

## Kinetics and thermodynamics of removal of metal ions using EDTA-modified cation ion exchange resin

Smita N. Katariya, Sanjeev Kumar, Ran Bahadur Yadav\*

*Applied Chemistry Department, Faculty of Technology and Engineering, The Maharaja Sayajirao University of Baroda, Vadodara - 390001, Gujarat, India, Tel. +91 9408091499; email: rbyadavmsu@gmail.com (R.B. Yadav), Tel. +91 8866225394; email: simsk1896@gmail.com (S.N. Katariya), Tel. +91 9427453243; email: drksanjeev@gmail.com (S. Kumar)*

Received 2 January 2021; Accepted 24 June 2021

---

### ABSTRACT

Amberlite IRA-400(Cl<sup>-</sup>) (polymeric resin) has been modified with disodium salt of ethylenediaminetetraacetic acid (Na<sub>2</sub>EDTA). The modified chelating resin (MCR) has been characterized by energy-dispersive X-ray spectroscopy, scanning electron microscopy and Fourier transform infrared spectroscopy techniques. Distribution coefficient ( $K_d$ ) has been determined with MCR for various metal ions (Co<sup>2+</sup>, Ni<sup>2+</sup>, Cu<sup>2+</sup>, Zn<sup>2+</sup>, Cd<sup>2+</sup>, Hg<sup>2+</sup>, Pb<sup>2+</sup>) and  $K_d$  data have been analysed using Langmuir and Freundlich adsorption isotherms. Thermodynamic parameters, (equilibrium constant, standard Gibbs free energy, enthalpy and entropy changes), using various chemical kinetics model (pseudo-first-order, pseudo-second-order or intra-particle), have been computed by performing metal ion exchange at different temperatures (299, 309, 319 and 329 K). Elution behaviors of above metal ions have been observed using various electrolytes (NH<sub>4</sub>NO<sub>3</sub>, HNO<sub>3</sub>, HClO<sub>4</sub>, CH<sub>3</sub>COOH). It has been found that exchange process follows Langmuir adsorption isotherm together with second order kinetic model.

*Keywords:* Transition metal ions; Heavy metal ions; Sorption; Modified chelating resin; Langmuir isotherm

---

### 1. Introduction

Aqueous bodies are most valuable and essential components on the earth. Due to unique nature, water is required for various vital activities of living systems. Also, it plays important role in industries because of its abundance and solvent property. Unfortunately, quality of water resources is deteriorating day by day due to growth in population/civilization, domestic sewage, agricultural activities, industrialization, geological and climate changes [1–4]. The important environmental issue for water pollution is the presence of heavy metal ions coming from various sources. Many heavy metals are

highly toxic (cobalt, nickel, copper, zinc, cadmium, mercury and lead). These metal ions are chemically and biologically non-degradable and are toxic even at very low concentrations [5–8]. Various industries such as mechanical, metallurgical, mining, pigment, paper, etc, release wastewater containing metal or metal derivatives [9–12]. Above toxic metal ions remain one of the serious public health problems for human health. Heavy metal toxicity can cause hypertension, nephritis, abdominal pain, vomiting, anaemia, brain diseases, high blood pressure, genetic defect and lung cancer [13–17]. Recently, different methods are adopted for treating waste water [18–20]. Different methodologies (precipitation, adsorption, electroplating,

---

\* Corresponding author.