Doehlert design as optimization approach for the removal of Pb(II) from aqueous solution by Catalpa Speciosa tree leaves: adsorption characterization

Javad Zolgharnein*a, Tahere Shariatmanesha, Neda Asanjarani*a, Abdolali Zolanvari*b

*aFaculty of Science, Department of Chemistry, Arak University, Arak 38156-8-8394, Iran
Tel. +98 86 3417701-2042; Fax: +98 86 34173406; email: j-zolgharnein@araku.ac.ir

bFaculty of Science, Department of Physics, Arak University, Arak 38156-8-8394, Iran

Received 17 April 2013; Accepted 3 October 2013

ABSTRACT

Catalpa speciosa tree leaves were used to remove Pb(II) from aqueous solutions. Removal process was optimized by applying experimental design strategy. Optimization was based on the application of a two-level full-factorial design for screening the significant variables followed by a Doehlert design to find out an appropriate model which leads to determine the optimum conditions. The empirical models were developed in terms of effective factors: pH, initial concentration of metal ion Cm and sorbent mass(s) have been found statistically adequate to describe the process responses, that is, removal percent and the capacity uptake of Pb(II). The multiresponse optimization of Pb(II) removal process has been carried out using desirability function approach. To this end, Derringer’s desirability function (D) has been applied for mathematical optimization of the simultaneous multiresponse problem. Thus, the optimum conditions of Pb(II) removal process have been found as: pH = 4.43, s = 0.07 g, and Cm = 104 mg L⁻¹. Responses were confirmed by experiments 86 and 14.7 mg g⁻¹ for R% and q, respectively. The morphology and structure of biosorbent during adsorption process was characterized by FT-IR spectroscopy, X-ray diffraction and scanning electron microscopy techniques. Experimental data were also fitted to various isotherm models. Potentiometric titration, pHPZC, and the competitive effect of alkaline and alkaline earth metal ions during the loading of Pb(II) indicate that ion exchange is the predominant mechanism for the adsorption of Pb(II) by C. speciosa tree leaves.

Keywords: Catalpa speciosa; Desirability function; Doehlert design; Pb(II); Potentiometric titration