Abstract

When you think of a glass of water, what words come to mind? Clean? Safe? Refreshing? Unfortunately, those words don’t describe most of the drinking water in the world. According to the World Health Organization, 1 in 3 people on Earth don’t have access to safe drinking water. Children in some parts of Africa, for example, may need to walk for miles to get access to a bottle of drinking water. No matter where you live, people need clean water. Think about it. We need water for drinking, cooking, bathing, handwashing, and growing food. We need water to survive.

Copper is a contaminant that makes water unsafe to drink. We created a new material – ZIOS – that can take copper out of the water and use it in other industries. We tested ZIOS to see how much it reduced copper levels in water. We also tested how quickly it does that, and if it would work in acidic environments. Our data support that ZIOS is a good solution to cleaning up copper pollution.

Introduction

Metals are a part of our everyday life. Your body needs metals, such as sodium, potassium, and calcium, to function and to keep you healthy. Yet some metals can be dangerous. We call these metals toxic heavy metals. Why? We call them heavy because they have high densities. We call them toxic because they are harmful to human health.

Copper is one of the most widely used heavy metals. Copper is a metal that our bodies need in small amounts, but it becomes toxic at high levels. Many rivers and streams contain copper because many industries use this metal. Scientists consider a waterbody polluted with copper when the levels are too high. To protect human health and the environment, scientists need to remediate (clean up) the copper. Copper remediation is difficult. Current processes are expensive. They do not always do a good job of removing traces of copper without also removing other metals from the water at the same time.

We wanted to create a method that can effectively remediate copper at a low cost. Our method uses the scientific process of adsorption. Adsorption occurs when ions or molecules of one substance stick to the surface of another substance (Fig. 1).
Methods

We created ZIOS, a new supramolecular structure that adsorbs copper ions. In a supramolecular structure, molecules bond together rather than atoms. To make ZIOS, we mixed together three different molecules in water at 50°C, and they reacted to form small crystals. We used x-rays to see how the different molecules arranged themselves and saw that hydrogen bonds held the molecules together in a crystalline structure (Fig. 2).

Once we created ZIOS, we tested how well it adsorbed copper ions. We also tested a different copper adsorbent, known as ZIF-8. We already know that ZIF-8 is an excellent copper adsorbent so we used it as a comparison for how well ZIOS adsorbed copper ions.

To test the adsorption of copper, we put both ZIOS and ZIF-8 into a solution of copper chloride and water. We waited about 30 minutes and then checked the copper ion levels. We checked them again after 75 minutes.

We wanted to see if these adsorbents could adsorb copper when other ions are present. We tested ZIOS and ZIF-8 in water samples that contained copper, manganese, nickel, sodium, calcium, and iron. Then we measured the levels of each ion.

Finally, we tested ZIOS and ZIF-8 in water samples with a low pH to see if the environment would change their ability to adsorb copper.

Results

We placed both ZIOS and ZIF-8 in a solution with initial copper ion levels of 425 parts per million (ppm). After 30 minutes, ZIOS had reduced the copper levels to less than 1.5 ppm, while ZIF-8 had dropped the levels to about 42 ppm. After 75 minutes, the copper concentration in the solution with ZIOS was still less than 1.5 ppm, but the levels for ZIF-8 had increased to 115 ppm.

When we tested these adsorbents in water with lots of ions, ZIOS adsorbed 98% of the copper ions, but ZIF-8 only adsorbed about 53%. ZIOS and ZIF-8 also lowered the iron and nickel levels. ZIOS removed more iron and nickel than ZIF-8 (Fig. 3A).

When the pH was low, ZIOS lowered the copper levels, but it did not lower the iron and nickel levels. ZIF-8 had the opposite effect: at low pH, ZIF-8 adsorbed high levels of iron, but not copper (Fig. 3B).

pH is a scale used to measure if a solution is an acid, base, or neutral. Pure water is neutral with a pH of 7.

We tested ZIOS and ZIF-8 in water samples with a pH of 2.45, which means they were very acidic.

![Figure 2: The structure of ZIOS.](image-url)
**Discussion**

Our results show three important findings about our new material, ZIOS.

1. ZIOS can reduce the amount of copper in the water up to 50 times faster than other adsorbents, such as ZIF-8.
2. ZIOS can also remove iron and nickel from water. When it removes these ions, it still removes copper as effectively as it did when only copper was present.
3. ZIOS works to only remove copper in acidic environments because the copper levels went down to similar levels at low pH, whereas the levels of other metals remained the same.

**Conclusion**

Everyone should have access to clean drinking water. Our material, ZIOS, can provide a new option for copper adsorption that is faster and more effective than many of our current options. It can help people get access to the water that they need to be healthy.

You can also help make sure that people have access to clean drinking water. You can support a non-profit organization, such as Thirst Project or charity: water. Thirst Project uses donations to dig wells and provide water filters to communities all over the world. Charity: water funds water projects internationally. Your support brings clean water to those who need it.

**Glossary of Key Terms**

- **Adsorbent** – the substance that the contaminant ions stick to. For example, ZIOS is the adsorbent for copper ions.
- **Adsorption** – the process that occurs when ions or molecules of one substance stick to the surface of another substance.
- **Contaminant** – a substance that pollutes or makes another substance impure. For example, copper is a water contaminant.
- **Crystalline** – a description of a substance that has the form of a crystal or is made of crystals.
- **Desorption** – the process when a substance is released from the adsorbent’s surface.
- **Hydrogen bond** – a weak bond that forms between molecules when one has a positive charge (of a proton) and the other has a negative charge. The attraction between the positive and negative charges holds the molecules together.
- **Ions** – atoms that have a positive or a negative charge because they have lost or gained electrons.
- **pH** – a scale used to measure if a solution is an acid, base, or neutral.
- **Remediate** – to clean up pollution from soil, groundwater, or surface water.
- **Supramolecular structure** – a large structure that forms when many molecules bond together.
- **Toxic heavy metals** – metals with a high density that are dangerous to human health. Examples include copper, mercury, and arsenic.

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HEAVY METAL POLLUTION: HOW CAN WE MAKE WATER SAFE TO DRINK?

Why is access to clean water so important?

Why is copper considered a toxic heavy metal?

How do we know that ZIOS remediates copper pollution in water?

How do we know that ZIOS works better than other current adsorbents?

Research a nonprofit organization that helps address the global water crisis. Write a paragraph or create a presentation or poster summarizing the charity’s mission and evaluating their effectiveness at meeting their mission.

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