Researchers develop low energy, cost-effective wastewater purification system

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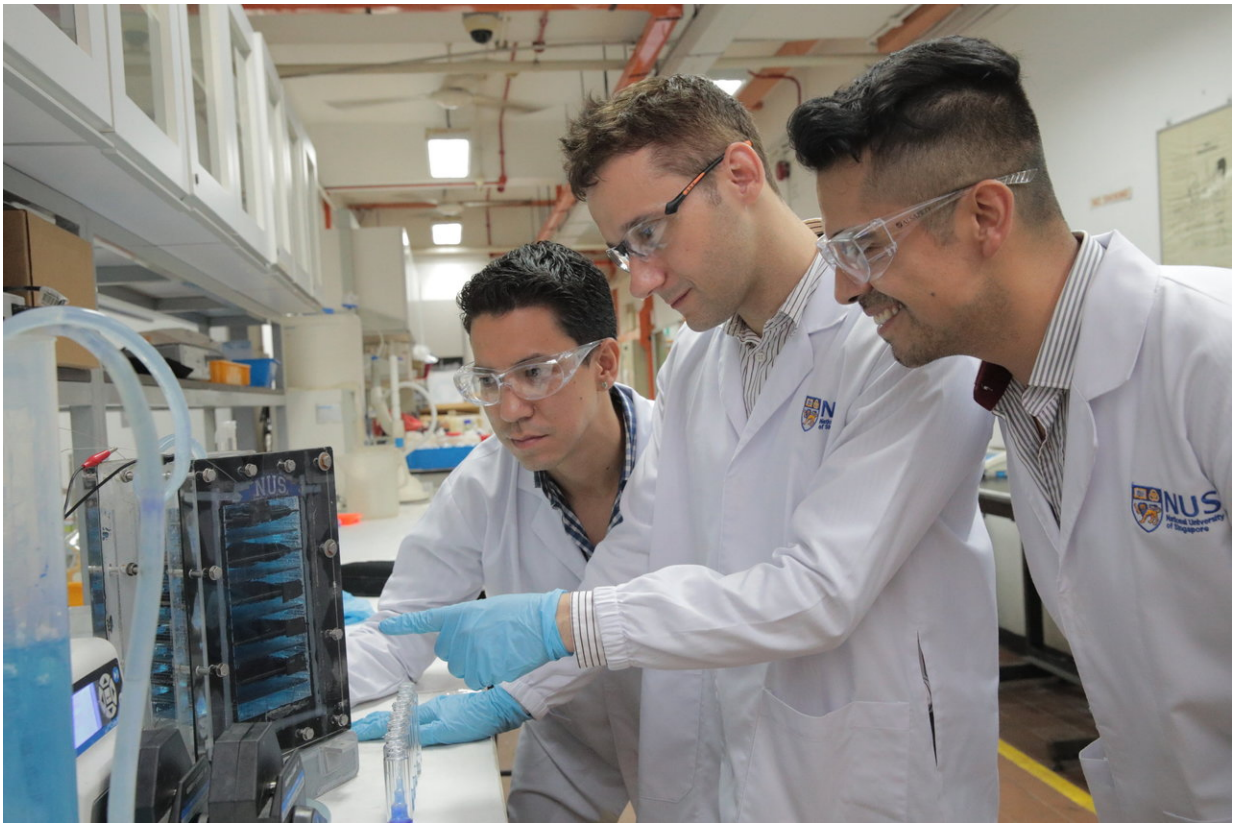

Researchers from NUS Faculty of Engineering have come up with a novel wastewater purification system that can remove up to 99 per cent of hard-to-treat organic compounds found in industrial wastewater. Credit: National University of Singapore

A team of scientists from the National University of Singapore (NUS)

has come up with a novel approach to treat industrial wastewater using electricity as a reagent for purification. The method can remove up to 99 per cent of hard-to-treat organic compounds found in various types of industrial wastewater. The NUS-developed system operates on low electrical power and does not generate secondary waste, such as sludge, that requires further costly residual waste processing such as incineration.

"Despite the great advances in wastewater treatment technologies, the removal of refractory organic compounds remains a costly and challenging process. Our invention provides an environmentally-friendly solution and helps to raise the overall standard of industrial wastewater treatment," said Assistant Professor Olivier Lefebvre from the Department of Civil and Environmental Engineering at NUS Faculty of Engineering, who is the leader of the research team.

For instance, wastewater from the electronics and pharmaceutical industries may contain high concentration of solvents and mixtures of complex organic substances, while wastewater from farmlands may contain high concentration of pesticides or herbicides. These organic compounds are not biodegradable and can be harmful to humans and the environment.

"Our electrochemical system has shown that it can achieve complete mineralisation of any organic pollutant. This means the system can completely remove organic compounds in the wastewater by degrading them into water and carbon dioxide. This novel system can also be incorporated as a pre-treatment to an existing wastewater treatment scheme. It operates on low electrical power and the system could easily be combined with solar power and other purification methods such as using membranes and biological treatments," explained Asst Prof Lefebvre.

Removing organic impurities from wastewater efficiently

The system developed by the NUS scientists uses electrochemistry to treat water and wastewater and does not require chemicals to be physically added into the system.

NUS scientists created a robust, highly efficient and easy to operate water purification system for industrial wastewater. This NUS invention operates on low electrical power and does not generate secondary waste, such as sludge, that requires further costly residual waste processing such as incineration. Credit: National University of Singapore

The treatment begins with the pumping of wastewater into the system's chamber. As electric current is passed, electrodes in the chamber generate hydrogen peroxide and hydroxyl radical (one of the most powerful oxidising agents) that will react with the complex organic compounds in the water. The generated hydrogen peroxide and hydroxyl radical are completely used up during the treatment and they continuously break down the complex compounds into simpler molecules, until all organic contaminants have been degraded into water and carbon dioxide.

Eco-friendly and cost-effective alternative for wastewater treatment

As today's industries increasingly require large volumes of high quality water for their processes, the demand for ultrapure water and maximising its reuse is also escalating. The global market for wastewater recycling and reuse reached nearly US$12.2 billion in 2016 and is expected to reach over US$22 billion by 2021, at an estimated compound annual growth rate of about 13 per cent.

Besides benefitting farmland, electronics and pharmaceutical industries, the new electrochemical system developed by the NUS team could potentially be utilised by heavy manufacturing industries that require ultrapure water for their processes such as mining, oil and gas, and textile industries; and the shipping industry for the disinfection of problematic ballast water from ships. It could also be applied to treat micro pollutants in domestic wastewater as well as manage water purity in various outdoor environment such as in controlling algal growth in water bodies and purifying landfill leachate.

"When we started this project in July 2014, we aimed to use our expertise in electrochemistry and know-how in reactor design to create a

robust, highly efficient and easy to operate water purification system for industrial wastewater that can reduce the need for third party processing or disposal. Our low-voltage electrochemical system can be installed in manufacturing plants of many different industries. The factories can easily reuse the treated water for their other processes and even control how pure the water is, according to their different needs," said Asst Prof Lefebvre, who is also a Principal Investigator at NUS Engineering's Centre for Water Research.

Next steps in research

Asst Prof Lefebvre and his team have applied for two patents for the technology used in the electrochemical system and they are now testing the system on more types of industrial wastewater to further refine the design and optimise the efficiency of the system. In addition, the team has recently developed superior graphene electrodes that can speed up the system's water purification process. They are also looking to collaborate with industry partners to commercialise the technology.

Provided by National University of Singapore