Modifying Activated Carbon with 2-Amino-*p*-cresol as a Low-Cost Adsorbent for Removing Hg(II) and Pb(II) Ions from Aqueous Solution

Zuhair Ali Abdulnabi[1*], Muhand Kadhum AL-Tememi[1], Ahmed Yousif Hammood[1], Rana Tariq Shabili[1], Lina Alaa Mousa[1], and Meaad Khalaf Hussain[2]

[1]*Department of Marine Chemistry, Marine Science Center, University of Basrah, Basrah 61004, Iraq*

[2]*College of Medicine, University of Basrah, Basrah 61004, Iraq*

* ***Corresponding author:***

email: zuhir38@yahoo.com

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Abstract: *A novel approach was developed to modify activated carbon with 2-amino-p-cresol, aiming to synthesize a cost-effective adsorbent for removing mercury and lead ions from polluted water. The synthesized adsorbent was characterized using powder XRD, SEM-EDS, and FTIR. To evaluate the modified surface's removal efficiency, elemental concentrations in aqueous solutions were determined using FAAS and CVAS. Batch adsorption experiments were conducted to investigate the simultaneous removal of Hg^{2+} and Pb^{2+} ions, with particular focus on key operational parameters, including contact time, temperature, mixing speed, and solution pH. The results demonstrated exceptional removal efficiencies, achieving 99.68 and 90.27% for Hg^{2+} and Pb^{2+} ions, respectively, with adsorption capacities of 4539.08 and 2248 µg/g, respectively. Adsorption data were analyzed using three isotherm models: Langmuir, Freundlich, and Temkin. The Freundlich model provided the best fit for mercury adsorption, whereas the Langmuir model accurately described lead ion adsorption behavior. Thermodynamic functions (ΔG°, ΔH°, and ΔS°) were calculated to elucidate the nature of the adsorption processes. Additionally, metal ion desorption and recovery were assessed using HCl at varying concentrations. Optimal recovery was achieved for 60 min using 0.5 and 2.0 M for Pb^{2+} and Hg^{2+}, respectively.*

Keywords: *batch adsorption process; activated carbon modification; cold atomization method; thermodynamic function*

■ INTRODUCTION

Activated carbon is a carbonaceous material that consist of graphite-like multilayers containing functional groups, which exhibit exceptional efficiency in removing a wide range of pollutants. This is primarily due to its high adsorption capacity, extensive porosity, and large surface area of 300–2500 m^2/g. Activated carbon can be divided into two main types: granular activated carbon and powdered activated carbon [1-2]. Granular activated carbon has an irregular shape, with particle sizes ranging from 0.5 to 2.5 mm, while powdered activated carbon consists of finer particles, typically less than 0.15 mm in diameter [3-4]. Activated carbons can be derived from various natural and industrial waste materials that are rich in carbon content, such as bituminous coal, charcoal, lignite, coconut shells, palm, wood, plastic, textiles, and paper waste [5-7]. The surface of activated carbon contains a variety of functional groups, which are influenced by the preparation method and the structure of the raw materials used. These functional groups include carboxyl, carbonyl, hydroxyl, lactone, anhydride, ether, and quinone groups [8-9]. The production of activated carbon often involves oxidation agents, which increase the concentration of carboxyl groups on the surface. These groups play a crucial role in enhancing the adsorption capacity for various pollutants in aqueous solutions. Specifically, the presence of carboxyl groups facilitates strong bonding with toxic organic contaminants, such as dyes, phenols, and hydrocarbons [10-12], as well as inorganic