Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2017.20875

78 (2017) 231–240
June

Study of the iron(III)-modified clinoptilolite in the adsorption of phosphate from aqueous medium: mechanism and kinetics

Iva Kaplanec[a], Aleksander Rečnik[b], Gregor Mali[c], Nevenka Rajić[a,*]

[a]*Faculty of Technology and Metallurgy, Karnegijeva 4, 11000 Belgrade, Serbia, Tel. +381 11 3370 503; Fax: +381 11 3370 387; emails: nena@tmf.bg.ac.rs (N. Rajić); ikaplanec@tmf.bg.ac.rs (I. Kaplanec)*
[b]*Jožef Stefan Institute, SI-1001 Ljubljana, Slovenia, Tel. +386 1 477 39 00; Fax: +386 1 251 93 85; email: aleksander.recnik@ijs.si*
[c]*Department of Inorganic Chemistry and Technology, National Institute of Chemistry, Hajdrihova 19, SI-1001 Ljubljana, Slovenia, Tel. +386 1 467 02 00; Fax: +386 1 476 03 00; email: gregor.mali@ki.si*

Received 1 February 2017; Accepted 24 April 2017

ABSTRACT

Clinoptilolite-rich tuff (Z) enriched with Fe(III) was studied in the removal of phosphate ions present in aqueous medium at pH = 6.5. Fe(III) modification was performed by a simple wet impregnation giving the product (FeZ) with about 18 wt% Fe. Transmission electron microscopy showed the presence of a flaky Fe(III) amorphous precipitate on the clinoptilolite sheets and a preserved clinoptilolite crystallinity. The modification increased the specific surface area from 28.6 to 140.3 $m^2 g^{-1}$. FeZ effectively adsorbed phosphate, the removal rate at 298 K varying from 86% to 42.5% (for C_0 = 50 mg dm^{-3} and C_0 = 400 mg dm^{-3}). The sorption isotherms were in accord with the Langmuir model, giving for the Langmuir constant (R_L) values in the range 0–1 that are characteristic of a favourable adsorption. The data for adsorption kinetics were best described by the pseudo-second-order model suggesting chemisorption as the phosphate sorption mechanism. Intra-particle diffusion was present in the adsorption, but it was not the rate-limiting step. A ^{31}P static spin-echo mapping nuclear magnetic resonance (NMR) measurement was performed for studying the phosphate–FeZ interaction. The results showed that the phosphate adsorption on FeZ proceeds through electrostatic interactions and covalent bonding, the latter being more pronounced.

Keywords: Clinoptilolite; Phosphate adsorption; Adsorption mechanism; ^{31}P NMR; Kinetics; TEM

* Corresponding author.