Engineers devise new method to remove harmful E. coli from water

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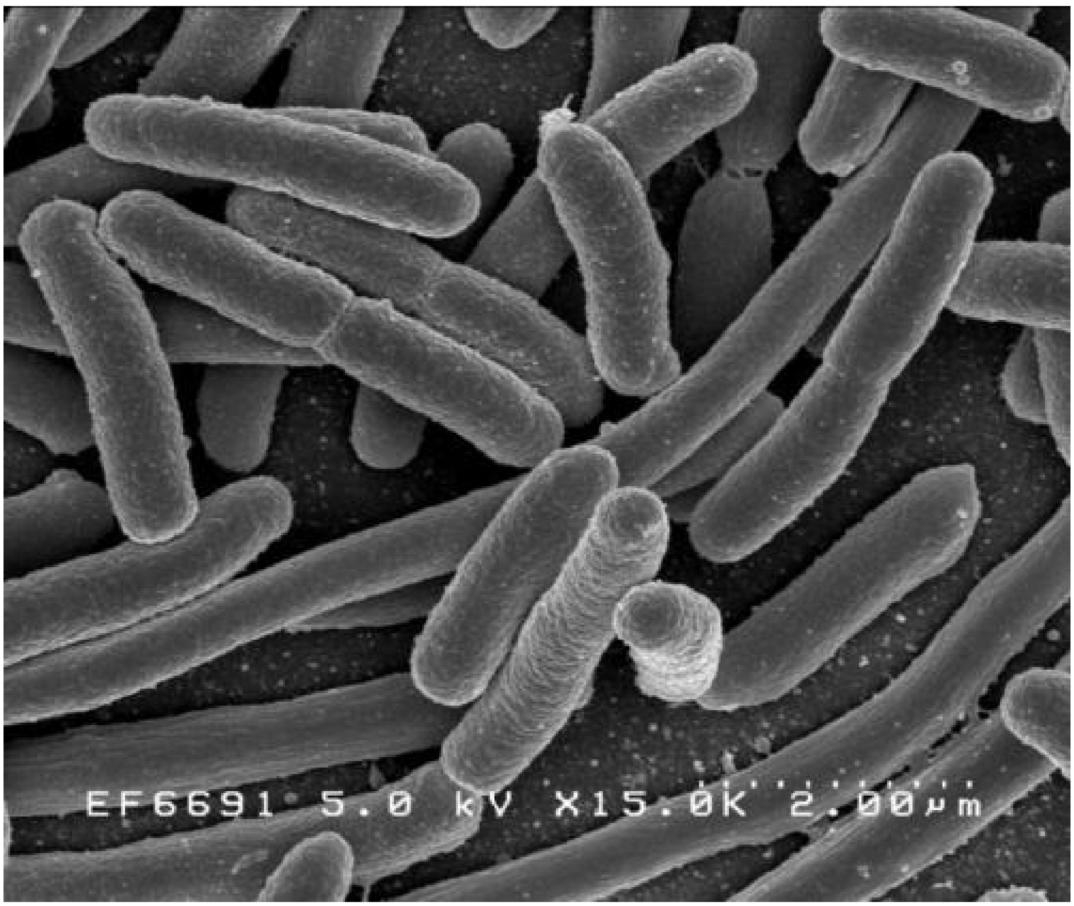

Escherichia coli. Credit: Rocky Mountain Laboratories, NIAID, NIH

Engineers at Monash University have come up with an improved method to remove potentially deadly bacteria, such as E. coli, from water using graphitic carbon nitride and sunlight.

The international team, led by Professor Xiwang Zhang in Monash University's Department of Chemical Engineering, combined graphitic carbon nitride with polyethylenimine (PEI) to destroy harmful pathogens E. coli and Enterococcus faecalis from water within 45 minutes and 60 minutes respectively.

This new photocatalyst method is low cost and metal-free, which prevents secondary pollution of leached metal ions during the filtration process.

If upscaled, this solar-driven method could significantly improve the treatment of large volumes of water. It also has the potential to be integrated into current solar water disinfection technology in countries with limited access to fresh water.

Published in the journal *Applied Catalysis B: Environmental*, Professor Zhang says integrating their photocatalyst into solar water disinfection technology could nearly ensure complete and rapid disinfection in a more sustainable way.

"Infectious diseases caused by waterborne pathogens threaten the health of people worldwide," said Professor Zhang, who is also the Director of the ARC Research Hub for Energy-efficient Separation.

"Graphitic carbon nitride has gained broad attention as a metal-free photocatalyst for water disinfection. However, it has limits in its capacity to remove pathogens completely using photocatalysis. What we've been able to do is fuse graphitic carbon nitride with PEI to boost photocatalytic properties of this material and test it on waterborne bacteria. We discovered the PEI functionalisation can, in effect, tune the photochemical reactions on graphitic carbon nitride. We found that the positively charged PEI on graphitic carbon nitride could promote the contact between photocatalyst and bacteria cells (negatively charged surface) via electrostatic adhesion, which can enable reactive oxygen species to kill the trapped bacteria cells."

A previous study published by the research team in *ACS Catalysis* found PEI on graphitic carbon nitride provided a trap site for photoinduced holes. Through this, PEI can tune the photochemical reactions to generate more reactive oxygen species for bacteria inactivation.

Through this process, PEI changes the surface charge of the composite photocatalyst to be positive; in nature, the surface of bacteria cells is negatively charged due to the specific moieties of their cell structure.

As such, the positively charged PEI on graphitic carbon nitrate can promote contact between photocatalyst and bacteria cells via electrostatic adhesion. In this way, PEI traps the bacteria cells in water. The trapped cells are then killed by the generated reactive oxygen species through photocatalysis.

Through this process, under solar light irradiation, the research team was able to remove 99.99 percent of E.coli from water in 45 minutes, and the same percentage of Enterococcus faecalis within 60 minutes.

"This PEI functionalisation process is simple. It can be shared with desperate communities across the world after further research is conducted on the development of photocatalysis devices," Professor Zhang said.

Professor Xiwang Zhang (Monash University, Chemical Engineering) led the study, titled "Cooperatively modulating reactive oxygen species generation and bacteria-photocatalyst contact over graphene carbon nitrate by polyethylenimine for rapid water disinfection."

More information: Xiangkang Zeng et al. Cooperatively modulating

reactive oxygen species generation and bacteria-photocatalyst contact over graphitic carbon nitride by polyethylenimine for rapid water disinfection, *Applied Catalysis B: Environmental* (2020). DOI: 10.1016/j.apcatb.2020.119095

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