Applied Surface Science Advances 18 (2023) 100502

Contents lists available at ScienceDirect

Applied Surface Science Advances

journal homepage: www.sciencedirect.com/journal/applied-surface-science-advances

Adsorptive removal of Pb^{2+} ions using stable imine linked covalent organic frameworks: A simulated and experimental studies

H. Shanavaz [a], S. Archana [a], M.K. Prashanth [b], K. Yogesh Kumar [a,*], V.S. Anusuya Devi [c], S.B. Benaka Prasad [a], Fahd Alharethy [d], Byong-Hun Jeon [e,*], M.S. Raghu [c,*]

[a] Department of Chemistry, Faculty of Engineering and Technology, Jain University, Bangalore 562112, India
[b] Department of Chemistry, BNM Institute of Technology, Banashankari, Bangalore 560070, India
[c] Department of Chemistry, New Horizon College of Engineering, Outer Ring Road, Bangalore 560103, India
[d] Department of Chemistry, College of Science, King Saud University, Riyadh 11451 Saudi Arabia
[e] Department of Earth Resources and Environmental Engineering, Hanyang University, 222, Wangsimni-ro, Seongdong-gu, Seoul 04763, Republic of Korea

ARTICLE INFO

Keywords:
COF
Solvothermal
Lead removal
Adsorption
Statistical analysis

ABSTRACT

Porous organic frameworks that are bound covalently are eye-catching materials in the current research. The present work describes the solvothermal synthesis of a combination of 3,3′,5,5′-tetramethyl-[1,1′-biphenyl] 4,4′-diamine and benzene-1,3,5-tricarbaldehyde through covalent bonding to generate TBBT-covalent organic framework (TBBT-COF). The structural, morphological, and computational characterizations confirm the formation of COF. TBBT-COF has been used as an adsorbent for the removal of Pb^{2+} ions from aqueous media. The effects of pH, initial metal ion concentration, competing ions, and adsorbent dosage were optimized to attain maximum adsorption of Pb^{2+}. The kinetics follow pseudo-second-order and govern the chemisorption of Pb^{2+} with the imine group of TBBT-COF. The X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS) analyses of TBBT-COF after adsorption of Pb^{2+} support the chemisorption of $Pb^{2+}$with TBBT-COF. The 2D contour and 3D surface response plots were used to assess the specific and comparative effects of the experimental variables. An analysis of variance (ANOVA) of the regression model was used to establish the relevance of the primary influencing variables on the adsorption of Pb^{2+}over TBBT-COF. It was found to remove 99 % of Pb^{2+} in 90 min. The results of the real-sample analysis show the efficient removal of Pb^{2+} even in the presence of other cations. The statistical analysis of the adsorption has been conducted, which indicates the suggested models closely match the experimental data. The high surface area, covalency, and stability of TBBT-COF show its good adsorbent properties.

1. Introduction

Water is an essential natural source that is getting polluted across the globe due to uncontrolled human activities [1,2]. The buildup of heavy metals, dyes, pesticides, insecticides, and pharmaceuticals is the main cause of water pollution [3,4]. Heavy metals are of different types based on their toxicity level. Cu, Fe, Mn, and Co are the essential metals; Zr, Li, Al, and Ba are non-essential metals; Sn and As are less toxic; and Hg, Pb and Cd are highly toxic metals [5,6]. Lead is being used in batteries, tyres, vehicles, pesticides, paints, electroplating, mining, and ceramic industries [7,8]. The high stability of Pb persists in water, accumulates in soil, and then enters the food chain and causes ecological imbalance [9]. The permissible limit of Pb in drinking water is 0.01 mg/L [10,11]. Exposure to Pb causes several health issues among humans, like low fertility, depressive disorder, renal damage, anaemia, peripheral neuropathy, and miscarriage [12–14]. Hence, to reduce these health risks, it is essential to treat the accumulated lead in water.

Many techniques have been found in the literature for the removal of lead, like reverse osmosis, membrane filtration, coagulation, ion-exchange, electrochemical deposition, photocatalysis, and adsorption [15–18]. Many of these methods have their own limitations, like incomplete removal, toxic byproducts, being tedious, not being economical, and requiring high energy [19–22]. Adsorption is a simple surface phenomenon known for its efficiency, simplicity, cost-effectiveness, and speed [23]. A variety of materials have been used as adsorbents, such as clays, aluminosilicate minerals, metal oxides,

* Corresponding authors.
E-mail addresses: yogeshkk3@gmail.com (K.Y. Kumar), bhjeon@hanyang.ac.kr (B.-H. Jeon), dr.msraghu@newhorizonindia.edu (M.S. Raghu).

https://doi.org/10.1016/j.apsadv.2023.100502
Received 1 September 2023; Received in revised form 29 October 2023; Accepted 13 November 2023
Available online 18 November 2023