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Simultaneous removing of Pb²⁺ ions and alizarin red S dye after their complexation by ultrasonic waves coupled adsorption process: spectrophotometry detection and optimization study

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Abstract

Funthenalized chitosan (CS) was composited with mesoporous SBA-15 and characterized via different techniques such as FT-IR and FE-SEM. Subsequently, this new material was applied for simulations ultrasound-assisted adsorption of Pb²⁺ ion and alizarin red S (ARS) dye after their complexation. Efficient conventional variables in adsorption process such as initial ARS and Pb²⁺ concentration, adsorbent mass and sonication time were studied by small central composite design (CCD) and optimized with desirability function approach. Lack of fit testes and model summary statistics for linear, 2FI, quadratic and cubic models were investigated and according to the insignificant lack of fit and maximizing the R-squared (R²), adjusted R-squared and the predicted R-squared quadratic model was selected for other step analysis for removal of ARS dye, while, for Pb²⁺ ions 2FI model was selected as best model. Quadratic model ANOVA for ARS dye removal shows the F-value parameter (683.91), very low p-value model (<0.0001) and p-value lack of fit (0.0568) that implied this model was highly significant. Also, 2FI model ANOVA for Pb²⁺ ions removal shows the F-value parameter (282.51), very low p-value model (<0.0001) and p-value lack of fit (2.05). According to desirability function approach maximum removal percentage of ARS (87.61%) and Pb²⁺ ions (83.54%) was shown at optimum of condition that were set as at: 25 and 25 mg L⁻¹, 0.028 g and 11.8 min for initial ARS and Pb²⁺ ions concentration, adsorbent mass and sonication time, respectively. Finally, it was found that the equilibrium and kinetic of adsorption process follow the Langmuir isotherm and pseudo-second-order kinetic model, respectively. From the Langmuir isotherm, maximum monolayer capacity (q_{max}) was obtained 50.25 and 57.14 mg g⁻¹ for ARS and Pb²⁺ ions removal, respectively.

Keywords: Alizarin red S; chitosan, mesoporous SBA-15; Pb²⁺ ions; ultrasound-assisted adsorption

1. Introduction

Pb²⁺ ions as a toxic heavy metals which have been applied in many industries such as lead glasses, photovoltaic cells, paints, pigment, chemical industries and lead-acid batteries that enter easily to the environment and considered as a longstanding environmental contaminant [1-4]. Also, alizarin red S (ARS) as anthraquinonoid dye was used in various fields including dyeing textile, finishing process of woven, wool and cotton textiles [5-8]. Hence, single and simultaneous presence of ARS dye and Pb²⁺ ions in the wastewater and food materials leads to

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