NOTE

Self-Diffusion Studies in Polystyrene Nuclear Grade Resin

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The self-diffusion studies of Cr^{3+} and Fe^{3+} ions in a gel type polystyrene sulphonic acid resin (nuclear grade) was carried out. All the plots obtained for self-diffusion of Cr^{3+} and Fe^{3+} ions in nuclear grade cation exchanger Indion-223 show the linear relationship and the tendency of passing through origin.

Ion exchanger is an integral part of nuclear power plants and nuclear industries. Radioactive charged species transfer energy to an ion exchanger making the system more susceptible to rapid deterioration that results in loss of exchangable sites and decrosslinking of resin matrix. Therefore quantitative knowledge of self-diffusion in polystyrene nuclear grade resin is of prime importance.

Self-diffusion kinetics of polystyrene grade resin in chromic and ferric forms was followed by tagging of counter ions of the resin by radioactive tracers. Indion-223 resin was obtained from Ion Exchange (India) Ltd., Mumbai for the entire work. 0.5 g of the moist resin in above forms were transferred to 500 cm^3 of very dilute solutions of respective chlorides containing the activity of ^{51}Cr or ^{59}Fe as the case may be. Activty of these solutions was adjusted in such a way that aliquots of 0.5 cm^3 of the solution gave 5000–11000 counts per min. After the time gap of 30 h, which is sufficient to give the radioactive ions to distribute uniformly throughout the exchanger, the solution was separated from the resin and its remaining activity was measured. The decrease in activity was the activity taken up by the resin. Resin was treated for complete removal of occluded ion.

For measuring the exchange rates limited bath technique was used. 100 cm^3 of 0.1 M $CrCl_3$ or $FeCl_3$ taken in 250 cm^3 beaker was kept in a thermostat at constant temperature. After complete thermal equilibrium, the exchange reaction was started by quickly adding 0.5 g of labelled exchanger into it. Simultaneously, the stop watch was started and 0.5 cm^3 aliquots of solution were withdrawn using micro-pipette taking care that each time the solution was free from resin and its activity was measured. Aliquots of the solution were collected in counting tubes already calibrated for some activity. The time interval between pipetting was adjusted for 30 sec during the first 10 min. The last aliquot was taken up after 1 h and reading was repeated 4–5 times and averaged. The deviation was within ±0.5% on the mean NaI (Tl) scintillation detector and a single channel analyser manufactured by ECIL (India) was used for counting radioactivity.

The experimental data obtained for kinetics of ion exchange were analysed using Boys theory[1]. The amount exchanged, F, is expressed as $F = S_t/S_\infty$; where S_t is the counts rate at time t and S_∞ for $t = \infty$. It is seen that as the concentration increases the rate becomes independent of concentration beyond its certain level and this is according to the criterion for the partical diffusion process as per Boys' theory. Working concentration of Cr^{3+} and Fe^{3+} ions was fixed at 0.1 M for self-diffusion studies. In unirradiated form the rate of exchange is seen to be increased as the temperature is raised. This is probably due to the increasing ionic mobility as the temperature is increased.

Diffusion coefficients were computed using Reichenberg equation[2]. All the plots of B_t versus t for self-diffusion mechanism of Cr^{3+} and Fe^{3+} ions in the exchanger used show the linear relationship and tendency of passing through the origin (Figs. 1–3). The diffusion coefficient values are calculated from the slope of the plots and the equation
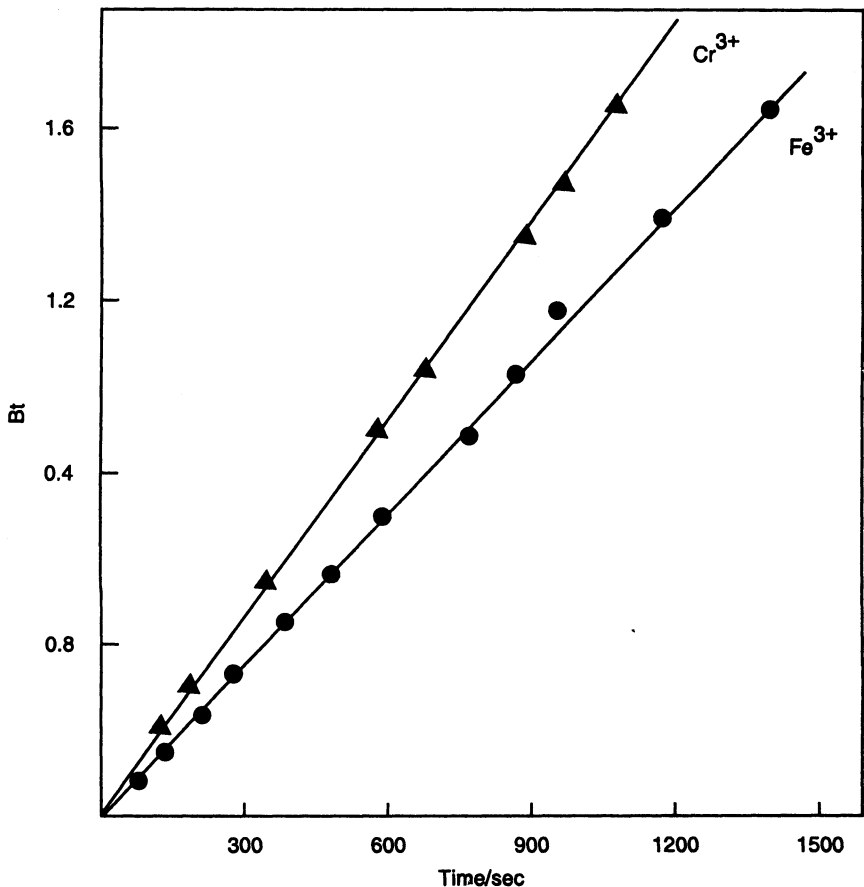
$$B = \pi^2 D/r^2$$

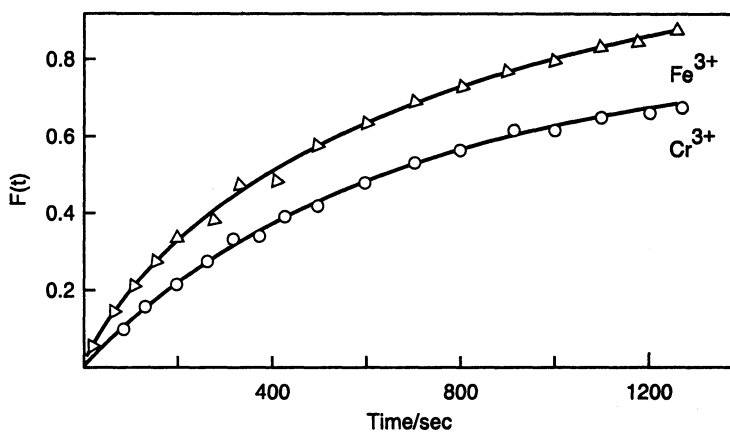Fig. 1   Self diffusion kinetics for nuclear grade polystyrene resin fractional attainment of equalibrium at 303 K

Fig. 2 B_t *vs.* T plots for the polystyrene nuclear grade resin at temperature 303 K
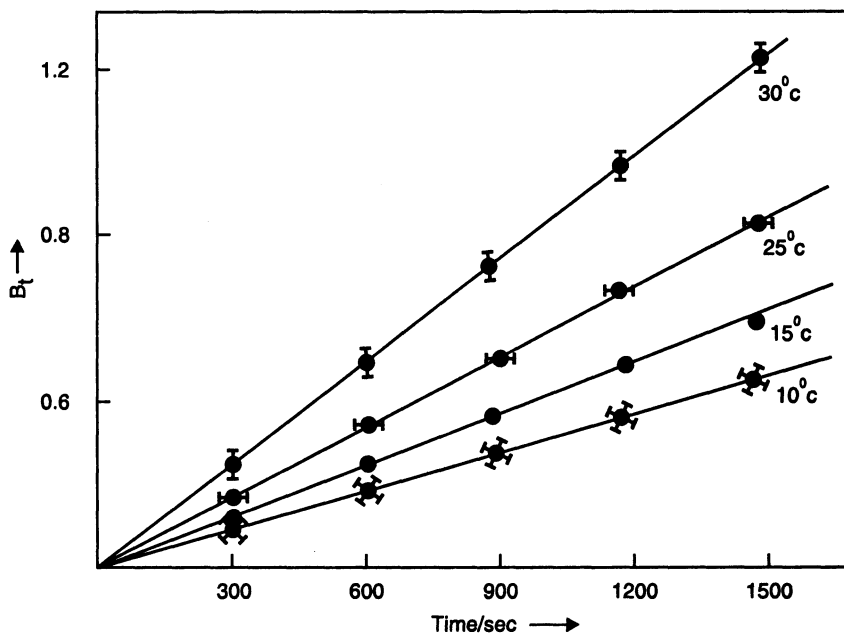

Fig. 3 B_t *vs.* T plots for the self diffusion kinetics of Cr^{3+} ions in polystyrene nuclear grade resin at different temperatures

REFERENCES

1.   G.E. Boyd, A.W. Adamson and L.S. Yera (Jr.), *J. Am. Chem. Soc.*, **69**, 2838 (1947).
2.   D. Reichenberg, *J. Am. Chem. Soc.*, **75**, 589 (1953).