

Valorization of fruit wastes (pistachio shells) as adsorbent for the removal of Zn from aqueous solutions under adverse acidic conditions

C.A. Aggelopoulos^{a,*}, E. Moschopoulou^a, P.G. Klepetsanis^{a,b}, C.D. Tsakiroglou^{a,*}

^aFoundation for Research and Technology Hellas-Institute of Chemical Engineering Sciences (FORTH/ICE-HT), 26504 Patras, Greece, Tel. +302610965205; Fax: +302610965223; emails: caggelop@iceht.forth.gr (C.A. Aggelopoulos), ctsakir@iceht.forth.gr (C.D. Tsakiroglou), elenmosch@yahoo.gr (E. Moschopoulou) ^bUniversity of Patras, Department of Pharmacy, 26504 Patras, Greece, email: klepe@upatras.gr

Received 24 November 2016; Accepted 20 March 2017

ABSTRACT

Low-cost adsorbents (LCAs) were prepared from pistachio shells after minor treatment over the temperature range 300°C-500°C, under nitrogen, carbon dioxide, and air atmosphere. The LCAs were evaluated with respect to their capacity to remove zinc (Zn) from aqueous solutions under adverse acidic conditions (pH < 4), where the dissolution of oxides/hydroxides is favored and low sorption capacity of the raw material is expected. Potential changes of the sorption capacity were interpreted in terms of: (i) the surface functional groups identified with attenuated total reflection Fourier transform infrared spectra; (ii) the pore space morphology quantified by N, sorption data, Hg intrusion porosimetry, and scanning electron microscopy images; (iii) the phase crystallinity analyzed with X-ray diffraction; and (iv) the thermal stability recorded with thermogravimetric analysis. For all aqueous solutions, including those having the highest initial Zn concentration (100 mg/L), the maximum Zn removal efficiency was observed for the air-activated adsorbents at 500°C and 400°C. In contrast, for the N₂- and CO₂-activated adsorbents, the Zn removal efficiency was comparable with that of the raw pistachio shells. For air-activated adsorbents, the Zn removal efficiency was enhanced with the activation temperature and holding time increasing, while no effect of the heating rate on adsorbent sorption capacity was evident. The characteristics of the investigated adsorbents were found fully compatible with the observed Zn sorption capacity and potential sorption mechanisms. Specifically, the enhancement of the sorption capacity of air-treated adsorbents might be due to: (i) the higher pore surface area and volume associated with physical sorption; (ii) the presence of mineral phases (calcite) triggering the metal precipitation; and (iii) the presence of oxygen-rich functional groups associated with complexation and/or electrostatic attraction. The equilibrium sorption data sets of raw pistachio shells were fitted satisfactorily to both Langmuir and Freundlich isotherms, whereas the corresponding data sets of air-activated adsorbents were better fitted to Langmuir isotherm.

Keywords: Zinc; Adsoption; Heavy metals; Biomass; Pyrolysis; Activation

* Corresponding author.

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