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Interweaving two dimensional mesoporous covalent organic frameworks for efficient removal of mercury from aqueous solution

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ABSTRACT

The current study defines the ultrasound-assisted solvothermal synthesis of covalent organic frameworks (COFs) using a combination of 4,4′-diaminobiphenyl and trialdehyde (BDTA-COF). The X-ray diffraction (XRD) studies confirm the formation of COF, which aligns better with AA stacking than AB stacking. The morphology of the formed COFs is a flower-like structure. The Fourier transform infrared spectroscopic (FTIR) results show that imine linkages are forming and that the aldehayde and amine peaks are not present. The formed BDTA-COF was found to be mesoporous and exhibit 2.4 nm pore size with 472 $m^2\ g^{-1}$ surface area. BDTA-COF has been evaluated for the effective removal of Hg^+ from an aqueous solution through adsorption. Maximum adsorption efficiency (99 %) was achieved by optimizing the parameters like selectivity of metal, concentration, pH, amount of adsorbent. The nitrogen atoms from the imine linkages and the oxygen atoms in BDTA-COF are the primary active sites for effective adsorption of Hg^+. The adsorption kinetics control the chemisorption of Hg^+ with the BDTA-COF's imine group since the results fit well with the pseudo-second-order model. Among the various isotherm models, the BDTA-COF/Hg^+ system followed the Langmuir model and insists on the monolayer adsorption phenomena. After adsorption, the XRD shows a slight change in peak positions, and the SEM image indicates the deposition of micrometer-sized particles onto the BDTA-COF. After adsorption, FTIR and X-ray photoelectron spectroscopic (XPS) tests show the interaction of functional groups of BDTA-COF and Hg^+. High surface area, covalency, porosity, ordered confinement, imine linkages and stability of COFs could be the reasons for good adsorption efficiency and need additional tuning for practical applications for adsorption removal of pollutants from water.

1. Introduction

The current global landscape presents a significant problem in terms of the availability of clean water, as a large portion of the existing water sources are contaminated through various means [1,2]. Industries such as batteries, fertilizers, pesticides, dyes, paper, mining, and electroplating are discharging significant quantities of heavy metals into major water bodies such as rivers, lakes, and subterranean water sources [3]. Heavy metals are highly soluble and mobile and cannot undergo degradation like organic contsminants [4,5]. Mercury is one of the heavy metal present in water and the World Health Organization (WHO) states that the maximum amount of mercury is 0.006 mg l^{-1} [6]. Heavy metals in surface and groundwater at levels higher than the maximum allowable limit are extremely dangerous to both humans and ecosystems. Higher amount of Hg^+ can cause neurological and developmental problems, particularly in fetuses, babies, and young children [7,8]. Chronic exposure can cause tremors, memory loss, and cognitive impairment. Mercury has the potential to stay in the environment, damaging aquatic ecosystems. It bioaccumulates in fish and other aquatic species, increasing concentrations in predators, including humans, that eat these organisms [9]. This can upset environmental equilibrium and reduce species diversity. In order to lessen water

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