

CHAPTER 6

ALCOHOLYSIS OF EPICHLOROHYDRIN

6.1 INTRODUCTION

Alcoholysis of epichlorohydrin with allyl alcohol yields a product, 1-allyloxy-3-chloro-2-propanol, which is an important precursor of allyl glycidyl ether a useful functional monomer. The conventional method of producing 1-allyloxy-3-chloro-2-propanol made use of sulphuric acid or perchloric acid as a catalyst. The reactions using sulphuric acid and perchloric acid as catalysts were very slow, even when these catalysts were employed in high concentrations. In addition, rapid deactivation of the catalyst was observed. Much higher concentration of sulphuric acid under reflux were required for completely converting epichlorohydrin into the hydroxy ether. The rapid deactivation observed with sulphuric acid catalyst implied that the acid may have reacted either with allyl alcohol, epichlorohydrin or the product hydroxy ether to form an alkyl sulphate, resulting in the loss of acidity. Though perchloric acid did not lose its acidity during the reaction so drastically as sulphuric acid, the catalytic activity was still poor. In addition to these complications, the effluent containing the acid had to be treated and extracted to avoid corrosion and environmental problems.

Ring opening reactions of epoxides with various nucleophiles have been catalysed by acid or base, being accompanied by configurational inversion on the substituted carbon. γ -alumina promoted nucleophilic ring opening of epoxides with amines, alcohols and carboxylates gave stereospecific β -functionalised alcohols in good yield under mild reaction

Nucleophilic substitution with azide is an important reaction for the synthesis of alkyl azides which are useful precursors for the synthesis of amino compounds and nitrenes. Alkali azides such as NaN_3 and LiN_3 are readily available azide sources. However, since these inorganic azides were sparingly soluble in nonpolar organic solvents, the use of supported azide reagents appeared to be effective. Thus, CaY - supported NaN_3 has been reported to react very efficiently with 1,2 - epoxyoctane in benzene affording the normal ring opening product, 1-azidooctan-2-ol, in good yield (Onaka *et al.*, 1989b). Zeolite supported NaN_3 reagents found further application in the regioselective ring opening of 2,3-epoxy-1-alkanol (Onaka *et al.*, 1986 and 1989b).

In the homogenous liquid phase alcoholysis of epichlorohydrin with allyl alcohol at 45°C, heteropoly acid catalysts efficiently catalysed the nucleophilic ring opening of epoxides with alcohol into the corresponding β -hydroxy ethers in the liquid phase under relatively mild reaction condition (Izumi and Hayashi, 1980). In the presence of a heteropoly acid catalyst, epichlorohydrin reacted with allyl alcohol via an $\text{S}_{\text{N}}2$ mechanism and was completely converted, with high selectivity, to normal ring-opening product 1-allyloxy-3-chloro-2-propanol. No polymeric by-product was formed.

The limitations of the conventional alcoholysis of epichlorohydrin with allyl alcohol catalysed by sulphuric acid or perchloric acid can be overcome by using heterogeneous solid acid catalysts which are environmentally acceptable, readily recoverable, non-corrosive, non-toxic, non-volatile, easy to handle and can be recycled. In this context, the present study on the use of solid acid catalysts for alcoholysis of epichlorohydrin with allyl alcohol gains significance.

The preparation of various catalysts and the experimental set up have been described in the experimental section in chapter 2. The alcoholysis of epichlorohydrin with allyl alcohol was carried out using

modified clay, supported zinc chloride and supported DTPA catalysts. To repress unfavourable polymerisation of epichlorohydrin, excess of allyl alcohol was used. The progress of the reaction was monitored by withdrawing samples and subjecting them to gas chromatographic analysis. The product was found to be 1-allyloxy-3-chloro-2-propanol and no polymeric by-product was formed. The product was confirmed by GC-MS and ^1H NMR studies represented in Figures 6.1 and 6.2 respectively.

6.2 ALCOHOLYSIS OF EPICHLOROHYDRIN ON MONTMORILLONITE K10

The catalyst samples were prepared by activating montmorillonite K10 with different concentrations of HCl (0.3, 0.5, 0.7 and 1 M). The effect of the acid activation, catalyst weight and reaction temperature on the alcoholysis of epichlorohydrin were investigated.

6.2.1 Effect of acid activation of montmorillonite K10

The acid activated montmorillonite K10 (0.3M, 0.5M, 0.7M and 1M) catalysts were tested for their activity towards alcoholysis of epichlorohydrin (13 mM) with allyl alcohol (147 mM) using 0.75 g catalyst at 30°C. The results are shown in Table 6.1 and Figure 6.3. As the concentration of acid for activation of montmorillonite K10 increased the conversion was found to decrease. Montmorillonite K10 (unactivated) was found to have negligible activity, under the same experimental conditions.

6.2.2 Effect of catalyst weight

The effect of catalyst weight was investigated on montmorillonite K10 (activated in 0.3 M HCl) for alcoholysis of epichlorohydrin (13 mM) with allyl alcohol (147 mM) at 30°C in the range of 0.25 to 1 g. The conversion of

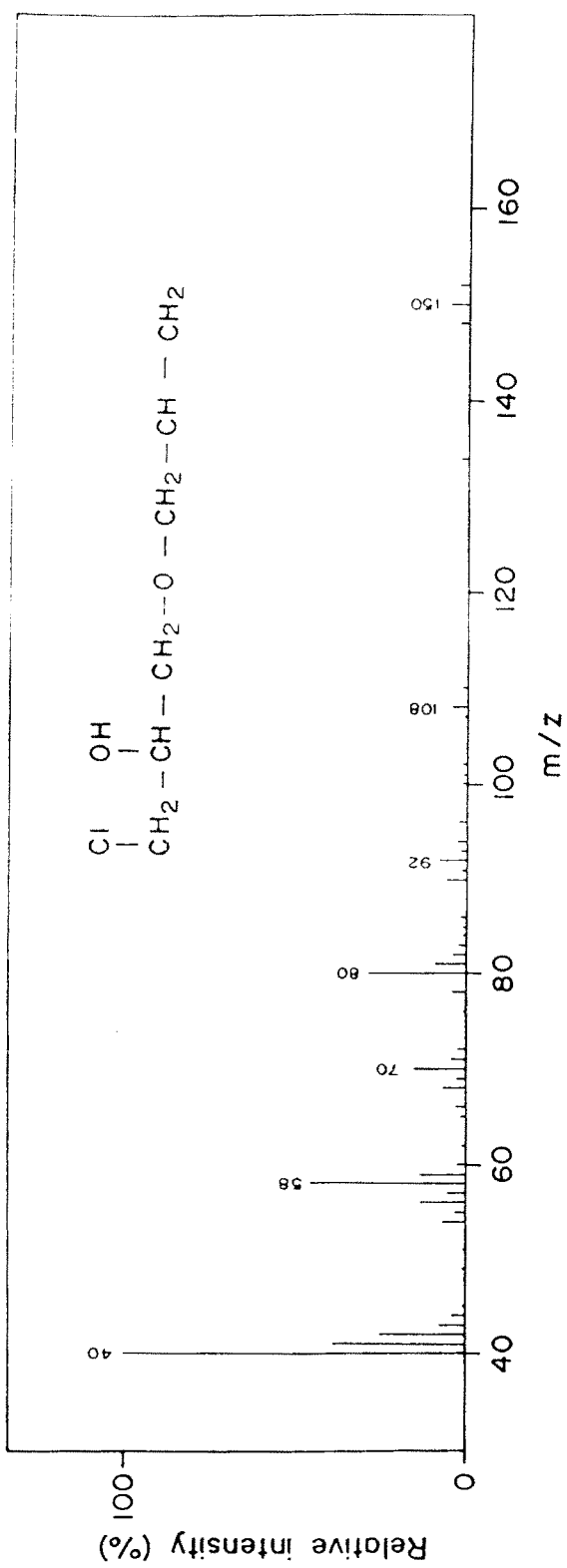


Figure 6.1 Mass spectrum of the product of alcoholysis of epichlorohydrin

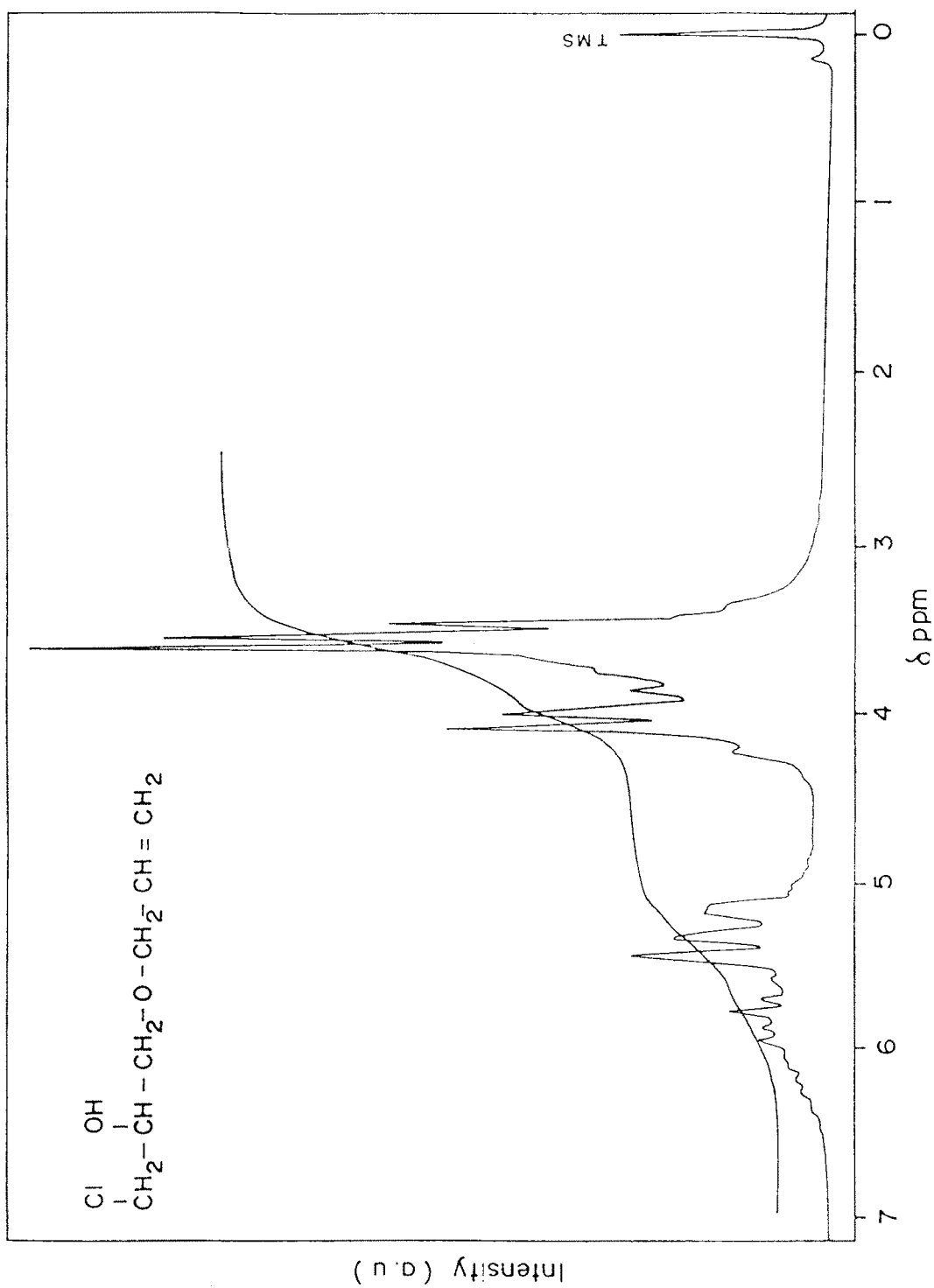


Figure 6.2 ^1H NMR spectrum of the product of alcoholysis of epichlorohydrin

Table 6.1

**Effect of acid activation of montmorillonite K10
on alcoholysis of epichlorohydrin**

Catalyst = 0.5g of montmorillonite K10 (activated in 0.3 M HCl)
Reaction temperature = 30°C ; Epichlorohydrin : allyl alcohol = 1 : 11.3

Time (m)	Conversion of epichlorohydrin (%)			
	Mont K10 (unactivated)	Mont K10 (0.3M HCl)	Mont K10 (0.5 M HCl)	Mont K10 (0.7 M HCl)
0	0	0	0	0
30	3.0	45.0	36.1	30.0
60	4.1	66.0	54.0	46.2
90	5.0	78.1	66.1	56.8
120	5.2	87.0	76.9	65.1
150	5.3	94.0	83.0	70.0

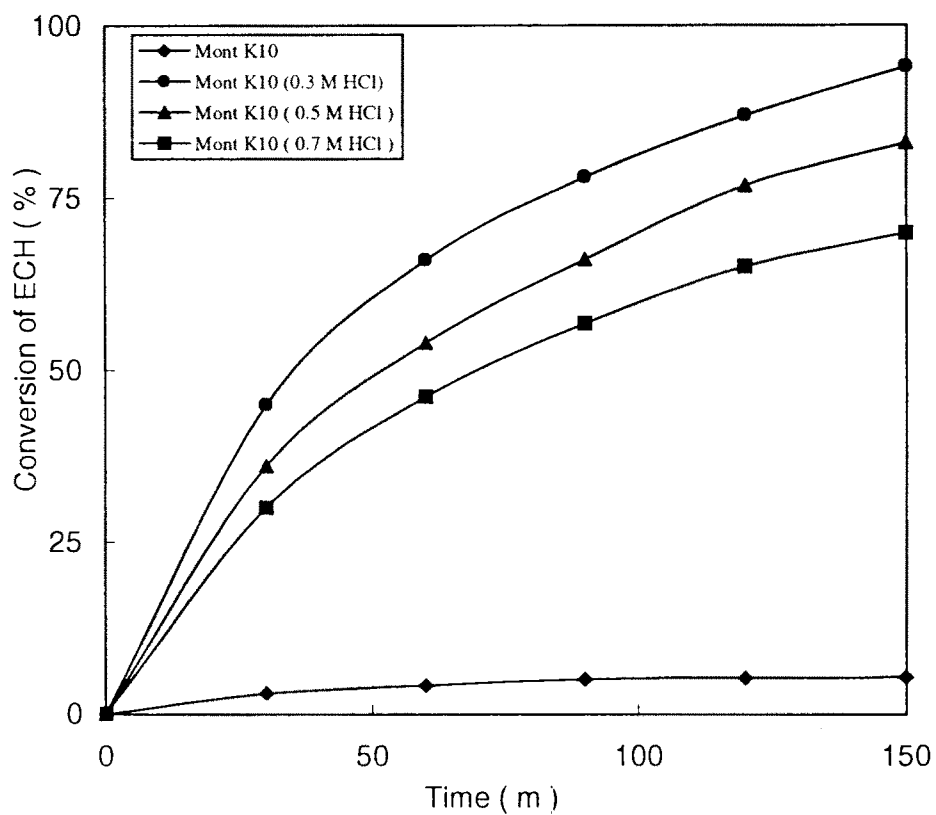


Figure 6.3 Conversion of epichlorohydrin as a function of time on montmorillonite K10 activated in HCl of different concentrations

Catalyst = 0.5g montmorillonite K10

Reaction temperature = 30°C

Epichlorohydrin : Allyl alcohol = 1 : 11.3

epichlorohydrin was found to increase with increase in catalyst weight as shown in Table 6.2 and Figure 6.4.

6.2.3 Effect of reaction temperature

The effect of reaction temperature on the conversion of epichlorohydrin catalysed by montmorillonite K10 (activated in 0.3 M HCl) was investigated in the temperature range of 30°-50°C. In general, as the temperature increased, the conversion of epichlorohydrin also increased. The product was 1-allyloxy-3-chloro-2-propanol and no polymeric by-product was formed. The experimental data shown in Table 6.3. Figure 6.5 indicate the effect of temperature on the conversion of epichlorohydrin.

6.2.4 Kinetic analysis

The reaction followed first order kinetics with respect to epichlorohydrin, as seen from the plot of $\ln (A/A-x)$ vs time at different temperatures which gave straight lines passing through the origin (Table 6.4 and Figure 6.6). The activation energy (E_a) of the reaction calculated from the slope of the Arrhenius plot was 34.8 ± 0.2 kJ/mole. The results are shown in Table 6.5 and Figure 6.7.

In order to understand the mechanism of alcoholysis of epichlorohydrin over acid activated montmorillonite K10 (0.3 M HCl), the value of the adsorption constant on the solid surface was determined from the initial rates of formation of 1-allyloxy-3-chloro-2-propanol at different initial concentrations of epichlorohydrin. The results are shown in Table 6.6 and Figure 6.8.

The experimental data was analysed on the assumption that Langmuir-Hinshelwood mechanism was the most probable one for the

Table 6.2

Effect of catalyst weight on the alcoholysis of epichlorohydrin catalysed by montmorillonite K10 (activated in 0.3 M HCl)

Catalyst = Montmorillonite K10 (activated in 0.3 M HCl)

Mole ratio of epichlorohydrin to allyl alcohol = 1 : 11.3

Reaction temperature = 30° C

Time (m)	% conversion of epichlorohydrin at different catalyst weights			
	0.25 g	0.5 g	0.75 g	1.0 g
0	0	0	0	0
30	27.5	39.8	45.0	55.0
60	37.5	54.0	66.0	73.0
90	43.0	59.8	78.1	86.0
120	45.6	62.0	87.0	95.0
150	47.0	63.6	94.0	100.0

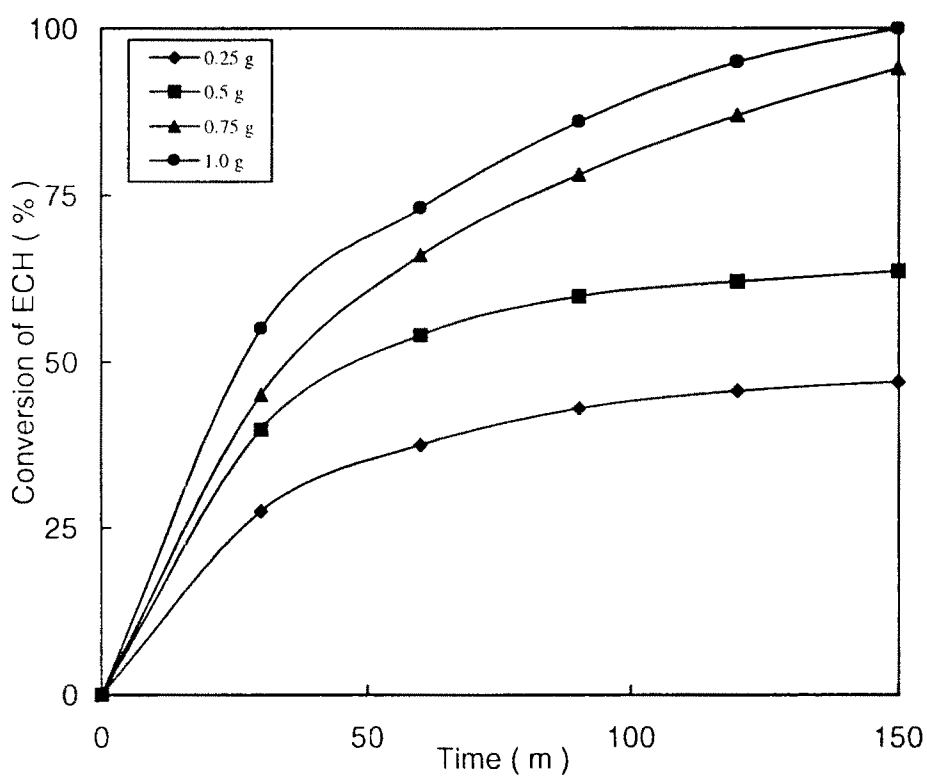


Figure 6.4 Conversion of epichlorohydrin catalysed by montmorillonite K10 (0.3 M HCl) as a function of time at different catalyst weights

Catalyst = Montmorillonite K10 (activated in 0.3 M HCl)
Mole ratio of epichlorohydrin to allyl alcohol = 1 : 11.3
Reaction temperature = 30°C

Table 6.3

Effect of reaction temperature on the alcoholysis of epichlorohydrin catalysed by montmorillonite K10 (activated in 0.3 M HCl)

Catalyst = 0.5g montmorillonite K10 (activated in 0.3 M HCl)
Mole ratio of epichlorohydrin to allyl alcohol = 1 : 11.3

Time (m)	% conversion of epichlorohydrin at different temperatures		
	30 °C	40°C	50°C
0	0	0	0
5	10.0	16.0	22.0
10	18.3	28.0	36.6
15	23.5	36.2	47.0
20	29.0	43.0	55.6
25	34.6	49.4	62.5
30	39.8	54.0	68

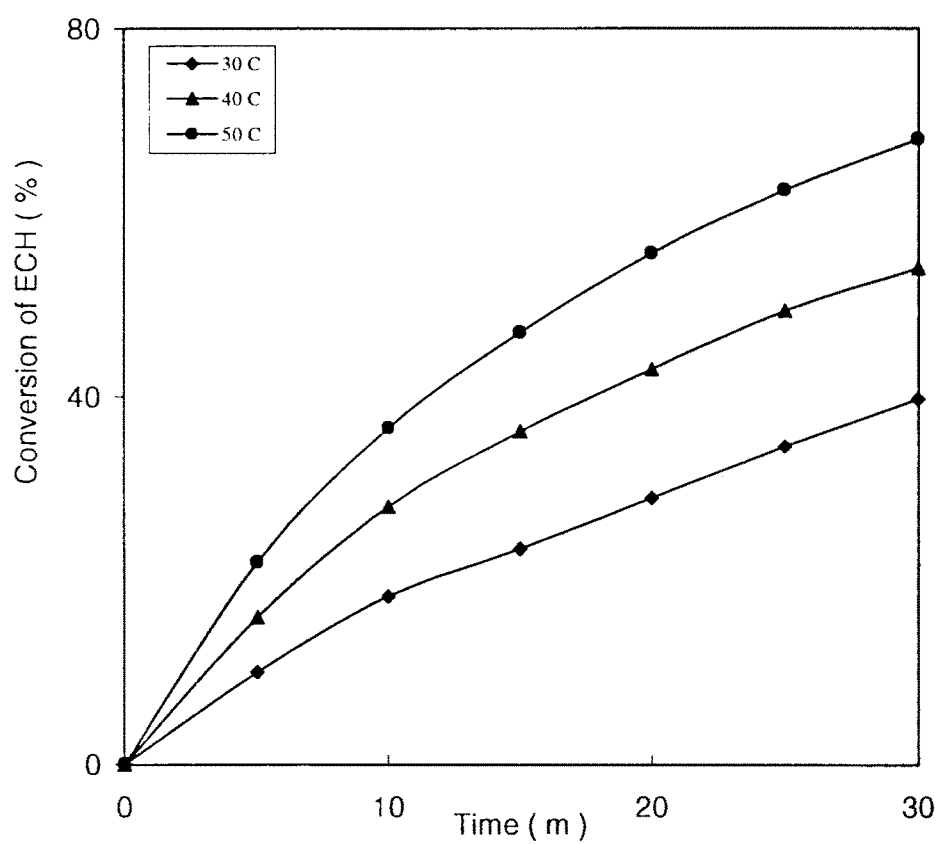


Figure 6.5 Conversion of epichlorohydrin catalysed by montmorillonite K10 as a function of time at different reaction temperatures

Catalyst = 0.5 g montmorillonite K10 (activated in 0.3 M HCl)
Mole ratio of epichlorohydrin to allyl alcohol = 11.3

Table 6.4

Kinetic studies on the alcoholysis of epichlorohydrin catalysed by montmorillonite K10 (activated in 0.3 M HCl)

Catalyst = 0.5 g montmorillonite K10 (activated in 0.3 M HCl)
 Mole ratio of epichlorohydrin to allyl alcohol = 1 : 11.3

Time (m)	30 °C		40 °C		50 °C	
	% yield	Ln (A/A-x)	% yield	Ln (A/A-x)	% yield	Ln (A/A-x)
0	0	0	0	0	0	0
5	10	0.11	16	0.17	22	0.25
10	18.3	0.20	28	0.33	36.6	0.46
15	23.5	0.27	36.2	0.45	47	0.64
20	29	0.34	43	0.56	55.6	0.81
25	34.6	0.43	49.4	0.68	62.5	0.98
30	39.8	0.51	54	0.78	68	1.14

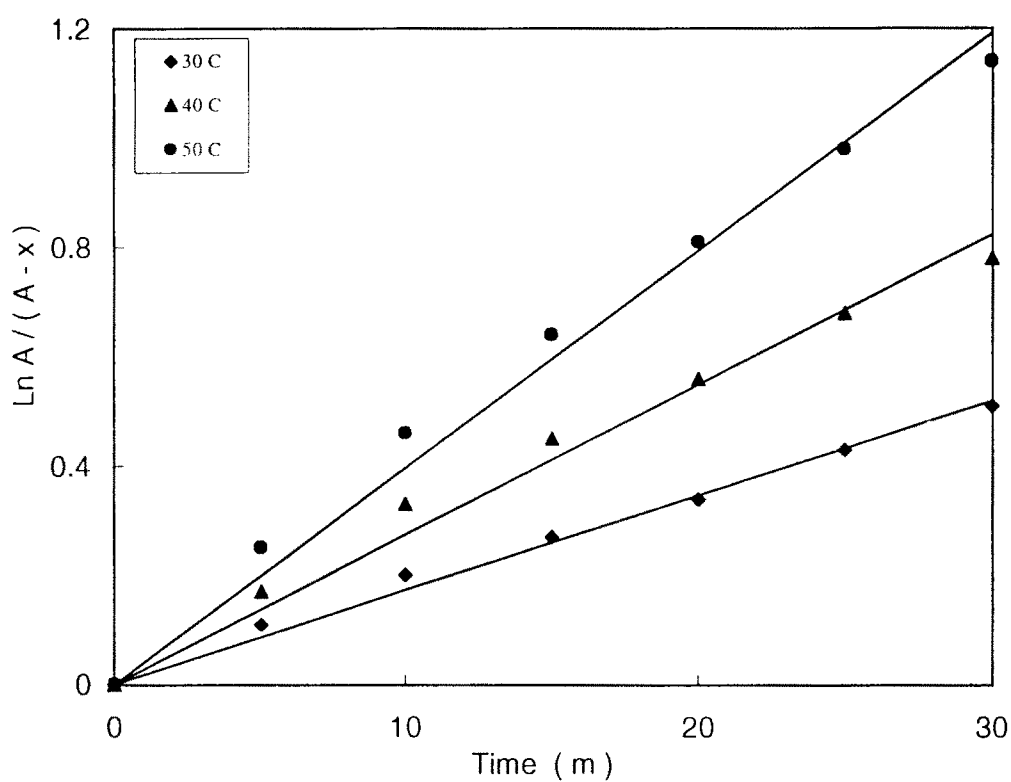


Figure 6.6 Plot of $\ln (A/(A-x))$ vs time for the alcoholysis of epichlorohydrin catalysed by montmorillonite K10 (activated in 0.3 M HCl) at different reaction temperatures

Catalyst = 0.5g montmorillonite K10 (activated in 0.3 M HCl)
Mole ratio of epichlorohydrin to allyl alcohol = 1 : 11.3

Table 6.5

Arrhenius parameter for the alcoholysis of epichlorohydrin catalysed by montmorillonite K10 activated in 0.3 M HCl (cf : Table 6.4)

Temp K	1000K / T	First order rate constant $k \times 10^{-3} \text{ min}^{-1}$	Ln k
303	3.30	18.0	-4.02
313	3.20	30.8	-3.48
323	3.10	41.6	-3.18

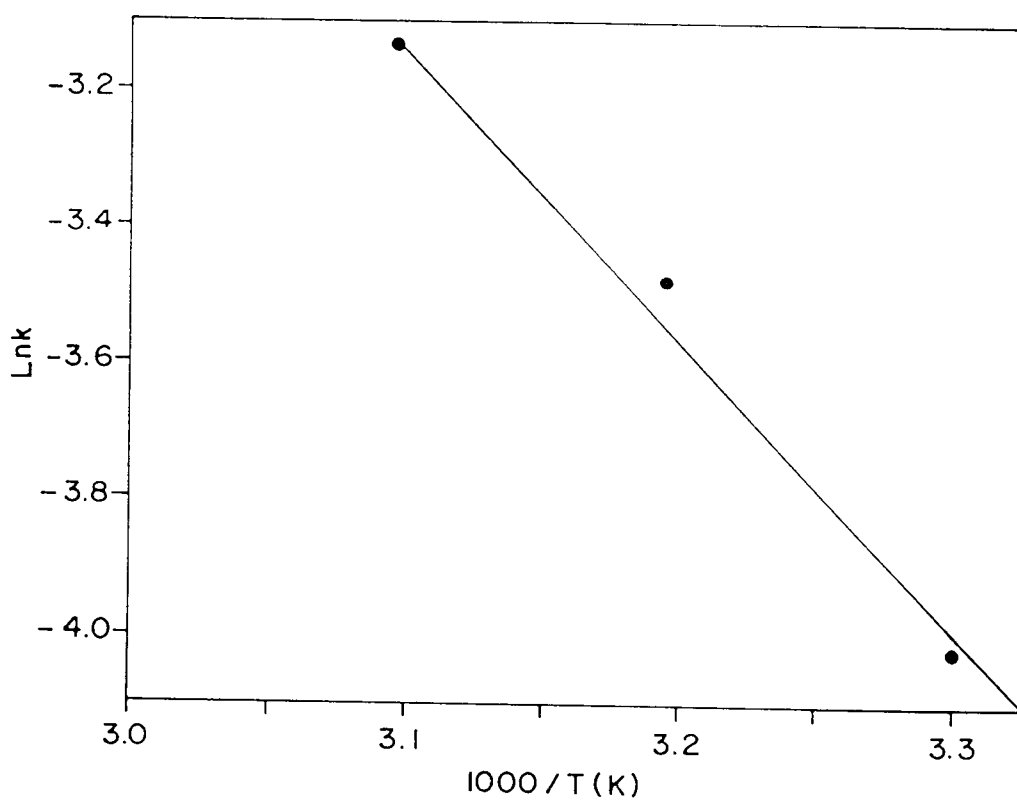


Figure 6.7 Arrhenius plot for the alcoholysis of epichlorohydrin catalysed by montmorillonite K10 (activated in 0.3 M HCl)

Table 6.6

Effect of initial concentration of epichlorohydrin on the alcoholysis of epichlorohydrin catalysed by montmorillonite K10 (activated in 0.3 M HCl)

Catalyst = 0.5 g montmorillonite K10 (activated in 0.3 M HCl)
Reaction temperature = 30 C ; [Allyl alcohol] =147 mM

Time (m)	Concentration of epichlorohydrin (mM)				
	7.69	10.26	12.82	15.38	17.95
0	7.69	10.26	12.82	15.38	17.95
5	7.15	9.39	11.54	14.00	16.6
10	6.69	8.62	10.47	12.90	15.0
15	6.22	8.03	9.81	11.80	13.9
20	5.77	7.49	9.10	10.95	13.0
25	5.38	6.87	8.38	10.21	12.1
30	4.95	6.41	7.72	9.78	11.5

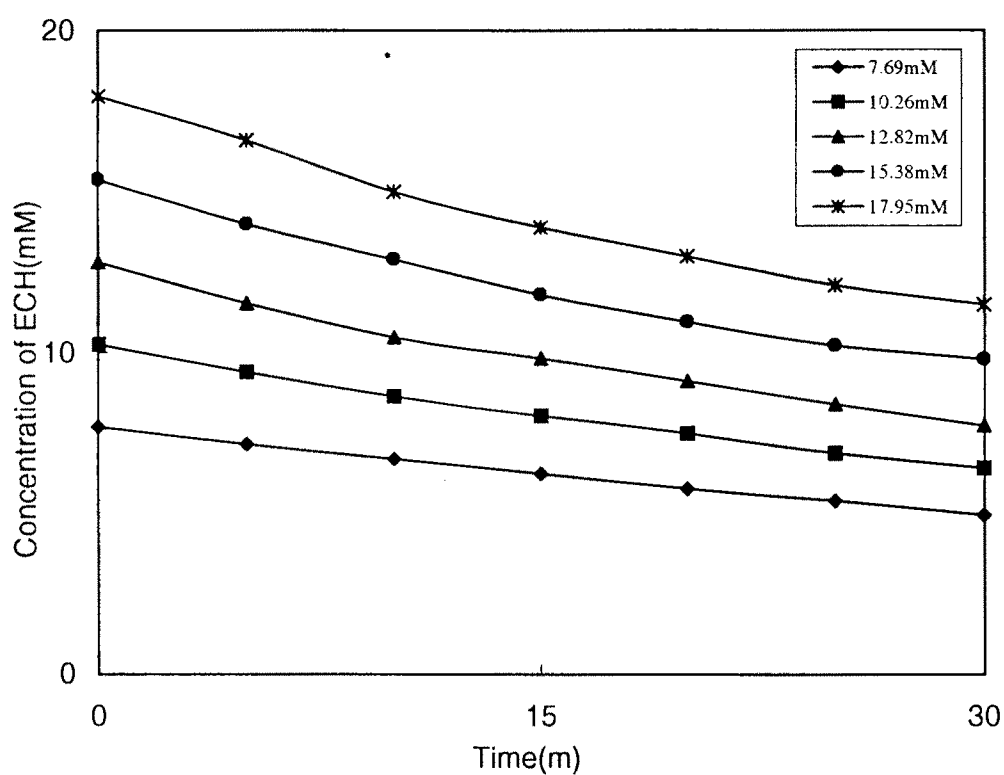


Figure 6.8 Variation of epichlorohydrin concentration as a function of time at different initial concentrations of epichlorohydrin

Catalyst = 0.5 g montmorillonite K10 (activated in 0.3 M HCl)
Reaction temperature = 30°C; [Allyl alcohol] = 147mM

alcoholysis of epichlorohydrin. This assumption was checked by fitting the experimental data into the linear equation in 4.4.

The plot of $1/r$ Vs $1/C_0$ gave a straight line with a positive intercept (Table 6.7 and Figure 6.9). The adsorption equilibrium constant K_a and the specific rate constant k_1 were calculated to be 7.52 M^{-1} and $2.5 \times 10^{-3} \text{ Mmin}^{-1}$ from the slope and intercept respectively. The linearity of the plot indicated that Langmuir-Hinshelwood mechanism is an acceptable one for this reaction.

6.3 ALCOHOLYSIS OF EPICHLOROXYDRIN ON ZINC CHLORIDE SUPPORTED ON MONTMORILLONITE K10

The catalyst sample of zinc chloride supported on montmorillonite K10 (activated in 0.3 M HCl) was examined for its activity towards alcoholysis of epichlorohydrin (13 mM) with allyl alcohol (147 mM), using 0.75 g zinc chloride impregnated on montmorillonite K10 (2 mM/g loading) at 45°C. This catalyst was found to be inactive for alcoholysis of epichlorohydrin with allyl alcohol.

6.4 ALCOHOLYSIS OF EPICHLOROXYDRIN ON DTPA IMPREGNATED ON VARIOUS SUPPORTS

The catalysts were prepared by impregnating DTPA on various supports such as silica MCM-41, titania and acid activated montmorillonite K10. The catalytic activity of the samples towards alcoholysis of epichlorohydrin was studied.

6.4.1 Effect of catalyst loading

The effect of loading of the active component DTPA on the catalytic activity towards alcoholysis of epichlorohydrin was investigated by preparing

Table 6.7

Variation of initial rate of alcoholysis of epichlorohydrin catalysed by montmorillonite K10 (activated in 0.3 M HCl) at different initial concentrations of epichlorohydrin (cf : Table 6.6)

$C_0 \cdot 10^{-3} \text{M}$	$r \cdot 10^{-4} \text{Mm}^{-1}$	$1/C_0 \text{M}^{-1}$	$1/r \text{M}^{-1}\text{m}$
7.69	1.37	130.04	7.32
10.16	1.71	97.57	5.83
12.82	2.24	78.0	4.47
15.38	2.57	65.0	3.80
17.95	2.90	55.71	3.44

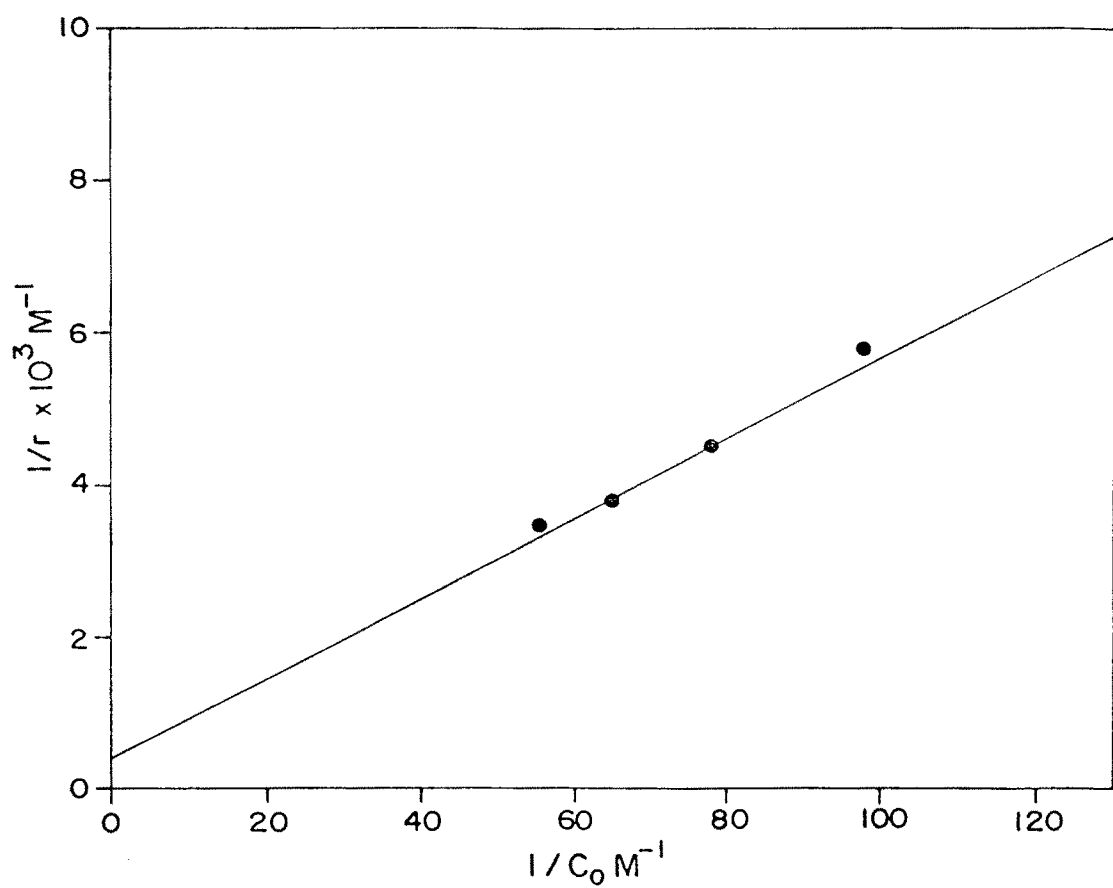


Figure 6.9 Plot of $1/r$ vs $1/C_0$ for the alcoholysis of epichlorohydrin catalysed by montmorillonite K10 (activated in 0.3 M HCl)

catalysts with different concentration of DTPA on silica in the range of 10 to 50 wt% and using 0.4 g catalyst at 30°C. The optimum quantity of loading of DTPA was found to be 40 wt%. The results are shown in Table 6.8 and Figure 6.10.

6.4.2 Effect of catalyst weight

The effect of catalyst weight on the alcoholysis of epichlorohydrin (13 mM) with allyl alcohol (147 mM) was investigated by varying the amount of DTPA impregnated on silica in the range of 0.2 to 0.6 g. The conversion of epichlorohydrin was found to increase, with the increase in amount of catalyst weight as showing in Table 6.9 and Figure 6.11. The optimum catalyst weight was found to be 0.4 g.

6.4.3 Catalytic activity of DTPA impregnated on various supports

The catalyst samples of 40wt% DTPA supported on montmorillonite K10, silica, titania and MCM-41 were examined for their activity towards alcoholysis of epichlorohydrin (13 mM) with allyl alcohol (147 mM), using 0.4 g catalyst at 30°C. The results are shown in Table 6.10 and Figure 6.12.

6.5 DISCUSSION

The various results obtained in the present study with regard to the alcoholysis of epichlorohydrin may be summarised as follows :

1. The various catalysts prepared in the present study may be classified into
 - (i) acid activated montmorillonite K10 (activated in 0.3 M, 0.5 M, 0.7M and 1 M HCl)

Table 6.8**Effect of DTPA loading on silica on the alcoholysis of epichlorohydrin**

Catalyst = 0.5g DTPA impregnated on silica
 Mole ratio of epichlorohydrin to allyl alcohol = 1 : 11.3
 Reaction temperature = 30°C

Time (m)	% conversion of epichlorohydrin at different DTPA loadings				
	10%	20%	30%	40%	50%
0	0	0	0	0	0
15	9	11	17.6	24	27.5
30	14.2	20	30	40.1	44
45	17.6	26.9	37.5	50	53
60	20	30	41	54.2	58

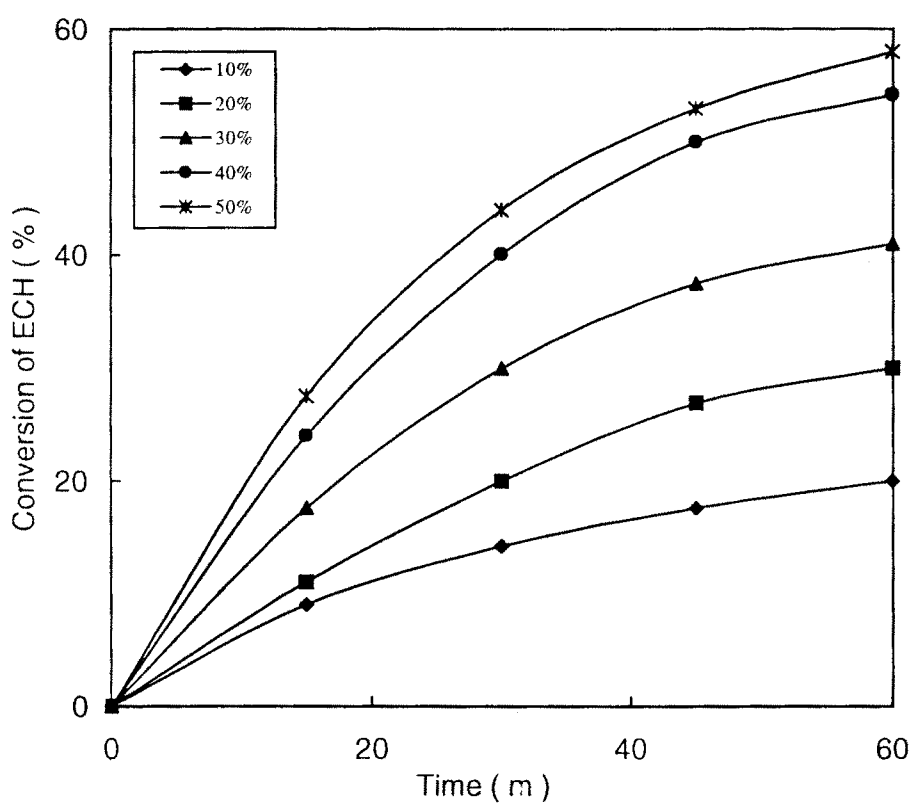


Figure 6.10 Conversion of epichlorohydrin catalysed by DTPA impregnated on silica as a function of time at different DTPA loadings

Catalyst = 0.5g DTPA impregnated on silica
Mole ratio of epichlorohydrin to allyl alcohol = 1 : 11.3
Reaction temperature = 30°C

Table 6.9

**Effect of catalyst weight on the alcoholysis of epichlorohydrin
catalysed by DTPA impregnated on silica**

Catalyst = DTPA impregnated on silica (40 wt%)

Reaction temperature = 30°C

Mole ratio of epichlorohydrin to allyl alcohol = 1 : 11.3

Time (m)	% conversion of epichlorohydrin at different catalyst weights		
	0.2 g	0.4 g	0.6 g
0	0	0	0
15	14	24	35
30	19.1	40.1	52.6
45	24	50	61
60	27.8	54.2	67.8

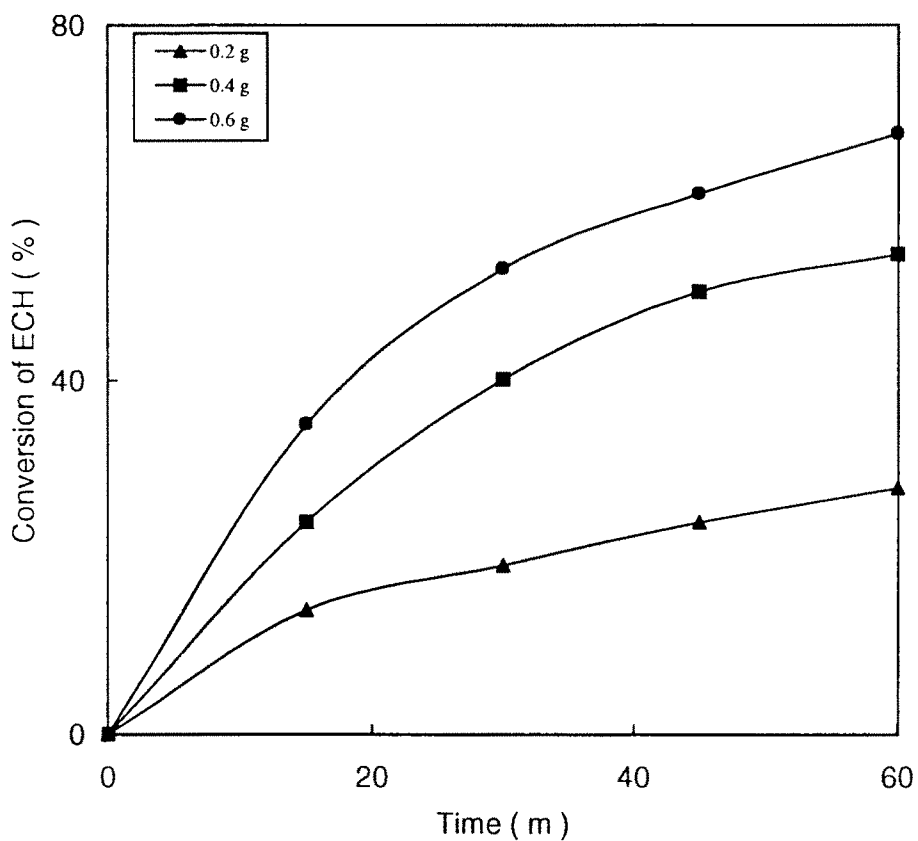


Figure 6.11 Conversion of epichlorohydrin catalysed by DTPA impregnated on silica as a function of time at different catalyst weights

Catalyst = DTPA/silica (40 wt% DTPA)

Mole ratio of epichlorohydrin to allyl alcohol = 1 : 11.3

Reaction temperature = 30°C

Table 6.10

**Catalytic activity of DTPA impregnated on various supports
for the alcoholysis of epichlorohydrin**

Catalyst = 0.4g (40 wt %) ; Reaction temperature = 30°C

Mole ratio of epichlorohydrin to allyl alcohol = 1 : 11.3

Time (m)	Conversion of epichlorohydrin (%)			
	DTPA / TiO ₂	DTPA / K10 (0.3M HCl)	DTPA / SiO ₂	DTPA / MCM -41
0	0	0	0	0
15	21.0	22.0	24.0	37.5
30	31.0	34.6	40.1	50.0
45	37.9	43.0	50.0	57.7
60	44.6	48.0	54.2	64.0

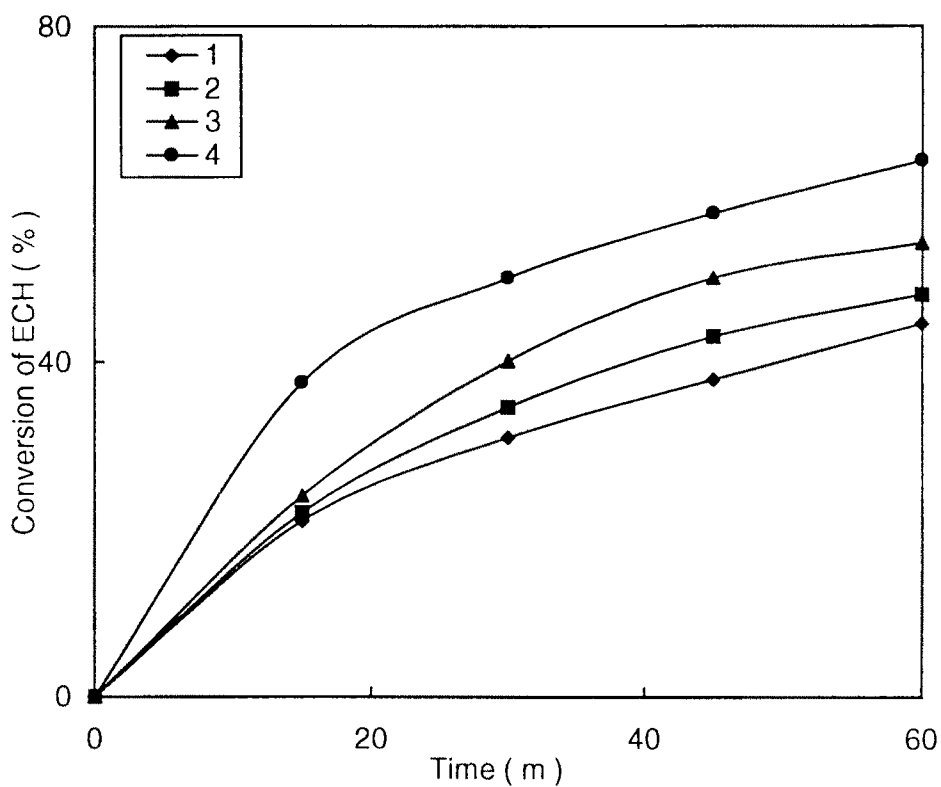


Figure 6.12 Conversion of epichlorohydrin as a function of time over DTPA impregnated on various supports

1 = DTPA / Titania ; 2 = DTPA / montmorillonite K10 ;

3 = DTPA / Silica ; 4 = DTPA / MCM-41

Catalyst = 0.4g (40 wt % DTPA)

Mole ratio of epichlorohydrin to allyl alcohol = 1 : 11.3

Reaction temperature= 30°C

- (ii) ZnCl_2 impregnated on montmorillonite K10 (activated in 3 M HCl)
 - (iii) DTPA impregnated on acid activated montmorillonite K10 (0.3 M HCl), silica, MCM-41 and titania.
2. Montmorillonite K10 was found to be less active for the alcoholysis of epichlorohydrin with allyl alcohol (about 5%). But treatment of montmorillonite K10 with hydrochloric acid (0.3 M HCl) tremendously increased its catalytic activity (94% conversion) towards alcoholysis of epichlorohydrin.
 3. The study on the effect of acid activation of montmorillonite K10 (0.3 M, 0.5 M, 0.7 M and 1 M HCl) on alcoholysis of epichlorohydrin showed that montmorillonite K10 activated in 0.3 M HCl exhibited higher catalytic activity.
 4. ZnCl_2 impregnated on montmorillonite K10 (activated in 3 M HCl) failed to catalyse alcoholysis of epichlorohydrin.
 5. Supported DTPA catalysts were found to be active for alcoholysis of epichlorohydrin. Among various supported DTPA catalysts, DTPA impregnated on MCM-41 showed higher activity towards alcoholysis of epichlorodrin.

6.5.1 Correlation of catalytic activity and surface acidity

Montmorillonite K10 has been shown to possess weak acid sites and Bronsted acid sites. Acid activation of montmorillonite K10 by treatment with hydrochloric acid (0.3 M, 0.5 M, 0.7 M and 1 M) enhanced the strength of Bronsted acid sites, as indicated by the shift in peak temperature as seen in DSC thermogram. The presence of strong Bronsted acid sites facilitated the alcoholysis of epichlorohydrin. Though the strength

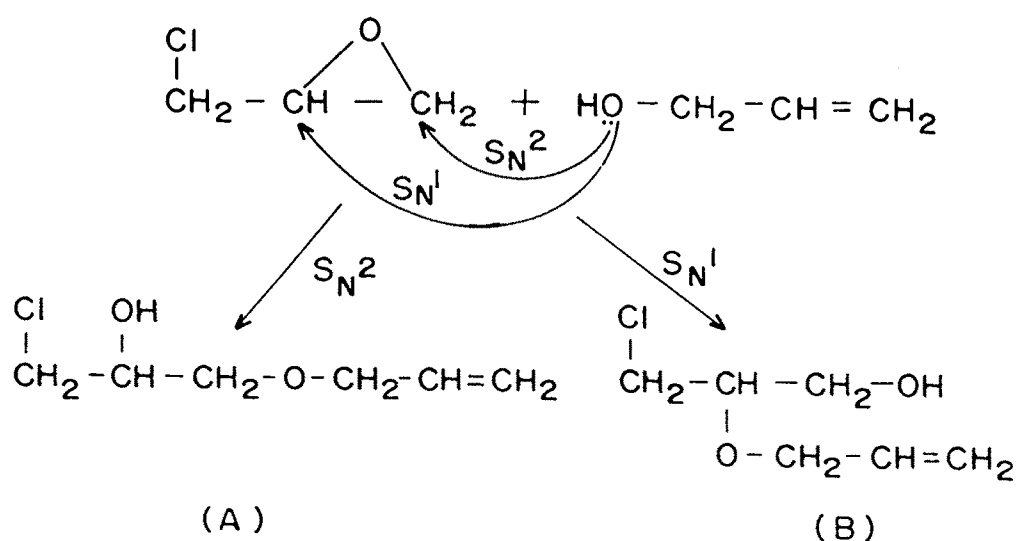
of Bronsted acidity was almost the same for montmorillonite K10 activated in 0.3 M, 0.5 M and 0.7 M HCl, as can be seen from the DSC thermogram data (Table 3.6), the catalytic activity of montmorillonite K10 activated with 0.3 M HCl was higher, which can be attributed to the higher density of Bronsted acid sites on its surface.

DTPA impregnated on silica and MCM-41 were found to possess higher density of Bronsted acidic sites, which facilitated alcoholysis of epichlorohydrin.

6.5.2 Product analysis and mechanism of alcoholysis of epichlorohydrin over solid acid catalysts

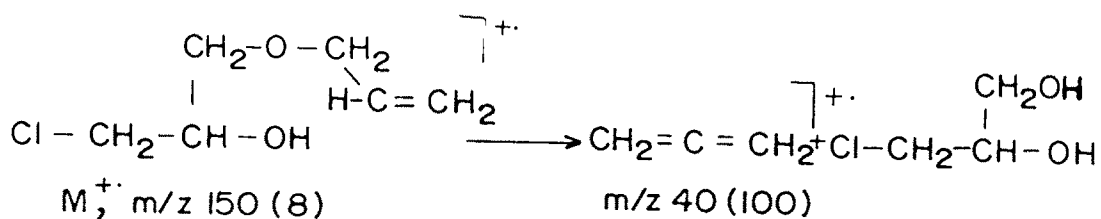
The confirmation of the product obtained and the mechanism of the reaction for alcoholysis of epichlorohydrin can be derived on the basis of the mass spectral analysis of the product.

Alcoholysis of epichlorohydrin with allyl alcohol can proceed through either of the following two mechanisms :

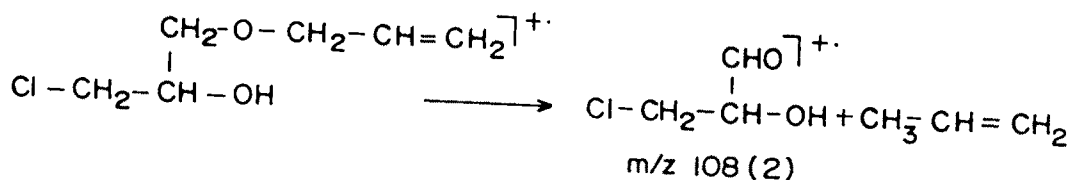


The mass spectrum of the product as presented in Figure 6.1 showed m/z values with their relative abundance for the significant peaks as 150(8), 108(2), 92(5), 80(30), 70(18), 58(50) and 40(100).

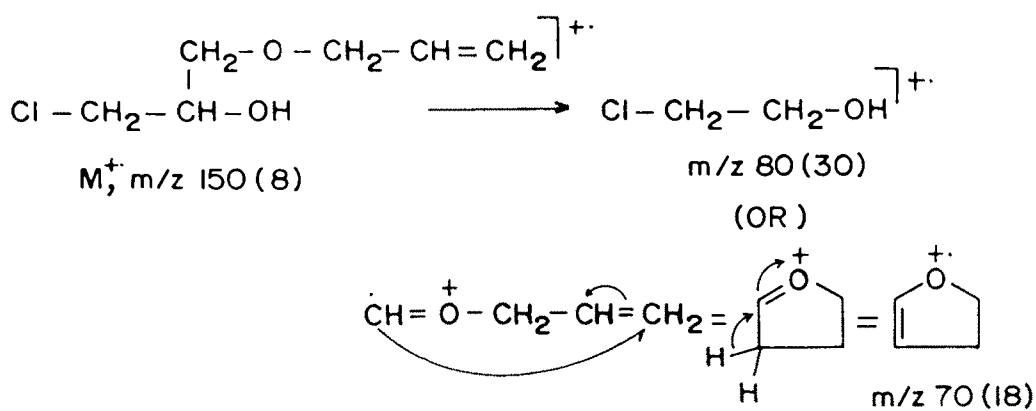
The peak at m/z 150(8) has been attributed to the molecular ion. The most abundant ion having the m/z value of 40 corresponds to $\text{CH}_2=\text{C}=\text{CH}_2$ and its formation is illustrated below.



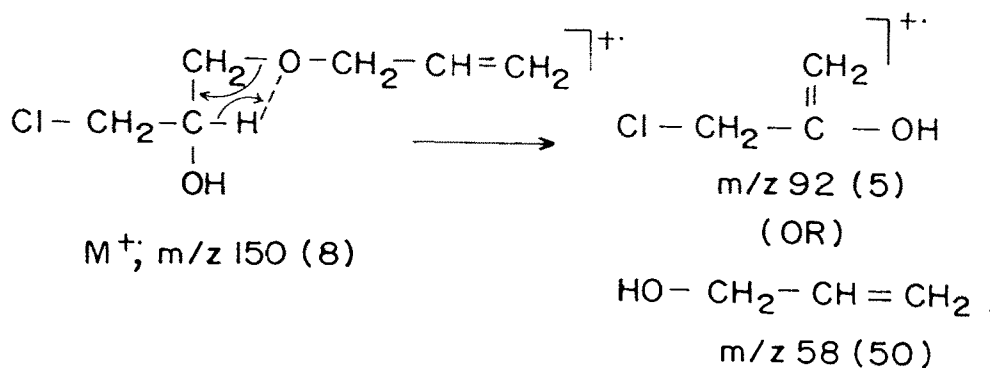
The peak corresponding to m/z value of 108(2) has been assigned to compound A arising as a result of the cleavage of C-O bond followed by the migration of one hydrogen atom.



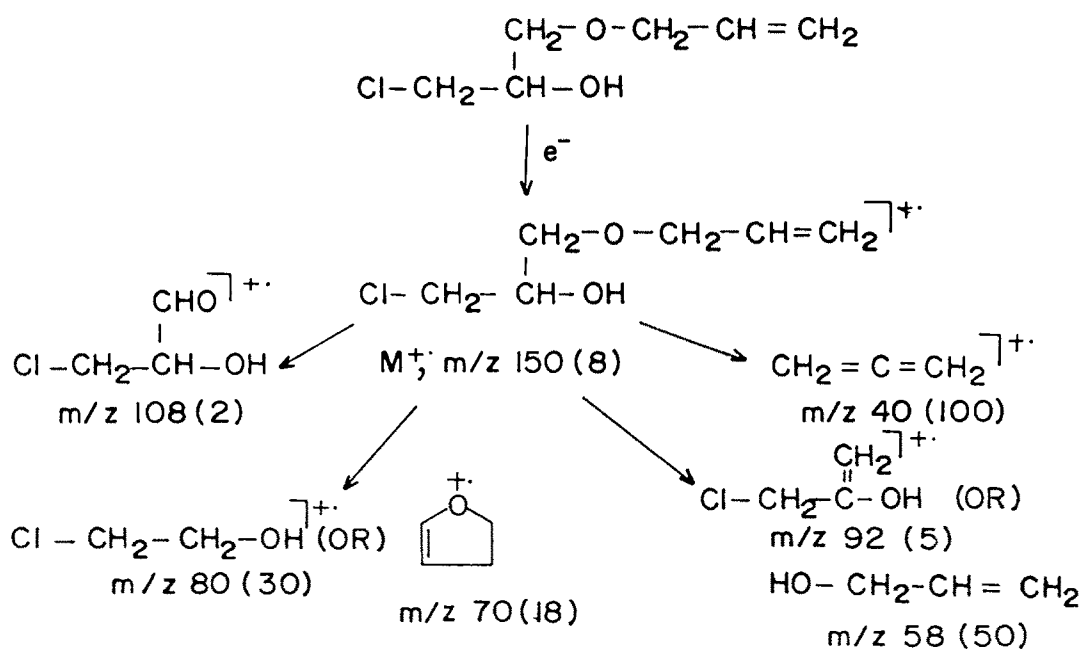
The fragment ions at m/z 80(30) and 70(18) are rationalised to be resulting from the cleavage of the $\text{C}_1\text{-C}_2$ followed by the migration of β -hydrogen. The sequence of the cleavage can be written as



The ions at m/z 92(5) and at m/z 58(50) are postulated to have been formed by the cleavage of C-O bond followed by the migration of β -hydrogen atom.



The formation of fragments at m/z 58, m/z 70, m/z 80 and at m/z 92 supports structure (A) for the product of alcoholysis of epichlorohydrin. The entire fragmentation pattern for the mass spectral analysis of the compound A is shown in the following page.



The product A could have been obtained only if the reaction had proceeded by an S_N2 mechanism. An S_N1 product would have resulted only if a stable carbenium ion intermediate had been formed in the first step. Acidic conditions were found to favour only abnormal ring opening of epichlorohydrin (Parker and Isaacs, 1959). But, under the present experimental conditions, the normal ring opening product, 1-allyloxy-3-chloro-2-propanol was obtained. Since epichlorohydrin does not form a stable carbenium ion even under strongly acidic condition, sterically less hindered epoxy carbon is attacked by alcohol, yielding a normal ring opening product by proceeding via S_N2 mechanism. In addition, more bulky nucleophile (allyl alcohol) favours only an S_N2 product. This behaviour has also been observed in the case of alcoholysis of epichlorohydrin catalysed by heteropolyacid under homogeneous conditions (Izumi and Hayashi, 1980).

6.6 CONCLUSIONS

The following conclusions can be arrived at, on the basis of the present study on alcoholysis of epichlorohydrin over modified clay and supported DTPA catalysts.

1. Montmorillonite K10 was found to be less active for alcoholysis of epichlorohydrin.
2. Treatment of montmorillonite K10 with hydrochloric acid enhanced the catalytic activity towards alcoholysis of epichlorohydrin.
3. On comparing catalytic activity of montmorillonite K10 activated in hydrochloric acid of different concentrations, (0.3 M, 0.5 M, 0.7 M and 1 M) montmorillonite K10 activated in 0.3M HCl was found to be highly active.
4. $ZnCl_2$ impregnated on montmorillonite K10 (activated in 3 M HCl) was not active for the alcoholysis of epichlorohydrin.
5. Supported DTPA catalysts were active for alcoholysis of epichlorohydrin. DTPA impregnated on MCM-41 was found to show higher activity.
6. Strong Bronsted acid sites facilitated alcoholysis of epichlorohydrin.
7. The exclusive formation of 1-allyloxy-3-chloro-2-propanol confirmed that the alcoholysis of epichlorohydrin with allyl alcohol proceeded through S_N2 mechanism.

8. The kinetic analysis for alcoholysis of epichlorohydrin with allyl alcohol on acid activated montmorillonite K10 showed that the reaction followed first order kinetics with respect to epichlorohydrin and Langmuir-Hishelwood adsorption seemed to be the most probable mechanism.