APPLICATION OF NEWLY SYNTHESIZED 8-HQ5-SAMF RESIN IN THE PURIFICATION OF WASTE WATER

R. N. Singru,[1] V. A. Khati,[2] W. B. Gurnule,[3] A. B. Zade,[4]
[1] *Principal, Chintamani College of Science, Pombhurna, Chandrapur, India*
[2] *Department of Physics, Institute of Science, Nagpur, India*
[3] *Department of Chemistry, Kamla Nehru College, Nagpur–440 009,India*
[4] *Department of Chemistry L.I.T. Nagpur-440 019, India*
*Corresponding Author; Email: rajeshsingru@in.com.
Tel. 91-712-2750078, Cell: 9423122292, Fax: 91-0712-2747853

Abstract

Synthesized 8-HQ5-SAMF polymer resin in the laboratory and studied its eco-friendly chelating ion-exchange properties. In Chelating ion-exchange study metal ion uptake of resin was determined at three different variables such as different electrolytes and their different concentrations, different shaking time and different pH of the solution, for seven metal ions viz. Fe^{3+}, Cu^{2+}, Ni^{2+}, Co^{2+}, Zn^{2+}, Cd^{2+} and Pb^{2+}. 8-HQ5-SAMF polymer resin is proved to be a eco-friendly cation exchange resin and can be used for the purpose of purification of environmental waste solution.

Introduction

The presence of heavy metals in the environmental area is a cause of concern. Removal of these metals has become increasing interest and need to have certain analytical technique [1, 2, 3]. Chelating ion-exchange chromatography is one of the powerful techniques. Chelating ion-exchange has attained the status of unit operation in chemical industries. For chelating ion-exchange study organic ion exchange is chiefly of interest [4,5,6]. The present paper deals to explore synthesis, study of morphology and its eco-friendly ion-exchange property of 8-HQ5-SAMF-III polymer resin.

The purpose of present study, is to explore the adsorption behaviour of seven metal ions Fe^{3+}, Cu^{2+}, Ni^{2+}, CO^{2+}, Cd^{2+} Zn^{2+}, and Pb^{2+} on the newly synthesized copolymer resins 8-HQ5-SAMF-III at different pH values, different concentration of different electrolytes and at different shaking time intervals. The adsorption behaviour of these metal ions is based on the affinity differences towards the chelating resins as functions of pH, electrolyte concentrations and staking time. The copolymer resins under investigations are found to be cation exchanger having both ion-exchange group and chelating group in the same polymer matrix and the resin can be used selectively for the purpose of purification of waste water. One of the important applications of chelating and functional polymer is their capability to recover metal ions from waste solution. Hence the chelating ion exchange property of the 8-HQ5-SAMF-III copolymer resin was also reported for specific metal ions [7, 8].

Experimental

Synthesis of 8-HQ5-SAMF copolymer

Copolymer 8-HQ5-SAMF was synthesized by condensing 8-Hydroxyquinoline-5-Sulphonic Acid, melamine and formaldehyde in a mole ratio of 2:1:5 in the presence of 2M HCl as a catalyst at 140^{0}C for 6 h in an oil bath. The structure of 8-HQ5-SAMF-III copolymer has been depicted in Fig.1. The purified copolymer was finally ground to pass through a 300 mesh size sieve and used in all experiments carried out in the ion exchange study.

Ion-Exchange property

Experimental procedure:

25mg resin sample + 25ml electrolyte solution + 2ml, 0.1M metal nitrate solution, required pH was adjusted by 0.1M HNO_3 or 0.1M NaOH. The contents were stirred mechanically for 24 hrs filtered and filtrate was titrated with standard EDTA solution with proper indicator (Experimental reading). Similar procedure was repeated without polymer (blank reading).

Using this procedure, the metal ion uptake of 8-HQ5-SAMF polymer resin was determined for above seven metal ions at three different variables such as different electrolytes ($NaNO_3$ and Na_2SO_4) and their different five concentrations, different shaking time intervals and different pH of the solution.

Determination of metal ion uptake at different electrolytes and their concentrations

The above procedure was performed at two different electrolytes ($NaNO_3$ and Na_2SO_4), each with five different concentration (0.01, 0.05, 0.10, 0.50 and 1.00 mol).

Metal ion adsorbed (uptake) = (X-Y) Z millimols

Determination of percentage metal ion uptake at different shaking time

The above procedure was performed at various shaking time intervals (1,2,3,4,5,6 and 24 hrs) by assuming 24 hrs is the equilibrium state where maximum metal ions get adsorbed,

$\therefore$ % metal ions uptake = (X . 100)/ Y.

Determination of metal ion uptake (distribution ratio) at various pH 1.5 to 6

The above experimental procedure was carried out using 1M $NaNO_3$ solution.

$\therefore$ Distribution ratio (D) = zx/y.2/0.025

Where, X gm = the amount of metal ion in 2ml 0.1M metal nitrate solution before uptake.

Y gm = the amount of metal ion in 2ml 0.1M metal nitrate solution after uptake.

Z = Difference between actual experimented reading and blank reading.

ZX = Amount of metal ion on resin; 2ml = Volume of aqueous metal nitrate solution

0.025 gm = Weight of resin in gram

Results and Discussion

Study of morphology by Scanning electron microscopy (SEM) – SEM micrographs were recorded at two different magnifications.

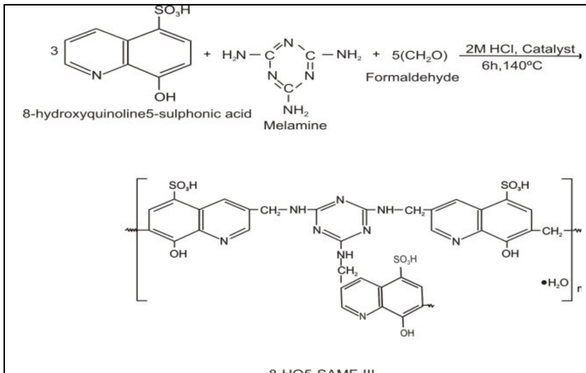	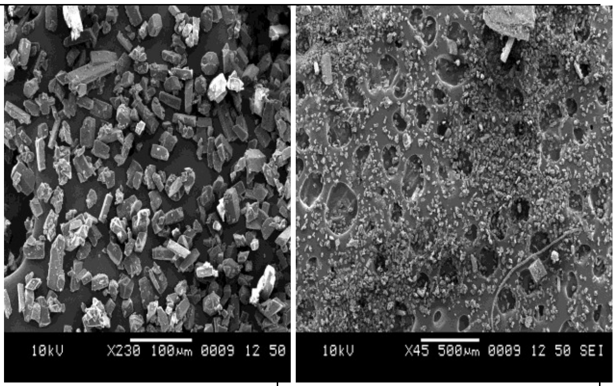
Fig. 1. Reaction and structure of 8-HQ5-SAMF resin	Fig. 2a and 2b. SEM of 8-HQ5-SAMF polymer resin

Fig.2a. Shows scattered particles nature i.e. spherulites which indicate the presence of crystalline nature. Fig.2b. Shows fringed micelle model having shallow and deep pits on the surface which indicate the presence of amorphous nature.

Therefore SEM study shows transition structure between crystalline and amorphous nature. Amorphous nature indicates to show ion-exchange property.

Ion-Exchange property

Effect of different electrolytes and their media of different concentrations on metal ion uptake:

SO_4^{2-} forms strong complex with all metals as it is strong ligands. NO_3^- forms strong complex with Co^{2+}, Zn^{2+}, Cd^{2+} and Pb^{2+} ions as pH is higher. ∴ Polymer may difficult to break this complex, make metal ions free for adsorption [8, 9]. ∴ Metal ion decreases on increasing concentration.

While NO_3^- form weak complex with Fe^{3+}, Cu^{2+} and Ni^{2+} as pH is lower

∴ Polymer may break this complex, can make metal ions free for adsorption. Hence metal ion uptake increases. (Fig.3)

Effect of shaking time on percentage metal ion uptake:

The graph shows that percentage metal ion uptake depends on shaking time and nature of metal ions. By increasing shaking time metal ion uptake increases but increase depend upon size of metal ions. Metal ion- $Fe^{3+} > Cu^{2+} \approx Ni^2 \approx Co^{2+} \approx Zn^{2+} > Cd^{2+} \approx Pb^{2+}$ (Fig.4)

Ionic size - 0.52 0.61 0.69 0.90 0.90 1.10 1.19

Fe^{3+} require 3 hrs, Cu^{2+}, Ni^2, Co^{2+} and Zn^{2+} require 5 hrs and Cd^{2+} and Pb^{2+} require 6 hrs to attain equilibrium [9,10].

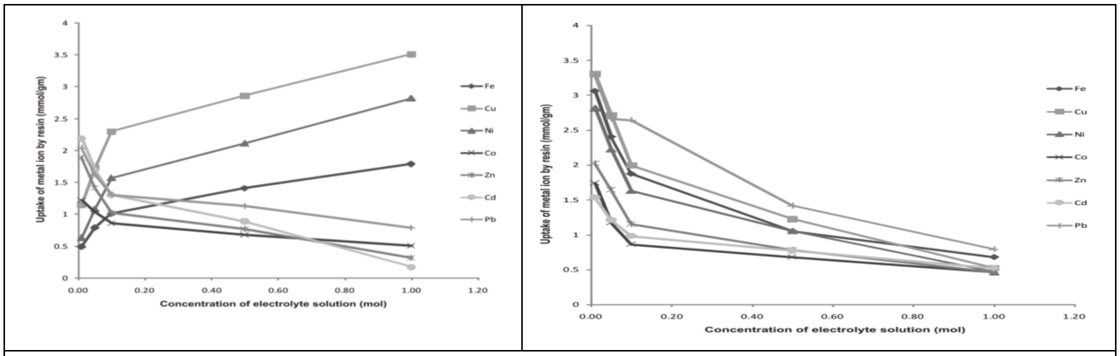

Fig. 3. Effect of concentrations of electrolytes a) $NaNO_3$ and b) Na_2SO_4 ion metal ion uptake

Metal ion solution + electrolyte solution → [Metal - NO_3^- / SO_4^{2-}] complex.

Effect of pH on distribution ratio

The result shows that distribution ratio depends upon the pH of the solution. (Fig. 5).At lower pH (from 1.5 – 3) Fe^{3+} has highest distribution ratio, while at higher pH (from 3 – 6) the Cu^{2+} and Ni^{2+} have higher distribution ratio rather than other metal cations which may be due formation of strong and stable complex between resin with metal ions.Co^{2+}, Zn^{2+}, Cd^{2+} and Pb^2 form rather weak complex with resin therefore shows lower distribution ratios.The stability of complexes may depend upon various factors such as amphoteric nature of polymer resin, atomic number of ions, electrostatic factor, sterric influence, pH etc.

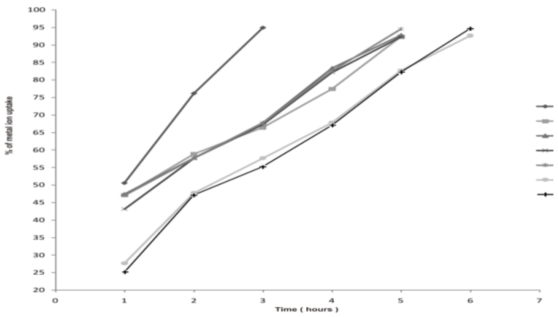

Fig.4. Effect of shaking time on % metal ion uptake

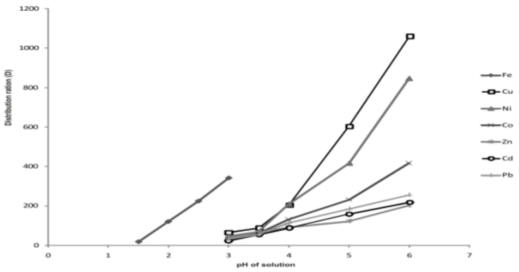

Fig. 5 : Effect of pH on the distribution ratio.

Conclusion

This study of ion-exchange reveals that 8-HQ5-SAMF polymer resin is proved to be a eco-friendly cation exchange resin and can be used for the removal of hazardous metal ions from the environmental area, for the purification of industrial waste solution and for the purpose of purification and desalination of water.

References

Dutta, S.; and Das, A. (2005) Ind J. Chem. Tech. 12, 139.

Lutfor, M. R.; and Silong S. (2000) Europ. Polym. J., 36, 2105.

Jadhao. M.; Paliwal, L. J.; and Bhave, N. S. (2005) Ind. J. Chem., 44, 225.

Patel, S. A.; Shah, B. S. and Patel, R. M. (2004) Iran. Polym. J., 13, 445.

Shah, B. A.; Shah, A. V. And Shah, P. M. E. (2008) J. Chem., 5, 291

Das S. C. (2000) J. Ind. Chem. Soc., 77, 69.

Rahangdale S. S.; Zade A. B. and Gurnule, W. B. (2008) J. Appl. Polym. Sci., 108, 747.

Tarase M. V.; Zade A. B. and Gurnule, W. B. (2008) J. Appl. Polym. Sci., 108, 738.

Singru, R. N.; Zade, A. B. and Gurnule, W. B. (2008) J. Appl. Polym. Sci., 109, 859.

Jadhao, M. M.; Paliwal L. J. and Bhave N. S. (2008) J. Appl. Polym. Sci., 10, 508.