Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2018.23038

126 (2018) 196–207
September

Sorption of heavy metal ions onto e-waste-derived ion-exchange material – selecting the optimum isotherm

Akanksha Kalra[a], Pejman Hadi[a], Hamish R. Mackey[b], Tareq Al Ansari[b], Gordon McKay[a,b,*]

[a]*Chemical and Biomolecular Engineering Department, Hong Kong University of Science and Technology, Clear Water Bay Road, Hong Kong SAR, China, Tel. +974 44541408; emails: gmckay@hbku.edu.qa (G. McKay), akanksha.kalra@manuchar.com (A. Kalra), pejman.hadimyavagh@stonybrook.edu (P. Hadi)*
[b]*Division of Sustainable Development, College of Science and Engineering, Hamad Bin Khalifa University, Education City, Qatar Foundation, Doha, Qatar, emails: hmackey@hbku.edu.qa (H.R. Mackey), talansari@hbku.edu.qa (T. Al Ansari)*

Received 10 March 2018; Accepted 25 August 2018

ABSTRACT

This study evaluates the adsorption of metal ions, such as copper, lead and zinc, onto a silicate-based ion-exchange resin produced by activating the non-metallic fraction of printed circuit board e-waste, designated activated non-metallic-fraction printed circuit board (A-NMF-PCB), to determine the equilibrium saturation-exchange sorption capacities. The A-NMF-PCB experimental results obtained showed significant sorption-exchange capacities for copper, lead and zinc at 2.9, 3.3 and 2.1 mmol/g, respectively. These uptake values are higher than most commercial resins. The equilibrium data were analyzed using seven conventional isotherm equations, namely Langmuir, Freundlich, Langmuir–Freundlich (L–F) or Sips, Redlich–Peterson (R–P), Toth and Dubinin–Radushkevich. Five error analysis methods – sum of errors squared, hybrid error function, Marquardt's percent standard deviation, the average relative error and sum of the absolute error – were applied to each isotherm model, which were then used to obtain the best-fit model. The results demonstrated the outstanding sorption capacities of copper, lead and zinc on A-NMF-PCB. These isotherm models were then optimized by changing parameter values to get the least error value. The L–F model gave the best result for copper removal, R–P model for lead and the Toth model for zinc. The HYBRID (HYB) error function proved to be the optimum function and consequently all the isotherm models were rationalized and compared on the basis of using the HYB method. It is critical to obtain the most accurate isotherm and isotherm parameters to design sorption treatment plants.

Keywords: Error analysis; Heavy metal ions; Ion exchange; Lead; Copper; Zinc; PCB-derived waste sorbent

* Corresponding author.