High-tech materials purify water with sunlight

March 16 2014

Sunlight plus a common titanium pigment might be the secret recipe for ridding pharmaceuticals, pesticides and other potentially harmful pollutants from drinking water. Scientists combined several high-tech components to make an easy-to-use water purifier that could work with the world's most basic form of energy, sunlight, in a boon for water purification in rural areas or developing countries.

The talk was one of more than 10,000 presentations at the 247th National Meeting & Exposition of the American Chemical Society (ACS).

Anne Morrissey, Ph.D., explained that the new technology could someday be incorporated into an easy-to-use consumer product that would remove these stubborn pollutants from drinking water as a final step after it has already been treated with conventional methods.

Her group at Dublin City University in Ireland started with a compound called titanium dioxide (TiO_2), a powder used to whiten paints, paper, toothpaste, food and other products. With the right energy, TiO_2 can also act as a catalyst—a molecule that encourages chemical reactions—breaking down unwanted compounds in drinking water like pesticides and pharmaceuticals. Morrissey explained that modifying current water treatment methods to get rid of these potentially harmful species can be costly and energy-intensive, and often, these modifications don't completely eliminate the pollutants.

But Morrissey said TiO_2 is usually only activated by ultraviolet light, which is produced by special bulbs. To access titanium dioxide's properties with the sun's light, Morrissey and her group experimented with different shapes of TiO_2 that would better absorb visible light. She found that nanotubes about 1,000 times thinner than a human hair were best, but they couldn't do it on their own.

That's why she turned to graphene, a material made of sheets of carbon just one atom thick. "Graphene is the magic material, but its use for water treatment hasn't been fully developed," she said. "It has great potential." Morrissey put the TiO_2 nanotubes on these graphene sheets. Pollutants stuck to the surface of the graphene as they passed by, allowing TiO_2 to get close enough to break them down.

Her research group successfully tested the system on diclofenac, an anti-inflammatory drug notorious for wiping out nearly an entire vulture population in India.

"We're looking at using the graphene composite in a cartridge for one-step drinking water treatment," said Morrissey. "You could just buy a cartridge off the shelf and plop it into the pipe where the drinking water comes into your house." The cartridge system would also ensure that the graphene stays immobilized and does its job without contaminating the clean water.

Morrissey noted, however, that the technology will never be strong enough to completely clean drinking water on its own. Rather, she sees it as a polishing step after traditional water treatment processes to mop up the most insidious pollutants.

That could be especially useful in her home country, where she said many rural communities use small water treatment systems that only supply a few dozen homes. Because they don't have the infrastructure that large-scale urban treatment plants do, she thinks that a cartridge that could clean with only the sun's energy could help make their water safer.

Ultimately, Morrissey said there are still many questions to answer before declaring her TiO_2-graphene system a success. One of the biggest is making sure that when it breaks down pollutants, it is producing harmless byproducts. She also wants to make sure that the energy required for the system compares favorably to simply using TiO_2 with ultraviolet light. But so far, she reported, her design seems to be easier to make and dispose of than other visible-light activated TiO_2 purifiers.

More information: Using nanomaterials to remove emerging micro-pollutants from water:

Abstract
There has been a growing awareness of the existence of micro-pollutants such as detergents, dyes, pesticides, herbicides and pharmaceuticals in the environment in recent years. At the same time, conventional water and wastewater treatments such as adsorption, ozonation, UV and bio-degradation can only partially remove these micro-pollutants from treated water. Semiconductor photocatalysis using titanium dioxide (TiO2) has also been very well researched due to the potential of complete degradation of organic compounds and the minimization of waste disposal and energy consumption. However, TiO2 also has limitations, not least the requirement for UV light, which impede its application in an industrial wastewater treatment process. To overcome the disadvantages of TiO2, different TiO2 nanostructures (nanoparticle, nanotube, nanowire and mesoporous beads) were modified in a series of experiments with i) activated carbon (Integrated Photocatalytic Adsorbents) and ii) with graphene to develop visible-light responsive TiO2-based photocatalysts. The effectiveness of the new composites was tested on a number of pharmaceuticals, including diclofenac, (which is now on the EU watch list), with graphene/TiO2nanotubes giving the best

results. A graphene oxide sponge was also produced, which showed an exceptional adsorption capacity for the removal of a wide range of compounds (equilibrium reached in an hour) and with a higher efficiency than that of activated carbon.

Provided by American Chemical Society

Citation: High-tech materials purify water with sunlight (2014, March 16) retrieved 11 July 2024 from https://phys.org/news/2014-03-high-tech-materials-purify-sunlight.html