate sticks to test burning and structural properties of the resulting formulations was also conducted.
(d) Development of a Mechano-Responsive Ink for Security Printing

Rohit Dulal; Materials Engineering and Science Program

Mentor/Advisors: Dr. Cassandra Degen; Mechanical Engineering Department and Dr. Jon Kellar; Materials and Metallurgical Engineering Department and Dr. Jeevan Meruga; Materials and Metallurgical Engineering Department

Security printing is a field that involves developing anti-counterfeiting, print solutions for high value/high impact documents and products. A mechano-responsive ink would be a new covert security feature that could be used to help prevent counterfeiting. This research investigated the use of spiropyran, a well-known mechanophore, covalently linked into a PDMS matrix. In addition to its mechanochromic properties, spiropyran is also photo- and thermochromic, adding to the multifunctionality of its use as a covert ink. Primary research investigated printing plain PDMS (polydimethylsiloxane) with toluene using an automated pneumatic dispensing system - a Nordson EFD (Engineered Fluid Dispenser). The specific curing and printing parameters were tuned to obtain precise dimensions in a printed film of the low viscosity uncured PDMS mixed with toluene. A solution of spiropyran dissolved in toluene and mixed with PDMS was used to print a quick response (QR) code, demonstrating proof-of-concept for this system as a security end product. Future work includes evaluating the mechanical properties of the printed film using DMA (Dynamic Mechanical Analysis). The results from this portion of the analysis will be used to further understand the mechano-responsiveness of spiropyran in a printed film of PDMS and its applications within the security printing field.
Monte Carlo molecular simulation packages are extremely useful tools for obtaining information about various chemical and physical systems. MCCCS Towhee is a Monte Carlo molecular simulation program which is well known for the breadth of systems it is able to simulate. However, it cannot simulate chemical reactivity. The goal of this thesis was to write an addition to Towhee in order to give it the required functionality to handle chemical reactivity, with the primary focus being put on chemisorption. A Morse potential was implemented into the Towhee code for potential energy calculations and a new force field file was created to pass the required parameters into the program. Nonlinear least squares fits on Lennard-Jones potential energy curves were performed to obtain the required Morse parameters. Then various pure chemical simulations were run to test the accuracy of the potential energy calculations as well as the Morse parameters from the regression. Chemisorption simulations were also run to test the accuracy of the implemented 2D density profile.

This is the first time chemisorption has been simulated in the open-source world. It is also the first time solvent structural data has been obtainable in a chemisorption simulation, and the first time a system which undergoes both physisorption and chemisorption in a solvent environment has been able to be simulated. In addition, this functionality allows systems which have multiple solvents to be simulated as well as systems with super-critical components. The changes made to Towhee in this thesis have allowed Towhee’s already broad borders to be expanded to allow for multiple types of reactive simulations. This ability is important because many industries heavily rely on catalytic chemistry for the production of their products. As such the practical applications for this addition are quite broad.
Solution combustion synthesis (SCS) has recently been explored as one method to synthesize metal oxides (e.g. Co$_3$O$_4$) that can serve as catalytic precursors for the hydrolysis of sodium borohydride (NaBH$_4$). In this work, SCS is used to produce the mixed metal oxide lithium cobalt oxide (LiCoO$_2$) and Cobalt Oxide (Co$_3$O$_4$) from cobalt nitrate, lithium acetate, and glycine. These SCS materials subsequently were observed to be effective catalyst precursors for NaBH$_4$ hydrolysis. Further characterization was conducted with DSC, BET, SEM, and XRD to observe phase content, surface area, surface morphology and structure. To remove residual impurities from the SCS material the materials were heated at a rate of 10°C min$^{-1}$ and held for 30, 60, and 120 min at temperatures ranging from 500-900°C and subsequently characterized. It was found that the layered phase of LiCoO$_2$ results at heat treat temperatures above 700°C. Optimum catalyst loading and kinetics were assessed using 0.6-2.0wt.% aqueous solution of NaBH$_4$ at 25, 35, and 45°C.
The Large Underground Xenon (LUX) experiment operated at the Sanford Underground
Research Facility (SURF) from 2012-2015, and is currently being decommissioned. It was a
two-phase time projection chamber (TPC) that uses 370 kg of xenon to detect particle
interactions. LUX has produced the most sensitive results to date, excluding Weakly Interacting
Massive Particles (WIMPs) to $1.1 \times 10^{-46}$ cm$^2$ at 50 GeV c$^{-2}$[1].

This talk will provide a brief introduction to the theory of dark matter, as well as an overview of
the techniques LUX used to search for WIMPs. It will also provide an overview of the final LUX
results and the work being performed to understand the detector and its backgrounds. Finally, a
brief description of the LUX-ZEPLIN (LZ) experiment that will replace it at SURF will be
provided.

[1] Results from a search for dark matter in the complete LUX exposure, LUX Collaboration,
https://arxiv.org/abs/1608.07648
(b) Participating in the development of the Deep Underground Neutrino Experiment (DUNE)

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 mechanisms governing these neutrino-oscillations is the primary goal of long-baseline neutrino physics.

In order to ensure experimental success, radiological backgrounds have to be measured and modeled in computer simulations in order to determine the radiological cleanliness requirements. At SDSMT we screen detector materials and develop tools for the DUNE collaboration simulation efforts as well as develop models and simulations ourselves. In addition, man-made radioactive sources will contribute to the calibration of the low-energy regime, relevant for possible detection of supernova neutrinos. The performed simulations will help characterize the optimal design of radioactive calibration sources, including deployment routes inside the DUNE detector, as well as the radiological cleanliness requirements.
(c) Detecting Ultra-Low Levels of Alpha Radioactivity

Michael Bowles; Physics Department
Mentor/Advisor: Dr. Richard Schnee; Physics Department

The BetaCage is a proposed low-background, ultra-sensitive, non-destructive Time Projection Chamber for measuring alpha- and beta-emitting isotopes on material surfaces, crucial for Dark Matter experiments. The BetaCage will boast much better alpha and low-energy electron sensitivity than is currently available from any instrument—commercial or otherwise. Sensitive and/or inexpensive isotope dating can be performed with the BetaCage on beta-emitters like Pb-210, Si-32, and H-3. I will describe the detector's design and plans to demonstrate the alpha sensitivity of a prototype version at SDSM&T.
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 ultra-low-radon cleanroom was built at the South Dakota School of Mines & Technology (SD mines). Cleanroom air is supplied by an optimized vacuum-swing-adsorption radon mitigation system that has achieved a > 1000× reduction from an input activity of $79.60 \pm 0.68$ Bq/m$^3$ to a cleanroom activity (at 90% confidence) of 0.067 Bq/m$^3$. The SD mines cleanroom has achieved lower radioactivity than any other on the north American continent.
The Caving mining method involves undermining, fracturing and breaking of the orebody. Sometimes, these ores contain uranium, which is the major source of radon. Radon, a radioactive gas, decays into its progenies with relatively shorter half-life and releases harmful radiation into the mine environment. Fractures act pathway for radon transport if pressure and/or concentration gradient exist. Hence, this challenge is complicated in the fractured zones of a propagating cave, which is characterized with fractures. To proactively mitigate radon exposure, adequate knowledge of the flux is required. The methods used to predict radon flux includes laboratory study, field measurement and numerical analysis. There are limitations to laboratory studies and field measurements due to difficulty in replicating the degree of fracturing in ore sample and inaccessibility to these zones. Hence, this study develops a discrete fracture network (DFN) model to predict radon through the fractured rock with specific application in cave mines. The radon transport model considers advection, diffusion, and radon generation rate with decay. This study identifies four non-conventional dimensionless parameters that affect the radon flux and the radon flux obtained compares closely with measured values in literatures. An independent study on the dimensionless parameters derived suggests that: the degree of fracturing in rocks contributes to radon flux more than the rock sizes, the advection velocity increases radon flux into the mine and radon generation rate significantly affects the radon flux.
Aseptic loosening and implant infection are the primary causes of premature orthopedic prostheses failure. Much interest has been directed towards developing coatings that will extend the lifetime of orthopedic implants by preventing these common modes of failure. Current trends in the technical literature point toward a focus on the design of multifunctional coatings that will address both aseptic loosening and implant infection simultaneously. Objectives in this research area include reducing the generation of implant wear particles through the use of wear-resistant coatings and effectively eliminating bacteria by introducing antibacterial agents to the implant region. As wear particles generated from articulating surfaces can initiate or exacerbate implant loosening and risk of bacterial infection at or around the implant site can persist for years, a wear-resistant coating exhibiting long-term and controlled antibacterial functionality would significantly improve the lifetime and performance of orthopedic implants.

With these goals in mind, the proposed design of a coating exhibiting both wear resistance and antibacterial effectiveness will be presented. The design combines an established wear-resistant coating with a well-known antibacterial agent. Nanocomposite coatings, such as the TiSiCN system fabricated by plasma-enhanced reactive magnetron sputtering, exhibit a combination of desired mechanical and tribological properties due to a multiphase structure consisting of hard nanocrystallites embedded in a tough, amorphous matrix. By distributing silver nanoparticles throughout the amorphous phase in a controlled manner, antibacterial functionality may be introduced to the TiSiCN system while maintaining mechanical integrity. The challenges faced in the past associated with controlling silver distribution and release from similar ceramic coatings will be discussed and opportunities offered by the TiSiCN system will be identified.


(b) The Effect of Particle Type on di-2-ethylhexyl Phthalate (DEHP) Gas-Particle Partitioning

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

Phthalates, such as di-2-ethylhexyl phthalate (DEHP), have been found to be associated with asthma, allergies, endocrine disruption, neurological diseases, and obesity. Methods of exposure to phthalates include ingestion, inhalation, and dermal absorption, as they are emitted from products in the indoor environment to the air. The role of particles in the emissions and transport of phthalates has been widely demonstrated. The gas-particle partitioning coefficient is a key parameter in predicting transport and exposure, but currently, the role of particle type and size in partitioning behavior is not well characterized. In order investigate these effects on gas-particle partitioning, experiments have been developed to measure the gas-particle portioning coefficient that will move inert gases and particles through parallel tubes laden with DEHP. A TSI Model 3480 electrospray aerosol generator will be used to introduce approximately monodisperse particles ranging from 15 to 50 nm in diameter into the tubes with nitrogen gas added to create sufficient flow. Particle type will be varied between organic and inorganic particles, using sucrose and oleic acid as the organic particle and ammonium sulfate as the inorganic particle. The particle size distribution will be measured with a TSI NanoScan. The DEHP concentrations will be measured with thermal desorption coupled with gas chromatograph/mass spectrometer (GC/MS). Because DEHP is an organic material, organic particles are expected cause a higher partitioning coefficient between the surface and bulk air. Finding the influence of the type and size of particles on the partitioning coefficient will improve models of transport and exposure to phthalates.
(c) Single Molecule Tracking (SMT) of Membrane Receptors in Endocytosis

Ni Putu Dewi Nurmalasari; Nanoscience and Nanoengineering Program
Dr. Jing Liu; Nanoscience and Nanoengineering Program

The diffusive dynamics of membrane receptors which is difficult to comprehend solely by imaging techniques, is critical in understanding their roles in keynote cellular activities, such as endocytosis. We use single molecule tracking (SMT), which detects individual particles with nanometric precision and tracks the particles’ trajectories, to quantitatively characterize the movement of the receptors on cellular membrane. SMT allows for the observation of the particles as they appear and disappear (merge or split). SMT also calculates the binning time of the particles. In addition, by fitting mean squared displacement of the trajectory, it estimates the diffusion coefficient which determines whether the particle is immobile, normal diffusion, confined diffusion and super diffusion. In this report, the mobility of ligand and receptor with blebbistatin treatment in the cell membrane is investigated. It was found that blebbistatin treatment increases the number of particles appearing in all frames and the binning time of the particles. However, diffusion coefficient of the particles is reduced by blebbistatin treatment in both ligand and receptor.

![Fig.1](image)

Fig.1 (a) Motion analysis of particles at frame 61 (b) diffusion analysis for all tracks (c) mean diffusion coefficient of tracks for ligand and receptor with or without blebbistatin

References:
(d) Dynamic Imaging and Mechanical Tension Measurement of Non-Muscle Myosin IIB in Live Cells by FLIM-FRET Microscopy

Divya Kota; Nanoscience and Nanoengineering Program

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

Divya Kota1, Jing Liu1, Indra Chandrasekar2, Ryan Hart2

1 Nanoscience & Nanoengineering Program, South Dakota School of Mines and Technology
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The sub-cellular and intra-cellular molecular interactions and the changes involved in live cells is a peculiar and dynamic nature. The measurement of those dynamic interactions in various physiological, pathological and developmental processes is a challenge faced by the scientists until today. The sophisticated imaging research lends a helping hand in proposing new methods to measure the dynamics by time-resolved single molecule microscopy by providing high spatial and temporal resolution from single living cells.

In this project, our goal is to measure cellular force generation (sub-cellular, intra-cellular) and membrane tension in live cells by performing fluorescence lifetime imaging microscopy- Forster resonance energy transfer (FLIM-FRET). [1] The FRET based tension sensor probe [2] of Non-Muscle Myosin MIIB is created, an actin associated motor protein that maintains the global and local membrane tension which is essential for cell migration, cell adhesion and endocytosis. [3-4] Characterization of these cellular forces leads to a greater understanding of cell migration, cellular mechanosensing, tissue formation, disease progression. The scope of our research is to illustrate and analyze the cytoskeletal dynamics and their significance in addressing important problems in developmental systems.

References:

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. 3D images of soybean root nodules were captured using two-photon induced fluorescence microscopy. The resulting images were computationally analyzed using the localization code by Weeks and later adapted by Kilfoil and analyzed in the context of the root architecture. Our findings are consistent with known roles of Auxin and Cytokinin in developing plant roots, and the method is the first quantitative description of these regulatory hormones tied to specific plant architecture. The method is being adapted to understanding the roles of these key hormones in the development of root nodules.

The method is being adapted to understanding the roles of these key hormones in the development of root nodules.

**Figure 1:** Multi-photon induced fluorescence images of **Left.** Soybean lateral root tips and **Right.** Soybean lateral root primordia. Each image shows 3 channels (red, green, and blue), and a composite image where yellow shows regions of overlap. The channels correspond to TdTomato (red), GFP (green, top right), root autofluorescence (blue).

**REFERENCES:**


Motivated by a desire to reduce multiple waste biomass substrates and recover energy locally, a bench scale apparatus was developed to process waste through the hydrothermal liquefaction (HTL) mechanism. HTL is a process that utilizes the favorable solvent effects of water at subcritical conditions to break down almost any biomass to form a diesel-like fuel, considered in this analysis as heavy bio-oil (HBO) and a solid fuel known as biochar. Thorough literature examination reveals current continuous HTL systems available require extensive processing of the feedstock prior to feeding and specialized pumps to facilitate flow through the reactor. By adjusting to a simpler feed mechanism, the novelty of the developed bench scale system allows for large particle loading with minimal to no pretreatment. Recent breakthroughs exposed the necessity to recycle HTL process water to increase conversion and reduce waste products. Differences between a sufficiently mixed batch reactor and the prototype tubular non-agitated reactor will be explored for mass transfer attributes. Experimentally, the setup comprises a 5L pressurized feed tank, 400mL tubular reactor, as well as accompanying gas, liquid, and solid separation vessels. An apparatus such as this benefits from automatic control that consists of an OPTO22 SNAP-PAC system interfaced with necessary valves and input devices. Commercial grade nitrogen is the agent of choice to inert all vessels due to its safety and minimal cost. The system was optimized for maximum waste liquefaction rates at minimum energies through examination of temperature and residence time effects. HBO was recovered through solvent extraction of the biochar residue with the use of a Soxhlet extractor which continuously recovers acetone to reduce cost and minimize operator interface. Analysis of product streams have shown over 60wt% liquefaction with nearly 20wt% bio-oil yield by input mass. During non-stop operation, the apparatus is capable of processing pinewood at a rate of 1.5 kg/day producing 200 g/day of bio-oil. Preliminary results have shown additional routes of carbon recovery are possible via biological treatment, with Enterobacter RC202 cultivation, of the process water and subsequent HTL of the bacterial biomass for HBO production.

Unconventional drilling techniques, including horizontal drilling and hydraulic fracturing have greatly enhanced crude oil production from the previously impermeable shales such as Bakken Shale. The majority of crude oil production from the Bakken shale occurs in North Dakota (ND), strengthening its oil industry and businesses, job market, and its gross domestic product. However, similar to oil production from contemporary shales, the oil extraction from the Bakken shale can result in a new set of water resource impacts. For example, hydraulic fracturing process generates significant amount of oil and gas wastewater (OGW) (flow back and produced water) that is characterized by unusual levels of total dissolved solids (TDS) (60,000-200,000 mg/L) and chemical oxygen demand (COD) (1000-70,000 mg/L), and a range of organic and inorganic contaminants. These characteristics reduce amenability of OGW in conventional treatment facilities including activated sludge process. Currently, the OGW in Bakken is piped or trucked onsite prior to disposal into Class II injection wells, causing wastewater spills during transport to injection sites. This study investigates the use of Microbial capacitive deionization cell (MCDC) for treatment and desalination of produced water from tight oil targets including Bakken Shale. The desalinated water can be reused in the oil fields. Interestingly, the MCDC technology can be used to generate electricity during the desalination process. The MCDC study was carried out using a specially enriched, mixed microbial population that can survive hypersaline conditions encountered in OGW. This study was based on the OGW from a representative, hydraulically fractured oil well in ND. The MCDC was evaluated for nearly twenty consecutive cycles of a fed-batch operation that lasted for nearly 149 days. The results indicate that the MCDC can be used to achieve 80% COD removal efficiency and 39% TDS removal efficiency. The current study used alternate current (AC) electrochemical impedance spectroscopy (EIS) to develop a deeper insight on the factors that influence major bio-electrochemical reactions affecting MCDC performance. The EIS results showed the full cell impedance in the MCDC reactor was 6.69 kΩ.cm² and ohmic resistance was 0.14 kΩ.cm². EIS results also suggested that for the model MCDC studied, electron transfer from the mediator to the electrode was a dominant charge transfer processes in the bio-energetic pathway. Cyclic voltammetry measurements also suggested role of redox-active mediators in the MCDC. SEM, Raman and XRD results showed gradual fouling of electrodes and membranes with salts of calcium and sodium due to which overall increase in the MCDC impedance was observed during the experiment. The fundamental understanding developed in this study can be used to improve scalability prospects of MCDC technology.
(c) Quantitative and Fluorescence Analyses of Dissolved Organic Carbon Emanating from Mountain Pine Beetle-Impacted Watersheds of Upper Rapid Creek

Jesse Punsal; Civil and Environmental Engineering Department

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

Understanding the sources of surface water pollution and contamination is a crucial step in the formation of effective watershed management policy. Organic matter resulting from the decomposition of mountain pine beetle (MPB) (*Dendroctonus ponderosae*) infested trees can impair surface water quality. Surface water sampling sites within upper Rapid Creek watershed in Black Hills of South Dakota were selected based on varying MPB progression. Organic matter characterization of impacted and unimpacted areas was performed by measuring ultraviolet absorption (SUVA), non-purgeable organic carbon (NPOC) concentration, and excitation emission matrix (EEM) spectra, as well as a suite of colorimetric general chemistry analyses. Preliminary results indicate an increased presence of colored dissolved organic matter (CDOM) within MPB sub-watersheds, with increased levels of humic- and fulvic-CDOM signatures. In this presentation, preliminary results from these on-going field and laboratory analysis efforts will be discussed.
(d) Net-zero Energy Housing Research on the Pine Ridge Indian Reservation

Kimberlynn Cameron; Civil and Environmental Engineering Department

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

The Pine Ridge Indian Reservation (PRIR), located in southwestern South Dakota, is home to the Oglala Sioux Tribe and is the eighth largest reservation in the United States (U.S.). The Oglala Lakota County also has the lowest per capita income in the entire U.S., with an 80 percent unemployment rate. Due to a housing shortage, many Pine Ridge Indian Reservation residents live in structurally unsafe and overcrowded homes, which contribute to poor indoor air quality (IAQ) and poor health. Statistically, Native Americans have a higher risk of health problems associated with poor IAQ, particularly asthma, than the non-Native US population. The Native American Sustainable Housing Initiative (NASHI) is a non-profit organization that seeks to provide affordable, sustainable, and culturally appropriate housing for the residents of Pine Ridge through an educational collaboration to design, build, and test research homes that employ various construction types. As part of NASHI, a net-zero energy straw bale home was built on the Pine Ridge Indian Reservation, and the home’s IAQ was monitored to identify critical problems, in order to inform the design of future sustainable “net-zero” housing. Monthly radon, formaldehyde, particulate matter, temperature, and humidity testing was conducted inside the home to determine the home’s IAQ, comparing testing results to appropriate standards and recommendations. To date, radon levels were well below the EPA’s mitigation limit of 4.0 pCi/L. Formaldehyde levels ranged from 0.009-0.12 parts per million (ppm), always above the California Office of Environmental and Health Hazard Assessment’s (CA-OEHHA) recommended exposure limits. Additionally, over the past 24 months, the Illinois Department of Public Health’s (IDPH) recommendation was exceeded five times. Currently, the formaldehyde source in the home is unknown, but cigarette smoke and an engineered wood product are potential sources. Further laboratory testing is being conducted with the suspect wood product to determine the source.
The popularity and variety of bio-based polymers are increasing as the chemical industry identifies and develops commercial biomass alternatives for traditional petroleum-based products. Environmental impacts and renewability of novel biochemical processes or materials must be determined in a quantitative manner to support sustainable development. A life cycle assessment (LCA) model was constructed for programmed photodegradation of polymeric/oligomeric materials derived from renewable bioresources. This research evaluates the sustainability for the production of 2,5-furandicarboxylic acid (FDCA), a polymer building block, from 5-hydroxymethylfurfural (HMF), an intermediate derived from renewable resource fructose. A phototrigger is attached to the monomers during the polymerization process, resulting in a polymer that degrades in the presence of UV light. The LCA results indicate that 38 to 49% of environmental impacts were attributed to the conversion of FDCA to polymer, where electricity consumption and use of non-renewable chemicals such as dichloromethane and other solvents were significant contributors. The process of recycling of polymeric material reduced all environmental impacts, suggesting that recycling outweighs the impacts caused by the production of phototriggers.
(a) Industrial Repair of Active Leaks Using Cold Spray.

Oladimeji Oladejo; Materials Engineering and Science Department

Mentor/Advisors: Dr. Bharat Jasthi; Materials and Metallurgical Engineering Department and Dr. Christian Widener; Materials and Metallurgical Engineering Department and Mechanical Engineering Department

Leak detection in a pipeline is followed by investigations of the best approach to deal with the problem, this is highly dependent on the flow properties of the line which in turn affects the cost and effectiveness of the process. Currently, the use of epoxy materials and seal clamps is being applied in the industry but these approaches have limitations which have to be improved on. Pipe size difference, line service and weight makes some of these methods less desirable. In this study, cold spray process will be utilized in the repair of active leaks in piping systems, the objective of the study is to explore the limits of a leak which can be sealed by the cold spray process, the amount of materials to be deposited for different flow parameters and crack geometries.
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. In this talk microstructural analysis of commercially available Ti-6Al-4V feedstock powders and their cold spray deposits is presented to identify the ideal powder microstructure for cold spray processing. Several feedstock powders (i.e. gas atomized, plasma atomized, hydride-dehydride) in as-received condition and their cold spray deposits were characterized using optical microscopy and scanning electron microscopy. Powders were deposited using a high pressure cold spray system and the coating quality was compared with respect to porosity, hardness, and adhesion strength.
Friction Stir Welding Pin-tool is a device that can withstand high temperatures and still able to retain most of its low temperature properties advantages. This has been a topic of research over the years and a source of inspiration for our research. Our project is designed to use low cost materials in the design of functional graded pin-tool that give an equi- or near equivalent properties of a bulk cermet material pin tool. Using our background of metallurgy coupled with Finite Element Analysis and Laser additive manufacturing, this research is focused on the use of metallurgical favored combinations of transition metals compositions in the design of a pin-tool that was made and tested. Then a scientific study of the properties of the pin-tool was carried out to analyze its mechanical and structural properties.

Figure 1: Temperature Gradient Through FEA Model Pin-Tool

References
Cold spray processing is a solid state deposition process commonly used to deposit dense metal coatings. The technique has potential, however, for depositing surface coatings for biomedical applications. As revision surgeries are complicated, 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. As-processed coatings were characterized using optical microscopy, scanning electron microscopy, x-ray diffraction, and contact angle goniometry. Adhesion strength of 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. Cell morphology, viability, differentiation, and mineral deposition were investigated.
(e) Fabrication of Alumina Coatings on Steel Substrates using a combined technique of Cold Spray and Plasma Electrolytic Oxidation

Sushma Priyanka Karanam; Materials and Metallurgical Engineering Department

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

Sushma Priyanka Karanam\textsuperscript{b}, Frank Kustas\textsuperscript{a}, Bharat K. Jasthi\textsuperscript{b}, Michael K. West\textsuperscript{b}

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Abstract:

The main objective of this study is to investigate the feasibility of depositing an aluminum oxide (Al\textsubscript{2}O\textsubscript{3}) layer on steel substrate by combining cold spray and plasma electrolytic oxidation (PEO) techniques. The cold spray technique was used to deposit a pure aluminum layer on the 430 stainless steel substrate as the first step. This coated substrate was subjected to oxidation through PEO process. The oxidation of the substrate is carried out in sodium silicate (Na\textsubscript{2}SiO\textsubscript{3}) electrolyte. Electrochemical testing of the coatings is performed in 3.5% NaCl solution to understand the resultant corrosion properties. Phase identification and microstructure were analyzed using Scanning Electron Microscope (SEM) and X-ray Diffraction (XRD) techniques. XRD results confirm the formation of crystal phases γ-Al\textsubscript{2}O\textsubscript{3} and σ-Al\textsubscript{2}O\textsubscript{3} on steel substrate after the PEO process. Abrasion and erosion testing were also performed to understand the wear performance of these coated specimens.
The main objective of this work is to investigate the microstructure and mechanical properties of cold spray deposited Oxide Dispersion Strengthened (ODS) steels. Conventional manufacturing of the ODS alloys involves time consuming and expensive prior mechanical alloying of the metal powder along with the dispersoids followed by compaction, sintering and thermomechanical processing steps. However, in the current research, ODS steels will be manufactured using the supersonic Cold Spray (CS) approach. In the cold spray process, powder particles (blend of metallic and oxide dispersoids) are accelerated by a supersonic gas jet at a temperature lower than the melting point of the powder, resulting in the formation of a bonded layers from particles in the solid state. Thus, the deleterious effects of high temperature oxidation, evaporation, melting, crystallization, residual stresses, gas release, and other common problems for traditional manufacturing of ODS alloys are mitigated or eliminated. The experimental approach of preparing the ODS 316 austenitic stainless steel powders with 10nm yttrium oxide dispersion and technical challenges involved in the cold spray approach are presented and discussed.
Graduate Poster Presentations

Session P-G1  8:00 – 9:30 AM Posters #1-6 Ballroom Surbeck Center

#1 Oxidation-reduction Potential Controlled Microaeration of very high Gravity Ethanol Fermentations

John Moore; Chemical and Biological Engineering Department
Mentor/Advisor: Dr. Patrick Gilcrease; Chemical and Biological Engineering Department

Due to the harsh conditions of very high gravity (VHG) fermentations and the resulting ethanol concentrations (up to 23.8% v/v depending on conditions, strain, and initial substrate concentration), yeast struggle to achieve maximum ethanol yields. At the beginning of a batch fermentation, high glucose concentrations (>150 g/L) create an osmotic gradient; this can hamper cell growth and lower the ethanol yield and rate of ethanol production. After a significant amount of glucose has been converted to ethanol, ethanol can compromise the yeast cell membrane and in turn decrease overall ethanol yield and rate of ethanol production. It has been shown that sparging a small amount of air during fermentation can counter the detrimental effects of a VHG fermentation medium (Liu, Xue, Lin, & Bai, 2013). Controlling the amount of air sparged can be difficult because traditional dissolved oxygen probes cannot be utilized to measure such low oxygen concentrations; therefore, oxidation reduction potential (ORP) probes can be implemented to control the air supplied to the fermentation. It has been shown that certain levels of ORP control (in the range of -50 to -150 mV) can maximize the ethanol yield. This work will investigate the use of ORP controlled microaeration during continuous fermentation and its effect on ethanol yield, specific rate of ethanol production, residual glucose concentration, cell concentration, cell viability, and glycerol production by attaining steady state measurements at varying ORP set points.

Cocrystallization of energetic materials is at the forefront of the energetics community. The objective is to obtain materials that have high performance and low sensitivity. In this work the co-crystallization technique is used to stabilize the highly sensitive energetic material, namely hexanitrohexaazaisowurzitane (CL-20) using triaminotrinitrobenzene (TATB) as a co-former. Two methods are explored: rapid nucleation solvent/antisolvent method and resonance acoustic mixing (RAM) technology. The materials produced from both methods are characterized by optical microscopy, x-ray powder diffraction (XRD), raman spectroscopy, and differential scanning calorimetry (DSC). Although the characterization results were close in some instances the RAM product was not consistent with the solvent antisolvent method as well as reported results in literature. More research is needed to confirm the formation of a true co-crystal.
Nanoparticle drug delivery has shown much promise in vitro and in vivo as it provides a foundation that can be easily tailored depending on the characteristics of the disease. Modifications such as size, shape, material composition, drug payload, and targeting moieties affect the cellular internalization and drug release kinetics as well as the therapeutic efficacy. While there are currently over 50 FDA-approved nanomedicines, only eight of those are approved for the treatment of cancer [1]. Non-small cell lung cancer (NSCLC) is the leading cause of cancer morbidity in the United States, but only Abraxane® (albumin-bound paclitaxel) is approved for treatment [2]. For clinical trials and eventual FDA approval, nanoparticles must be consistent in biological behavior and pharmacological profile. Unfortunately, nanoparticles are typically produced in small, non-homogenous batches which leads to difficulty in experimental reproducibility and scale up for commercial production.

As such, this research aims to show and optimize the factors that most affect particle size, polydispersity, drug encapsulation efficiency, and drug release profile. These factors include solvent/polymer interactions, synthesis method, polymer chemistry, and polymer molecular weight. To study processing parameters, nanoparticles are produced with flash precipitation method using polystyrene as the model polymer and several agents with varying degrees of hydrophobicity (i.e. fluorescein, rhodamine B, DiD oil) as the model drug. Optimization factors investigated thus far 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. To study polymer chemistry and polymer-drug interactions, poly(lactic-co-glycolic acid) (PLGA) with paclitaxel will be used. Therapeutic encapsulation efficiency and therapeutic release profiles will be measured by ultraviolet/visible light absorption (UV/Vis).
Security printing and anti-counterfeiting technology must be ever changing to stay ahead of counterfeiters. Specifically, finding new methods and new materials to use as security features on valuable items can thwart forging. In this regard, superhydrophobic silica nanoparticles are one material to provide a novel approach. The silica nanoparticles are treated with alkyl silanes and then mixed with polystyrene. The alkyl silane turns the naturally hydrophilic silica particles hydrophobic and the polystyrene aids in adhesion. The particles are printed on paper and the contact angle of water on the particles is tested. It was found that with specific printing conditions superhydrophobic surfaces resulted. There are two printing methods that are being tested. Adhesion tests will be performed on the silica nanoparticles to find out if adhesion is greater with different approaches.
Biodegradable materials have been used in a variety of applications (e.g. endovascular stents and bone implants) to mitigate long-term complications often caused by permanent implants, while also eliminating costly follow-up surgery to remove the implants. In this regard, magnesium and magnesium alloys have gained considerable attention for use in biodegradable implants due to their excellent biocompatibility, non-toxicity, ideal mechanical stiffness, and their unique ability to naturally degrade (corrosion) in the physiological environment. Furthermore, magnesium is also an essential element in the human body (240-420 mg/day recommended daily intake), an ideal attribute for biodegradable materials. While magnesium actively corrodes in the physiological environment, the corrosion rate is often too rapid, resulting in the loss of implant mechanical integrity and high hydrogen gas evolution. This research focuses on the development of additive manufacturing technology to produce biodegradable magnesium alloy implants with controlled biodegradation behavior. Additive manufacturing offers the potential to develop compositionally gradient biodegradable implants and complex implant designs for improved biological function. In this work, microstructure, mechanical properties and corrosion behavior of commercial wrought WE43 (Mg-Y-RE (rare earth)) magnesium alloy and direct energy deposition (laser powder deposition) WE43 samples were investigated. Microstructure characterization was conducted using optical metallography. Mechanical properties were evaluated using Vicker’s microhardness testing. Finally, corrosion (biodegradation) behavior was evaluated using potentiodynamic polarization and immersion testing in simulated body fluid.
Metal-organic chemical vapor deposition (MOCVD) is commonly used in the production of group III-V semiconductors. Aluminum is a group III metal, it is an abundant element which is inexpensive and easy to procure. Elemental aluminum is lattice matched to Ga$_{0.82}$In$_{0.18}$As (GaInAs) with an in-plane $45^\circ$ rotation with regards to the (001) plane. Incorporated Al layers in III-V semiconductors could form a buffer layer, lift-off layer, or a reflecting layer to improve solar cell efficiencies. Yet it is not used in III-V semiconductors due to the difficulty in splitting the Al-C bonds in the trimethylaluminum source material and depositing elemental aluminum through normal MOCVD processes. Plasma enhanced MOCVD is one method being explored to tackle this problem. A hydrogen plasma formed in the reactor inlet can provide enough energy to separate the Al-C bonds in the trimethylaluminum source material and aid in the deposition of elemental aluminum. Through the use of transmission electron microscopy and powdered X-ray diffraction, the change from depositing an Al-C alloy to depositing elemental Al was seen when hydrogen plasma enhanced MOCVD is used.
#7 Photomultiplier Assembly for Cosmic Ray Veto System for AlphaBACH Detector

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A large volume Alpha-Beta-radiation-Assay CHamber (AlphaBACH) 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. 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 AlphaBACH 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 as well as allowing nuclear forensics for counter terrorism.

A cosmic ray veto system, consisting of large panels of plastic scintillators surrounding the AlphaBACH, will even further improve the sensitivity. Photomultipliers with high voltage dividers have to be designed, assembled and tested before they can read-out the plastic scintillator panels in the final configuration of the cosmic ray veto system.
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 the DD-generator gun, Cf-252 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 characterized before the actual deployments of the sources will be performed, in order to assess if they are suitable and what the detection efficiency in the detector is.

A new neutron telescope, utilizing He-3 proportional counter tubes, is being developed within the framework of the LUX/LZ project.
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 do not belong in the body. There are three types of endocytosis: phagocytosis, pinocytosis, and receptor-mediated endocytosis. Differences in the structural characteristics of cells undergoing phagocytosis and pinocytosis were observed by TEM. The phagocytic vesicles are called “phagosomes” and are filled with engulfed solid materials where as the pinocytotic vesicles are called “macropinosomes” and are filled with fluid materials, which have been taken into the cell. In particular, we will present a quantitative comparison of vesicle characteristics for three different types of macrophage samples: (1) normal phagocytosis, (2) normal pinocytosis and (3) stimulated pinocytosis. Stimulation increases the cell activity and increases the number of endosomes within each cell. The quantitative analysis between stimulated and non-stimulated cells shows increased activity of the endocytosis process due to treatment. We also will discuss the clathrin-mediated endocytosis process in macrophages to elucidate the role of clathrin (protein) molecules in maturation and degradation of endosomes in macrophages. We compare, control samples (with clathrin) to knockout cells (without clathrin). For cells in which clathrin has been knocked out, intraluminal vesicles (ILVs) and late endosomes (LE) are present, showing that ILV degradation correlates to the presence of clathrin.

Figure: TEM images of macrophages showing: (a) phagocytosis for Non-stimulated cells, (b) pinocytosis for stimulated cells, and (c) clathrin-mediated endocytosis with the presence of ILVs inside LEs.

REFERENCES

# Power Dependence and Spectroscopic Imaging of Near-Infrared to Visible Upconversion Luminescence from NaYF₄:Yb³⁺: Er³⁺ Nanoparticles on Silver Nanowires.

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Upconversion, wherein the frequency of light is altered by summing individual quanta of light energy, producing higher energy photons in the process, has many useful applications in energy, imaging and communication technologies. Lanthanide-doped NaYF₄:Yb,Ln³⁺ upconverting nanoparticles have attracted a great deal of attention due to their relatively high efficiency and deplorability (compared to other types of upconverting materials). These upconverting nanoparticles (UCNPs) besides being chemically stable and nontoxic, produce upconverted light at high signal to noise ratios, but their low absolute efficiency (≈3-4%) currently limits their use in practical applications. Studies have shown that the luminescence intensity of UCNPs can be enhanced in close proximity to metallic nanostructures. Since the efficiency of upconversion luminescence from lanthanide-doped upconverting nanoparticles, such as NaYF₄:Er³⁺,Yb³⁺ nanoparticles, depends on excitation intensity, the relative enhancement of upconverted emission will also depend on intensity. In this work, our aim is to determine the power dependence of near-infrared to visible upconversion luminescence enhancement from NaYF₄:Yb³⁺:Er³⁺ nanoparticles supported on silver nanowires, and to interpret the relative enhancement in terms of a rate equation analysis in order to elucidate the mechanisms for enhancement, ultimately down to the single nanowire level.

References:

Figure 1. a) TEM images of NaYF₄:Er³⁺,Yb³⁺ upconverting nanoparticles. b) Representative spectra showing the maximum/minimum intensity counts of Ag nanowires on β-NaYF₄:Yb³⁺, Er³⁺ UCNPs in PMMA thin film. Inset is a 20× magnified view of the spectra of minimum intensity counts.
Incorporation of aluminum epilayers in III-V photovoltaic materials could be a promising step towards the future of photovoltaic technology by improving the quality of low-cost photovoltaic devices. Aluminum can be used as buffer layer for the growth of films on it, therefore it can dissipate the thermal energy formed in the solar cells.

We used transmission electron microscopy and powdered x-ray diffraction technique to characterize Al on GaAs substrate grown by two different methods, standard metalorganic chemical vapor deposition and plasma assisted metalorganic chemical vapor deposition technique. Lattice imaging and energy dispersive x-ray analysis from TEM showed the deposition of polycrystalline aluminum-carbon compound when the standard MOCVD technique was used. The analysis of x-ray diffraction and electron diffraction showed the presence of an Al₄C₃ phase due to strong aluminum-carbon bond in the trimethylaluminum source. However, powder XRD investigation of growth on both glass and GaAs substrates using plasma assisted MOCVD technique revealed the presence of Al (111), Al (200) and Al (220) distinct peaks.
Correlative Photo-Activated Localization Microscopy and Atomic Force Microscopy of Transferrin Receptors in COS-7 Cells

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We report progress on simultaneous PALM and AFM imaging of COS-7 cells, one of the laboratory cell lines derived from the kidney of the African Green Monkey in the 1960’s1. The cells have been transfected to express PA-mcherry, a photo-activatable fluorescent protein, fused to the transferrin receptor, a carrier protein used to import iron into the cell. The use of PA-mcherry allows us to perform photo-activated localization microscopy (PALM), a novel super-resolution microscopy method achieving 10-50nm resolution, surpassing the Rayleigh criteria 50-10X2. Here, we use PAmcherry to track the transferrin receptors using PALM imaging, to investigate receptor distribution on unroofed cells. We aim to correlate the PALM imaging with the topography of the cell, obtained by AFM. By combining these methods, we will have a clear description of any observed clustering and evidence of receptor clustering in relation to the cell architecture, including clathrin endocytic pits (cages) and the network of actin filaments. Similar methods are used to track the binding of Carbohydrate Binding Modules (CBMs), polysaccharide specific binding proteins which are a component of cellulase enzymes, by employing a PA-mCherry - CBM fusion construct for super-resolution PALM imaging of CBMs on nanocellulose substrates3,4.

References:

Biomaterials are widely used in today’s medical, dentistry, and biotechnology applications but that was not the case a short 60 years ago. The first generation of biomaterials began around 1940 with the objective being bioinertness. The objectives of biomaterials have evolved toward the regeneration of functional tissue. Properties of current biomaterials include biointeractive, responsive, and resorbable characteristics that promote stimulation of specific cell responses at the molecular level. Regardless of the material introduced to the body, a host immune response is initiated once applied within the biological system known as the foreign body response. Ultimately, the nature and magnitude of the foreign body response can lead to the degradation of the material with subsequent clinical device failure.

The initiation of the FBR involves the recognition of the material as foreign by neutrophils. This initiation could potentially be intervened by inhibiting neutrophil recognition. Immediately, the inserted biomaterial acquires a layer of host proteins which modulates the host inflammation and wound healing response. Controlling the interaction between the absorbed proteins and the adhesion receptors of the inflammatory cells could minimize inflammation response. The progression of events continues with migration of monocytes to the implant site, their differentiation into macrophages, and ultimately the generation of a fibrous formation around the material. The most common prevention of the foreign body response is the combination of preventing protein absorption (surface modification with polyethylene glycol (PEG)) and drug delivery applications with the applied implant. This approach possesses the potential of minimizing inflammation and fibrosis through steroidal and non-steroidal anti-inflammatory, and angiogenic drugs.

The THP-1 cell line is a human leukemia monocytic cell line. It is extensively used to study monocyte/macrophage functions, mechanisms, signaling pathways, and nutrient and drug transport. It’s ability to act like a native monocyte-derived macrophage combined with its immune response characteristics make it an ideal model for studying the foreign body reaction. These cells can be differentiated into different classes of macrophages as well as dendritic cells through different laboratory techniques and treatments. The indications of inflammation and immune response will be observed through cytokine screening, gene and protein expression. Combining marker genes with techniques such as qPCR will provide quantifiable data of differentiation. Cell surface markers and cytokine levels can be obtained through immunofluorescence. The resulting immunofluorescence can be benchmarked against known inflammatory agonists to quantify the level of inflammation response. Once a THP-1 model is validated, it can be used to observe host immune responses to standard materials used as implants. Ultimately this model will be used to screen interventions designed to protect biomaterials from FBR.
Over the last few decades, synthetic biodegradable polymers captured the attention of drug delivery scientists with their prominent features—biocompatibility and in vivo degradation into benign materials. Different classes of synthetic biodegradable polymers (polysters, polyanhydrides and polyethers) have different properties (degradation method and rate, hydrophobicity, and thermal stability) which can be tailored for specific applications. The breadth of monomers used in these different classes of biodegradable polymers is limited, which has led to various post-synthesis modifications of these materials to expand their properties for specific applications. The aim of this project is the establishment and optimization of polymer synthesis procedures which can be utilized with novel monomers to tailor biodegradation and thermal stability of innovative biodegradable polymers.

The optimization was performed by synthesizing homopolymers of poly(lactic acid) and poly(sebacic acid) by melt polycondensation of lactic acid and sebacic acid. The operating parameters investigated were reaction time, temperature, pressure and the effect of acetylation of monomers on degree of polymerization. The resulting polymers were characterized by H-NMR for purity and to determine the average molecular weights of the homopolymers synthesized. H-NMR study revealed the successful synthesis of homopolymers of sebacic anhydride(PSA) and homopolymers of lactic acid (PLA). The molecular weight (5000) of poly sebacic anhydride was obtained at polymerization temperature 150°C under vacuum for 5 hours of reaction time. Optimization of parameters for PLA synthesis is ongoing.

Future characterization of synthesized polymers will include Gel Permeation Chromatography (GPC) to determine the polymer molecular weight distribution. Thermal properties will be studied using Differential Scanning Calorimetry (DSC). To study the influence of monomer composition on biodegradation we are developing a COMSOL Multiphysics model which considers 1) Time dependent variables - number average molecular weight of long chains, number of chain scissions per unit volume. total number of hydrolysable units of all the long chain per unit volume, average degree of polymerization of all the short chains, total number of hydrolysable units of all the short chains formed. 2) Kinematic parameters - Diffusion coefficient of short chains in a degrading polymer, porosity of the polymer caused by loss of short chains. The degradation profile of PLA using COMSOL model was validated against literature values.

Future work will look at expanding the monomers used in the synthesis process and expanding the system to study biodegradable copolymer systems.
Graphene Oxide-epoxy Nanocomposite as an Effective Coating to combat Microbial Induced Corrosion

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Metals and its alloys have been successfully used as electrodes in several abiotic electrochemical devices including hydrogen fuel cells. Specifically, the 3D metal foams possess exceptional properties (e.g. high surface area, porosity and 3D open structure) that can promote the performance of a given electrochemical device. The nickel foam has been recently used as a template to obtain 3D graphene electrode structure using a chemical vapor deposition process. Nevertheless, the use of both 2D and 3D metallic structure is rather discouraged in biotic electrochemical devices such as Microbial fuel cells, primarily due to the risk for microbial induced corrosion (MICs). Past studies have shown the use of polymer coating for underlying metal protection to be vulnerable to MIC in organic rich environment such as wastewater. In case of graphene-coated nickel foams, defects in the graphene can promote metallic corrosion. Recent studies have shown graphene oxide (GO) - polymer composite can effectively control MIC with GO’s dual role as a nanofillers and antimicrobial properties. Here we report the use of Graphene oxide-Bisphenol A epoxy resin (GOE) composite coating for protection of Nickel foam exposed to wastewater (WW). GOE was synthesized using mechanical mixing and sonication. Dip coating was employed to obtain a GOE coating thickness of 20 μm on the Nickel surface. Scanning Electron microscopy (SEM) was employed to ascertain the structure of nanocomposite coating on 3D Ni foam structure. Fourier transform infrared (FTIR) spectroscopy showed the interaction of carboxyl group in the GO with the epoxy resin. SEM images showed the uniform spread of GOE composite on the 3D nickel foam structure. Electrochemical analysis in a three electrode corrosion cell was used to study the corrosion behavior. Preliminary results have shown the effectiveness of GOE composite to reduce MIC. After 290 hours of exposure to WW, corrosion rates using linear polarization resistance (LPR) method for Ni coated with GOE (Ni-GOE) was one order of magnitude lower (0.12 mills per year (mpy)) than that of bare nickel foam (1.75 mpy). During the same period the open circuit voltage for Ni-GOE stayed more positive at -408 mV compared to that of bare Ni which was at -609 mV further affirming the lower tendency of Ni-GOE to undergo MIC. Electrochemical impedance spectroscopy also indicated Ni-GOE to have at least 4 times higher charge transfer resistance (16 KΩ/cm^2) than that of bare Nickel (4 KΩ/cm^2). In conclusion, this study highlights the effectiveness of GO as nano-filler to combat MIC. Long term studies are required to study the biofilm formation on the surface of Ni-GOE which is critical for its application in bioelectrochemical devices such as Microbial fuel cell.
Many industries, notably the automotive and aerospace industries, are now utilizing thermoplastic matrix composites (TPMCs) for their improved strength and stiffness properties compared to pure thermoplastic polymers, as well as their manufacturability compared to traditional thermoset matrix composites. The increase in the utilization of TPMCs ushers in the need for the development and characterization of joining methods for these materials. A widely used technique for joining thermoplastics is ultrasonic spot welding (USSW). During USSW, high frequency, low amplitude vibrations are applied through an ultrasonic horn resting on the polymer surface. The vibrations induce frictional heat, producing a solid state joint between polymer sheets. Advantages such as short weld cycle time, fewer moving components and reproducibility make this technique attractive for automation and industrial use. Prior work showed USSW as a feasible, repeatable joining method for a polycarbonate matrix filled with chopped glass fibers. The mechanical properties required for full characterization of the TPMC used in this work were not provided by the manufacturer. As such, the constitutive behavior of both as-received and USSW thermoplastic composite material (polypropylene matrix filled with 30 wt% chopped glass fibers) was characterized. The fiber orientation and distribution in TPMCs has a direct impact on constitutive behavior. To characterize these qualities, optical techniques such as scanning electron microscopy (SEM) and micro computed tomography (micro-CT) were employed. Digital image correlation (DIC) was used to acquire full field strain measurements from the composite material under different loading scenarios. Because the constitutive behavior of polymers is greatly dependent on temperature, temperature measurements during the USSW process and measurement of mechanical properties as a function of temperature will be conducted through infrared (IR) imaging and dynamic mechanical analysis (DMA), respectively. Following the calibration of the constitutive model for the polypropylene matrix TPMC, the mechanical and thermal properties will be used to develop a computational framework for the purpose of predicting the structural response of a composite joint under various loadings.
Epoxy foams utilizing tailorable volume fractions of continuous, micro-channel-shaped void structures have been developed using sacrificial fiber templates. The resulting micro-channel network is anisotropic, and has been characterized both mechanically and thermally. As the volume fraction of micro-channels is increased, the thermal insulation capability also increases, but the mechanical properties are substantially reduced. In an effort to offset the mechanical property losses, a variety of low areal density fiber veils have been used as reinforcement for the micro-channeled structure. Carbon fiber, aramid fiber, and polyphenylene sulfide fiber veils were used. The lightweight veils, which are simply stacked in a desired sequence with the sacrificial fiber template, reinforce the mechanical properties of the composite with only minimal bulk density contributions. The veil fiber content was varied relative to the micro-channel fraction to study the mechanical response of a series of low bulk density composites. It is expected these veil materials can be utilized as reinforcement while still allowing for excellent thermal insulation capabilities to be achieved in final hybridized, multi-functional composite designs.
Surface Interaction are fundamental aspects to understanding the role of surface chemistry. In this work, we report the patterning of polycarbonate materials by direct laser interference ablation. This process shows a straightforward patterning technique based on the number of shots of the laser ablation on the polycarbonate material. These patterns were characterized by atomic force microscopy and optical microscope.
Bow echoes are a sub-classification of a Mesoscale Convective System (MCS) characterized by an intense line of convection that takes on a bow-like shape when viewed on weather radar. While these systems can produce a wide range of severe weather hazards (including large hail, tornadoes, and flash flooding), they are typically recognized to be producers of straight-line damaging winds. One mechanism by which these storms can produce damaging winds is through the descent of a rear inflow jet (RIJ) near the leading edge of the system. While this mechanism is well understood, bow echoes with descending versus non-descending RIJs can be difficult to discern operationally due to issues with radar sampling in the near-surface layer. Unless the storm is very close to the radar site, a lack of data near the surface makes it difficult to determine if the RIJ is descending in a manner that would produce damaging winds at the ground.

This study is using polarimetric radar data to assess the microphysical characteristics of bow echoes with descending and non-descending RIJs. In a convective storm negative buoyancy, induced by cooling from melting and evaporation, can create a strengthened downdraft and force the descent of a RIJ. With the recent upgrade of the National Weather Service WSR-88D network to dual polarization, information related to these processes may be available in an operational framework. For instance, regions of melting hydrometeors can be identified using the specific differential phase and correlation coefficient products. Similarly, regions of small liquid drops that may favor enhanced evaporation can be identified using differential reflectivity and specific differential phase. If patterns in these fields unique to descending RIJ cases are identified, they could be used to detect a descending RIJ in the absence of near-surface Doppler wind data.

Archived polarimetric radar data for bow echo cases from the years 2013-2015 have been gathered and are being analyzed for common polarimetric signatures. Bow echoes that occurred close to radar sites were selected so that Doppler velocity data can capture RIJ descent, if present. Additionally, Storm Prediction Center severe weather reports were analyzed to help confirm likely cases of RIJ descent, based on reports of widespread damaging winds. This presentation will focus on results of the case study comparison of descending and non-descending RIJ cases and lay the groundwork for a more extensive numerical modeling study that will build upon these results.
The Ogallala and Arikaree units of the High Plains Aquifer consist of a heterogeneous sequence of silts, sands, clays, and gravels which were deposited in a fluvial setting. Due to the hydrogeologic complexity and variability of these units, it can be difficult to estimate hydrologic parameters for these units. For locations without monitoring wells, these values have been derived in the past through statistical equations or by building simulation models.

Artificial neural networks (ANNs) consist of interconnected nodes of computational units (called neurons) that can be used to model complex, non-linear relationships between inputs and outputs. ANNs can be used to predict missing data values and have proven faster, more accurate, and more reliable than statistical methods. ANNs can be constructed in many programming languages, with varying numbers of neurons and layers, and with different transfer functions (which allow individual neurons to make decisions during the training phase). Most importantly, ANNs are adaptive; they change in response to data that the network receives during the training phase. Once trained, ANNs can be used for predictive analytics.

Machine Learning algorithms such as ANNs use fewer assumptions than statistical models and are thus less subject to over-fitting. ANNs can be used for both supervised and unsupervised learning. Supervised learning is generally used for regression analysis, time series prediction, and modeling. Unsupervised learning is used for classification, such as pattern and sequence recognition.

For this project, a multi-layer feed-forward neural network (MLP) will be constructed in the Python programming language. The MLP will be trained on published hydrological data. Model calibration can be completed by withholding 20% of the published data during the training phase, and then comparing MLP predicted hydrologic values against field-measured hydrologic values. The MLP can then be used to model hydrologic parameters and surface water-groundwater interaction for these High Plains Aquifer units.
Due to the finite nature of fossil material, any loss of specimens is a potential loss of irrecoverable scientific data. In the Pierre Shale of Western South Dakota, this risk is compounded by the fissile nature of the rocks and the high erosion rates. This study examines erosion rates of the Sharon Springs Formation of the Pierre Shale group using both erosion rate estimates from erosion bridge measurements and calculated from close range photogrammetric models. These erosion rates are compared to precipitation events, wind speed, and wind direction to determine a primary driver of erosion in the area. Erosion rates and erosion drivers are then compared against movement of fossil specimens and qualitative examinations of the study area to construct a model to measure risk of losing fossil material before being able to recover it in the field. Risk to fossils does not seem to be linearly related to erosion rates, but may occur at a threshold where flow is high enough to form small streams.

Since the beginning of large-scale mechanized cave mining methods, researchers have used various engineering techniques to understand and predict the nature of cave propagation [1]. Among the different engineering techniques, numerical modeling techniques are gaining popularity as they can provide a more fundamental, rigorous and robust assessment of the cave propagation [1].

This study uses the state-of-the-art continuum numerical code, FLAC3D (Itasca 2012), for analyzing changing cave conditions of a propagating cave in both block and panel cave mines. [2] Pierce et al. (2006) exemplify the current state-of-the-art algorithm in rock mechanics for cave propagation analyses [3]. This research uses his algorithm for performing the sensitivity analysis to study the effects of rock strength and ore extraction rate on the cave porosity.

To investigate the effect of the in-situ geomechanical conditions and imposed production schedule on the cave porosity, conceptual models of both panel and block cave mines were developed by considering two different rock mass properties (RM1 and RM2). Post peak properties of rock masses were (plastic strain) applied to the model by considering the appropriate Cohesion and friction angles for the two rock masses. The effect of extraction rate on the cave porosity was examined by applying two different velocity values of 0.0001 m/s and 0.0002 m/s at the grid points in the roof of the undercut.

Cave porosity was calculated as a function of volumetric strain using a FISH code, a programming language embedded within FLAC3D. During the cave evolution, for each zone of the model, initially the bulk densities were calculated using the predicted volumetric strain; from the bulk density values, porosity of the cave was calculated. Soft softening constitutive model was used for this study.

In conclusion, cave propagation rate and porosity depend on the rock mass strength and the extraction rate. From the predicted porosity values, it was observed that mobilized zone of the cave has a porosity of 0.4 which was close to the value reported by the previous researchers. Seismogenic zone has a porosity value in the range of 0.4 to 0.025. The elastic zone has a negligible porosity of below 2.94e-4.

References


Block/panel caving is a process which involves undermining the ore body and allowing it to fall under its own weight. This method is gaining popularity in mining low grade, deep-seated, and massive mineral deposits mainly due to its higher production rates and low production costs. However, in the extraction of mineral deposits containing uranium mineralization using block/panel mining method, radon gas emission is a major concern for mining operations. Therefore, design of an effective ventilation system for such operations is vital to the safety of the personnel. The main aim of this study is to evaluate the effect of changing cave conditions (rock fragmentation, porosity, and radon generation rate) on the air flow resistance of the cave and gas emissions during the cave evolution. This study uses a continuum based Computational Fluid Dynamics approach, and provides important insights for designing an effective ventilation system for block/panel caving mines.

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Block/panel caving is an underground mining method that uses the concept of gravity to mine and exploit massive, steeply dipping, deep-seated ore deposits which cannot be mined by conventional open pit methods. Ventilation is one of the key elements in the underground mining methods especially in block caving method (involving Uranium ore) where radon gas is a major concern for mining operations.

This study investigates the effect of changing cave characteristics (porosity) on the air flow resistance of the cave and gas emissions from a mature panel cave. A continuum based computational fluid dynamics approach is used for the study. The predicted cave airflow resistance values and radon emission rates are useful data for mine ventilation engineers in designing an effective ventilation system for block/panel cave mines.
#25 A Phylomorphospace Approach to Examining the Role of Habitat in Diversification of Lucinidae (Bivalvia, Mollusca)

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

Lucinids are the most diverse chemosymbiotic family with over 400 known extant species living at a range of latitudes, water depths, and habitats. Lucinids have been around since the Silurian, however, it was not until the appearance and diversification of shallow-water vegetation (i.e. seagrass beds and mangrove forests) that lucinids diversified. Molecular phylogenies have been used for reconstructing the evolutionary history of deep and shallow-water lucinid taxa, but has not assessed the role habitat plays in shell morphology. Constructing a phylogeny while assessing shell shape in relation to habitat will aid in understanding how the diversification of shallow-water vegetation aided in the radiation of lucinids. This study will utilize a phylomorphospace to visualize and test for diversification events throughout time, and if these diversification events are associated with morphologic diversification related to habitat. A phylogeny will be combined with a multivariate morphospace to produce a phylomorphospace to visualize evolutionary changes in the shell shape of the Lucinidae. Fossil stratigraphic range data and molecular data from 14 lucinid taxa will be used to produce a time-calibrated phylogeny. Geometric morphometric analyses will be used to obtain shell shape data from the lucinid taxa. The phylomorphospace will then be used to examine how the shape of the lucinid shell is related to habitat.

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1Stanly, SM. 2014. Evolutionary radiation of shallow-water Lucinidae (Bivalvia with endosymbionts) as a result of the rise of seagrasses and mangroves. Geology 42:803-806.
Prevalence of Clinically Relevant Antibiotic Resistance in Resident Bacteria in Selected Sites of the Big Sioux River

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

Dr. Linda C. DeVeaux¹ and Dr. Lisa A. Kunza²
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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 antibiotic 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 enterohemorrhagic *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 have extended 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. Our research has demonstrated that antibiotic resistance genes are present in selected areas of the Big Sioux River that are of clinical relevance, as well as bacterial isolates that are resistant to multiple antibiotics from Big Sioux water samples. We will continue to determine the source of antibiotic resistant bacteria and associated health risks that may lead to improved monitoring and remediation efforts for bacteria in the future.
#27 Climate Change Vulnerability Assessment and Effective Drought Management Adoption for Buffalo

Joseph Wilder; Civil and Environmental Engineering Department

Mentors/Advisors: Dr. Venkata Gadhamshetty; Civil and Environmental Engineering Department and Dr. Scott Kenner; Civil and Environmental Engineering Department

Coauthors: Dr. Scott Kenner; CEE, Dr. Venkata Gadhamshetty; CEE, Dr. William Capehart; CEE, Dr. Maribeth Price; GEOE, Dr. Kurt Chowanski; GEOE, and Mark Yeske; CEE

With climate variability continuing to increase, tribal resource managers need a methodical guide to help manage their buffalo herds. Many tribes do not have adequate buffalo management plans, if any at all. To ensure long-term sustainability of their buffalo herds, predictive climate change models need to be applied to help make key decisions. The purpose of this applied research project is to develop a systematic guide in which tribal resource managers can understand the vulnerability to climate variability and make knowledgeable decisions regarding adaptive best management practices (BMPs). A goal of this project is to evaluate and assess the impacts of climate change and drought on the resources and land of the Intertribal Buffalo Council’s (ITBC) member tribes and assist the ITBC in developing management plans.

Buffalo herds on Indian lands are managed for various purposes to promote spiritual revitalization, cultural enhancement, ecological restoration, and economic development. The Environmental Protection Agency (EPA) suggest that climate change is already starting to and will continue to affect tribal traditions; some due to the disappearance of culturally significant animals, such as buffalo (EPA, 2017). Per the EPA, climate variability is projected to affect precipitation patterns, the amount of winter and spring precipitation, the number of days with heavy downpours, summer dryness, and the duration of time periods without rainfall.

Nine climate change indices such as mean monthly temperature, mean monthly precipitation, and mean monthly soil moisture, that may affect bison vulnerability to climate change will be related to projected changes and known effects. An example of this relation can be seen in Table 1. By recognizing variables that may affect bison vulnerability to climate change and implementing suggested BMPs to overcome these impacts, tribal resource managers will be able to efficiently manage their resources, including forage, water, and bison.

Table 1: Climate Chance Indices and Related Changes and Effects

<table>
<thead>
<tr>
<th>Climate Change Index</th>
<th>Projected Change to Known Climate Conditions</th>
<th>Relevant Climate Conditions</th>
<th>Current Effects of Known Climate Conditions on Forage Projection</th>
<th>Current Effects of Known Climate Conditions on Water Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Monthly Temperature</td>
<td>Warmer winter temperatures</td>
<td>Less snow and more rain</td>
<td>Reduced water storage as snow can reduce forage production</td>
<td>Reduced water availability, increased demand on available sources</td>
</tr>
<tr>
<td></td>
<td>Warmer spring temperatures</td>
<td>Less snow and more rain, earlier and faster snowmelt</td>
<td>Earlier change in bison metabolic rate can increase forage demand by bison</td>
<td>Reduced water availability, increased risk of flooding</td>
</tr>
</tbody>
</table>

Fossil Foraminifera and Sedimentary Trace Elements Reconstruct low-Oxygen Conditions in the Gulf of Alaska over the past 60,000 Years

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

During the last ice age, millennial-scale episodes of expanded low-oxygen conditions occurred around the margins of the North Pacific, however the drivers of these events are not well understood. Here we combine faunal and geochemical analyses to investigate the timing and severity of low-oxygen events in the North Pacific at a slope (682 m) over the past 60,000 years.

Multivariate faunal analyses based on the relative abundances of benthic foraminiferal species reveal a distinct faunal assemblage characterized by high abundances of taxa associated with dysoxic to suboxic conditions including Bulimina tenuata, Bolivia pacifica, and Epistominella pacifica. Sedimentary trace element analyses show enrichment in Re, Mo, and U where these faunas are found, supporting these foraminiferal faunas as low-oxygen indicators. These fossil assemblages have no faunal analog within the modern Gulf of Alaska, thus these faunas may represent a more intense OMZ (Oxygen Minimum Zone) in the past than present in the modern Gulf of Alaska.

High relative abundances of Nonionella sp., Stainforthia fusiformis, and small-bodied taxa common in settings with high phytodetritus co-occur with some of these low-oxygen assemblages, suggesting a link between low-oxygen events and increases in organic matter flux to the seafloor. These assemblages occurred during the most recent deglacial (~12,000 kyr), during MIS 3 from ~45,000-55,000 years ago, with shorter-term events through the last glacial period (20,000-60,000 years ago), contemporaneous with previously recorded abrupt warming events. Associated glacial melt-water pulses may have contributed nutrients to the Gulf of Alaska, stimulating productivity, or contributed to stratification; both mechanisms could result in low-oxygen bottom waters.

High rates of sedimentation in Pleistocene will enable future high-resolution studies (50 years) across low-oxygen events to determine how abrupt these changes in oxygenation were in the past. In addition, additional geochemical proxies, such as oxygen and carbon isotopes, will help test the association of low-oxygen events with changes in productivity or meltwater input. This knowledge is critical to forecasting the future of Gulf of Alaska as it can help to understand the chances of occurrence of severe hypoxia in the modern as well as the future which may heavily affect the coastal life and fisheries.
Alterating the distribution of nutrients can have major implications on aquatic ecosystems. Phosphorus loading is most commonly known form of nutrient loading, seen in the formation of toxic algal blooms. However, nitrogen loading can also have detrimental impacts. The Kootenai River was known to be ultraoligotrophic, due to the historically low concentrations of nitrogen and phosphorous. Nitrate levels have increased in the Kootenai since the mid 2000’s, while soluble reactive phosphate (SRP) concentrations continue to be found at or below detection limits. To better understand the rate of nutrient uptake and the impacts of nitrate loading, we completed a depth profile of Koocanusa Reservoir and a longitudinal study of the Kootenai River. We sampled the reservoir every 5 meters from the surface to the bottom in 4 locations, with the deepest location exceeding 100 meters. We divided the river into three reaches based upon varying characteristics. From the Libby Dam, managed by the Army Corps of Engineers, through Libby, MT, the Kootenai flows with a low sediment load and high light penetration through the water column. At the Idaho/Montana border, a nutrient addition site introduces phosphorus into the river during the summer months to stimulate algal productivity. The last section, from Bonners Ferry, Idaho to the Canadian border, the river meanders with low gradient and higher sediment loads. Based on nutrient distribution and light availability, the nitrate loading may influence each section of the river differently. We will examine the efficiency of nitrate uptake in the reservoir and river. If the imbalance of nitrogen to phosphorous continues to increase due to nitrate loading, the biota may shift within the river leading to a decline in biodiversity and alter food web dynamics.
This component of the MACRO (Macroecological Riverine Synthesis) project focuses on characterization of hydro-geomorphology to relate riverine ecology through Functional Process Zones (FPZs) as defined by Thorp, et al. (2006). The overall project will include a comparison of riverine ecosystems of temperate and mountain steppe ecosystems between Continental United States and Mongolia. In the first year data was collected using adapted EPA Environmental Monitoring and Assessment Program (EMAP) (McDonald et al., 2002) and Physical Habitat (PHAB) protocols to provide characterization of selected sites associated with four different FPZs on three rivers (Carson, Bear and Humbolt) in the Great Basin. This information is used to compare riverine physical habitat characteristics along basins and between basins and to compare FPZ characterization to geomorphologic characterization through principal component and cluster analysis.

References:


Rapid Creek temperatures exceeded the daily maximum and weekly average standards, as set by the SDDENR, nearly 45% of the time in July and August 2010. Aside from increasing temperatures, Rapid Creek has a spatial temperature gradient increasing from the tail waters of Pactola Dam through Rapid City. If a stream becomes too warm or variability in temperature increases, organismal populations can be critically influenced. Coldwater thermal refuge is needed to provide protection for fish during the warm summer months. Tolerable thermal conditions are also important to the food source of the fishery. We will examine whether macroinvertebrate relative abundances are changing across the temperature gradient and compare the relative importance of temperature with other environmental variables that may explain differences in macroinvertebrate distribution and community composition. A shift in macroinvertebrate assemblages with the temperature gradient may influence quantity and quality of resources available to support fisheries. Additionally, our detailed analysis of thermal conditions will help indicate the availability of thermal refuge for the fish.
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 (Weschler and Nazaroff, 2008). High exposures combined with evidence of links between SVOCs and health disorders, such as asthma, allergies, endocrine disrupting disorders, and even neurological diseases, have raised concerns in the scientific community (Bornehag and Nanberg, 2010). Literature indicates that SVOC-particle interactions play a critical role in the transport of SVOCs from sources to humans (Liu et al., 2010). However, the nature of the transport of SVOCs from sources to human uptake are still not well characterized. In this investigation, the influence of particle size on the emissions and partitioning of di-2-ethylhexyl-phthalate (DEHP) will be measured in tubular chambers saturated with DEHP, with monodisperse ammonium sulfate particles introduced periodically. Monodisperse ammonium sulfate particles, in sizes ranging between 10 and 35 nm, will be introduced into the tubes. Gas Phase DEHP will be measured in the chambers before and after particles are introduced. Particle-DEHP interactions will be quantified as the partitioning coefficient, which is 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 the understanding of the role of particles on the emissions and transport of SVOCs and will improve comprehensive exposure assessments.

Durability is one of the most important considerations regarding the design of new concrete structures in aggressive environments. In particular, chemical reactions between naturally available sulfate ions and hydrated cement paste can affect the binding properties of cementitious materials. The two main types of damage associated with sulfate ions are the formation of gypsum and ettringite. Thaumasite is a rarer type of sulfate attack that can transform cementitious materials into a non-cohesive material. The purpose of this research is to evaluate the performance of portland-limestone cement in sulfate prone environments by investigating its impact on the physical, chemical, and mechanical properties of cement paste and mortar specimens. Specimens prepared by adding 5, 10, and 15% (with and without 5% fly ash) limestone powder with baseline cement will be exposed to sodium and magnesium sulfate solutions for a period of 12 months. The concentration of sodium and magnesium sulfate will be approximately 5% and the test will be performed at 5°C and 23°C. Sulfate exposures tests will include expansion of mortar specimens, and mass loss and compressive strengths measurement of cement paste specimens. In addition to this, in order to identify the products produced from sulfate attack, microstructural observations such as X-ray diffraction (XRD) and scanning electronic microscopy (SEM) will be performed on the paste specimens. Similarly, the effect of exposure solution type on sulfate ingression will also be evaluated. Preliminary research suggests that higher deterioration in cementitious materials will potentially happen in 15% limestone added cement at a temperature of 5°C.

References:


Microbiologically-induced calcite precipitation (MICP) is a biotechnology that is being extensively researched as a solution to enhance soil properties. MICP occurs when a urease-producing bacteria catalyzes the reaction of urea into a carbamate ion that degrades and initiates a series of reactions that, when combined with calcium, creates calcite. The effectiveness of MICP for soil cementation has been proven in research but there is currently not a viable application to real-world projects. Using the bacterium, *Sporosarcina pasteurii*, significant reductions of mass-loss from wind erosion have been observed in laboratory experiments. [1] Surface application of MICP can be performed by spraying the microbial solution on the surface of the soils and then applying a nutrient broth and calcium solution. The engineering use for MICP proposed in this research project focuses on using MICP for the stabilization of recently burned soils. Burned soils are physically reduced to small particles and the vegetation root matrix that held the soils in place is mostly lost after a fire which causes soils to become very susceptible to erosion. If a fire is intense it can sterilize the soils leaving behind no living microbial communities which can further increase time until vegetation recovery. Burned soils typically contain an increased abundance of elements, including calcium, that exist in the soils due to burned organic matter. Erosion of burned soils can cause a decrease in surface water quality including eutrophication of lakes. Natural and prescribed burning near riparian zones causes concern because of the chemical changes to the soils and downstream surface water. [2] The loss of nutrients from soils further decreases the vegetation recovery time. Applying a surface application of MICP to burned soils could potentially cement the soils particles together which would reduce mass-loss of soils from wind and water erosion. The solution would supply microbes and chemical nutrients to the soils and also maintain in place the nutrients from the burned organic matter so that vegetation recovery is faster and more abundant.

Experiments to be conducted for the research will show the environmental impacts of using MICP solutions to surface waters and vegetation regrowth and also create a Life Cycle Assessment (LCA) for the developed product. The effectiveness of the erosion resistance of burned soils with and without MICP application will be tested using erosion measuring devices such as: a rotational testing apparatus, a slot erosion testing device and a rainfall simulator. The amount of calcium chloride solution needed for adequate erosion control will be measured in unburned treated versus burned treated soils to determine if the increased calcium in burned soils reduces the amount of calcium additive needed while maintaining the cementation effects. The experimental results are predicted to show that the use of MICP biotechnology will increase vegetation recovery rates after a fire event while also reducing the required concentrations of potentially harmful chemicals.


#35 Modeling Nitrogen Transport from Septic Systems using Hydrus and STUMOD

Raul Vasquez; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. Mengistu Geza; Civil and Environmental Engineering Department

The Black Hills area has over 10,000 onsite septic systems many of which are above water tables and with karst limestone and alluvial sediment. The permissibility of these formations may allow constituents from septic tanks to travel fairly quickly through the soil into groundwater. This may require pre-treatment units such as aerobic treatment and sand as an alternatives to conventional onsite septic systems. However, to be cost effective, the design of these systems requires extensive investigations about their performance for site specific conditions.

A modeling approach supported by field and lab data will be used to improve the prediction of nitrogen fate and transport from the soil based systems. An unsaturated zone contaminant fate and transport models that are applicable to onsite wastewater treatments systems including Hydrus 2D and a simplified soil treatment unit model (STUMOD) will be applied.

Data acquired from Dr. Sawyers nitrate-nitrogen field samples will be used to calibrate both models using hydraulic loading, soil characteristics, depth of sample and model parameters. Once a suitable model is created for the soils provided, variations in parameters can be changed to investigate changes in design variation of onsite septic systems. Models will be verified by using a column filled with soils being investigated. The columns will receive an aqueous ammonia solution and a lysimeter used to determine nitrogen concentration at different depths in the column.

The expectation is that STUMOD and Hydrus 2D will model nitrate-nitrogen transport through soils common to Black Hills accurately. Design variations being investigated should reduce onsite septic tank nitrate-nitrogen reaching ground water. The added resources needed to build design variations will be significantly lower than contaminated ground water cleanup. The Model also has the potential to determine priority areas with clustered onsite septic tanks that should be integrated to the existing sewer.
Development of an Integrated Decision Support Tool (i-DST) for Implementation of grey/greens Stormwater Infrastructure with considering Cost Optimization.

Ali Shojaeizadeh; Civil and Environmental Engineering Department

Mentor/Advisor: Dr. Mengistu Geza; Civil and Environmental Engineering Department

Green infrastructure (GI) has demonstrated its potential to supplement traditional, grey infrastructure managing urban stormwater runoff and pollution. Low impact development (LID) is one type of green infrastructure that specifically emphasizes the best management Practice (BMP) of urban stormwater through reductions in post-development runoff by increasing on-site infiltration and reducing impervious surface cover. The need for watershed-level assessments of LID benefits and the identification of strategic locations for BMP implementation in urban watersheds should have been recognized. However, the performance and cost of green infrastructure techniques over their entire lifecycle are still relatively uncertain. This makes deciding between implementation of grey, green or hybrid approaches challenging. A decision support tool is needed that integrates the hydrologic and water quality benefits of green and grey infrastructure with a comprehensive life-cycle cost assessment (LCCA) that includes direct economic costs as well as co-benefits to society. This work summarizes the framework of such a planning-level, integrated decision support tool, called i-DST. Once developed, i-DST will contain modules that simulate continuous runoff and water quality, both using history climate data and under climate change scenarios. It will also use a multiple-criteria decision analysis to optimize stormwater infrastructure based on user-defined economic, environmental and societal objectives. Additionally, this work details a database of regional green infrastructure cost and performance parameters that allow for application of the tool across the different climatic regions of the United States. The primary outcome will be a decision support tool that can be used by municipalities to plan green and grey stormwater implementation. This will address the issues of uncertainty in life cycle costs, including environmental and social co-benefits, of implementation alternatives. The tool will allow for more efficient use of finite economic resources allocated to stormwater management, and the quantification of co-benefits will help justify investment in such projects.

Picture 1. Different types of BMP’s
Current estimates suggest that buildings are responsible for about 40 percent of U.S. energy usage. Nature has potential solutions for energy efficiency by integrating systems. Specifically, insects such as termites construct habitats that are structurally stable, regulate internal temperature and provide ventilation through the form of the structure. By computationally mimicking the bottom-up building processes of integrating structural system with ventilation, this study intends to develop a new paradigm for building design. The resulting forms can provide an avenue for new solutions in construction of habitats that require little to no external energy for ventilation, particularly in developing areas where the cost of energy is prohibitive.

SD Mines is involved in a multi-disciplinary and international project that builds on the current state of the art in engineering, atmospheric science and entomology. The methods explored include “bottom-up” agent-based modeling integrated with “top-down” environmental forcings from the local environment.

We focus here on the latter component, impact of atmospheric forcings on our study sites in Namibia. Local atmospheric forcings at both the weather and climate scale influence the orientation, thickness, porosity and other organic design attributes of these natural structures. We will present the downscaling of global forecast models and ensembles to the local scale and demonstrate their integration into CFD and agent-based models in this study.
Shear-thickening fluids have been shown to demonstrate unique damping and impact-resistance properties. Shear-thickening fluids (also known as dilatant fluids) are suspensions consisting of a particle-bearing medium which experience increased viscosity under increasing shear rate. A shear-thickening fluid that experiences impact will form a solid-like growth directly in front of the point of impact. This growth is known to move rigidly with the impactor, bear stress, and store elastic energy (Waitukaitis 2013). Upon impact, the impactor loses momentum due to the inelastic collision that happens with the solid-like growth. This mechanism explains why shear-thickening fluids have the impact-resistance and damping properties that they do. However, it is still not clearly known what occurs regarding lateral stress development during impact of a shear-thickening fluid. The research team will measure changes in lateral stress during impact of a cornstarch and water suspension. The relationships between the packing fraction, impact energy, and impact area vs. lateral stress will be analyzed. The results of this research will aid in better understanding the fundamental properties and applications of shear-thickening fluids’ reaction to impact.

#39 Life Cycle Assessment of Dryland Crop Rotation Diversification

Prashansa Shrestha; Civil and Environmental Engineering Department

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

Long-term, diverse crop rotation practices benefit agricultural sustainability. A cradle-to-field life cycle assessment (LCA) was used to quantify the rotational sustainability and environmental impact of wheat (*Triticum* spp.), fallow, cover crop, oilseed, and small grain dryland rotations in the northern Great Plains (NGP), US. Fourteen crop rotation practices of variable duration, inclusive of fallow and associated economics, were evaluated using results from a 13-year rotation study which included more than 200 observations. Rotation LCA impact evaluations were focused on calorific production, climate change potential, and freshwater eutrophication and ecotoxicity due to their direct link to agricultural productivity, economics, and nitrogen (N) application rates. Among the rotation durations evaluated, a four-crop rotation of winter wheat-safflower-pea-winter wheat resulted the lowest LCA environmental impact. The overall environmental impact of this four-crop rotation was substantially less than traditional crop practices (wheat-fallow). Oilseeds and legume-based fallow cover crops played a vital role in increasing calorific production and reducing the environmental burden of the rotations analyzed. Results reveal that non-cover cropped fallow generates a significant environmental burden, regardless of rotation. When rotation results were scored to evaluate agricultural production and sustainability, rotations which had lower fertilization rates were more environmentally and economically sustainable. Crop insurance subsidies were found to promote rotational diversity and improve economics of higher diversity rotations. The methodologies presented in this paper can be used effectively to evaluate sustainable farming techniques and encourage adoption of sustainable agricultural diversification and intensification practices.
Ensemble forecasting is currently one of the more effective methods of estimating forecast variability. Local and Regional ensemble forecasting allows the ability to collect a large number of possible forecast outcomes and can articulate forecast uncertainty but at a high computational cost.

SDSMT has developed a Confidence Index (CI); an algorithm applied to a single forecast to determine risk of forecast error. It is computationally less expensive compared to forecast ensembles. When applied to a region CI detects the presence of weather features that can lead to forecast error and creates a “score” that can be associated with forecast risk.

In this project we are working to determine if the national ensembles created by NOAA and CI forecast risk scores are comparable ways to assess forecast risk and if existing national and global forecast ensembles can be integrated into the CI algorithm to better predict overall forecast uncertainty and risk.
#41 CARE for the HealthCARE Workers?!
Haleh Barmaki; Industrial Engineering Department
Mentor/Advisor: Dr. Adam Piper; Industrial Engineering Department

According to Occupational Safety and Health Administration (OSHA) (2015) U.S. hospitals report 58,000 work-related injuries and illnesses.

These injuries include musculoskeletal disorders (MSD) related to patient handling, pathogens, tuberculosis and slips, trips and falls (EHS, 2015).

Healthcare nurses are the group at the major risk of MSD whom require fast and effective solution as they have devoted their lives to the people.

While the number of such disorders rises, the number of working solutions stays still.

In this study, we propose a technology that interacts with healthcare workers and the specialized hospital equipment such as dialysis seats. Hence, with introducing an interactive interface healthcare workers such as nurses can understand the impacts of their posture while working with their patients as they move.

References:

In this paper, we investigate malicious detection and avoidance of black hole attack for smart metering network. In terms of routing protocol, the reactive routing protocol AODV (Ad hoc On-Demand Distance Vector) is commonly adopted for smart metering network and is considered in our paper. However, the default AODV is vulnerable to black hole attacks. To detect and avoid black hole attacks, we propose a new routing protocol, termed E-AODV (Enhanced Ad hoc On-Demand Distance Vector) by modifying the RREP (Route Reply) system based on AODV. The RREP in E-AODV updates the destination sequence number corresponding to fresh route request. By comparing sequence numbers from multiple replies, it detects the existence of black hole behavior because the attacker usually sends a much higher sequence number, which is inequal to the actual one generated from the destination. After detection, the receiving meter sends a deny reply to the destination. Upon receipt of the deny reply, the destination regenerates RREP with a updated sequence number, which is kept to itself. Since attackers only respond when a new request is initiated, this time the attacker will not act because no request is initiated. Therefore, it is able to avoid the malicious meter. Extensive simulations are carried out in NS3 to evaluate the performance of E-AODV. Results show that E-AODV obtains considerately higher performance in terms of packet delivery ratio and throughput compared with the default AODV routing protocol.
Wireless smart meter network (WSMN) is a rising field of research in smart grid due to its flexibility and scalability. WSMN is able to properly control and monitor the power consumption in residential as well as commercial areas. A typical WSMN in a neighborhood consists of a large number of smart meters (SMs) and several data aggregation point (DAP). SMs are responsible for recording the electricity or gas consumption, as well as to transmit metering information to DAPs. DAPs eventually replay data to a utility center. Since a large number of smart meters and several DAPs are involved in a neighborhood WSMN. One fundamental and challenging problem is how to select appropriate locations for DAPs so that a least number of DAPs are needed for minimizing the maximum distance between DAP and its associated smart meters. In this presentation, we investigate the DAP placement problem by applying clustering algorithms to solve it. Three clustering algorithms, (i.e., self-organizing map, fuzzy C means, and K means) are evaluated. We will examine which algorithm works best by considering some parameters like shortest path from SMs to DAP, complexity, and number of SMs distribution in different groups.
In an increasingly connected world, solutions to real-world problems are complex and often outside the boundaries of traditional engineering. To meet these demands, educators must teach professional skills, such as awareness of social and cultural implications of designs, understanding and appreciation of diversity, and additional skills in project management, collaboration, and communication. This has been emphasized in literature on training future engineers (NAE). However, traditional engineering curricula does not often require cultural components or engage students with diverse thinking styles outside that of “typical” engineering students, who tend to be analytical. This disconnect between the traditional curricula and diverse thinking styles may contribute to low retention in engineering. Service learning is a known method by which the impact of designs on society can be directly experienced by students alongside technical problem solving, addressing the stated need for more engaged, socially aware engineers. The Engineering Projects in Community Service (EPICS) program is an innovative example known to present engineering in context, prepare students for the engineering profession, and improve the diversity of participants. In EPICS, teams of students earn academic credit by partnering with community organizations to define, design, build, and support engineering-centered projects to improve their communities. In contrast to typical curricula, the EPICS teams are multidisciplinary and vertically-integrated allowing students to interact with people from diverse backgrounds. Furthermore, the real-world projects allow students to naturally develop professional skills through work with each other, community partners, and advisors. With NSF support, EPICS has grown into a consortium of 24 universities. At each institution, the EPICS program maintains core values, but is also unique in some ways. EPICS@Mines was implemented at SDSMT in the 2016 fall semester and closely follows the successful model at Purdue, where EPICS has been shown to effectively engage women and underrepresented groups in engineering (Matusovich). The unique aspect of EPICS@Mines is the inclusion of Native American students as design collaborators for projects that benefit the Pine Ridge Reservation. It is the first EPICS program to collaborate with a tribal college; therefore, there is no literature indicating the effectiveness of engaging this underrepresented group; however, it is likely that the EPICS experience would also effectively engage Native American students. Thinking styles, intercultural competence, and critical thinking skills can be quantified and evaluated by utilizing assessments called the Herman Brain Dominance Index, Intercultural Development Inventory, and Reasoning about Current Issues respectively. Students at SDSMT and Purdue will be surveyed using these assessments along with a demographic survey. At each institution, two distinct groups of students will be surveyed: EPICS participants and non-EPICS students. It is expected that EPICS will engage students with more diverse learning typologies while increasing their intercultural competence and critical thinking skills. Additionally, the retention rate of diverse and underrepresented students in engineering is expected to be higher for EPICS participants. Preliminary results in the first semester support claims of increased participation from females and underrepresented populations. In the first semester, 41% of students were female and 55% underrepresented. Also, the funded student mentors, advisors, and research assistants were 50% female and 50% Native American.
Processing and Characterization of High Frequency Printed Electronics: Transmission Lines for Space Applications

Mingrui Liu; Materials Engineering and Science Program

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

Owing to their low cost, high efficiency, low environmental impact, and inherent mechanical flexibility, and printed electronics have become increasingly attractive for use in solar cells, RFIDs, flexible sensors, and antennas. NASA has become very interested in high frequency (> 40 GHz) printed antennas for space applications, as their use may lead to unparalleled long-distance signal transmission in space environments. A systematic study of processing and characterization of high frequency transmission Lines for printed electronics is presented.

Conductive silver inks were synthesized using C10 carboxylic acids as capping agents and subsequently printed using direct write printing (aerosol jet and pneumatic liquid dispensing). The effect of sintering conditions on the surface morphology of the silver transmission lines was evaluated using as-printed and as-cured silver inks were characterized using scanning electron microscopy, atomic force microscopy, and surface profilometry. In addition, the high frequency performance of the printed silver transmission lines was measured and the effect of sintering parameters on the high frequency performance is reported. Improved high frequency performance of the direct write printed silver transmission lines was achieved as surface void fraction decreased.
Influence of Austempering Temperature and time on the Formation of Ausferrite in the Developed Weld Deposits on Austempered Ductile Iron

Anirban Naskar; Materials Engineering and Science Program

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

Austempered ductile Iron (ADI) has attracted considerable influence in recent years because of its excellent mechanical properties such as high strength with good ductility, good wear resistance and good fatigue properties. The optimum mechanical properties of ADI could be achieved from the microstructure consisting of ausferrite and carbon-enriched stable retained austenite which, in turn, is a function of austempering time and temperature. In the present investigation, two different coated electrodes were developed and crack-free welds were deposited on ductile iron plates using optimised preheat and post heat temperature at constant welding parameters. The weld specimens were austenitized at 900°C for 2 hr and then rapidly transferred to a salt bath at austempering temperatures 300°C and 350°C, held for 1.5, 2 and 2.5 hr followed by air-cooled to room temperature. The effect of austempering time and temperature on the formation of ausferrite and carbon-enriched retained austenite has been identified by means of light and scanning electron microscopy and X-ray diffraction analysis. It is observed that maximum amount of carbon enriched-retained austenite and minimum amount of ausferrite are obtained at higher austempering temperature (350°C) and 2 hr holding time for both the electrodes. However, between the two electrodes maximum amount of carbon enriched-retained austenite was obtained in electrode containing relatively more amount of Ni, Mo and Mn.
Manual material handlers (MMH) is one of the occupational groups that see a high rate in work related musculoskeletal disorders (WMSD). Even with proper ergonomic programs in place, workers in distribution centers perform tasks that may expose their bodies to awkward postures, overexertion, heavy lifting, and work involving high repetitiveness. Musculoskeletal disorders (MSDs) are the largest category of workplace injuries, and was alone responsible for 31% of all work-related injuries in the US. In 2015, according to the Bureau of Labor Statistics (BLS). This present study had three aims: 1) to create an accurate procedure for capturing a person’s maximum voluntary contraction (MVC), 2) to design a program that would classify a lifting task from a lowering task, and 3) to classify a squat lift from a stoop lift by using electromyography (EMG) data. The study was designed to mimic real life lifts seen in a previous study conducted in a soda distribution center by the Industrial Engineering Department at the South Dakota School of Mines and Technology. Three data collection trials were conducted to. EMG data was collected from 38 participants by using 16 surface EMG sensors, mounted on the subjects’ back muscles. The pilot trial tested the initial designed method to collect MVC and lift data. Results from the pilot trial showed extremely high MVC values, and EMG data from the lifts was hard to evaluate. This resulted to a redesigned MVC collection and lifting procedure. The lift tasks in the main and secondary trial were assembled with a simple lifting and lowering task. With this new simplified procedure, uninstructed-, stoop-, and instructed- lift data were collected. Initial data processing showed MVC values below 65%, where 100% is maximum compression, indicating the new MVC method is more reliable than before. The EMG patterns from the lifting data also showed a clear pattern between multiple subjects in the lumbar- and thoracic- erector spinae muscles. The data from these two muscle groups were then utilized to create a pattern recognition program by using a principle component analysis (PCA) by singular value decomposition (SVD) classifier. The initial testing from this classifier shows that the program is able to determine the instructed lowering task from the lifting task.
#48 Inverse Modeling of Groundwater Flow and Transport Using Ensemble Kalman Filter

Zhendan Cao; Geology and Geological Engineering Department

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

During the last several decades numerical simulation is routinely utilized to evaluate the groundwater resources and predict the fate of contaminant plumes. The adequate characterization of spatially distributed hydrogeological parameters like hydraulic conductivity plays an important role in groundwater flow and transport simulations. However, due to the scarcity of measurements in combination with the large spatial heterogeneity it is not trivial how to characterize the spatial distribution of conductivity, and, consequently, groundwater flow and transport predictions call for an uncertainty assessment. Inverse modeling is often used to reduce model uncertainty by jointly conditioning on hard data (e.g., measured hydraulic conductivity from pumping test) and indirect data (e.g., the observed state information, such as hydraulic heads, concentrations and temperatures) to characterize the spatial variation of hydrogeological parameters that are the key for reliable predictions.

In this work, it is proposed to use the CPU-efficient Ensemble Kalman Filter (EnKF) method, a data assimilation algorithm, for updating the hydraulic conductivity using the head and concentration data. A synthetic experiment is used to demonstrate the capability of the EnKF to estimate hydraulic conductivity by assimilating dynamic head and multiple concentration data in a transient flow and transport model. In this work the worth of hydraulic conductivity, hydraulic head, and concentration data is analyzed in the context of aquifer characterization and prediction uncertainty reduction. The results indicate that the characterization of the hydraulic conductivity field is continuously improved as more data are assimilated. Also, groundwater flow and mass transport predictions are improved as more and different types of data are assimilated.
# Genetic Fingerprint of Bacteria Found in Surface Water of the Big Sioux River

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Current bacterial standards for recreational water quality in South Dakota are based on the amount of *E. coli* cultured from surface water. However, *E. coli* are not the only bacterium capable of causing human harm. Although the standard has a purpose, horizontal gene transfer could result in other bacteria present being a risk to human health. Analysis of bacterial genes present in fecally-contaminated, recreational surface water can provide insight into the possible human health risks in a way that is more effective than current culturing techniques. Since less than 1% of all bacteria can be cultured in the laboratory, analysis of the genes present provides a more encompassing scope of what is present and the risk that may pose to humans. In the laboratory, we developed a tool that provides a molecular analysis of the pathogenicity risk of the bacteria present in surface water samples. The tool operates by assessing the presence of genes that contribute to the pathogenicity of the surface water bacteria. The use of our tool allowed for the identification of genes commonly associated with human diseases.

We found the presence of several virulence genes in monthly samples taken from the Big Sioux River from April 2016 to March 2017. Of the six-month samples, *einV* was in 6% of the sample, *stx1* in 66%, *stx2* in 38%, *eaeA* in 69%, *espP* in 8%, and *toxB* in 23%. The presence of these genes confirms the existence of potentially harmful bacteria in surface water, as these genes included several commonly associated with enterohemorrhagic *E. coli* and Shiga toxin producing *E. coli*. It also indicates a potential risk for human infection despite being considered safe by current water quality standards. Future applications of this project include analyzing the other six months of surface water, and the year-long comparison will allow a better understanding of how surface water bacteria pathogenicity changes over time.
Didymosphenia geminata, more commonly known as didymo or rock snot, is a diatom that can produce large nuisance blooms and cause a variety of negative impacts on a freshwater ecosystem. Didymo has recently been documented in large blooms where it was previously undocumented or found in low abundance, including an increase in the mid-Atlantic region since 2007. Massive blooms in these areas will ultimately have an impact on the recreational, ecological, and aesthetic qualities of important watersheds. In order to investigate the presence and abundance of didymo in the mid-Atlantic region, sediment core samples in 1 cm increments from 9 riverine impoundments constructed after 1930 throughout Pennsylvania, Maryland, and New York were retrieved to be analyzed. Of the 9 lakes included, 6 had recently observed didymo blooms downstream and the other 3 had not yet documented didymo blooms within the watershed. All core samples were collected between August and September of 2016 with cores ranging from 18.5-42.5 cm in depth and in 2-17 m deep sections of lakes. The results from this investigation could lead to the suggestion that didymo is responding to the environmental factors such as climate change, not just from human introduction. This may also aid in the development of invasive species prevention efforts, watershed management, and regulatory action in the mid-Atlantic region. If didymo blooms continue to spread, alterations to biodiversity, distribution of native species, and function of freshwater ecosystems will occur.
Decapod crustaceans, including crabs or lobsters, do not readily preserve in the fossil record, thus it is rare to have collections large enough to study population-level characteristics. However, the Gale A. Bishop collection at South Dakota School of Mines and Technology (SDSM&T) contains thousands of fossil specimens of *Dakoticancer overanus*, a common Upper Cretaceous (Maastrichtian; 66 – 72.1 Ma) crab from the Western Interior Seaway (WIS). Previous research near Mobridge, South Dakota found that the *D. overanus* population had a 2.5:1 male to female ratio and were likely preserved as a life assemblage, or a population that is not time-averaged. However, there are many other WIS localities available to test the hypothesis that other localities would have similar gender ratios and preservational qualities. Here, I study two additional localities: Thompson Butte and Bump-Young Hill (Creston). From each site, the crab carapaces were measured (width and length) and the gender of each crab was determined from abdomen morphology. Differences in preservation quality of each fossil was also observed. Normality of the crab carapace size within sites were tested using Shapiro-Wilk tests; normal size distributions are not expected in time-averaged assemblages. Chi-square tests for independence were used to determine if gender ratios are consistent among sites and with previous data. Mann-Whitney tests were used to determine if body size was significantly different between genders and between sites. In addition, preservation quality was quantified using the presence or absence of the pleon on the abdomen and significant differences among sites were assessed using binomial tests. The Thompson Butte and Mobridge localities are similar to each other regarding gender ratios and preservation quality; however, Bump-Young Hill is significantly different – the fossils are less well-preserved and the gender ratio is different. All localities have a normal carapace size distribution and body sizes between gender are similar. Body sizes at Mobridge are different than those found at Thompson Butte and Bump-Young Hill. This study shows that conclusions concerning fossil assemblages from one locality cannot be extended to others because of various factors, including preservation quality, gender ratios, and body sizes. Thus, studies should be conducted separately at each site and then compared to each other before drawing wide-ranging conclusions.
Due to the proximity between implants and tissues, material surfaces play critical roles governing molecular and cellular responses that dictate the acceptance and longevity of an implant. Titanium is renowned for its corrosion resistance and biocompatibility, and has become the benchmark for the majority of load-bearing implants\(^1\). Improving this material's level of bioactivity has been of great importance, with the goal of significantly extending an implant's lifetime. One exciting method of enhancing cellular response has been through surface modification to form TiO\(_2\) nanotubes. These nanotubes are well known for their ability to influence adhesion, proliferation, differentiation, and migration of cells. This effect makes them an excellent choice for implants, however, like many metallic implants they are susceptible to bacterial contamination\(^2\). In this regard, bacterial contamination of metallic implants has contributed to hospital-borne infections and ultimately implant rejection, often necessitating repeat operations and treatments. The objective of this research was to evaluate several sterilization techniques that can be used while retaining the physical and chemical characteristics iconic to TiO\(_2\) nanotubes. TiO\(_2\) nanotubes were fabricated using anodic oxidation of titanium substrates in a two-electrode electrolytic cell. Samples were sterilized using three techniques (1) trypsin bath method, (2) nitric acid bath method, and (3) plasma etching to clean samples of TiO\(_2\) surfaces of contaminants. Specimen surface energy and hydrophobicity were evaluated using contact angle goniometry. It was determined that in comparison to plasma etching and trypsin, nitric acid, a common laboratory reagent, significantly removes organic contaminants while resulting in a negligible change in hydrophobicity.

References:


Determination of Monod kinetic Parameters for ADM-1 Modelling of Food Waste and Paperboard Waste Mixtures

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Solid waste treatment in forward operating bases (FOBs) of the US Air Force is challenging due to their isolated locations. FOBs require treatment technologies that can improve waste management and be energy efficient. Anaerobic digestion (AD), a biological process that converts biodegradable organic matter into biogas, is an adequate alternative for FOBs due to its potential to convert waste to energy. In FOBs, food waste (FW) and paper board waste (PPB) are the two main components of biodegradable waste. AD of FW and PPB is carried out by the microorganisms at very different rates because of the nature of their compositions. FW degrades quickly because it is rich in carbohydrates, lipids, and proteins, while PPB degrades slowly because it is rich in lignocellulose. Fast degradation of FW leads to rapid formation of volatile fatty acids (VFAs) which can inhibit methanogens; whereas slow degradation of PPB results in high retention times. Mathematical modeling could be a helpful tool to describe and predict conditions that lead to the accumulation of VFAs and faster degradation of PPB. Several studies have implemented mathematical modelling to provide a better understanding and facilitate better operation of AD processes. Consequently, mathematical modelling can improve the understanding of the AD process of FW and PPB mixtures. Thus, the objectives of this study are firstly, to obtain the Monod kinetic parameters of model compounds that can be expected to occur as metabolic intermediates during the anaerobic degradation of FW and PPB, and secondly, to apply those kinetic parameters in the Anaerobic Digestion Model 1 (ADM-1). For the first objective, batch tests were used to evaluate the degradation of acetate, butyrate, propionate, cellulose, gelatin, and olive oil. The Monod kinetic parameters, saturation constants ($K_s$) and maximum rates ($SMA_{max}$) were obtained through initial rates experiments of which the Monod plots were fit with linear regression to find the saturation constant and maximum rate. The experimental values obtained for $K_s$ were 0.237, 0.368, 0.06, 0.88, 4.42, and 1.72 g L\textsuperscript{-1} for acetate, butyrate, propionate, cellulose, gelatin, and olive oil, respectively. Likewise, the $SMA_{max}$ values were 0.000592, 0.000475, 0.000155, 0.037, 0.00674, and 0.0134 g COD g VSS\textsuperscript{-1} h\textsuperscript{-1} for acetate, butyrate, propionate, gelatin, cellulose, and olive oil, respectively. A higher $SMA_{max}$ obtained in the assays supplied with acetate is likely the result of acetate being readily taken up compared to butyrate and propionate. Higher $SMA_{max}$ obtained in assays supplied with complex substrates compared to VFAs are most likely the result of the production of H\textsubscript{2} during their degradation since H\textsubscript{2} is metabolized faster than acetate. A very high $K_s$ obtained from cellulose indicates a lower affinity compared to the other substrates. These parameters will be incorporated into the ADM-1. ADM-1 predictions will be compared to batch AD performance for FW and PPB, and model deficiencies will be discussed.
Hydrothermal liquefaction (HTL) process converts wet biomass under subcritical temperature (280-370°C) and pressure (10–25 MPa) to aqueous, solid char and gaseous products \(^1\). The process conditions, catalyst and biomass feedstock dictate product composition, distribution and yield. Under HTL conditions optimized for maximum bio-oil yield, the aqueous co-product (AP) invariably contains significant carbon (~ 40%) from the original feedstock \(^3\). The AP can be recycled for increased bio-oil yield. However, trace metals and acids accumulate with increasing cycles which limits the recyclability of AP to 10-20 cycles. The AP from cycle 1 and cycle 10 from HTL of lignocellulosic biomass (LCB) and simulated municipal waste was used as growth media to cultivate bacteria. The bacterial biomass was harvested and co-liquefied with fresh lignocellulosic biomass feedstock. Co-liquefaction of the bacteria with LCB in 1:1 and 1:3 weight ratio each produced ~33 % more total bio-oil. These had higher HHVs of 34.11 and 31.05 MJ/Kg, respectively compared with bio-oil from LCB feedstock alone which had HHV of 30.61 MJ/Kg.

Obtaining inspiration from biological and natural systems, or biomimicry, has been successfully employed in engineering and science to develop both new technology and new paradigms in design. Lessons from nature have been used in multiple engineering disciplines to develop innovative design solutions, but applications to building structures have been somewhat slower in taking hold. This research is one component of the project, “Integrated Structural and Ventilation System for Buildings through Biomimicry.”

Analyzing termite mounds to understand the relationship between environment, structure and thermal-fluid transport properties requires an understanding of the material from which they are constructed. Because mounds are organically-constructed from local soils deposited by individual termites and cemented together, there are almost no published data on their engineering material properties. Experimental approaches are required to determine the properties needed for finite element and computational fluid dynamics models include porosity, void distribution, permeability, thermal conductivity, and mechanical strength.

This research specifically seeks to quantify those properties using samples from the exteriors of termite mounds located outside of Otjiwarango, Namibia. The properties associated with the thermal-fluid transport are established by using visualization software to analyze the MicroXCT scans of the material microstructure. Additionally, the materials are tested using experimental methods for both geotechnical engineering and cementitious materials such as concrete.
ABSTRACT

Thermochemical water-splitting is a greener technology for H₂ production. It involves a cyclic operation of a moderately high temperature (\( \sim 1100^\circ\text{C} \)) regeneration step during which the redox material \((\text{AxFe}_2\text{O}_4)\) such as ferrite is partially reduced to \(\text{AxFe}_2\text{O}_4-d\), followed by a slightly lower temperature water-splitting step where \(\text{AxFe}_2\text{O}_4-d\) when exposed to steam produces H₂. Due to the cyclic nature of this process at high temperatures, redox materials undergoes grain growth leading to decrease in H₂ production. As such the requirements of higher temperatures make the process economically less viable. However, the use of solar technology can make it more sustainable. In this study, we attempted to address these challenges by developing thermally stable redox materials capable of producing steady H₂ volumes at lower temperatures under isothermal conditions. Several morphologies such as powdered mixtures, core-shell nanoparticles and immobilized ferrites are developed for thermal stabilization of ferrites will be presented. Effectiveness of solar cells was analyzed to meet the energy demand for the thermochemical water-splitting process. In addition, the outlet of the thermochemical water-splitting reactor was integrated with a fuel cell to convert the H₂ produced into electricity. Results obtained on H₂ volume generation and subsequent energy conversion will be presented.

Keywords: Thermochemical water-splitting, redox materials, isothermal, thermal stabilization, electricity.

References:
The use of titanium oxide nanotubes as a bioactive coating for titanium joint implants is a quickly growing field. This paper details a common method with improved and effective adjustments for consistently creating TiO\textsubscript{2} nanotubes via anodic oxidation. The procedure involves utilizing an electrolyte solution containing 1 wt% water, 0.35 wt% ammonium fluoride, and the remainder ethylene glycol. This solution is placed in a specialized housing with a Ti sample. Running an electric current through the system produces TiO\textsubscript{2} nanotubes on the sample via anodic oxidation. Nanotubes with varying diameters are consistently produced by manipulating the voltage running through the system. The results go as follows:

- 10 V ~ 20 nm diameter tubes
- 20 V ~ 30 nm diameter tubes
- 30 V ~ 50 nm diameter tubes
- 40 V ~ 60 nm diameter tubes

Another section to this paper involves successfully producing multiple samples simultaneously through a process known as bulk anodization. This procedure involves a specialized housing in which 5 samples were concurrently tested using an electrolyte solution containing 2.5 wt% water, 0.55 wt% ammonium fluoride, and the remainder ethylene glycol. The samples were run for 30 minutes at 60 volts. The results of the bulk anodization go as follows:

- Sample 1 ~ 97 nm diameter tubes, 10.0 nm wall thickness, 14.3 μm long
- Sample 2 ~ 102 nm diameter tubes, 9.2 nm wall thickness, 13.8 μm long
- Sample 3 ~ 102 nm diameter tubes, 10.1 nm wall thickness, 13.6 μm long
- Sample 4 ~ 100 nm diameter tubes, 10.8 nm wall thickness, 14.5 μm long
- Sample 5 ~ 103 nm diameter tubes, 9.9 nm wall thickness, 14.9 μm long

Keywords: TiO\textsubscript{2}, nanotubes, anodic oxidation, bioactive, bulk anodization
This study investigates the performance of a wave energy converter being developed at the National Renewable Energy Laboratory that uses flaps that can be rotated to decrease the forces felt from large waves, in an effort to decrease structural and material costs. These structural costs are the leading cost driver for most wave energy converters, so any decrease in structural costs will allow for the cost of energy from wave energy to become more competitive with other forms of energy generation. The sensitivity of converter hydrodynamics to flap angle and open flap length were investigated, in order to find a geometry control method that has finer control of the converter performance. A converter with four equal size flaps set in 15 degree increments, along with a converter of different size flaps set at fully opened or closed were considered. The device configurations were modeled to determine the hydrodynamic coefficients, from which performance values like absorbed power, foundation forces, and power-take-off torque could be calculated. It was found that performance values decreased as the flap angle increased, but the power-to-load ratio increased as the flap angle increased. This shows the benefits of using rotating flaps to decrease the forces felt as wave amplitudes increase, while also still generating a rated power over a large range of wave conditions. Using different size flaps set at open or closed also showed a finer control of hydrodynamic properties, with the selected flap length increasing with water depth, and the number of flaps increasing from four to six.

This research was conducted while on internship at the National Renewable Energy Laboratory under the advising of Dr. Nathan Tom, a post-doctoral researcher there.
Research on the formation and motion of colloidal particle chains under an AC electric field is being conducted to develop micro-robotic technology that can potentially be used in drug delivery, micro-surgery, and active sensors.

The final goal is to understand the formation of colloidal chain systems, characterize them, and probe the fundamental mechanisms under AC electric fields at work so we wanted to form chains, followed by the analysis of flexibility and propulsion shown in the chains.

This preliminary research developed procedures, equipment and a route to follow in the future for producing statistically significant data regarding the formation of flexible chains and their propulsion properties.

Specifically, we developed a procedure to form chains at 70 degrees Celsius using a heating unit we built while still being able to view the chains under a microscope. Previously, chains were formed in capillaries and they were not able to be extracted. Therefore, we developed a method to form a 1 mL solution of chains compared to the current few microliters while adding a way to extract the colloidal chains.

References:


Copper oxide loaded porous-wall hollow glass microspheres (PWHGMs) are a possible functional material system for anti-tamper security inks. The current loading method allows copper oxide to form on both the surface and interior of the microspheres. Surface copper oxide hinders multiple loadings and limits anti-tamper functionality. We report a copper oxide loading and cleaning method to increase loading effectiveness and remove surface copper oxide. PWHGMs were loaded with CuCl2 precursor solution under vacuum and baked at 450oC in an air furnace to promote copper oxide formation. Leaching process development was conducted using copper oxide formed on glass slides and solid wall glass microspheres. The final cleaning method was evaluated on PWHGMs. Scanning electron microscopy, energy dispersive spectroscopy and direct visual inspection were used to evaluate cleaning performance. The size, morphology and chemical composition of resulting copper oxide crystals were characterized using scanning electron microscopy in conjunction with energy dispersive spectroscopy.
The detection of dark matter is one of the next steps in understanding this universe. Therefore, detectors like that of the LUX experiment are paramount in modern research. However, the difficulty to detect it is an implicit part of what dark matter is. This means that any device meant to detect it will be prone to background interference, even if only a small number of background interactions are present. The Large Underground Xenon (LUX) detector employs numerous strategies, such as its underground location, to minimize the effect that background radiation has on its collection of data, but there is still some sources of interference that need properly weeded out. One of these in particular is the dust that tends to gather on the exposed surfaces of the detector.

Dust deposition is an interesting subject. On the one hand, it seems to be a commonplace issue, but it is also difficult to control into extreme cases. This, along with the dust’s ability to interfere with measurements at the required scale to detect dark matter particles makes it necessary to spend time testing cleaning and assaying methods in order to determine and minimize the dust levels across the various surfaces of the detector. This is what I’ve been working on in my design project for the past two semesters.

Glass slides have been used as a test surface which could be easily cleaned and assayed with various methods. The cleaning procedure began as some scrubbing with lint-free cloth and isopropyl alcohol, followed by air-brushing away the dust with an air gun of nitrogen. More recently, it has also included the use of an ultrasonic cleaner. Other methods, such as using an ion gun and applying a polymer to trap the dust, and then removing them both together.

Assaying techniques are also a focus of experimentation. An optical microscope with a backlight can be used directly on glass slides to see their dust content, but any larger, or less translucent objects will take a more advanced procedure. Current practice is the use of tape lifts. I.e. the application of acetate tape to the object in question, and then its removal, presumably with most of the dust that was on the object. We then attach the dusty tape to a slide. Twenty pictures are taken through the microscope of each tape lift to create a statistical representation of the dust density on the tape. This is prone to carry texture over from the object’s material, or bubbles from an imperfect seal, which can skew the data, making it difficult to find any definitive answers. This is another reason for further experimentation.

The initial cleaning method had a few problems: it was inconsistent, depending on who did the cleaning, it took more than preferable amounts of time to complete, and it didn’t get the dust levels low enough. Employing an ultrasonic cleaner makes some improvement, but it still has trouble finding the desired values. Thus, we’re studying further techniques. Firstly, running an ion gun over the surface may be able to displace more of the dust than simply using alcohol and the force from Nitrogen. And secondly, application of a polymer to the surface, and its subsequent removal has shown promising results of removing a majority of the dust along with the polymer itself.

In addition, LUX is a collaboration between multiple labs in multiple locations across the country, and to properly study this dust deposition, slides must sometime be transported from one location to another. To this end, there must be some way to keep the dust from falling off the slides during transportation. Thus far, we’ve been sandwiching slides together to hold the dust in place. I’ve been conducting a validation experiment of this method this semester. Additionally, it’s possible that dust may fall off the flat surfaces of slides in areas with high traffic or airflow, taking away from the resultant data’s accuracy. Another of my current endeavors is to test out some sticky slides, to see if they can give us better data in these areas.
The MAJORANA Collaboration has constructed and commissioned the DEMONSTRATOR experiment capable of demonstrating the feasibility of a 1-ton Ge detector to search for neutrinoless double beta-decay (0νββ) at the Sanford Underground Research Facility in Lead, SD. The DEMONSTRATOR is constructed as an array of natural and >86% enriched $^{76}$Ge crystals contained in an ultra-low background structure that maximizes the concentration of crystals while minimizing the amounts of structural materials. The experiment consists of two ultra-low background cryostats, referred to as Module 1 and Module 2. Each Module contains 29 close-packed P-type point contact germanium crystals enclosed in an ultra-pure copper cryostat. The cryostats are contained within a single graded shield that consists of an ultra-pure low-background inner shield surrounded by structural and additional gamma and neutron shielding materials and an active muon-veto system. The shield is purged with clean, liquid nitrogen boil-off within a radon exclusion enclosure. This system includes radon traps to further reduce the radon concentration of the purge gas. A radon monitor is integrated into the system to validate the level of radon reduction. This effectiveness of the purge system will be discussed along with the shield environment.

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, the Particle Astrophysics and Nuclear Physics Programs of the National Science Foundation, and the Sanford Underground Research Facility.
Dark Matter detectors operate by having a completely enclosed space as cut off from the outside world as possible and usually filled with a non-reactive substance. The detectors watch for any particle interaction which may be due to Dark Matter. To see this interaction, the detectors must be highly sensitive, with an unfortunate side effect being that the radioactivity of dust particles can register with the detector as a false positive. Therefore, the detectors must be kept extremely clean. So I have been spending the last year assaying detector components for and determining which cleaning methods leave the detector components as clean as possible. To do this, I have materials that will be used in the detectors collect dust, make tape lifts of the material to pull off the dust particles, and take images of the dust particles using a camera/microscope apparatus. These images are then run through a Matlab code that analyzes them and determines the average dust density on the sample. One of the first tests I did was on how effective using a nitrogen blower is on Kovar. The result is that while most dust is removed, it is still not clean enough for use in a dark matter detector. The Super CDMS collaboration was interested in how much dust accumulated on their Super CDMS Soudan detector during its assembly. The results determine how much dust is expected to accumulate during assembly of the Super CDMS SNOLAB detector. I also measured how the dust density changes on slides when they are transported long distances. This is to determine whether the dust count on slides changes to any noticeable extent while in transport and whether our cleaning and assaying procedures need to be modified to account for the changes. To do this, I went on a trip to Minnesota and back with multiple slide pairs. Most slides did show an increase in dust density with some dust particles transferring from one slide to another. Work is in progress to develop more robust procedures when transporting slides.
List of presenters, alphabetical by last name:

2017 Student Research Symposium Participants

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