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NOTE

The Application of Radiotracer Technique to Study Intrinsic Rate of Ion Exchange in Anion Exchange Resin (N-IP Type 2)

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^{131}I radioactive tracer is used as a tool to study the intrinsic rate of ion exchange reaction. Effect on concentration of ion exchange resin has been investigated. It is observed that the rate of ion exchange decreases as concentration of iodide solution increases and specific reaction rate is observed to be almost constant. Effect of temperature on ion exchange resin is also studied. Specific reaction rate is dependent on temperature. Amount of resin plays an important role in the reaction. It is observed that specific reaction rate increases as amount of resin increases. From the determined specific reaction rate the energy of activation has been calculated and observed to be 5.22 kJ/mole.

The data is available of natural and synthetic materials which are identified having ion exchanging properties. They possess varied applications in science and industries usually concerned with organic exchange. Resins are used in power plants to control purity of liquid streams. Ion exchanges are useful in the operation of reactors specially in the treatment to separate the fission products.[1–4] Ion exchange resins are used in sepration of uranium, plutonium, neptunium[5], etc.

The phenomenon of ion exchange was first noticed by Thompson[6] and Way[7]. The rate of ion exchange deals with exchange of unlike ions[8–11]. Only a few have been on the exchange of same ions. In the present investigation exchange of same ions has been studied by the radiotracer technique.

Iodide from the resin goes into iodide solution.

$$RI + I \rightleftharpoons RI + I$$

As the resin N-IP (Type 2) is widely in use in various fields, we thought that the study of iodine exchange using radiotracer technique may help in the further development of resin as well as its application.

N-IP (Type 2) is a strong basic anion exchanger containing Cl^- group and of size 0.3–1.2 mm. The resin was then converted into iodide form with 10% of 2 litres of KI solution at the flow rate of 1 mL/min. All solutions are prepared in double distilled water. The temperature was controlled by electronically controlled thermostat and the study at different temperatures is carried out.

The two series of experiments are carried out in the series.

(A) The effect of iodide ion concentration is studied, and

(B) The effect of amount of resin on kinetics of ion exchange is studied. In first series of experiments the concentration of iodide ion solution used is varied from 0.005 M to 0.02 M and labelled with radioactive iodide ion *i.e.* tracer 1 g of resin is then added in the solution with constant stirring at 30°C. The temperature is kept constant by keeping the solution in a thermostat. At an interval of 1 min, 1 mL of aliquot is taken in a dry test tube and its activity is measured. This is to be carried on till half an hour and further continued at infinite time to know the activity.

In the second series of experiments the amount of resin is changed from 1 g to 4 g keeping the procedure same.

In the present study the activity of tracer is used to follow the path of reaction and measured activity is corrected for the background and radioactive decay. However, there remains error of counting of radioactive sample which is given by standard deviation (n), where n is the activity of sample measured for 1 min. The activity used here is about 10000 counts per min; therefore the standard deviation is about 100 and due to it error is introduced in the counting. Some error is introduced due to pipetting out of sample; therefore the overall error in the present work is about +1%. It is seen from the results that specific reaction rate remains unchanged even though the iodide ion concentration is varied from 0.005 M to 0.02 M.

TABLE-1

EFFECT OF CONCENTRATION OF ION EXCHANGE RESIN

Volume of iodide ion solution 200 mL. Temperature 30°C.

Concentration of iodide ion solution	Specific Reaction Rate N-IP (Type 2)	Millimoles of iodide ion 200 mL solution	Amount of iodide ion exchanged N-IP (Type 2)	Initial rate of ion exchange millimole N-IP(Type 2)
0.005	0.142	1	0.523	0.074
0.01	0.145	2	0.431	0.063
0.02	0.143	4	0.304	0.043

Considering initial activity of iodide ion solution whose concentration is known and its activity at equilibrium; the amount of radioactive ion exchanged is calculated. At higher conccentration of iodide ion, higher amount of iodide ion is exchanged with the resin but relative to the amount of iodide ion in the solution lower fraction of it exchanges with the resin. The specific reaction rate is independent of the amount exchanged.

From the results the amount of iodide ion exchange per unit time at any instant during the exchange process can be calculated. As the concentration of iodide ion solution and the volume of latter is known, the activity due to radioactive iodide introduced in the solution for labelling represents the concentration. Hence from the activity which has been actually exchanged, the amount of iodide ion exchange by the first order process is calculated. Hence the amount of iodine ion exchange per unit time is obtained. It is the product of exchanged iodide ion and specific reaction rate. These rates of exchange have been calculated for various initial concentrations of iodide ion. The results of effect of temperature on ion exchange resin are shown in Table-2. In the second series of experiments, it is observed that specific reaction rate increases with amount of resin. The initial rate of exchange is obtained from the experimental results as mentioned above. The results are presented in Table-3.

TABLE-2
EFFECT OF TEMPERATURE ON EXCHANGE RESIN

Concentration of iodide ion solution 0.01 M.; Amount of resin 1 g.

Temperature (°C)	25	30	40
Specific reaction rate	0.113	0.145	0.176

TABLE-3
EFFECT OF AMOUNT OF RESIN ON ION EXCHANGE REACTION

Concentration of iodide solution = 0.005 M
Temperature 25°C; Amount of iodine ion in 200 mL solution = 1 millimole

Amount of resin (g)	Specific reaction rate	Fraction of iodide exchange/millimoles	Initial rate of ion exchange/millimoles
1	0.115	0.529	0.060
2	0.129	0.597	0.077
3	0.214	0.702	0.150
4	0.256	0.751	0.192

In the present investigation the following interesting features are observed. At constant temperature specific reaction rate remains almost constant for change in concentration in the range 0.005 M to 0.02 M. There is gradual increase in specific reaction rate as the temperature increases. There is tremondous change in specific reaction rate when amount of resin is increased from 1 g to 4 g. In the present investigation energy of activation was observed to be 5.22 kJ/mole.

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