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Composite Nanomaterials Purify Drinking Water Affordably

by Rachel Nuwer

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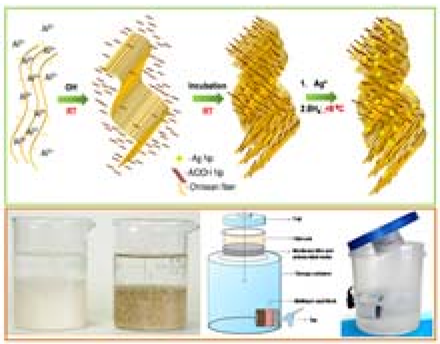

Top: Mechanism for the preparation of composite and origin of its physical strength in water due to network structure. (Bottom) Water purification device undergoing field trials in India and its performance evaluation. See complete caption after body of article below. Credit: Thalappil Pradeep. Click image to enlarge.

Each year, around 3.6 million people die because of issues related to contaminated water, poor hygiene, and unsanitary conditions. If those households most at risk could gain access to safe drinking water, more than 2 million lives could be saved. Now, one research team has proposed a cheap, safe means of achieving this with an all-inclusive drinking water purifier assembled from several nanocomposites.

"We wanted to show that it is possible to deliver affordable clean water that had all of the contaminants removed," says Thalappil Pradeep, a materials scientist at the Indian Institute of Technology Madras, and senior author of a paper published in the Proceedings of the National Academy of Sciences describing the new filter. "I've been on this dream for quite some time, it's a very big thing for me."

Pradeep and his students and colleagues began work on this project several years ago. Contaminated water may contain bacteria, viruses, protozoa, heavy metals, pesticides, or other potential toxins. They knew that silver ions, released from the metal in nanoparticle form, worked as a disinfectant for a number of bacteria and viruses found in contaminated water, while other inorganic toxins, such as lead, iron, and arsenic, can be scavenged from contaminated water with materials containing different chemical properties, particular to each of those elements. Iron oxyhydroxide nanopaprticles scavenge arsenic, for example, while manganese oxide adsorbs lead. "For a diverse array of contaminants, you can use a variety of nanostructured materials to finally get water that is purified," Pradeep says.

But contaminants found in the water tend to anchor to nanosilver surfaces, blocking the release of silver ions from them. To overcome this problem, the researchers created a unique family of nanocrystalline metal oxyhydroxide-chitosan granular composite materials. This material, which forms a cage-like matrix, strongly bonds to embedded nanoparticles. The nanoparticles remain

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isolated inside the matrix, which only allows ions to escape at a controlled rate. Those ions then kill microbes found in the water, without releasing nanoparticles.

The materials can all be prepared at room temperature in water, and they gradually settle to form a sand-like material. No electricity is required and all of the elements needed to build the filters are widely available and affordable. For each liter of water needed to make the composite, 500 liters of clean water can be produced. None of the composite materials themselves are toxic. When the material eventually stops releasing silver ions, hot water can get rid of the thin layer of scalants to regain activity in the composite. The purifiers would cost small families about US$2.50 per year.

Pradeep hopes to produce the filters in the remote villages where they are most needed. About 2,000 small community-scale units are being installed in west Bengal, an area plagued by arsenic contamination in its water. Pradeep thinks the filters could be deployed to more than 2 million people over the next two years or so, though other organizations will have to take responsibility for organizing those efforts. The same technology could eventually be used in other developing nations as well so long as tests were carried out to customize the filters to each particular country's conditions. If all goes well, the new composites could even provide a potential solution for achieving the United Nations millennium development goal of doubling the number of people with sustainable access to safe drinking water by 2015.

"People talk about nanotechnology from the context of advanced computing and high density data storage," Pradeep says. "Those are important, but at the same time frugal science is also important, and can make a larger impact in the short term."

Read the abstract in the *Proceedings of the National Academy of Sciences* here.

Complete caption:
(Top) Mechanism for the preparation of composite and origin of its physical strength in water due to network structure. Mechanistic scheme for the formation of aluminum hydroxide nanoparticles and random coiled chitosan network; aluminum hydroxide nanoparticles bind to chitosan network,formation of Ag-BM composite, as learned through various experiments. $Al3^{+}$ complexes with chitosan solution; alkali treatment leads to formation of aluminum hydroxide nanoparticles and random coiled chitosan network; aluminum hydroxide nanoparticles bind to chitosan network, possibly through covalent sharing of oxygen, leading to the formation of aluminum oxyhydroxide; and silver nanoparticles form on the aluminumoxyhydroxide–chitosan network.

(Bottom) Water purification device undergoing field trials in India and its performance evaluation. Schematic diagram of the device. Actual photograph of the device. Construction and assembly of the device are simple and can be done locally. The antimicrobial composition is used as granules and kept in the membrane filter. Carbon block is positioned just before the tap. Carbon block may also be used as a multilayer axial block, comprising adsorbents for specific regional contaminants such as arsenic, iron, and lead.

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