



Study of Hg(II) species removal from aqueous solution using hybrid ZnCl₂-MCM-41 adsorbent

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ABSTRACT

A novel ZnCl₂-MCM-41 adsorbent was prepared by method of solvent dispersion in toluene and characterized using XRD, N₂ adsorption–desorption, FTIR and TGA techniques. The synthesized ZnCl₂-MCM-41 sorbent possessed high specific surface area (602.3 m² g⁻¹), narrow pore size distribution (2.37 nm) and total pore volume (0.46 cm³ g⁻¹). The hybrid sorbent was applied for the removal of Hg(II) from aqueous solution under different experimental conditions by varying contact time, initial concentration of Hg(II), pH, presence of interfering ions and solution temperature. It was found that amount of Hg(II) sorption increased with enhancement of Hg(II) initial concentration, contact time and pH but decreased as the temperature increased. Optimum conditions obtained were 20 °C, pH 10 and contact time of 30 min. Effects of foreign anions and cations on Hg(II) removal were studied and it was found that chloride ion affected strongly on adsorption. For experimental data the Langmuir isotherm showed a better fit and maximum adsorption capacity was obtained 204.1 mg g⁻¹ for an initial concentration range 2–50 mg L⁻¹. From the *D*–*R* isotherm, the mean free energy was calculated as 9.128 kJ mol⁻¹ indicating that the sorption of Hg(II) was taken place by chemical reaction.

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1. Introduction

In recent years, heavy metal ion pollution has attracted a great deal of attention, especially mercury as a serious environmental threat. Mercury is known as the one of the most toxic metals in the environment because of its bio accumulative property and consequent toxic effects on human health [1]. Battery, paper and pulp, chlor-alkali production, oil refinery and paint manufacturing industries are main contamination sources of wastewaters by mercury ions. The maximum acceptable concentration of mercury in drinking water has been recommended 1 g L⁻¹ by the World Health Organization (WHO) [2]. The European Union introduces mercury as a major and hazardous pollutant and specifies a maximum allowable concentration of total mercury as low as 5 μg L⁻¹ for wastewater drains [3]. High exposure to Hg(II) causes to nerve disease, kidney and brain problems [4]. To achieve the permitted limits, a variety of treatment processes have been applied for mercury removal from aqueous solutions, including precipitation [5], coagulation [6], membrane separation [7], ion exchange [8], and adsorption [9–13]. Many efforts have been performed to reduce contaminants from aqueous solutions by adsorption processes because they are simple to operate and cost effective and have also efficient removal capacity. There has been a growing

need for adsorption technology that to have low overall cost, high stability, and to be more effective than the current technology. Nanotechnology suggests promising potential for removing mercury from contaminated water and wastewater rapidly, efficiently, and at lower costs. Several nano-based technologies are currently under study for the control of contaminants content (including mercury) of wastewater. The two main sections of this technology consist of nanoparticles and nanoporous adsorbents. The M41S family of silicate mesoporous molecular sieves with exceptionally large uniform pore structures was synthesized by researchers at Mobil Corporation in 1992. During this synthesis process, the negatively charged silica species interact with surfactant cations under hydrothermal conditions forming a self-assembled mesostructured composite, which after surfactant removal by calcinations an ordered mesoporous material is obtained (Fig. 1). This discovery has led to a scientific revolution in this field. The hexagonal mesophase, named as MCM-41, contains highly regular arrays of uniform-sized channels whose diameters are in the range of 15–100 Å. Type of template, the addition of auxiliary organic compounds, and the reaction parameters affect on the characteristics of this porous materials [14]. The pores of this produced new porous material are nearly as regular as zeolites, however, they considerably larger than zeolites. These properties of M41S family materials, are proposing new opportunities for applications in catalysis [15], chemical separation [16], adsorption process [17] and advanced composite materials [18].

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