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NOTE

Kinetics of Ion Exchange in Duolite A-161

R.S. LOKHANDE* and SANTOSHI R.D.TIWARI
Department of Chemistry, University of Mumbai, Santacruz (E), Mumbai-400 098, India

The rate of exchange between radioactive bromide ions on a resin and bromide ions in a solution has been studied. The investigation was carried out by varying the amount of bromide ion concentration of electrolyte (KBr) in the range of 0.005 M to 0.1 M and at various temperatures ranging from 27 to 50°C. Subsequently, the energy of activation was also calculated.

Key words: Kinetics, ion exchange, duolite A-161.

Vast amount of work has been carried out on the rate of ion exchange with the exchange of unlike ions, but data on the exchange of like ions are scanty. This information is useful in ion exchange chromatography and in the study of equilibrium in ion exchange reactions. The present investigation is an attempt to understand the kinetics of radioactive bromide ions on a resin and bromide ions in a solution. Hence, a typical case, the rate of ion exchange reaction in the anion exchanger Duolite A-161 has been undertaken where radioactive bromide ions are on the resin and inactive bromide ions are in the solution.

$$RBr^* + Br_{aq}^{-d} \rightarrow RBr + Br_{aq}^{*-}$$

The variation of the rate of exchange with the bromide ion concentration and the effect of change of temperature etc. has been studied. The energy of activation of the exchange process has also been evaluated.

The resin used (Duolite A-161) is a strongly basic anion exchanger, supplied by Henkel India Limited, Ratnagiri. The resin was in chloride form initially, which was further conditioned with 10% potassium bromide and was converted into bromide form. The ^{82}Br tracer isotope required for this was procured from Board of Radiation and Isotope Technology (BRIT), Mumbai.

The complete conversion of the resin into bromide form was checked as follows. 1.0 g of resin was equilibrated with water for 24 h. The water was drained out and the resin was mixed with 200 mL of 0.005 M KBr solution. After 24 h an aliquot of the solution was titrated potentiometrically. Only one peak for bromide ion was observed and no diminution in the bromide ion concentration was observed.

In the present investigation different concentrations of KBr were prepared from 0.005 M to 0.1 M and these solutions were labelled using ^{82}Br isotope.The activity

was adjusted in such a way that 1 mL of labelled KBr solution gave initial activity between 12000 to 13000 cpm. The activity was measured using gamma ray spectrometer. Fixed amount of ion exchange resin (0.5 g) in bromide form was added and by continuous stirring of solution the activity of the 1 mL solution was measured at an interval of every 2 min. Due to rapid exchange of radioactive bromide ions on resin with bromide ions on solution, the activity of the solution increased rapidly for an initial interval of time but after some time it increased slowly which indicates activity exchanged due to rapid as well as slow process. Similarly, the experiment was repeated for different temperatures (27 to 50°C) and another set of experiments was repeated by varying the amount of ion exchange resin from 0.5 to 2.5 g.

The kinetic study carried out in the present investigation reveals many interesting observations. Due to increase in temperature of KBr solution the collision between the radioactive bromide ions on the resin and the bromide ions on the solution increases and hence the reaction rates of rapid exchange process are observed to increase with rise in temperature (Table-1), but the increase is more sharp with increase in amount of ion exchange resin. With increase in amount of ion exchange resin the number of exchangeable counter ions increases resulting in an increase in the specific reaction rate (Table-2). When energy of activation is calculated for different concentrations it is observed that energy of activation value decreases with increase in concentration of electrolyte which is due to increase in number of effective collisions with rise in temperature (Table-3). The amount of bromide ions exchanged in millimoles when calculated for different concentrations of bromide ion solution was observed to increase with increase in concentration of bromide ion solution. The amount of bromide ions exchanged in miilimoles increases effectively with increase in amount of ion exchange resin.

TABLE-1
EFFECT OF TEMPERATURE ON REACTION RATES OF ION EXCHANGE REACTION

Concentration of Bromide ion solution = 0.005 M; Amount of ion exchange resin = 0.5 g

Temperature (°C)	27.0	35.0	40.0	45.0	50.0
Reaction rate (min^{-1})	0.096	0.126	0.142	0.159	0.176

TABLE-2
EFFECT OF AMOUNT OF ION EXCHANGE RESIN ON ION EXCHANGE REACTION

Concentration of Bromide ion solution = 0.005 M; Temperature = 27°C

Amount of ion exchange resin (g)	0.5	1.0	1.5	2.0	2.5
Specific reaction rate (min^{-1})	0.098	0.123	0.146	0.167	0.188

TABLE-3
EFFECT OF CONCENTRATION OF BROMIDE ION SOLUTION ON ENERGY OF ACTIVATION OF ION EXCHANGE REACTION

Amount of ion exchange resin = 0.5 g; Volume of bromide ion solution = 200 mL

Concentration of bromide ion solution (M)	0.005	0.01	0.02	0.04	0.1
Energy of activation (kJ/mole)	6.312	6.273	6.140	6.025	5.977

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