

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES TO STUDY THE EFFECT OF DIFFERENT CHEMICAL CONDITIONS ON ION EXCHANGE AND BREAK THROUGH CAPACITY OF NUCLEAR AND NON- NUCLEAR GRADE RESINS

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ABSTRACT

The present research study demonstrates the effect of different degradation medium like 20% H₂O₂, 0.1MHClO₄, Thermal degradation at 70.0°C, 100.0°C, 120.0°C and UV radiation effect at 254 nm on ion exchange capacity and break through capacity of resins viz DuoliteARA9366 and DuoliteA378. The data obtained from the studies shows that the break through capacity of fresh as well as chemically, thermally and UV radiation degraded resins samples were slightly higher than the ion exchange capacities of both fresh and degraded resins. The data obtained from studies reveals that the resins sites were blocked or less available for external exchange of mobile ions in the solvent medium during ion exchange reaction which was also supported or seen in FTIR and SEM micrographs of particular resin site. The data obtained from the study is helpful for selecting the resins for ion exchange reaction under stringent chemical conditions.

Keywords: Thermal, chemical degradation, ion exchange capacity, break through capacity FTIR, SEM.

I. INTRODUCTION

The selection of appropriate ion exchangers depends strictly on the needs of the system [1] and the process of selection becomes even more difficult at high concentrations for chemically similar ions in the waste water. In the past decade, inorganic ion exchange materials have a good alternative for replacement or complement for conventional organic ion exchange resins. Because of specific physical and chemical reasons the use of organic ion exchange resins is continued globally for various technical applications [2-3] and cannot be replaced by inorganic ion exchangers. The synthetic organic ion exchange resins having many industrial applications like purification and separations [4-5] and are mainly used for water treatment and in the preparation of demineralized water. The resins remove both radiological and non-radiological impurities [6-8]. Generally the resins used must be resistant at degradation effect and should exhibit consistent performance under various degradation conditions. In view of this, the present research work was carried out to understand the ion exchange capacity and break through capacity of nuclear and non-nuclear grade resin viz DuoliteARA9366 and DuoliteA378 exposed under different degradation medium like 20% H₂O₂, 0.1MHClO₄, Thermal degradation at 70.0°C, 100.0°C, 120.0°C and UV radiation effect at 254 nm. [9-11]. The performance behaviour of fresh as well as degraded resins was evaluated by studying their selectivity behaviour towards different anions in the solution and also for studying the feasibility of the ion exchange reactions[12-15].

II. METHOD & MATERIAL

2.1 Degradation of resins

In order to understand the effect of different degradation medium on the ion exchange capacities as well as the break through capacities [16-19] of the resins DuoliteARA9366 and DuoliteA378, 10g of both the resin in chloride form are taken in separate watch glasses and heated in oven separately at 70.0°C, 100.0°C and 120.0°C temperature for 24 h. After 24h, the thermally degraded resin is cooled over P₂O₅ in desiccators. Similarly the same quantities of resins were degraded in 20% H₂O₂, 0.1MHClO₄ chemical medium for 24h in 100ml beaker on magnetic stirrer. For UV radiation

effect about 10g of resins sample were taken on watch glass and kept in UV chamber for irradiation of UV light of wavelength 254nm for 24h. After irradiations the resins were washed with ethanol, dried and used for further experimental study.

2.2 Determination of anion exchange capacity of fresh resins and degraded resins.

A 100 mL of 0.1N NaNO₃ is passed [20] separately through the ion exchange column containing 0.500g of anion exchange resins in Cl⁻ form, and eluted at the rate of 2 mL/min. through column. The eluted solution is titrated against 0.1N standard silver nitrate solution.

$$\text{Anion Exchange Capacity (A)} = \frac{0.1 \times V}{0.500} \quad (1)$$

Where V is the volume of 0.1N AgNO₃ solution consumed during titration.

2.3 Determination of breakthrough capacity of the fresh and degraded resins

Pipette out 25 mL of 0.1N KCl solution in a 250 ml beaker and titrated potentiometrically [21] with 0.1N AgNO₃ solution using Ag metal as an indicator electrode and saturated calomel electrode as reference electrode. Note the titre value as x mL. Ishthe column containing fresh anion exchange resin with distilled deionised water. Reject the washing and bring the solution level to 1 mL above the bed level. Transfer 25 mL of the 0.1N KI solution on to the resin column and adjust the flow rate to 5 mL/minute. When the added 25 mL 0.1N KI solution comes to the bed level add another 25 mL of 0.1N KI solution. Collect 25 mL of the eluent at a time and titrate potentiometrically with 0.1N AgNO₃ solution. Repeat the process till the titre value reaches the original titre value obtained with 25 mL 0.1N KCl solution. By plotting a graph of the volume of the 0.1N KI solution transferred against the titre value of 0.1N AgNO₃ solution. From the graph the break through volume (V₁) of the resin was obtained.

Now,

$$V_2 = \frac{\text{Total volume of eluent (0.1N KI) x break through volume (V}_1)}{\text{Volume 0.1N KI solution taken (25 mL)}} \quad (2)$$

Since 1 mL of 1N AgNO₃ = 74.5 g of KCl

Therefore

$$V_2 \text{ mL of 0.1N AgNO}_3 = \frac{V_2 \times 74.5 \times 0.1}{1000} = y \text{ g of KCl} \quad (3)$$

$$\text{Therefore break through capacity of resin,} \quad y = \quad (4)$$

Weight of resin (0.5)

The break through capacity of both fresh and degraded resins Duolite ARA-9366 and Duolite A-378 were determined experimentally as per the above procedure and results are shown in Table 1 and Table 2.

III. RESULT & DISCUSSION

The ion exchange capacity of fresh as well as degraded resins was determined by using the equation.

$$\text{Anion Exchange Capacity (A)} = \frac{0.1 \times V}{0.500} \quad (1)$$

Similarly the break through capacities of fresh as well as degraded resins was given by the equation,

$$\text{Break through capacity of resin (B),} \quad y = \frac{\quad}{\text{Weight of resin (0.5)}} \quad (2)$$

Table 1. Break through capacity and anion exchange capacity of fresh and degraded resin DuoliteARA-9366

Resins	Resin Conditions	Ion Exchange Capacity(A) (meq./0.5 g)	Break through capacity(B) (meq./0.5 g)
DuoliteARA-9366	Fresh	2.30	2.774
DuoliteARA-9366	Degraded at 70.0°C	1.80	2.443
DuoliteARA-9366	Degraded at 100.0°C	1.78	2.059
DuoliteARA-9366	Degraded at 120.0°C	1.72	1.98
DuoliteARA-9366	Degradation medium 0.1M HClO_4	1.664	1.960
DuoliteARA-9366	Degradation medium 20% H_2O_2	1.804	2.138
DuoliteARA-9366	Degradation medium UV radiation $\lambda = 254\text{nm}$	1.774	2.033

Table 2. Break through capacity and anion exchange capacity of Fresh and degraded resins DuoliteA-378

Resins	Resins Conditions	Ion exchange capacity (meq./0.5 g)	Break through capacity (meq./0.5 g)
DuoliteA-378	Fresh	0.740	0.9536
DuoliteA-378	Degraded at 70.0°C	0.728	0.802
DuoliteA-378	Degraded at 100.0°C	0.720	0.782
DuoliteA-378	Degraded at 120.0°C	0.628	0.677
DuoliteA-378	Degradation medium 0.1M HClO_4	1.948	2.471
DuoliteA-378	Degradation medium 20% H_2O_2	0.58	0.636
DuoliteA-378	Degradation medium UV radiation $\lambda = 254\text{nm}$	2.316	2.816

3.1 FTIR spectrum of fresh (at room temperature) degraded DuoliteA378resin.

FTIR spectra of fresh and various degraded samples of [22] DuoliteA378 were recorded in KBr pellets using a FTIR PerkinElmer 1750 spectrophotometer. The degradation effect on the resins was studied by comparing the FTIR spectra of fresh resin with that of degraded resins

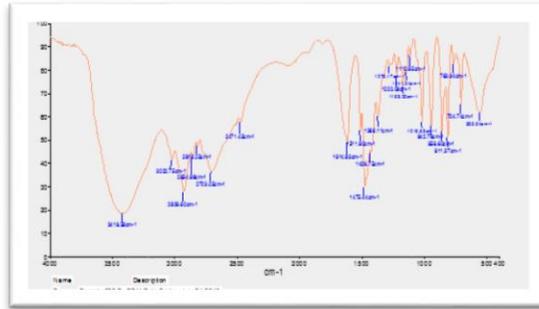


Figure 1 FTIR Spectrum of fresh resin DuoliteA378

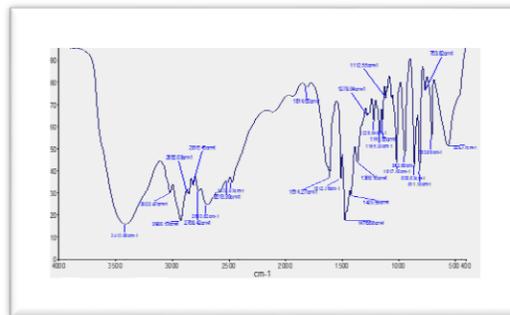


Figure 2 FTIR Spectrum of degraded resin DuoliteA378 at 70.0°C

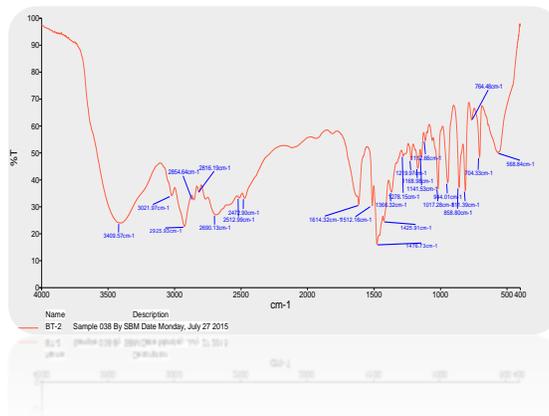


Figure 3 FTIR Spectrum of 20% H₂O₂ DuoliteA378

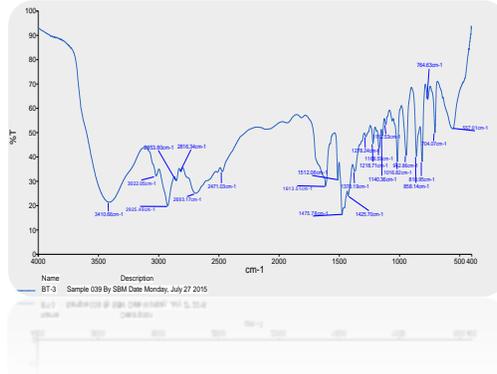


Figure 4FTIR Spectrum of 0.1MHCIO4DuoliteA378

3.2. Scanning electron microscopy (SEM) studies of fresh (at room temperature) and degraded DuoliteARA9366resin

Scanning electron micrographs of both fresh and degraded resin surfaces were obtained with the help of SEM [23] technique using JSM-6380LA Scanning Electron Microscope (Jeol Ltd., Japan).. The pictures were taken at an excitation voltage of 15 kV under a 90 Pascal pressure and a magnification of x150, x500, x1000,x 2500 and x5000.

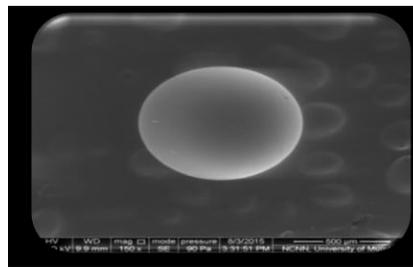


Figure 5.SEM image of fresh DuoliteARA9366.

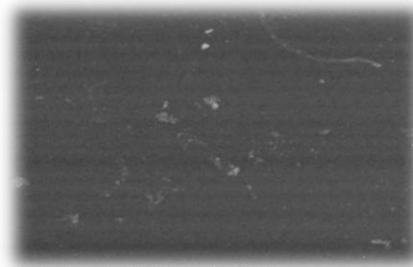


Figure 6 SEM of DuoliteARA9366resin degraded at 70.0°C

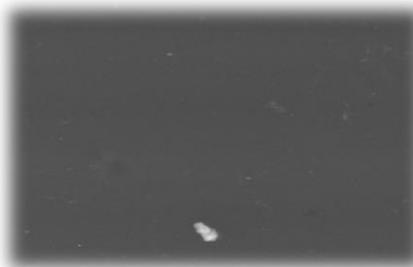


Figure 7SEM of DuoliteARA9366 in 20% H₂O₂ .

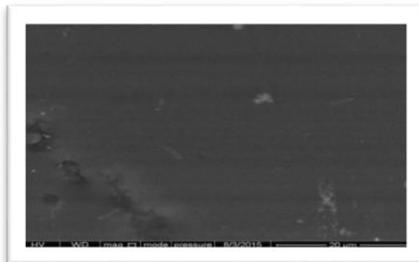


Figure 8.SEM of DuoliteARA9366 in. 0.1MHClO₄

On comparing the values of ion exchange capacity and breakthrough capacity (from Table1& table2) of fresh and degraded resins DuoliteARA9366 and DuoliteA378 under different chemical conditions it was observed that the ion exchange capacity and break through capacity goes on decreasing. Under thermal condition, these capacities reduced from 1.80 to 1.74 and from 2.44 to 2.05 at 70.0°C, 120.0°C and 1.66 and 1.98 for 0.1MHClO₄ for resin DuoliteARA9366 indicating that under this condition ion exchangeable groups in resins sites are seen blocked. This was also supported by FTIR and SEM images of the resin DuoliteARA9366. But in case of 20% H₂O₂ both values were slightly higher 1.804 and 2.138 but less than fresh resin DuoliteARA9366 whereas under UV radiation both values are 1.774 and 2.033 reveals that resin DuoliteARA9366 is less affected or degraded in 20% peroxide medium. The same trend was observed for ion exchange capacity and break through capacity values for the resin DuoliteA378 exceptions only for 0.1M HClO₄ and UV radiation medium, in these medium both values were little high as comparing to other chemical conditions (see Table2) which were also supported by FTIR and SEM(fig 1 to fig 8).

IV. CONCLUSION

Ion exchange technology is widely being used for separation of particular ionic species in presence of other. The selection of suitable ion exchange material is still more difficult when the process involves separation of two or more chemically similar ionic species in the solution. In most of the cases the resins are subjected to stringent operational conditions during which the stability of the resins is a crucial issue. Under such critical conditions the present experimental work will be useful in deciding about the selection of suitable ion exchange material. The results of such studies will help in selection of suitable ion exchange resins for efficient industrial applications.

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