



## Ion-exchange equilibrium of cesium/hydrogen ions on zirconium molybdate and zirconium iodomolybdate cation exchangers

B. El-Gammal\*, G.M. Ibrahim<sup>1</sup>, S.H. El-Kholy, S.A. Shady

Hot Laboratories Center, Atomic Energy Authority, P. No. 13759, Cairo, Egypt, email: [belalelgammaal@hotmail.com](mailto:belalelgammaal@hotmail.com) (B. El-Gammal)

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### ABSTRACT

The ion-exchange behavior of  $^{134}\text{Cs}^+$  onto zirconium molybdate (ZM) and zirconium iodomolybdate (ZIM) under batch conditions was achieved in different media. Acetic acid and EDTA were used as organic ligands; whereas sodium chloride and sodium nitrate were used as inorganic media containing  $\text{Na}^+$  as competing ion for  $^{134}\text{Cs}^+$  adsorption on ZM and ZIM. Based on Davis and Debye–Huckel Equations, the activities and the activity coefficients of the corresponding concentrations were calculated. Different isothermal models were used to express the effect of activity on the amount of  $^{134}\text{Cs}^+$  sorbed onto ZM and ZIM. The best-fitted adsorption isotherm models were in the order of BET > Freundlich > Temkin > Sips > Langmuir in case of  $^{134}\text{Cs}^+/\text{ZM}$ , while the order was Temkin > Freundlich > BET > Langmuir > Sips in case of  $^{134}\text{Cs}^+/\text{ZIM}$ . Traditional surface complexation models (SCMs) could not account for the sorption of  $^{134}\text{Cs}^+$  onto ZM and ZIM in presence of different ligands or competing ions; the 2-*pK* basic Stern model and the triple-layer model (TLM) was not satisfactory, due to the high number of adjustable parameters involved in these model variations. Furthermore, a purely diffuse layer model (DLM) generally gave the poorest fit to experimental data when combined with the 1-*pK* approach and was only slightly better when combined with the 2-*pK* formalism. Therefore, a new model, surface site competition complexation model (SSCCM) was developed by G. M. Ibrahim and B. El-Gammal, based on 2-*pK* DLM to test several sets of data, including those containing ligand complexes and competing cations. The theoretical basis, postulates, the model equations, and the calculations were discussed in detail. The new SSCCM succeeded in explanation of the marked sets of sorption data in distinctive ionic strengths giving rise to the different activities, species, and their distributions in existence of both the organic complexing ligands as acetic acid and EDTA and sodium as monovalent competing ion. The SSCCM explained the results of the solubility's of the inorganic species by calculation of their logarithmic ionic activity products and the corresponding saturation indices. In addition, the surface charges and surface potentials were computed. Since the calculations in the SSCCM are based on the activities, the model could predict the real formation constants, and in turn, it could be precisely used to calculate the different thermodynamic parameters. Negative free energy changes indicate the spontaneous nature of the sorption process, while the positive values for both enthalpy change and entropy change indicates that the sorption process is entropy directed.

*Keywords:*  $^{134}\text{Cs}^+$ ; Zirconium molybdate; Zirconium iodomolybdate; Distribution Coefficient; Isothermal models; Surface site competition complexation model; Thermodynamics

\*Corresponding author.

<sup>1</sup>Present address: King Khaled University, Bisha Branch, Saudi Arabia.