Microbes May Convert Greenhouse Gases to Biofuels, Biodegradable Plastics and Electricity

Microbes discovered by researchers from South Dakota School of Mines & Technology are at the center of new research that could lead to the conversion of greenhouse gases into biofuel, biodegradable plastics and even electricity.

In 2009, the former Homestake Mine was a dark, wet and difficult place to conduct research. The deepest mine in North America began filling with water following its closure in 2002. As momentum built to turn the mine into an underground lab, pumps were installed to remove water from the flooded shafts and tunnels. As the water receded, Rajesh Sani, Ph.D., an associate professor in the Department of Chemical and Biological Engineering at SD Mines, was among the first researchers to enter the deeper sections of the mine. Sani and his team were not 5,000 feet underground hunting for precious minerals, they were looking for bugs. "The microbes we found were as good as gold," he said with a smile.

Extremophiles are microorganisms that live in harsh environments. They have learned to thrive in places such as the geothermal vents of the mid-Atlantic rift, the frigid waters of Antarctic lakes or the veins of hot water found in tiny cracks deep underground. Extremophiles have evolved unique characteristics that make them useful to scientists like Sani. Twelve years after that first trip, the former Homestake Mine is now the Sanford Underground Research Facility (SURF). Today, the microbes discovered inside SURF are at the center of new research at SD Mines.

The BuG ReMeDEE

In 2017, the National Science Foundation (NSF) awarded a US$6 million grant to Sani and his team to study the range of extremophiles that consume methane. The project is named Building Genome-to-Phenome Infrastructure for Regulating Methane in Deep and Extreme Environments (BuG ReMeDEE, pronounced "bug remedy"). This research is helping scientists better understand the methane cycle in the hot water fissures under Yellowstone National Park and deep inside SURF. The methane cycle is the generation and consumption of methane by various microbes.

Research scientists such as Saurabh Dhiman, Ph.D., in the chemical and biological engineering department at SD Mines, are also exploring how some of these microbes can be genetically engineered to better convert methane into value-added products or reduce the impact of future methane emissions on the environment. Venkata Gadhamshetty, Ph.D., civil and environmental engineering department and Navanietha Rathinam, Ph.D., chemical and biological engineering department, will be converting methane into biopolymers and electricity using SURF extremophiles. The research could also open doors for new economic development opportunities in industry that can use these genetically-modified microbes for processing greenhouse gas and converting it to biofuel, biodegradable plastics or electricity.

"This BuG ReMeDEE consortium will garner the world's attention on the significance of analyzing the methane regulation in deep subsurface and extreme environments," said Sani, the principal investigator of BuG ReMeDEE.

Converting plants to plastics

The extremophiles discovered in the Sanford Lab may also be key to building an industrial process that can convert plant matter into low-cost plastics that are renewable and biodegradable.

A team of researchers with the Composite and Nanocomposite Advanced Manufacturing — Biomaterials Center (CNAM), led by David Salem, Ph.D., at SD Mines believe the Sanford Lab extremophiles hold huge commercial promise. "The top 10 petroleum-based polymers make up about a US$500 billion global market," said Salem. "These biopolymers potentially can cover the whole range of properties of those."

South Dakota's Research and Commercialization Council (RCC) through the Governor's Research Center Program has awarded SD Mines CNAM US$1.8 million to develop commercially viable processes for manufacturing these materials.

Tip of the microbiome

Sani and his team have made multiple trips into the depths of the Sanford Lab in the last decade. Each milligram of mud or water brought back out can yield thousands of microbes. Each trip brings new discoveries and new species and what's perhaps most exciting are the discoveries yet to come. "We know only about one percent of the microbiome in these areas, 99 percent remains unknown," said Sani. www.sdsmt.edu.

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