Quarterly Newsletter
Fall 2020

SD EPSCoR UPDATE

Linking South Dakota's Future with STEM Research

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Summer Student Research at Dakota State University

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SD EPSCoR
RESEARCH. EDUCATION. ECONOMIC DEVELOPMENT.

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AT LEFT

Dr. Govind Chilkoor, a research scientist at South Dakota Mines, uses the autoclave to sterilize growth media and glassware used for the microbial corrosion experiments. More on pp. 3-5.

ON THE COVER

Dakota State University students in lab, from left, clockwise: Sammy Drummond (Australia), Christina Mulu (Ethiopia) and Jared Dewitt (South Dakota). More on pp. 8-9.

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South Dakota 2D BEST

2-Dimensional Materials for Biofilm Engineering, Science and Technology

The South Dakota 2-Dimensional Materials for Biofilm Engineering, Science and Technology (2D-BEST) Center is a collaborative research partnership involving South Dakota's six state universities, three tribal colleges, two private universities and the Governor's Office of Economic Development.

Preventing Metal Pipe Corrosion

2D coating reduces impact of sulfate-reducing bacteria.

Images and **Text** By
Christie Delfanian, SDSU Marketing & Communications

Corrosion costs the U.S. water and wastewater industry about $36 billion annually, or 3.1% of the nation's gross domestic product, according to a 2002 U.S. Federal Highway Administration study. Those annual losses have now risen to an estimated $58.5 billion.

A little goes a long way.

A thin, single layer of graphene material only 1 atom thick may reduce metal pipe corrosion rates as much as 100 times, according to Dr. Govind Chilkoor, a research scientist at South Dakota Mines. These new crystalline 2D materials could mean big savings to industries.

All the piping and equipment used to treat water and wastewater can be prone to corrosion," explained Dr. Chilkoor. He developed and tested 2D materials as part of his doctoral work at South Dakota Mines under the tutelage of associate civil and environmental engineering professor Dr. Venkata Gadhamshetty, who received a National Science Foundation CAREER award to support the 2D materials research for microbial corrosion research.

As part of that project, Chilkoor examined whether 2D materials can reduce the impact of sulfate-reducing bacteria, one of the main culprits responsible for corrosion in the water and wastewater industry. “Steel exposed to chemicals corrodes at a rate of 1.3 milliinch (thousandths of an inch) per year, but in the presence of sulfate-reducing organisms, it will corrode 24 milliinch per year,” he said.

Bacterial buildup and corrosion

As wastewater flows through a metal pipe, sulfate-reducing bacteria begin colonizing the interior surface and form a slimy film within 10 days. The bacteria excrete a sticky polymer substance and, as the microorganisms accumulate, form a biofilm. “If you put a biofilm under a scanning electron microscope, you will see lots of live bacteria,” he explained.

The sulfate-reducing bacteria corrode the metal in several ways, Chilkoor said. First, the bacteria pull electrons from the steel surface. Second, the bacteria consume organic matter in the wastewater, producing hydrogen sulfide that then erodes both cast iron and stainless steel.

Applying polymer coatings to reduce corrosion has had limited success. The thin plastic coatings are prone to biodegradation. “The microbes get into small pores in the coating and consume the plasticizer in the polymer,” Chilkoor explained.

Polymer coatings can also become brittle, crack and peel, which then releases toxins from pigments and organic compounds in the polymer into the water. “This can be a problem for humans and aquatic life,” he noted. Furthermore, for applications such as heat exchangers designed to cool a hot liquid, the polymer coatings can disrupt functionality, he pointed out.

Developing 2D materials

“With 2D materials, we can make thin coatings, less than 1 nanometer thick,” he explained. When he applied 2D graphene to metal and exposed it to sulfate-reducing bacteria in what is known as a corrosion cell, the microbes did not attach to the surface.

“Graphene can be very antimicrobial. It can induce oxidative stress and the bacteria will die,” he said.

NEW FACES AT THE SD EPSCOR OFFICE

Nolan Ortbahn, Intern

Currently an undergraduate student at Augustana University, Nolan Ortbahn is studying secondary education and STEM, with emphases in biology and chemistry, and will graduate in spring 2021. Ortbahn’s research has focused on how to best implement safe sanitation practices in India for its diverse communities. A native of Pierre, South Dakota, Ortbahn plans on becoming a high school science teacher in S.D. while pursuing a graduate degree. He is supporting the SD EPSCoR staff by organizing events and assisting with the creation of written communications from the department.

Peggy Kapusta
Communications Director

Prior to joining SD EPSCoR in April as its communications director, Peggy Kapusta served as the director of online communications for Augustana University, an SD EPSCoR partner institution. Her past work experience includes Wells Fargo EFS (student loans) and Microsoft in marketing and communications roles. She earned a bachelor’s degree in journalism from South Dakota State University. Kapusta develops and manages website and social media content, helps organize events, and promotes the positive impacts of research and STEM education in South Dakota.

In addition, graphene is highly conductive and will have good heat transfer in a heat exchanger. "What's exciting about 2D graphene is the thinner it gets, the stronger it is," he said. "One single sheet is very strong, in terms of tensile properties and Young's modulus." While polymer coatings use a filler to enhance strength and reduce porosity, 2D materials can use 1– to 2% as much material and get the same properties as a polymer with 60% filler, he explained.

In addition, he developed a 2D material using hexagonal boron nitride. Known as white graphene, its properties are similar to graphene, Chilkoor explained. "A single layer of boron protects metal, but it is electrically insulating."

Chilkoor and Gadhamshetty are continuing their work through the state's newest research center, 2-Dimensional Materials for Biofilm, Engineering, Science and Technology Center, or 2D BEST. Gadhamshetty is one of the center's lead researchers working on 2D materials and metal corrosion.

The research center is funded through a five-year, $20 million National Science Foundation Research Infrastructure Improvement Track-1 grant awarded to SD EPSCoR and the SD Board of Regents. Faculty from 11 state universities and colleges are involved in the center, including eight SDSU researchers who will use 2D graphene to improve the ability of nitrogen-fixing bacteria to colonize soybean roots.

As part of 2DBEST's infrastructure-building efforts, the researchers will purchase new chemical vapor deposition and pulsed laser deposition equipment that will help move 2D materials toward commercialization.

Currently, the corrosion group is using chemical deposition equipment, which accommodates only small metal pieces, to synthesize the 2D materials, Chilkoor said. To bring 2D materials to a commercial market, "we need to coat a whole pipeline."

Gadhamshetty said, "The goal of the 2D BEST is not only to be on the cutting edge with respect to 2D materials synthesis equipment and expertise, but equally significant is to use this research to understand and cater to the unique needs of agriculture, biotechnology and coating industry and small-scale businesses in South Dakota and beyond."

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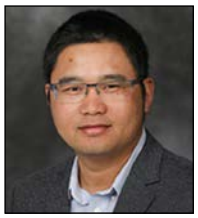
New Faculty Hires

Susan Citrak, Northern State University Assistant Professor of Chemistry
— Dr. Citrak came to NSU from San Francisco. She has a particular interest in and passion for environmental remediation, and believes inorganic materials can play a key role in this endeavor.



Steven Wu, University of South Dakota Assistant Professor of Chemistry
— Dr. Wu's research has centered around the synthesis of functional fluorescent nanomaterials, and his research for SD EPSCoR and the Track-1 program focuses on biomarkers and biosensors.

2D Best Track-1 Seed Grant Awards

Text By
Marie Severson,
Spring Intern
at SD EPSCoR
and also a USD
graduate student

The first year's seed grants were awarded in early 2020 for high-risk, high-reward biofilm research at the intersection of biofilms, 2D materials and big data.

These first four seed grants totaled $199,996. Four seed grants will be awarded annually.

A brief description of each Year-1 Seed Grant follows:

Exploring Rheology Properties of Biofilm with Multifractal and Multiscale Data Analytics

Dr. Shankarachary Ragi, Assistant Professor in the Department of Electrical Engineering at South Dakota Mines, received a $50,000 seed grant to collaborate with Dr. Venkata Gadhamshetty and Dr. Govind Chilkoor at South Dakota Mines, and Carol Lushbough and Dr. Etienne Gnimpieba at the University of South Dakota to create new methods to better understand how biofilms work in relation to the surface to which it is applied. For example, biofilms are a 2-dimentional material that can be applied to the surface of a metal such as copper, to regulate the growth of corrosive bacteria. This protective biofilm could be used in infrastructures such as water pipes, medical devices, and oil and gas pipes. Coating metal pipes with biofilm may control the growth of corrosive bacteria and significantly decrease financial and environmental costs from leaks and spills related to biocorrosion.

Radio Frequency Transparent Coating Solution for Preventing Microbial Corrosion on Antennas in Harsh Environments

Dr. Sayan Roy, Assistant Professor in the Department of Electrical Engineering at South Dakota Mines, received a seed grant

Shane Star (left, with Dr. Govind Chilkoor on right) is a 2020 SD EPSCoR 2D BEST Native American GA fellowship recipient from the Pine Ridge reservation in South Dakota. Along with other 2D BEST researchers, he developed a method to incorporate graphene nanofillers in commercial epoxy coatings on mild steel surfaces. This coating offered a corrosion protection efficiency of 99.9% in abiotic conditions, as well as aggressive microbial conditions.
Photo by
Dr. Venkata Gadhamshetty, South Dakota Mines

in the amount of $50,000 to investigate ways to protect communication antennas from corrosion, in collaboration with Dr. Venkata Gadhamshetty, also at South Dakota Mines. Dr. Roy is researching the interaction of protective biofilms on communication equipment, such as antennas, that are vulnerable to corrosion due to harsh environmental conditions. The equipment used in industrial, defense, and precision agriculture is so sensitive, that even a minute crack in the surface can hinder its operation. Dr. Roy is investigating the interaction between the biofilm and the electromagnetic waves used by the equipment to ensure there is no interference. Preliminary studies have already demonstrated the protective effect the biofilm has on copper, commonly used in monitoring and communications equipment.

"Beyond the 2020 Vision: Building Research, Education and Innovation Partnerships for South Dakota," will not only advance study of biofilms in the state, but also will spur the development of statewide science education and workforce development infrastructure.

Development of Porous Concave Gold Nanoparticles for the SERS Detection of Functional Biofilms

Dr. Chaoyang Jiang, Associate Professor in the Department of Chemistry at the University of South Dakota received a $49,996 seed grant to collaborate with Dr. Grigoriy Sereda of USD, to develop a unique substrate constructed of gold nanomaterial that will facilitate the analysis of the chemical components of biofilms. This will allow Dr. Jiang to characterize biofilms for use in specific applications. Additionally, the interaction between biological samples grown on dental material and biofilms will be examined to gain additional knowledge of how biofilms can be used. The data obtained from this research will be archived in a database containing information on a variety of other biofilms and accessible for further research in this area. This will enhance the knowledge of two-dimensional biofilms and encourage research collaboration within the state.

Characterizing Nitrogen Fixing Biofilms of Indigenous Food Plants Pediomelum esculentum (Prairie Turnip) and Shepherdia argentea (Buffalo Berry)

Dr. Nicholas Klein in the Environmental Science Department at Sinte Gleska University has been awarded a $50,000 seed grant to investigate plants (stem, root and root nodule biofilms) that have significant food and medicinal value for the Plains tribes. Together with Dr. Jose Gonzalez and Dr. Sen Subramanian, both of South Dakota State University, the researchers will work to characterize the structural features and root microbial communities in *Pediomelum esculentum* (prairie turnip) and *Shepherdia argentea* (buffalo berry). With the aid of beneficial bacteria, rhizobia, these unique indigenous plants have the ability to fix nitrogen. Dr. Klein is investigating the mechanisms of nitrogen fixation, root colonization and the plants' relationship with rhizobia. This research is intended to spark interest in Native American students and community members to preserve traditional knowledge through scientific research.

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From left to right, Christina Maloney (Illinois) and Sammy Drummond (Australia) at Gaylor's lab.

Summer DSU Research

Through astrobiological research conducted this summer, four Dakota State University (DSU) students studied chemical compounds and minerals found throughout the solar system that – in certain planetary environments – undergo chemical reactions that produce molecules essential for life.

Images and **Text** By
Dr. Michael Gaylor

The ability to adapt to sudden, unexpected change, always a valuable skill, is especially helpful these days. It's a skill that Dr. Michael Gaylor's team of research students at Dakota State University (DSU) in Madison, South Dakota, began practicing daily in early May.

Dr. Michael Gaylor, associate research professor of chemistry, welcomed this first cohort of undergraduate students participating in an intensive 10-week research and training program.

Due to COVID-19 travel/work restrictions, Gaylor met regularly with his four students via Zoom meetings, WhatsApp and email messaging. Through these forums, the team began reading/discussing the relevant literature, reviewing/discussing previous foundational data sets generated in the Gaylor Lab during the academic year, and learning the theory and techniques they would be using in the lab.

7th Annual Undergraduate Research Symposium

presentation by Belle Ross of University of South Dakota

Undergraduate STEM students, faculty and others across the state gathered virtually on July 29 to participate in the seventh annual SD EPSCoR Undergraduate Research Symposium. View the students' projects involved in the NSF EPSCoR RII Track-1 project and other NSF Research Experiences for Undergraduates (REU) programs at *sdepscor.org/symposium*.

Under Dr. Gaylor's mentorship, the students conducted planetary simulation experiments aimed at determining how non-living chemistry could have transitioned to living chemistries on the primordial Earth some 4-billion years ago.

Despite COVID-19 travel/work restrictions, the students found that chemicals called polycyclic aromatic hydrocarbons (or "PAHs") — abundant on present-day Earth and within meteorites and believed important for jumpstarting life — undergo reactions in the presence of catalytic minerals common on the planets and moons of our solar system. They produce some of the very same chemicals that make cellular life possible on Earth today.

The team's longer-term goal is to use these findings to develop diagnostic methods to identify these same types of chemical reactions happening on other planets as possible indicators of the existence of life.

According to Gaylor, "The NSF EPSCoR funding provided the funds to support these ambitious, talented students who may otherwise had to work summer jobs that would not have advanced their preparation for post-graduate study."

The students continue their research efforts this fall.

- Jared Dewitt (Colman, South Dakota) is now a sophomore concentrating in chemistry at DSU and plans to enter a MD-PhD program after graduation.
- Sammy Drummond (Melbourne, Australia) is now a senior concentrating in physics and chemistry at DSU. He plans to pursue graduate studies in physics after graduation.
- Christina Mulu (Addis Ababa, Ethiopia) is now a sophomore concentrating in chemistry, mathematics, and computer science. She plans to pursue doctoral studies in biochemistry after graduation.
- Christina Maloney (Rockford, Illinois) is now a junior concentrating in biology and chemistry at Iowa State University. She plans to study veterinarymedicine after graduation.

NSF Early CAREER and Track-4 Proposal Development Workshop

Oct. 27 (Tuesday) 9 a.m.–12:45 p.m. CDT.
Offered online; limited to 50 participants

Dr. Kelvin Chu (former NSF program officer) with The Implementation Group (T.I.G.) will conduct the workshop.

Details and registration form at sdepscor.org/career

Eligible faculty* in South Dakota who are considering submitting an NSF CAREER or Track-4 proposal are encouraged to attend.

*Others interested in strengthening their proposal writing skills may participate if slots are available.

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Faculty Researcher Spotlight: Nick Klein

Dr. Klein is an instructor of environmental science at Sinte Gleska University (SGU) in Mission, South Dakota, as well as advisor for the SGU chapter of AISES (American Indian Science and Engineering Society).

Text By
Marie Severson,
Spring Intern
at SD EPSCoR
and also USD
graduate student

Having grown up on a cattle ranch on the Rosebud Reservation in South Dakota, Dr. Nicholas Klein developed a deep appreciation for the protection of tribal lands, food independence within the reservation, and the environment. Preservation of traditional Lakota medicinal and food plants, water quality, and bison ecology and management are areas of particular interest to him.

Klein studied biology at Augustana University before earning a Ph.D. in ocean science at the University of Southern California. After teaching in Los Angeles for a couple of years, he came home to South Dakota to teach at Sinte Gleska University (SGU) in Mission.

Although Klein started out as a pre-med student, his high school teachers and college professors encouraged him to continue pursuing his passion for field research.

By engaging SGU students in summer research internships supported by SD EPSCoR, Klein fosters communication skills, critical thinking, experimental design and presentation of research findings. “On a personal level, EPSCoR allows me to network and communicate with educators and researchers at every institution in South Dakota. This helps me collaborate with other programs to improve the experience for students here at SGU,” he said

Aŋpétu Omášte (Sunny Day)

Sinte Gleska University (SGU) greenhouse staff stand ready to examine a buffalo berry bush. All are current SGU students or graduates. SGU greenhouse staff from left to right: Cleo White Face (student), Taima Valandra (student), Carmelita Sully (director), Sannita Blue Thunder (student) and Karita Marshall (staff).

Image By
Nick Klein

I really enjoy field science and working outdoors. I also like the interdisciplinary nature of our work, which allows us to work in ecology, chemistry, microbiology and traditional Lakota knowledge at once.

— Dr. Nick Klein, Sinte Gleska University

Dr. Klein shares his appreciation for the well-being of reservation lands with the tribe and local residents. "Our research will strengthen the growing food sovereignty and food independence work here on the reservation, and helps us protect and preserve tribal lands, particularly in the face of global warming."

When he is not teaching or in the field with his students, Klein enjoys getting his exercise by running or hiking. He also expresses his creative side by playing guitar, painting or simply relaxing with a good book.

NATIVE GRADUATE STUDENTS

South Dakota's National Science Foundation EPSCoR RII Track 1 project supports Native American students attending graduate school in South Dakota and supporting Track 1 project activities. **Congratulations to these students:**

- **Travis Grablander**, South Dakota Mines
- **Tanner Hall**, University of South Dakota
- **Krista Horvath**, Sinte Gleska University
- **Dera Iyotte**, Sinte Gleska University
- **Joseph Laubach**, South Dakota Mines
- **Leon Leader Change**, University of South Dakota
- **Shane Star**, South Dakota Mines
- **Elisha Yellow Thunder**, South Dakota State University

An objective of the SD EPSCoR Track-1 project is to increase the number of Native Americans qualified to be faculty members at the three Tribal Colleges and Universities in South Dakota: Oglala Lakota College, Sinte Gleska University and Sisseton Wahpeton College.

See details at *sdepscor.org/diversity*.

Summer Teacher Workshops

Text By Nolan Ortbahn, Intern

As everyone started quarantining, initial plans to conduct in-person teacher workshops at six locations across South Dakota became unrealistic this summer. But demand for the remote learning exceeded project goals. More than 180 teachers from across the state participated in remote training that focused on teaching a biofilm instruction module developed by biofilm researchers and education specialists at Black Hills State University (BHSU).

Dr. Ben Sayler, NSF EPSCoR Track-1 education lead and professor at BHSU, believes that the virtual environment was a success. "We found that the virtual format both allowed many to participate who wouldn't have traveled, otherwise, and built relationships among teachers across geographic regions. These relationships have the potential to pay dividends long into the future."

Participants were provided a $300 stipend and the opportunity to earn a graduate credit for their work during the 3-day workshop. Summer 2021 workshops are expected to be a mix of virtual and in-person. New material will build on the framework established in 2020 and focus on teaching five additional curriculum modules currently being developed and pilot-tested.

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SAVE THE DATES AND REGISTER

South Dakota Innovation Expo
Oct. 20, Rapid City
Oct. 22, Sioux Falls
sdinnovationexpo.com

NSF Career and Track-4 Proposal Development Workshop
Oct. 27, Online, 9 a.m.–12:45 p.m. CDT
sdepscor.org/career
(Learn more on page 9.)

WIN Talent Draft Day 2020
Nov. 13, Sioux Falls and Online
sdepscor.org/talent

The National Science Foundation (NSF) is celebrating its 70th anniversary this year. Our South Dakota researchers are grateful for NSF-funded support of fundamental research, advanced technical education, STEM teacher training, long-term ecological monitoring, small business development, entrepreneurial training, major research instrumentation and more. **Details at sdepscor.org/history.**