# Green Synthesis of Magnetic $CuS/Fe_3O_4$ Nanocomposite for Selective Adsorption of Mercury From Water

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## INTRODUCTION

- $Hg^{2+}$ contamination from artisanal mining threatens ecosystems and human health (toxic levels found in hair, nails, urine).[1] Current adsorbents lack selectivity and are difficult to recover.
- To address these limitations, magnetically recoverable $CuS/Fe_3O_4$ nanocomposites are designed using castor oil – a renewable, non-edible solvent. CuS exhibits exceptional $Hg^{2+}$ affinity through soft-soft acid-base interactions[2], while $Fe_3O_4$ permits magnetic separation to prevent secondary waste.
- This approach eliminates toxic solvents, directly supporting **UN SDG 6 (clean water)** and **SDG 12 (responsible consumption)**.

**Figure 1**. Accessing water at a contaminated source

## AIM AND OBJECTIVES

❑ This research aims to develop a green solvothermal synthetic route for the synthesis of $CuS/Fe_3O_4$ nanocomposites for the adsorption of mercury in water.

- To prepare and characterize $CuS/Fe_3O_4$ nanocomposites through a castor-oil-based solvothermal synthesis route.
- To investigate the adsorption performance of the as-synthesized $CuS/Fe_3O_4$ nanocomposites toward $Hg^{2+}$ ions in water: (a) to evaluate the influence of pH, adsorbent dosage, contact time, and initial concentration on the adsorption process and (b) assess their selectivity and regeneration.
- To assess the adsorption behaviour of the $CuS/Fe_3O_4$ nanocomposite in different real water matrices, including river water, borehole water, and tap water.

## METHODOLOGY

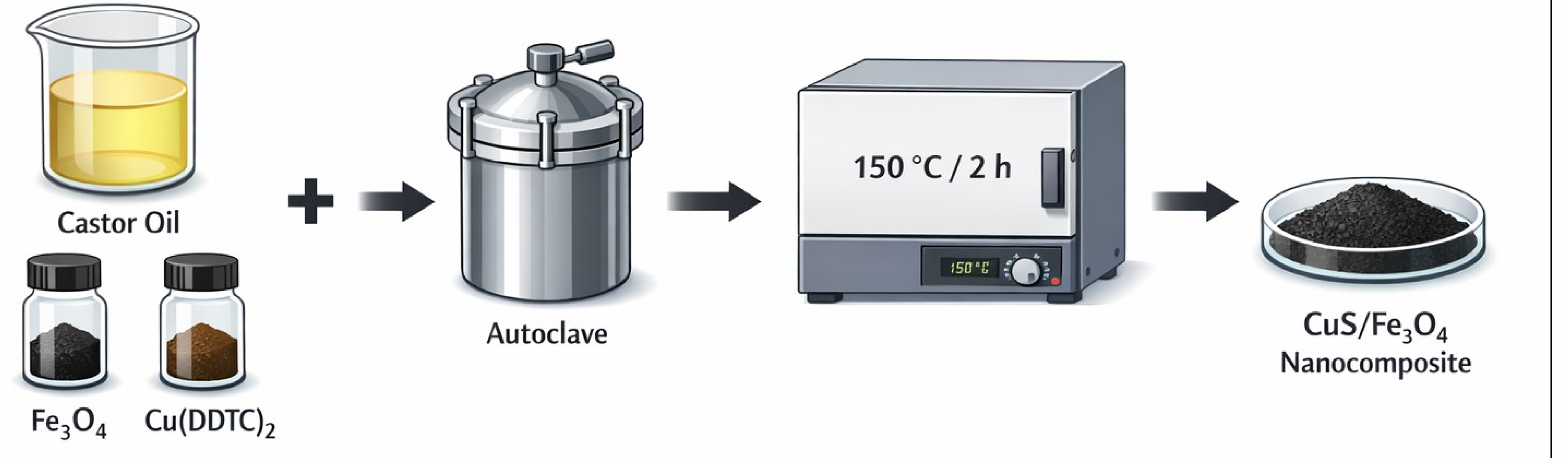
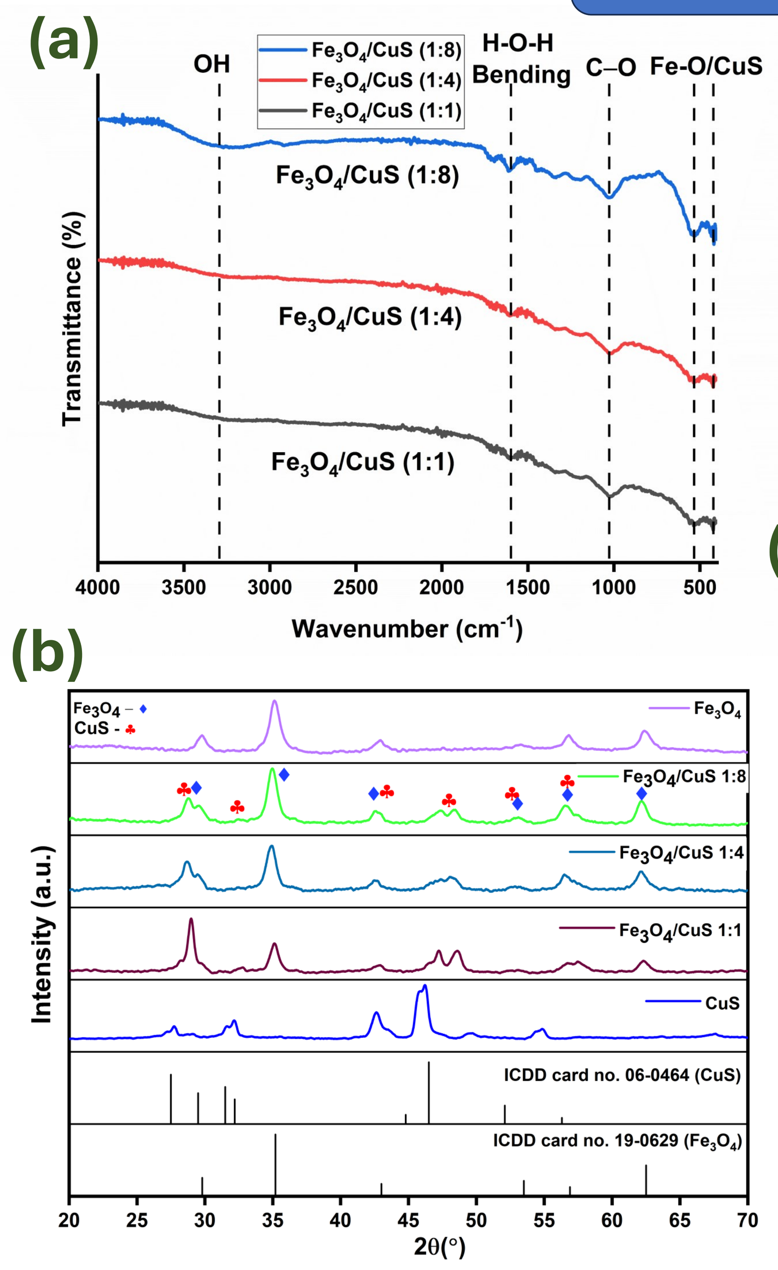



Figure 2. Solvothermal synthesis of $CuS/Fe_3O_4$ Nanocomposites in Castor Oil

## CHARACTERIZATION



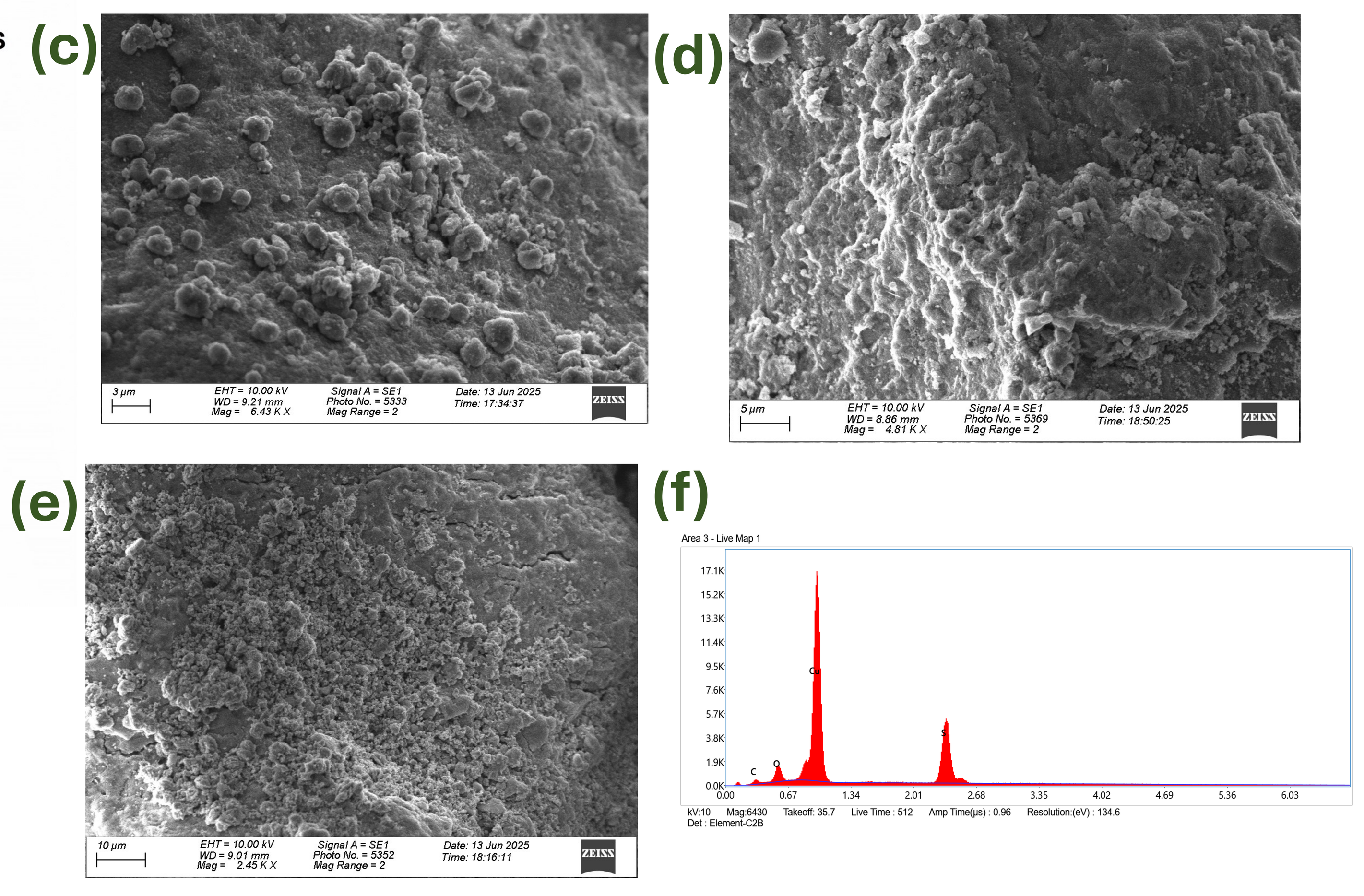




Figure 3 . (A) Stacked FT-IR spectrum (B) Stacked XRD pattern (c-e) SEM images and (f) EDX spectrum of $CuS/Fe_3O_4$ composites (1:1, 4:1, 8:1)

- **$Cu(DDTC)_2$:** TGA: 25.97% weight remaining (CuS)
- **$Fe_3O_4$:** XRD confirms **inverse Spinel Phase**;
- **CuS:** XRD shows hexagonal covellite phase.

## 5. ADSORPTION PERFORMANCE

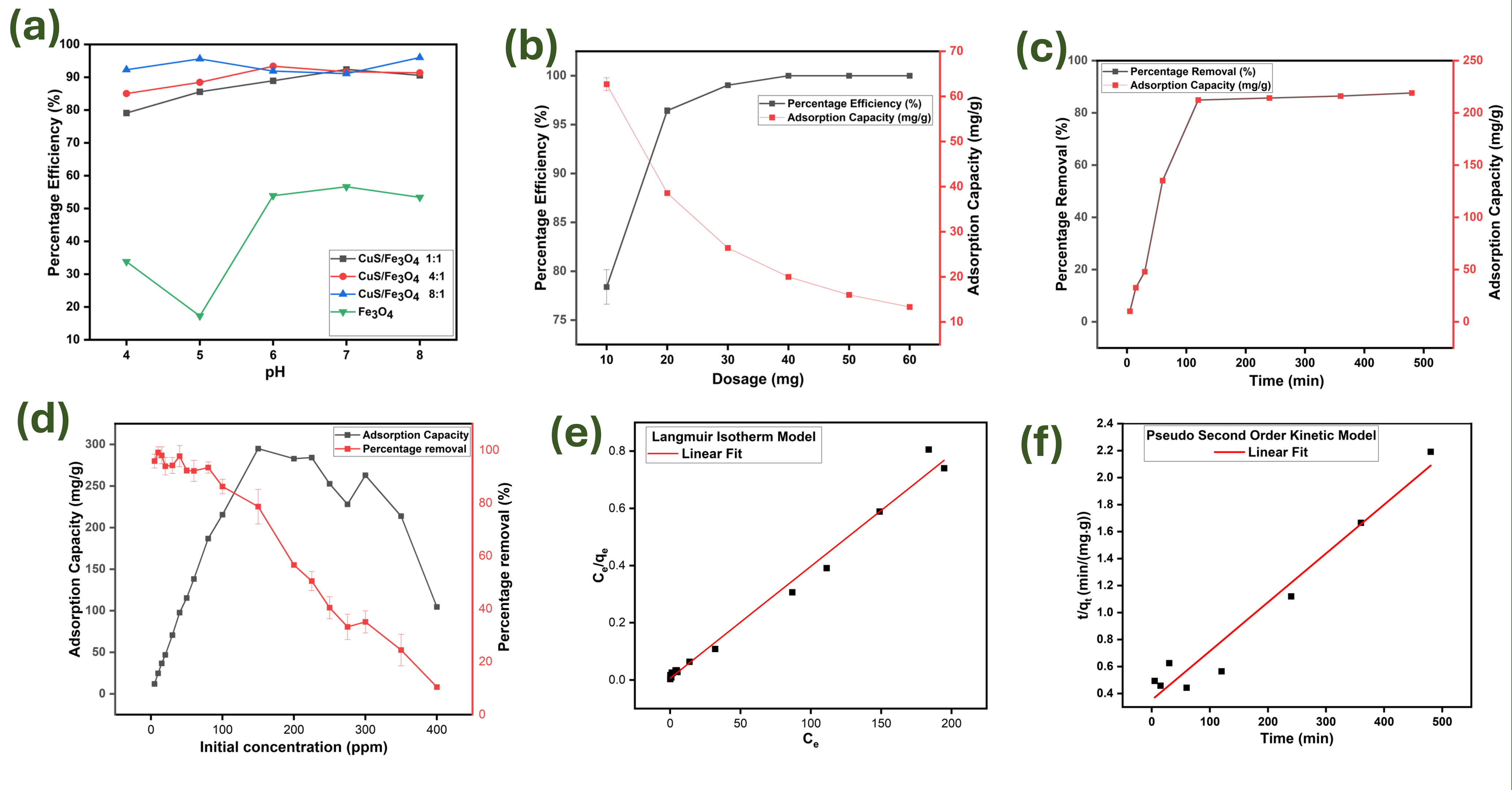



**Figure 4.** Adsorption optimization and modeling for $Hg^{2+}$ removal: (a) effect of pH on $Hg^{2+}$ adsorption; (b) effect of adsorbent dosage; (c) effect of contact time; (d) effect of initial $Hg^{2+}$ concentration; (e) Langmuir isotherm model; and (f) pseudo-second-order kinetic model.

## SELECTIVITY STUDIES

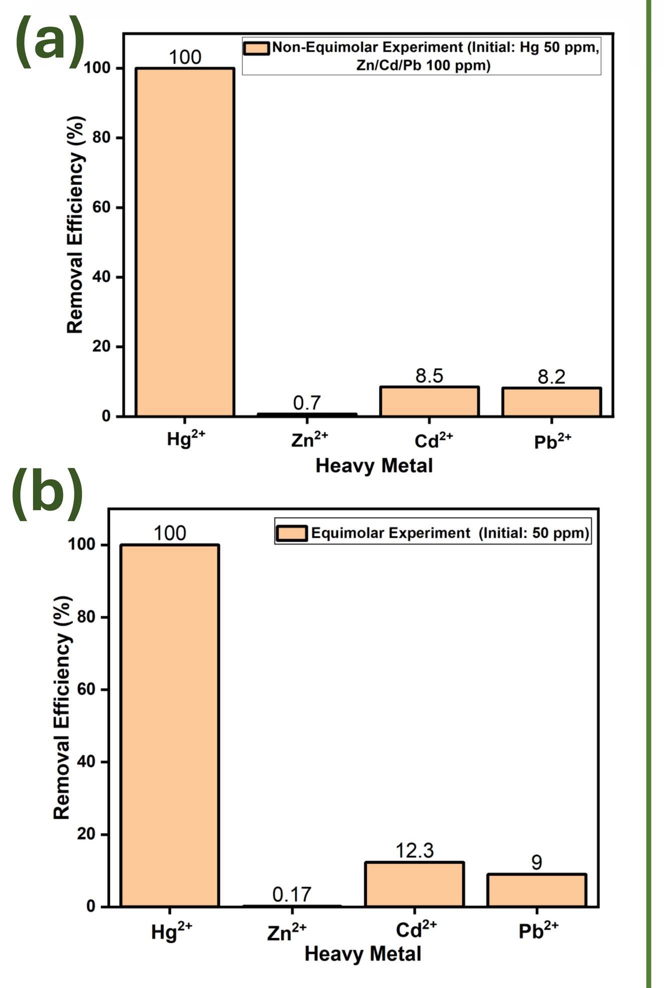



**Figure 5.** (a) $Hg^{2+}$ selectivity in an equimolar multi-ion system; (b) $Hg^{2+}$ selectivity in a non-equimolar multi-ion system using $CuS/Fe_3O_4$

## PERFORMANCE IN REAL WORLD WATER

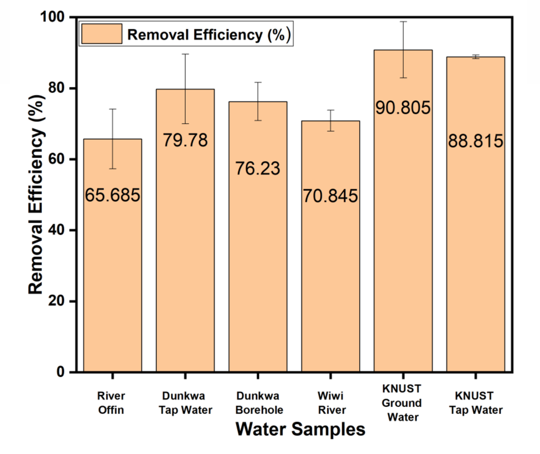



**Figure 6.** $Hg^{2+}$ removal performance of $CuS/Fe_3O_4$ nanocomposite in real world water samples.

## REGENERATION STUDIES

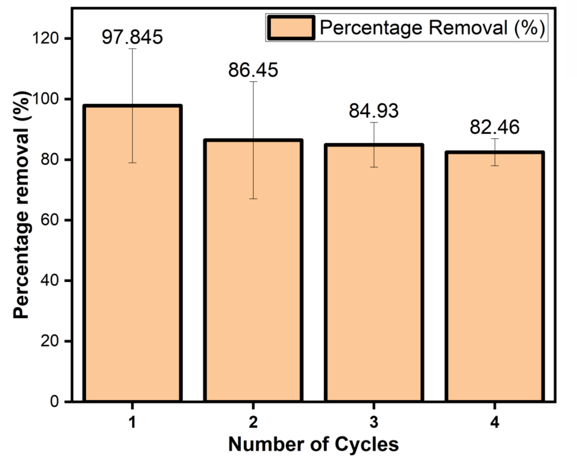



**Figure 7.** Reusability of $CuS/Fe_3O_4$ over four adsorption–desorption cycles

## CONCLUSION

- $CuS/Fe_3O_4$ nanocomposites were successfully synthesized via a green castor oil route.
- The 1:8 ratio showed the highest $Hg^{2+}$ adsorption capacity (295.03 mg/g).
- Excellent selectivity, reusability, and real-water performance confirmed its potential for mercury remediation.

## REFERENCE

1. Adimado & Baah (2002). Mercury in human blood, urine, hair, nail, and fish *Bull. Environ. Contam. Toxicol.*, *68*, 339.
2. Wadi et al. (2024). Mercury removal by porous sulfur copolymers. *Colloids Surf.* A, 606, 1253.

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