In just seconds, low-cost porous organic polymer can cut toxic metal concentrations in water to inconsequential levels

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Aquifers, lakes, and rivers that supply drinking water rarely contain metal contaminants. When water passes through service lines and home plumbing systems, however, corrosion can introduce small amounts of lead, cadmium and other heavy metals that are toxic to human health.

Recently, the World Health Organization lowered the recommended lead concentrations in drinking water to 10 parts per billion (ppb) to help prevent accidental poisoning.

Reaching such low lead concentration levels typically requires time-consuming precipitation reactions or expensive reverse osmosis systems that also remove essential minerals, such as calcium, from drinking water. A team led by Yugen Zhang and Jackie Y. Ying from the A*STAR Institute of Bioengineering and Nanotechnology has now developed a technology that greatly improves purification efforts. They used a porous polymer that selectively binds to lead and other heavy metals in flowing water.

Filtering water through porous substances, such as activated charcoal, is one of the oldest and most effective decontamination technologies. Over the past few decades, chemists have developed newer materials called porous organic polymers (POPs), which combine nanometer-scale pore sizes with highly tunable molecular building blocks. These attributes have made POPs appealing platforms for isolating and storing gases such as hydrogen and carbon dioxide, as well as catalytic supports.

Zhang, Ying and co-workers recently synthesized a POP known as mesoporous poly-melamine-formaldehyde (mPMF) with exceptional carbon-capture capabilities. The material has a high surface area arising from a chemical structure composed of nitrogen-bearing aromatic rings that link into larger, nanoscale loops through hydrocarbon-amine units. Because the nitrogen atoms found in this POP have a strong binding affinity for heavy metals, the team suspected that mPMF could also act as a sorbent for water purification.

After a simple one-step reaction to create the inexpensive mPMF polymer, the researchers placed it into water contaminated with an excess of lead ions. Remarkably, more than 99 per cent of the toxic metal was removed within 5 seconds, reducing the lead levels to part-per-trillion concentrations. Removal efficiencies were equally high in stationary and more challenging dynamic flow conditions. Furthermore, the team could recover the lead ions and recycle the sorbent using simple dilute acid treatments.

In-depth experiments revealed that mPMF's ultrafast adsorption behavior was due to an open porous structure that allows full access to nitrogen atom binding sites. These sites also removed heavy metals such as cadmium and palladium but had little affinity for calcium and potassium cations – a selectivity that could make an immediate impact in commercial applications.

More information: Tan, M. X., Sum, Y. N., Ying, J. Y. & Zhang, Y. A mesoporous poly-melamine-formaldehyde polymer as a solid sorbent for toxic metal removal. *Energy & Environmental Science* 6, 3254–3259 (2013). dx.doi.org/10.1039/c3ee42216j

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