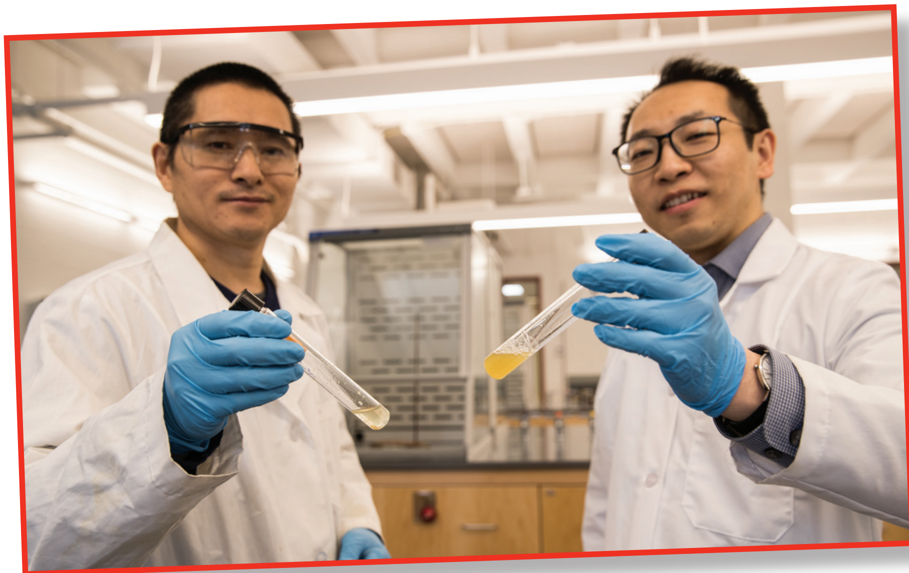

NJIT researchers and Daiyong Deng (left) and Mengyan Li (right) analyzed the bacterium Mycobacterium dioxanotrophicus PH-06 to discover a critical enzyme that begins the breakdown process of 1,4-dioxane.

CHEMICAL-FEASTING BACTERIA PROVIDE NEW KEY FOR REMOVING "LIKELY CARCINOGEN" FROM CONTAMINATED WATER

While not featured on most product ingredient labels, the organic chemical stabilizer and manufacturing byproduct, 1,4-dioxane, can be found in countless everyday household items — from shampoos and cosmetics to laundry detergents and antifreeze.

Partly due to its widespread use over many decades, the chemical has now been implicated by the Environmental Protection Agency (EPA) as an "emerging contaminant of concern" at groundwater and drinking water sites across the U.S., with no effective method for its removal yet established.

Now, scientists at NJIT have uncovered a rare enzyme in bacteria with the ability to degrade the "likely human carcinogen" and water contaminant, 1,4-dioxane.

Researchers say the discovery could help lead to more effective means for treatment of water contaminated by this highly-soluble chemical, known for its resistance to conventional water purification and treatment efforts.

The research is featured in the American Chemical Society journal *Environmental Science & Technology Letters.*

"Many products we use every day use a mixture of more than 100 chemicals, and we don't realize that some of them contain traces of 1,4-dioxane that are washed down our drains and released into the environment," said Dr. Mengyan Li, assistant professor of chemistry and environmental science at NJIT. "A one-time exposure isn't extremely toxic, but contamination in drinking water can have a chronic effect that raises cancer risk.

"What we are doing is studying microbes that actually consume this contaminant as their food," Li explained. "We hope this research can attract public attention to the idea that bacteria can be very effective in removing contaminants like 1,4-dioxane from the environment or via engineered venues."

In their study, Li and NJIT research colleagues Daiyong Deng and Fei Li analyzed a key enzyme associated with the unusual metabolic abilities of Mycobacterium dioxanotrophicus PH-06 — a microbe capable of feeding on 1,4-dioxane as its primary source of energy.

Li's lab was able to identify and characterize the critical role of one enzyme, propane monooxygenase, which leads the way in decomposing 1,4-dioxane's stable circular structure so it can be converted to fuel for the bacteria.

NJIT researchers Mengyan Li and Daiyong Deng analyzed the bacterium Mycobacterium dioxanotrophicus PH-06 to discover a critical enzyme that begins the breakdown process of 1,4-dioxane.

"What makes 1,4-dioxane so stable and hard to decompose is that it has a circular structure," said Li. "What this bacterial enzyme does is the most difficult task…it begins to disassemble this circular structure and break it apart so that it can be more easily degraded by other enzymes.

"One might think of this enzyme as leading the charge of an army that is sieging a heavily protected fortress," Li added. "It is on the front lines making the breakthrough so the reinforcements can join in."

According to data on environmental releases from the EPA's Toxics Release Inventory, approximately 675,000 pounds of 1,4-dioxane were released to the environment in 2015.

Li says some remediation approaches, such as treatment with oxidizing chemicals, can be too costly and are not known to be eco-friendly. Other efforts that apply absorbents to trap water contaminants typically require additional treatment to prevent land disposal problems where the concentrated chemical is released back into the environment.

"We think the best way forward is to have the microbes eat the 1,4-dioxane," said Li. "They naturally eliminate this contaminant by converting it into their biomass and into carbon dioxide. When you tackle large-scale environmental issues like 1,4-dioxane contamination, it is better to have a sustainable solution."

Li's lab is now seeking to develop new approaches to monitor and accelerate the performance of the newly discovered bacterial enzyme. The team is also exploring ways to scale up application of 1,4-dioxane-consuming bacteria for field use. With more study, Li's lab soon hopes to demonstrate the feasibility of microbe-based 1,4-dioxane remediation efforts outside of the lab.

"There are numerous environmental factors that might affect the microbes' performance if you were to simply inject these cultures into places of contamination directly, so we have to study that further," said Li. "However, drinking water facilities may be able to use add-on facilities like bioreactors or biologically active filters where water passes through the system, and the bacteria inside consume the 1,4-dioxane so that the discharge is clean water. That could be a treatment we apply, and I believe we are getting there." ■

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