

New water treatment process could help fight dangerous bugs

Chlorine-resistant bugs including cryptosporidium could be killed by oxidation using UV light and titanium dioxide catalyst



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A new disinfection process could help to protect water supplies from the dangerous bug cryptosporidium, it was announced today (9th September 2002).

The microscopic parasite, which is resistant to conventional chlorination, has caused health scares in the UK and around the world.

More than 150,000 people were ordered to boil their water when cryptosporidium was discovered in Glasgow's water supply in August this year. Outbreaks have also occurred in other parts of Scotland, Northern Ireland and north-west England. A fictional case even featured in the BBC medical drama, *Holby City*. Although contamination is not usually fatal, more than 100 people died in the worst outbreak, in Milwaukee, Wisconsin, in 1993.

The new treatment process developed at the University of Newcastle on Tyne employs widely available, non-toxic titanium dioxide and UV light to disinfect water supplies. It has been pioneered as part of the Government's programme for Waste Minimisation through Recycling, Re-use and Recovery in Industry. The Engineering and Physical Sciences Research Council provided a grant of just over £187,000 for the three-year project, with support from industrial partners including Ineos Chlor (formerly part of ICI) and Huntsman Polyurethanes.

A multidisciplinary team was set up at Newcastle, working across the Departments of Chemical and Process Engineering, Civil Engineering and Chemistry.

'Cryptosporidium is a very nasty bug and there have been a number of occasions when standard chlorine treatments have failed on

major water installations,' says Dr Terry Egerton of the Department of Chemistry. 'We have already demonstrated on a small scale that this new process kills off cryptosporidium. We now need to scale up the work and carry out detailed microbiological analysis. There is real potential for safeguarding water supplies from these dangerous bugs.'

The use of titanium dioxide in water treatment has attracted interest for some time, as concern mounts about shortcomings of chlorination. It acts as a catalyst, absorbing ultraviolet light and generating hydroxyl radicals that oxidise organic contaminants and kill bacteria. However, existing photocatalytic processes have been uneconomic.

The new technique, which can destroy organic contaminants as well as water-borne organisms, increases efficiency by a factor of 10. Instead of using a slurry of titanium dioxide powder, the material is formed into electrodes to which a small electrical current is applied.

WMR3
(Waste Minimisation through Recycling, Re-use and Recovery in Industry) was a collaborative industrial research programme supported by £12m of funding from EPSRC and DTI during 1995 – 2003.



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Practical water treatment reactors have already been successfully tested with hard-to-destroy organic molecules such as nitro-phenols, and in disinfection of *E. coli* bacteria. A UV lamp is placed within cylindrical electrodes. Results demonstrate that destruction of *E. coli* is much more effective than conventional photocatalytic disinfection using titanium dioxide powder. Another advantage is that there is no need to separate titanium dioxide particles from a slurry suspension.

'The results demonstrate that the use of titanium dioxide in photo-electrochemical treatment is now a serious option,' says Dr Egerton. 'We are now carrying out a programme of catalyst development to increase the efficiency of the electrode still further.'

The process offers additional safety benefits as it eliminates the need to store potentially hazardous chemicals such as chlorine, hydrogen peroxide and ozone.

Future applications could include small-scale recirculating water systems in hotels and hospitals and even domestic water purifiers that fit under the sink. A key advantage would be low maintenance requirements, making systems relatively cheap to run. In the defence industry, there is interest in using the process for air and water treatment in confined spaces, for example in submarines.

Additional project details and background

Why are alternatives to chlorine needed for water treatment?

Regulatory bodies worldwide have called for a gradual improvement in water treatment standards. Chlorine is widely used for water treatment but can sometimes react with other chemicals in waste streams to form worse pollutants such as THMs (trihalomethanes).

There have been concerns that chlorination alone may not kill some water-borne organisms such as cryptosporidium. Interest has been growing in advanced oxidation processes in which hydroxyl radicals are used to kill bacteria or oxidise organic contaminants.

What is cryptosporidium and how can it make you ill?

Cryptosporidium is a microscopic parasite that exists naturally in the environment and is commonly found in farm animals and their faeces. If swallowed it can cause severe diarrhoea and stomach cramps. Although it usually has no lasting effects on people who are fit and healthy, the elderly and those suffering other health problems can be at greater risk.

Cryptosporidium can be transmitted by contaminated water and there is increased awareness of the possibility of water borne outbreaks through failures in water treatment or run-offs of water from farmland.

What are the attractions of using titanium dioxide in water treatment?

Titanium dioxide is non-toxic, relatively cheap and widely available. It is commonly used in paints, suncreams and toothpaste – and even added to food products.

Common forms of titanium dioxide are semiconductors. Absorption of UV light generates highly active hydroxyl radicals, capable of oxidising organic contaminants or killing water-borne bacteria and other organisms such as cryptosporidium.

Why hasn't titanium dioxide already been used?

Two problems have held back photocatalytic treatment using titanium dioxide in powder form. The efficiency of hydroxyl radical generation is reduced by a process known as electron-hole recombination. In addition, titanium dioxide particles have to be separated from slurry after the treatment process takes place.

How does the new process overcome these limitations?

Titanium dioxide forms a photo-anode in an electrochemical cell. Applying a small electrical potential has been shown to increase efficiency for two key applications – oxidation of organic contaminants and disinfection of water containing bacteria such as *E. coli* and organisms such as cryptosporidium. There is no need to separate titanium dioxide particles after treatment.

A cylindrical reactor has been developed in which a centrally mounted UV tube is surrounded by a titanium dioxide electrode. Development is now taking place to increase photo-efficiency of the electrodes still further.

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