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Removal of copper by surface-modified celluloses: kinetics, equilibrium, and thermodynamics

Chung-Hsin Wu[a,*], Chao-Yin Kuo[b], Pui-Kwan Andy Hong[c], Meng-Jia Chen[d]

[a]*Department of Chemical and Materials Engineering, National Kaohsiung University of Applied Sciences, 415 Chien Kung Road, Kaohsiung, Taiwan, Tel. +886 7 3814526, ext. 5158; Fax: +886 7 3830674; email: wuch@kuas.edu.tw*
[b]*Department of Environmental and Safety Engineering, National Yunlin University of Science and Technology, Yunlin, Taiwan, Tel. +886 5 5347311; email: kuocyr@ms35.hinet.net*
[c]*Department of Civil and Environmental Engineering, University of Utah, Salt Lake City, UT, USA, Tel. +1 801 5817232; email: hong@civil.utah.edu*
[d]*Department of Environmental Engineering, Da-Yeh University, Da-Tsuen, Chang-Hua, Taiwan, Tel. +886 983161092; email: f9405251@hormail.com*

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ABSTRACT

Cellulose surfaces were modified by phosphoric and citric acids, and the modified celluloses were used as adsorbents to remove Cu^{2+} ion from the aqueous solution. The modified celluloses were characterized by scanning electron microscopy, Fourier transform infrared spectroscopy (FTIR), and specific surface area/zeta potential analyzers. The citric acid-modified cellulose (CAMC) removed copper more efficiently than the phosphoric acid-modified cellulose (PAMC). Optimal preparation of CAMC was by heating the cellulose in 400 mL of 1.2 M citric acid at 150˚C for 3 h. FTIR measurements confirmed that the formation of carboxylic groups on CAMC surface, which increased binding with Cu^{2+} ions. The BET surface areas were 0.30, 0.44, and 2.4 m^2/g for the original cellulose, CAMC, and PAMC, respectively, with pore sizes of 64, 32, and 7.7 nm, respectively. Experimental results showed apparent second-order adsorption kinetics and Freundlich type of adsorption isotherms. The adsorption capacity of CAMC for Cu^{2+} ions was 15.1 mg/g; it increased with increasing pH, temperature, and adsorbent dose but decreased with increasing Cu^{2+} ions. Copper removal was via physisorption, and the process parameters ΔH° and ΔS° were determined at 11.9 and 116 J mol K, respectively, for CAMC.

Keywords: Adsorption; Cellulose; Citric acid; Copper; Isotherm; Kinetics

*Corresponding author.