Chemical Engineering Journal 200–202 (2012) 275–282

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Kinetic and equilibrium studies on the adsorption of calcium lignosulfonate from aqueous solution by coal fly ash

Hui-qin Li [a], Guo-he Huang [a,*], Chun-jiang An [b], Wen-xiang Zhang [a]

[a] MOE Key Laboratory of Regional Energy and Environmental Systems Optimization, Resources and Environmental Research Academy, North China Electric Power University, Beijing 102206, China
[b] Institute for Energy, Environment and Sustainable Communities, University of Regina, Regina, Saskatchewan, Canada S4S 0A2

HIGHLIGHTS

- Lignosulfonate (LS) is the important pollutant in pulp and paper mill wastewater.
- The kinetic and equilibrium studies on LS adsorption by fly ash were conducted.
- LS could be adsorbed onto fly ash with good removal efficiency.
- The adsorption process could be influenced by the solution chemistry.
- Fly ash as low-cost adsorbents showed the potential for the removal of LS.

ARTICLE INFO

Article history:
Received 17 April 2012
Received in revised form 12 June 2012
Accepted 12 June 2012
Available online 21 June 2012

Keywords:
Adsorption
Calcium lignosulfonate
Fly ash
Isotherms
Kinetics
Thermodynamics

ABSTRACT

Experiments were performed to determine the adsorption of calcium lignosulfonate (CLS) onto Shand and Boundary Dam (BD) coal fly ashes. The results showed that both Shand and BD fly ashes exhibited potential for CLS adsorption. The removal efficiency increased with increasing adsorbent dosage and the maximum was obtained in the dosage of 20 g/L. Adsorption processes were time-dependent and the maximum adsorption capacity was achieved in the contact time of 120 min. Also, the processes were temperature-dependent and the maximum adsorption capacity was obtained at 20 °C. Additionally, adsorption of CLS could well fit the Pseudo-second-order kinetic model and the isotherm experimental data were correlated well with the Freundlich and Langmuir equations. Thermodynamic studies suggested that the adsorption of CLS onto both kinds of fly ashes was exothermic, the thermodynamic parameters were as follows: ΔG (4.56, 5.06 kJ/mol), ΔH (−15.58, 12.12 kJ/mol), ΔS (−0.0688, −0.0588 kJ/(mol K)) for Shand and BD fly ashes, respectively. Adsorption efficiency decreased with increasing pH over the range pH 2–8 and there was a slight increase as pH further increased. The maximum was obtained in pH 2–3. Also, the adsorption behaviors of CLS onto fly ash could be influenced by the ionic strength and the maximum was obtained in NaCl concentration of 0.1 mol/L. The results will have significant implications for the treatment of complex pulp and paper effluent by adsorption on low-cost adsorbents.

1. Introduction

A large quantity of wastewater has been generated from various processes of the pulp and paper industry all over the world [1]. The pulp and paper mill wastewater (PPMW) exhibits the high level of chemical oxygen demand (COD), suspended solids (SS), toxicity, and color, which may lead to the pollution of surface water [2]. The composition of the PPMW may vary considerably, depending on the type of process, type of the wood materials, process technology applied, management practices, etc. [3]. As a regenerative raw feedstock, lignocellulosic material (LCM), including cellulose pulp, agricultural residues, waste paper, and non-wooden materials, has been widely used in paper production. Correspondingly, the produced wastewater often include large amount of lignosulfonate (LS) in manufacturing process of cellulose by the sulfite pulping method [4]. LS, as the sulfonated derivative of lignin, is a tridimensional phenolic polymer which can be formed through a dehydrogenative polymerization of three phenylpropanoid precursors linked together by different bonds. The sulfonation of side chains makes LS to exhibit a higher resistance to biodegradation even than lignin [5]. The release of excess LS presents a significant risk for environment. Thus there is an urgent need for effective and safe treatment of such pollutant.

* Corresponding author at: MOE Key Laboratory of Regional Energy and Environmental Systems Optimization, Resources and Environmental Research Academy, North China Electric Power University, Beijing 102206, China. Tel.: +86 61772018; fax: +86 10 51971284.
E-mail address: huang@iseis.org (G.-h. Huang).

1385-8947/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cej.2012.06.051