



## The development of novel nickel selective amine extractants: 2,2'-Pyridylimidazole functionalised chelating resin

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### ABSTRACT

A chelating ion exchanger, prepared by functionalising Merrifield resin with 2,2'-pyridylimidazole, was utilized to selectively adsorb and separate nickel from other base metal ions in synthetic sulfate solutions. The sorbent material was characterized by scanning electron microscopy (SEM), microanalysis, infrared (IR), X-ray photoelectron spectroscopy (XPS) and BET surface area. The distribution ratio (D) and the sorption capacity of the microspheres toward Ni(II), Cu(II), Co(II) and Fe(II) ions was studied by using the batch and column methods, respectively. Ni(II) followed by Cu(II) showed the highest distribution ratio (D) and the highest sorption efficiency of nickel(II) ions around pH 2. The binary separation of nickel(II) from copper(II), cobalt(II) and iron(II) respectively, undertaken in a column study, through loading the metal ions at pH  $\approx$  2 followed by selective decomplexation, demonstrated the selectivity of the sorbent material for nickel(II). Thus, 2,2'-pyridylimidazole can be regarded as a nickel-specific extractant.

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### 1. Introduction

Separation of nickel from cobalt and other base metals such as copper and iron is known to have numerous challenges (Reddy et al., 2009). The application of solvent extraction (SX) no doubt has yielded, to some extent, the successful separation of nickel and cobalt with the application of organophosphorus reagents (Flett, 2005). Similarly, the hydroxyoximes have proved to be versatile extractants in the separation of copper with SX technique (Flett et al., 1973). However, these extractions are carried out at high pH values, and this necessitates for the precipitation of Fe(III) prior to these extractions since these extractants are oxygen donors which tend to co-extract ferric ions and other impurities (Reddy et al., 2009). For these reasons, there has been blossoming activity in the area of base metal separations in search for new adsorbents and liquid extractants (Gross and Cecille, 1991). It is, however known that solvent extraction has limited applicability when metals in pregnant solutions are present in low concentrations which is currently the case with nickel processing (Green and Hancock, 1982). Ion exchange is being revived as an alternative technique for the processing of such low grade ore feed solutions (Alexandratos, 2009). Ion exchange offers numerous advantages among which is their insolubility which renders them environmentally friendly, and the cycle of loading/regeneration/

reloading makes them reusable for many years owing to high mechanical strengths and toughness of the exchange particles (Agrawal et al., 2004).

Chelating ion exchangers have the ability to selectively chelate metal ions of interest through suitable functional group(s) (Gregor et al., 1952). Various polymeric support materials have been used in the design of chelating solid phase systems such as silica gel, cellulose, functionalised polymers such as chloromethylated polystyrene cross-linked with divinylbenzene resins (Merrifield resins) (Merrifield, 1963). Microporous resins are versatile in chelating divalent metal ions due to their numerous pores as shown by Lindsay et al. (1987). In the application of chelating resins, the amine containing resins have shown excellent adsorption property for metal ions and are widely applied in the separation and removal of metal ions. Chanda and Rempel (1993) showed that polyethylene amine on poly(vinylbenzaldehyde) has high selectivity for Fe<sup>3+</sup> over Cu<sup>2+</sup>, Ni<sup>2+</sup>, Co<sup>2+</sup>, Fe<sup>2+</sup>, Zn<sup>2+</sup> and Mn<sup>2+</sup>. Similarly, chelating resin containing benzoylacetanilide groups was successfully applied in the separation of Ti<sup>3+</sup> and Fe<sup>3+</sup> from Cu<sup>2+</sup>, Co<sup>2+</sup>, Ni<sup>2+</sup>, Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>2+</sup>, Mg<sup>2+</sup> and Al<sup>3+</sup> in the pH range 1.3–2.0 by Majee et al. (1988). Not much has been achieved, to the best of our knowledge, on the selective adsorption and separation of nickel in the presence of other base metal ions in a sulfate medium even with earlier works with the Dow resins and other chelating systems (Rosato et al., 1984; Grinstead, 1984).

In our earlier work with 2,2'-pyridylimidazole as an extractant (1-octyl-2,2'-pyridylimidazole (OPIM)) and dinonylnaphthalene

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