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Preparation of high surface area-activated carbon from lignin of papermaking black liquor by KOH activation for Ni(II) adsorption

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HIGHLIGHTS

- KOH activation is used to prepare lignin activated carbon.
- The lignin-activated carbon exhibits high specific surface area.
- The pre-carbonization is adopted to prepare activated carbon.
- Sorption kinetics, isotherm and pH influencing factor are investigated.
- Nonlinear curve-fitting is introduced for analysis.

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ABSTRACT

Low-cost activated carbon with high surface area was prepared from lignin of papermaking black liquor (BL) by KOH activation with pre-carbonization method. The effects of lignin/KOH ratio, activation temperature and activation time on the BET surface area were investigated. In addition, the adsorption capacity of Ni(II) on BLAC was also studied. Through BET surface area, scanning electron microscopy, Fourier transformed infrared spectroscopy and thermo gravimetric analysis, the BL-activated carbon (BLAC) was discovered to have porous structure with a high surface area up to 2943 m^2/g. The results showed that the lignin/KOH ratio was the main factor influencing the surface area and the maximum surface area activated carbon was obtained at lignin/KOH ratio of 3:1, the activation temperature of 750 °C and the activation time of 1 h. The sorption experiments indicated that the pseudo-second-order model was well fitted the kinetic data and the adsorption equilibrium data were better simulated by Langmuir model. The adsorption ability of Ni(II) increased with increasing pH, indicating the electrostatic attraction mechanism.

1. Introduction

Wastewater from some industries such as plating plants, welding, alloys manufacturing, tannery and silver refineries contains significant quantities of toxic heavy metals, despite strict environment regulations [1,2]. Ni(II) is one of toxic metals presented in wastewater, which poses serious threat on the health of human beings and local ecosystem. A wide range of treatment methods have been proposed to remove Ni(II) from aquatic environments, mainly membrane filtration, chemical precipitation, electrochemical reduction, ion exchange, adsorption [2] and phytoextraction [3]. Among these water treatment methods, adsorption is preferred for the removal of heavy metal from wastewater because it is lower cost and high efficient.

Activated carbons as an efficient adsorbents are widely applied to remove Ni(II) from wastewater due to its high surface area, extensive adsorption capacity and various surface functional groups. However, its widespread use is extremely restricted by its high production costs, hence the production of activated carbon from cheaper precursor has significant values. In recent years, many researchers have developed activated carbons from many cheaper and renewable precursors, such as several agricultural by-products including rice husk [4], date stones [5], peanut hull [6], coconut buttons [7], lotus stalks [8], hazelnut shell [9], chestnut shell [10], grapeseed [10] and orange skin [11].

Lignin is the main by-product in the pulp and paper industries. Black water pouring into the rivers from paper industries contains a large number of lignin, causing water pollution and the increase of COD in aquatic environments. Recently many researchers have reported about using kraft lignin to produce activated carbon through $ZnCl_2$ [12], water vapour [13] or H_3PO_4 [12] and the research on activated carbon preparation from lignin with KOH

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