

## NOTE

## Regeneration of Exhausted Ion Exchanger Resins Used in Water Treatment

R.A. KHALKHALI\*, M.H. CHAICHI†, R. MAHMOODLOO‡ and H.G. SOFLA

*Chemistry Department, Guilan University, Rasht, Iran*

*E-mail: ransari@guilan.ac.ir*

The regeneration of the two types of used resins (anionic and cationic), employing different acid, base and NaCl solutions, was investigated: The most efficient solutions for the regeneration of the used resins with the least pollution were found to be a mixture of HCl (5% w/v) + NaCl (10% w/v) for strong cationic resins and NaOH (3% w/v) + NaCl (10% w/v) for strong anionic resins.

**Key Words:** Ion exchange resins, Exhausted, Regeneration.

Ion exchange resins (anionic, cationic or mixed bed) are used for complete elimination of impurities (cations and anions) in the final step of water treatment (TDS < 700 ppm). They are synthetic insoluble organic cross-linked polymers incorporating charged sites, which can bind solute ions by direct coulombic interactions. Resins are extensively used for water and wastewater treatment, extraction, separation, analysis and catalysis<sup>1-5</sup>. Ion exchange resins are manufactured with a range of specific physical and broad range of chemical properties. They are generally of uniform spherical shape, with individual beads. Most ion exchanger resins with high ion exchange capacity are based on sulfonated polystyrene-divinylbenzene cross-linked copolymers. The most important factor in removal of ions from solutions by ion exchange resins is electrostatic forces.

Based on their active functional groups, ion exchange resins are classified as cationic and anionic exchangers. Cation exchange resins can remove all the metal cations and alkalinity from water. Cation-exchange resins incorporate acidic functional groups, possess fixed sites of negative charge that are covalently attached to the resin polymer (*e.g.*,  $-\text{SO}_3^-$  or  $\text{COO}^-$  groups) and are able to bind positively charged ions. The exchangeable cations are  $\text{H}^+$  or  $\text{Na}^+$ . Cation exchange resins are further classified into strong and weak acid cation exchangers<sup>4</sup>. Anion exchange resins are used for elimination of anions (*e.g.*,  $\text{SO}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ) from water and the exchangeable anion is  $\text{OH}^-$ . Anion exchange resins are also of two types, strongly basic and weakly basic anion exchange resins. The functional group in

†Chemistry Department, Mazandran University, Babolsar, Iran.

‡Electricity Power Plant, Neka, Mazandran, Iran.

strong anion exchangers is quaternary amine groups and the functional groups in weak anionic resins are tertiary or secondary amine groups. The anion exchange capacity and functionality of weakly basic anion resins, the same as weakly acidic cation resins, is strongly dependent on pH of the solution<sup>3</sup>. They are more efficient at acidic pH values. Anionic resins can effectively remove the organics as well as anions effectively. Organics such as humic acids, folic acids and tannic acids are present in tap water cause unwanted tastes, colors or odors in potable water supplies<sup>1,2</sup>. However, fouling the anion resins by precipitation of organics usually creates some problem such as decreasing ion exchange capability of resins and the operational costs<sup>5</sup>.

Cationic exchange resins used were polystyrene based sulfonic acid functional groups ( $H^+$  and  $Na^+$  form) with the trade mark LEWATIT S100 (Gel-type). Strong anionic resin used was polystyrene based with chloride ion form and quaternary amine functional group, with the trade mark LEWATIT M-504-MB (Gel-type). The details of the determinations of the different residual organics such as humic acids and inorganic pollutants (*e.g.*, heavy metals) in the resins and also the regeneration analysis were carried out using standard methods (titrimetric and spectrophotometric) as described in the procedures present in the laboratory of the plant.

When the ion exchange resins become exhausted and cannot accomplish any further ion exchange, the resins should be regenerated. The regenerant chemicals used for exhausted resins depend on the type of the resins. In this research,  $H_2SO_4$ , HCl, NaCl and NaOH solutions with different concentrations were used for regeneration of exhausted strong cationic and anionic exchanger resins used in water treatment in a power plant. The summary of the results obtained for regeneration of the two types of resins (strongly cationic and anionic) has been shown in Table-1.

TABLE-1  
REGENERATION OF STRONGLY ACIDIC CATION (SACER)  
AND STRONGLY BASIC ANION RESINS (SBAER)

Type of the used resin	Regenerant solution	Efficiency of regeneration
Cationic	HCl (2%)	50
" "	HCl (5%)	71
" "	HCl (10%)	60
" "	HCl (15%)	50
" "	HCl (20%)	40
" "	HNO <sub>3</sub> (2%)	60
" "	HNO <sub>3</sub> (5%)	85
" "	HNO <sub>3</sub> (10%)	75
" "	HNO <sub>3</sub> (15%)	60
" "	HNO <sub>3</sub> (20%)	40
" "	H <sub>2</sub> SO <sub>4</sub> (10%)	73

Type of the used resin	Regenerant solution	Efficiency of regeneration
" "	NaCl (2%)	65
" "	NaCl (5%)	75
" "	NaCl (10%)	90
" "	NaCl (15%)	70
" "	NaCl (20%)	60
" "	NaCl (10%) + HCl (5%)	89
" "	NaCl (10%) + HCl (5%) + HNO <sub>3</sub> (5%)	91
Anionic	NaOH (2%)	67
" "	NaOH (3%)	70
" "	NaOH (5%)	60
" "	NaOH (10%)	40
" "	NaCl (10%) + NaOH (3%)	84

As our results show (Table-1), the most useful regeneration solution with the least organic and inorganic pollutants, for strongly acidic cation resins NaCl (10%), HCl (5%), HNO<sub>3</sub> (5%) and a mixture of 10% NaCl + 5% HCl was found to be the most efficient. HNO<sub>3</sub> is not preferred because of its high cost. The best concentration for maximum regeneration for strongly anionic resins was found to be a mixture of 10% NaCl and 3% NaOH.

### REFERENCES

1. E. Korngold, N. Belayev, L. Aronov and S. Titleman, *Desalination*, **133**, 83 (2001).
2. F.J. De Silva, *Water Conditioning and Purification Magazine* (1997).
3. T.R. Kressman, *Effluent Water Treatment J.*, **6**, 119 (1996).
4. E.O. Skogley and A. Dobermann, *J. Environ. Qual.*, **25**, 13 (1996).
5. S. Rengaraj, K.H. Yeon and S.H. Moon, *J. Hazard Mater.*, **B87**, 273 (2001).

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