NOTE

Study of Chemical Yield after γ-Irradiation Treatment on Nuclear Grade Ion Exchanger, Indion-223

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Radiation treatment is given to the nuclear grade polystryrene resin Indion-223 using cobalt-60 gamma rays in different salt forms. The H_2SO_4 yield has been estimated which was found to increase as a function of absorbed dose and it is dependent on the counter action in the resin matrix. The estimation of the effluent of the exchanger was also carried out for its $BaSO_4$ content which also increases with the radiation dose of the exchanger.

The primary effects of radiation on ion exchange resin are degradation of crosslinking of the macromolecular structure along with the scission of ion exchange functional groups. As the consequence of radiation dose the resin beads become gouged, pitted, cracked and at times solubilized at higher doses. Irradiation also causes bead fracturing and agglomeration of resin. Hence this work is undertaken to understand the effects of radiation on the resin with reference to effluent analysis and the chemical yield determination with different cations. This is because the ion exchangers are extensively applied[1–6] in nuclear processing industries for various purposes. Variety of products are formed therein. These products significantly change the pH of the overall matrix. In this paper an attempt is made to estimate the yields of these species.

The resin studied is a nuclear grade strongly acidic polystyrene based resin, marketed under the code name Indion-223 and obtained from Ion Exchange (India) Limited, Mumbai. It is equivalent to Amberlite IRN-77 and is of nuclear grade and processed to the highest purity of standards to meet the stringent requirements of nuclear industry. Indion-223 is gel type resin containing 8% divinylbenzene and $—SO_3^{2-}$ functional group attached to the styrene matrix.

Known quantity of Indion-223 cation exchanger nuclear grade resin sample was irradiated in Na^+, Cu^{2+} and Ni^{2+} cationic forms. The resin was irradiated along with 5 mL double distilled water at different doses using cobalt-60 γ-source. The dose rate of the γ-source determined at that time was 0.25 Mrad/h. The pH of the solution was determined using digital pH meter model Li-122 manufactured by Elico Pvt. Ltd., Hyderabad. From the hydrogen ion concentration, H_2SO_4 available in the aqueous effluent of the irradiated resin was estimated.

The irradiation of an ion exchange resin and the radiolysis of water trapped within it produce a variety of products which significantly alter the pH of the overall matrix. The pH and the sulphate yields as $BaSO_4$ have been determined as a function of absorbed dose. In Table-1, the pH of the effluent of the irradiated resin observed after different doses absorbed over the range 0–12 Mgy are recorded.

TABLE-1
pH OF THE AQUEOUS EFFLUENTS OF INDION-223 IN DIFFERENT CATIONIC FORMS

Absorbed dose in M	Na^+	Cu^{2+}	Ni^{2+}
0	6.22	6.65	6.88
1	3.52	3.75	3.85
2	3.11	3.52	3.61
3	2.65	3.10	3.10
5	2.42	2.71	2.71
7	2.35	2.61	2.65
9	2.32	2.48	2.50
12	2.25	2.45	2.48

Formation of sulphuric acid due to free —SO_3^{2-} group in the effluent is calculated from the pH changes. It is seen that the sulphuric acid yield increases as a function of absorbed radiation dose by the resin. It is seen that the yield of sulphuric acid also depends upon the cation which is the counter ion of resin matrix. Hence the trend is found in the order $Na^+ > Ni^{2+} > Cu^{2+}$. In all these cases the yield attains saturation levels after a certain value of absorbed dose. H_2SO_4 is produce due to the scission of —C—SO_3 bond and subsequent hydrolysis[2].

$$R\text{—}SO_3H \longrightarrow R^+ + SO_3H^-$$

$$SO_3H^- \xrightarrow{H_2O} H_2SO_4 + H^+$$

Sulphate yields: In addition to the direct interaction, sulphate ion can be produced[8] in the radiolytic scission of the functional groups.

$$SO_3^{2-} + OH^- \longrightarrow SO_4^{2-} + H^+$$

Always the products released are mixture of H_2SO_4 and sulphate of the counter ion.

In a moist sulphonic acid resin, sulphate ion formation may be largely due to direct radiolytic scission of the functional group and subsequent hydrolysis of the radical products. Sulphate estimation is an indirect way to know the extent of exchange capacity loss. The sulphate ions released in the aqueous effluent of Indion-223 resin in various salt forms as $BaSO_4$ are given in Table-2.

In all the cationic forms studied the chemical yield attained the saturation value after certain absorbed dose. This indicates that at higher doses the chemical yield is observed to be independent of the absorbed dose.

TABLE-2
SULPHATE IONS ESTIMATED AS $BaSO_4$ IN THE EFFLUENT OF INDION-223

Absorbed dose in M	Na^+	Cu^{2+}	Ni^{2+}
2	18.5	4.8	5.7
5	82.1	35.0	45.6
7	95.0	45.0	55.0
9	115.0	66.0	72.0
12	117.0	71.0	81.0

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