Science for Environment Policy

Low energy water purification enabled by nanomaterial-coated sponges

A low cost, low energy method to disinfect water using electricity has been developed by researchers by combining carbon nanotubes (CNTs) and silver nano-wires with existing materials. The technology has the potential to be used in portable disinfection devices in developing countries.

Globally, an estimated 1.3 million children under five die every year from diarrhoeal diseases. Many of these deaths are caused by drinking water contaminated with microorganisms. In order to improve global access to safe drinking water and sanitation, the EU, and its Member States, have provided around €200 million per year to water supply, sanitation and hygiene ('WASH')[1] programmes in developing countries, and is the largest such donor in the world.

There are a number of treatment methods for disinfecting drinking water, such as membrane filtration and UV disinfection. However, these methods have a number of disadvantages, such as high maintenance costs and energy consumption. Chlorine disinfection is cheaper and more common, but can generate carcinogenic by-products. As such, more efficient, affordable and low energy water disinfection treatments are needed.

One possibility is the use of a process called 'electroporation', in which water is disinfected using an electric field. This kills harmful microorganisms by causing pores to form in their cell walls. Earlier studies have shown that the process works in principle, but needs high voltage electric fields, which use large amounts of energy, and is therefore costly.

However, this study shows how nanomaterials could be used to drive down the energy use and cost of electroporation disinfection.

The researchers coated commercially available polyurethane sponges with carbon nanotubes and silver nanowires. Together these turned the porous structure of the sponges into small conductive electrodes, with nanometre-sized tips that enhanced their local electric fields.

They tested the efficiency of the conducting 'nanosponge' in killing microorganisms using water 'contaminated' with four diarrhoea-causing bacteria, including *Escherichia coli* and *Salmonella enterica Typhimurium*, as well an example virus that infects bacteria, called 'bacteriophage MS2'.

Nearly all — 99.9999% — of all bacterial species were removed from the contaminated water when it was passed through the nanosponge. This was achieved with a significant reduction in voltage, from the thousands of volts indicated in other studies, to around just 10 volts. The sponge inactivated 99.4% of the viral particles, which required around 20 volts. Using an electron microscope the researchers confirmed that the electroporation was the mechanism causing the antibacterial effect.

Silver nanoparticles are considered a potential health risk, and the researchers measured silver in the filter water effluent, finding levels of 70 to 94 parts per billion (ppb). This is however very close to US national standards of 100 ppb. There are currently no EU standards for silver concentrations in drinking water.

The flow rate of water used was 15 000 litres per hour per square metre of sponge. However, there was no optimisation of the flow rate, or analysis of variable flow rates, as may be seen if the technology is used as a portable device.

By combining CNTs and silver nanowires with existing materials, the researchers have significantly improved the energy efficiency of electroporation, without sacrificing effectiveness. They suggest that the low cost, low energy consumption and speed of treatment would make the technology useful as a portable decontamination device, as well as for use in larger water treatment systems.

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Nanomaterials' functionality

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