

# Kinetic Studies for Synthesis of Organic Acid (Acetic Acid)

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**Abstract:** *Almost all the transformers in power systems contains transformer oil. Transformer oil acts as an insulating oil, also it maintains the power flow and voltage level conversion in the system. Due to ageing, high temperature, oxidation and other contaminants the oil gets degraded over the time. Therefore, for efficient power supply we should determine the behaviour of transformer oil under different uncertainties which can happen during the life span of oil. In this paper we have measured breakdown voltages (BDV) at different conditions with the help of BDV kit. During the experiments we found that the aged oil which has undergone routine filtration has significant more dielectric strength than the fresh oil. Also, the metal particles in the oil affects the BDV value drastically.*

**Keywords:** Transformer, Insulating oil, BDV, Dielectric strength, Contamination.

## I. INTRODUCTION

Esters are the result of the interaction between acids and alcohols in their most basic form. There are tens of thousands of distinct esters. commercially available for a wide variety of applications. In the synthetic world, lubrication is a tiny yet important class of chemicals. In severe cases, esters have shown to be quite beneficial.

Applications for the environment Acetic acid's ester Isobutanol (isobutyl acetate) is found in isobutyl acetate, large number of industrial uses Butyl acetates are a kind of butyl acetate that may be found in Mostly used as lacquer and varnish solvents. Its solvent capacity and low relative volatility make it suitable for adjusting evaporation rate and viscosity in coatings. It's particularly helpful as a solvent or thinner for acrylic polymers and vinyl resins, as a reaction medium for adhesives, and as a solvent for acrylic polymers and vinyl resins. In numerous applications and cosmetic compositions, it is used as a process solvent, leather dressings, and a process solvent [1-4].

Many researchers have investigated the esterification of carboxylic acids with alcohols in the presence of acid catalysts [5-12].

Salts like quaternary ammonium salt have also been utilised as a catalyst in carboxylic acid esterification [13]. Few mesoporous silicas have been functionalized with sulfonic acid groups, yielding efficient catalysts for the production of bisfurylalkanes and polyol esters. Typical homogeneous catalysts such as H<sub>2</sub>SO<sub>4</sub>, HCl, and CISO<sub>3</sub>OH are utilised, although separation is a challenge because to their miscibility with the reaction media. As a result, heterogeneous catalysts have gained popularity as a nonpolluting, non-corrosive, and long-acting alternative catalyst. Alime investigated the esterification of acetic acid with iso-butanol in the liquid phase using ion exchange resins [16]. Ragini and his coworkers had done their homework. The kinetics of diluted acetic acid esterification [17] with pure 2-ethyl-1-hexanol Exchange of cations resin is regarded as a significant catalyst in the production of esterification, for example, is a liquid-phase process.

[18] Etherification, for example. The kinetics of acetic acid esterification in the presence of a strong cation-exchange resin were investigated by Zheng and Zeng. They looked into the effects of various factors and came up with the second order rate equation [19, 20]. Meanwhile, a study on the esterification of acetic acid with propyl alcohol over a heterogeneous catalyst, Dowex Monosphere 650 C, was published [21], which detailed the reaction process and determined kinetic and thermodynamic parameters. This reaction has also been examined in the presence of solid acid Cationexchange resins by Liao and colleagues [22-24]. Gangadwala et al [1] have also carried out acetic acid esterification in the presence of ion exchange with n-butanol resins as catalysts in the range of temperatures at a lower molar ratio, the temperature ranges from 343.15 to 363.15 K. The rest of the parameters remain constant Despite several obstacles, research on this beneficial

response, high-level work as with the high molar ratio, the molar ratio is relatively restricted. The rate of reaction increases as the molar ratio increases, and the reaction time slows down as well. There are a variety of options. Research on alternative types of esterification Ion exchange resin-catalyzed reactions [25-34]

## II. MATERIALS AND PROCEDURES

### 2.1 Materials Employed

Acetic acid, n-butanol, and iso-butanol were all used in the study. Bought from Merck with a purity promise of Sodium Hydroxide (s.d. fine chemicals) is 99.8% pure. Phenolphthalein indicator, ltd., Boisar), (Qualigence fine chemicals, Mumbai). They're all of them were utilised without being purified any further. Amberlys as a starting point, Rohm and Haas' -15 was utilised. The catalyst, as well as its associated properties, are explain in Table 1[35].

### 2.2 Experimental Technique and Setup

The esterification of acetic acid was investigated in a 250 mL three-necked glass reactor. Batch mode of operation A reflux condenser is a device that reduces the amount of water in to prevent the loss of volatile chemicals, this method was adopted. In the water, the ion exchange resin was suspended. Using a stirrer, agitate the reaction mixture. Acetic The initial concentration of acid was employed. 1.93 mol/L and the reaction's starting volume the total volume of the combination was around 100 mL. A certain quantity of acetic acid and a catalyst are required. were injected into the reactor and heated to the desired temperature that you want

The temperature within the reactor was precisely regulated to within 0.5K. Butanol was injected to the reactor at the same temperature as the required temperature, and this was used as the zero time for the run. Volumetric measurements were taken on all of the reactants in the reactor. At regular intervals, samples small enough to be considered inconsequential in comparison to the amount of the reaction mixture were taken to monitor the reaction's progress.

## III. RESULT AND DISCUSSION

### 3.1 Kinetic Modeling

The general reaction rate for this reaction rate for this reaction written as-



A= acetic acid, B= butanol, E= butyl acetate and W=water

**Table 1:** Physicochemical properties of Amberlist 15

Skeleton	Styrene-Divinyl benzene
Type	Strong acid
Structure	Macro reticular
Functional group	Sulfuric (SO <sub>3</sub> H)
Particle size	0.600-0.685µm
Concentration of acid sites	4.53 m equiv/g. of dry resin
Internal porosity	0.36
Ionic form	Hydrogen

### 3.1 Elimination of Mass Transfer Resistance

Mass Transfer Resistance is Eliminated

External diffusion does not usually control the overall rate in reactions catalysed by ion exchange resins unless the agitation speed is very low or the reaction mixture is very viscous, according to previous studies [6-8, 18], and intraparticle diffusion resistances of the reactant in ion exchange resins are not as important. As a result, all of the studies were carried out with ion exchange resin supplied by the manufacturer (Rohm and Hass Co.) and at a constant 500 rpm.

### 3.2 Effect of Catalyst Loading

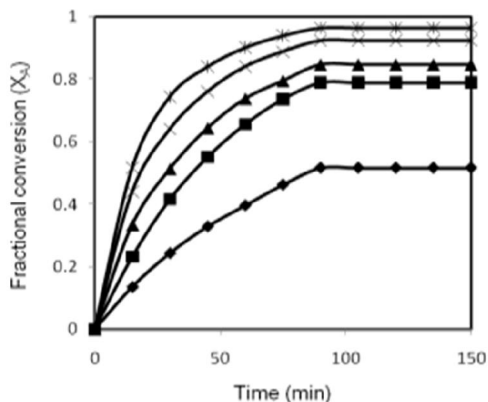
Figures 1–2 depict the influence of catalyst loading on esterification rate. The catalyst loading ranged from 4% to 11% (22.43 kg/m<sup>3</sup> to 139.6 kg/m<sup>3</sup>) for acetic esterification reactions while maintaining the acid with n butanol and isobutanol

other characteristics are kept constant (molar ratio 1:5) and 366.15 K in temperature). The transformation of acetic acid concentrations as a function of time at various concentrations

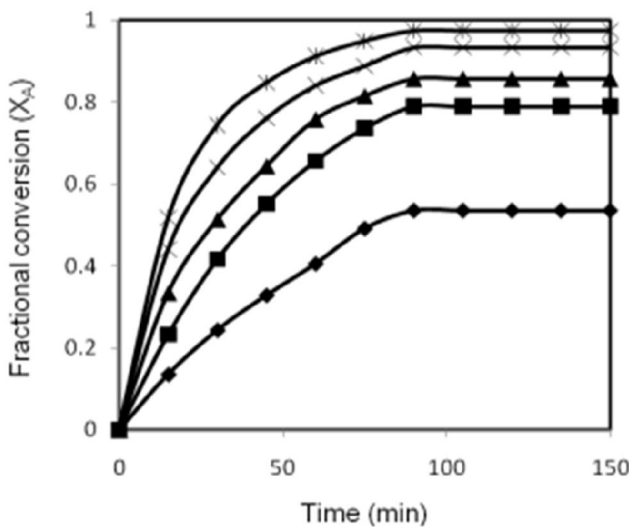
Figure 1 shows the catalyst loadings for nbutanol at 366.15 K and Figure 2 shows the loadings for isobutanol at 366.15 K. It was discovered that as the number of people using the internet grows, so does the number of people using the internet as the catalyst is loaded, the rate of acid conversion rises. With a rise in the number of active sites at a higher level, The rate of mass transfer is high when catalysts are loaded.

**3.3 Effect of Molar Ratio**

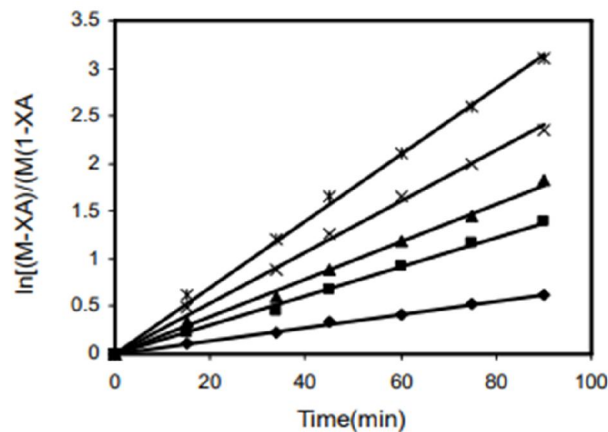
The initial molar ratios of alcohols to acetic acid were 1:3, 1:5, and 1:10 to evaluate the influence of the initial molar ratio on acetic acid conversion. Both n butanol and isobutanol have a 1:10 ratio.



**Figure 1:** Effect of catalyst loading (kg/m<sup>3</sup>). Temperature: 366.15 K, molar ratio (AA: NB): 1:5, □ 139.6, × 112.2, ▲ 89.7, ■ 67.3, ◆ 22.43.



**Figure 2:** Effect of catalyst loading (kg/m<sup>3</sup>). Temperature: 366.15K, molar ratio (AA: IB): 1:5, × 112.2, □ 139.6 ▲ 89.7, ■ 67.3, ◆ 22.43



**Figure 3:** Effect of catalyst loading (kg/m<sup>3</sup>).L.H.S of eq. 9 vs. Time.Temperature: 366.15 K, molar ratio (AA: NB): 1:5,  $\times$ 112.2 ,  $\circ$  139.6 ,  $\blacktriangle$  89.7,  $\blacksquare$  67.3,  $\blacklozenge$ 22.43

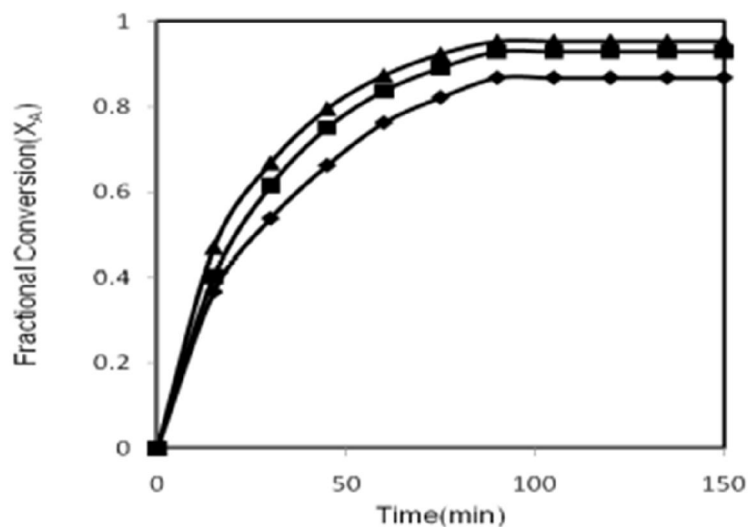
Increases in catalyst loading, temperature, and molar ratio occur when the catalyst loading, temperature, and molar ratio rise. The experimental data was simulated using the LHHW model.

n-butanol and isobutanol reactivity towards the butyl acetate is made by esterifying butyl acetate. The interaction of acetic acid with these alcohols was investigated. When various alcohols are compared, it is clear that activation is the most important factor. In the case of nbutanol, energy decreases from 28.45 kJ/mol to 23.29 kJ/mol in the case of isobutanol.

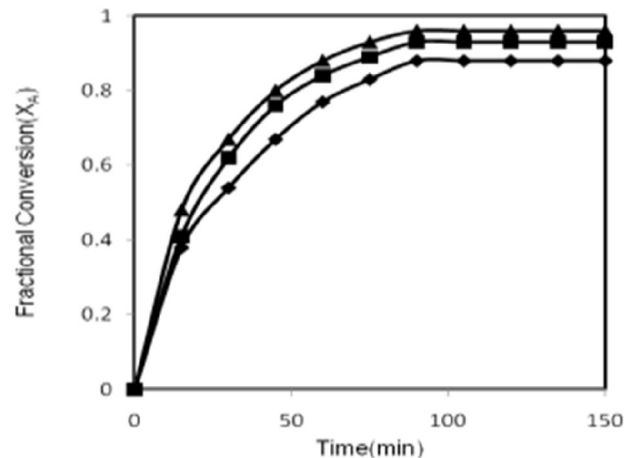
### 3.4 Effect of Temperature

The esterification of acetic acid with n butanol and Isobutanol on Amberlyst 15 at various temperatures and with various solvents produced the following findings. The reactant has a fixed beginning molar ratio of 1:5.

8 and Figures 9 show the results. It was discovered that



**Figure 4:** Conversion XA versus Time for different molar ratio of (AA: NB) for 112.2 kg/m<sup>3</sup> catalyst loading 366.15K,  $\times$ 1:10,  $\blacktriangle$  1:5,  $\blacksquare$  1:3



**Figure 5:** XA versus Time for different molar ratio for (AA: IB) for 112.2 kg/m<sup>3</sup> catalyst loading at 366.15K. , ▲ 1:10, ▲ 1:5, ■ 1:3

The absence of mass transfer effects is indicated by the fact that conversion rises with temperature. Roy and Bhatia [31] found a similar pattern in the data. Benzyl alcohol is used to esterify acetic acid. Both esterification processes occurred over Amberlyst 15

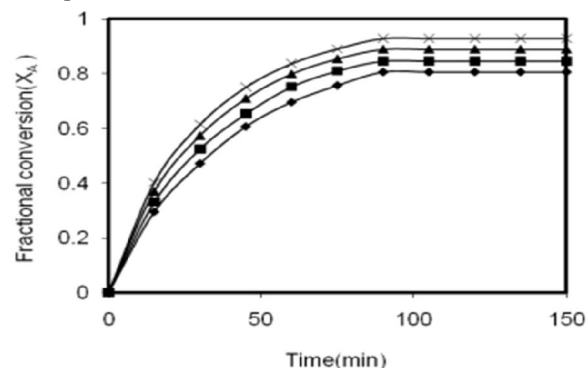
The experiments were conducted out in a temperature range of 0°C to +20°C. The temperature ranges from 351.15 to 366.15 K. The importance of temperature cannot be overstated, since it is necessary for a variety of processes. Identify the reaction's activation energy. The (k) data on observed reaction rate constants temperatures were adjusted to match the environment.

The model (Eq.13) and the Arrhenius-type equation (frequency factor),  $k_0$  (parameters), and  $k_0$  (parameters). (Activation energy) were calculated with the use of a linear regression model.

For n-butanol and isobutanol, the activation energy,  $E_0$ , was found to be 28.45 kJ/mol and 23.29 kJ/mol, respectively. For nbutanol and iso-butanol, the frequency factor,  $k_0$ , was determined to be 0.033 min<sup>-1</sup> and 0.082 min<sup>-1</sup>, respectively. A graph of  $-\ln$  at constant acid and alcohol concentrations,  $k$  vs  $1000/T$  concentrations, a straight line with a slope of is formed. (E/R) as seen in Figure 10.

#### IV. CONCLUSION

The kinetics of acetic acid esterification with n-butanol and isobutanol catalysed by Amberlyst 15 were investigated in this work. Investigated the rate of response was discovered



**Figure 6:** XA versus Time for different temperatures for (AA: NB) for 112.2 kg/m<sup>3</sup> catalyst loading at molar ratio 1:5, ×366.15K, ▲ 361.15K, ■ 356.15 K, ● 351.15 K

A yield of 5.3 g/g mol of acetic acid was produced using the catalyst. For both reactions, the rate constants were obtained by graphing the LHS of Equation (9) vs. t as a function of time as seen in Figures 3 and 4, The values of k are as follows: For both n-butanol and isobutanol, see table 2. In addition, Figure 5 and Table 2 show that Isobutanol's rate constant, k, is

larger than n-butanol. The k values were compared to the catalyst's weight was calculated, and it was discovered that there was a linear rise in k as w increased. (See Figure 5)

#### 4.1 Nomenclature

- B Butanol
- NB n-Butanol
- IB Iso-butanol
- AA Acetic acid
- K Rate constant for esterification
- CA Concentration of AA in the bulk at time  $t=0$  (mol/L)
- CB Concentration of B in the bulk(mol/L)
- CAS Concentration of AA at the surface of the catalyst, (mol/L)
- CBS Concentration of B at the surface of the catalyst, (mol/L)
- w Catalyst loading, (kg/m<sup>3</sup>)
- t Time, minutes
- T Temperature
- V Volume of the reaction mixture(L)
- M Molar ratio of alcohol to acid
- XA Fractional conversion of AA
- K Equilibrium rate constant
- Kw Adsorption rate constant for water
- KB Adsorption rate constant for alcohol
- $\alpha P$  Surface area per unit volume of the catalyst, m<sup>2</sup>/m<sup>3</sup>
- $\eta$  Effectiveness factor, Dimensionless
- k<sub>0</sub> Frequency factor (min<sup>-1</sup>)
- E<sub>1</sub> Activation energy (kJmol<sup>-1</sup>)
- k<sub>LSA</sub> Solid liquid mass transfer coefficient for AA, m/s
- k<sub>LSB</sub> Solid liquid mass transfer coefficient for NB and IB, m/s

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