Ion Exchange of Zeolite Na-P_c with Pb^{2+}, Zn^{2+}, and Ni^{2+} Ions

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Abstract: This paper examines the ion-exchange properties of synthetic zeolite Na-P_c, which was produced from perlite-waste fines and has a SiO_2:Al_2O_3 ratio of 4.45:1 and a cation-exchange capacity (CEC) of 3.95 meq g^{-1}. Although equilibrium is attained rapidly for all three metals, exchange is incomplete, with A_c(max) (maximum equilibrium fraction of the metal in the zeolite) being 0.95 for Pb, 0.76 for Zn, and 0.27 for Ni. In both Na → ½Pb and Na → ½Zn exchange, the normalized selectivity coefficient is virtually constant for ${}^{N}A_c$ (normalized equilibrium fraction of the metal in the zeolite) values of $\leqslant$0.6, suggesting a pronounced homogeneity of the available exchange sites. The Gibbs standard free energy, ΔG°, of the Na → ½Pb exchange calculated from the normalized selectivity coefficient is −3.11 kJ eq^{-1} and, for the Na → ½Zn exchange, it is 2.75 kJ eq^{-1}.

Examination of the solid exchange products with X-ray diffraction (XRD) revealed a possible decrease in crystallinity of zeolite Pb-P_c as suggested by the significant broadening and disappearance of diffraction lines. This decrease is associated with a reduction of pore opening, as indicated from Fourier-transform infrared analysis (FTIR), which in turn results in a decrease of the amount of zeolitic water. Thermogravimetric-differential thermogravimetric (TG-DTG) analysis showed that water loss occurs in three steps, the relative significance of which depends on the type of exchangeable cation and subsequently on the type of complex formed with the cation and/or the zeolite channels. Zeolite Na-P_c might be utilized in environmental applications, such as the treatment of acid-mine drainage and electroplating effluents.

Key Words: Heavy Metals • Ion Exchange • Perlite • Selectivity • Selectivity Coefficient • Zeolite P_c • Zeolitization

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