

EXPERIMENT NO. 1

Rate Study in a Plug Flow Reactor

Object:

- (1) To determine the order of reaction between sodium hydroxide and ethyl acetate using a plug flow reactor.
- (2) To find the rate constant at a particular temperature.

Theory:

Stoichiometric Equation: $\text{NaOH} + \text{CH}_3\text{COOC}_2\text{H}_5 \rightarrow \text{CH}_3\text{COONa} + \text{C}_2\text{H}_5\text{OH}$

(A) (B) (C) (D)

Mole balance: $\frac{V_R}{F_{A_0}} = \int_0^{X_A} \frac{dX_A}{-r_A}$

Rate Equation: $-r_A = k_2 C_{A_0}^2 (1 - X_A)(M - X_A)$ assuming 2nd order reaction

Where $M = \frac{C_{B_0}}{C_{A_0}}$, X_A = conversion of A, k_2 = rate constant

$$\frac{V_R}{F_{A_0}} = \frac{V_R}{v_0 C_{A_0}} = \frac{\tau}{C_{A_0}} = \frac{1}{k_2 C_{A_0}^2 (M - 1)} \ln \frac{M - X_A}{M(1 - X_A)} = \frac{1}{k_2} f(X_A)$$

Where $v_0 = v_A + v_B$ and $\tau = \frac{V_R}{v_0}$

Apparatus:

- (1) Stainless steel reactor in a constant temperature water bath
- (2) Stop watch

Dimension of the reactor:

Length of the coil: 609.6 cm

Inside diameter of the tube: 1.23cm

Volume of the reactor (volume of tube): 0.724 liter

Chemicals:

(i) Succinic Acid (N/50) (ii) NaOH (N/20) (iii) $\text{CH}_3\text{COOC}_2\text{H}_5$ (N/10) and (iv) Phenolphthalein indicator

Procedure:

- (i) Fill both the storage tanks of ethyl acetate, sodium hydroxide and calibrate the flow meters.
- (ii) Adjust the control valves to set the flow meters. Try to keep both the flow rates equal.
- (iii) After attaining steady-state, collect the sample in a flask from the outlet.
- (iv) Take 5 ml of this sample and titrate with the standard succinic acid solution with phenolphthalein as indicator.
- (v) Take 5 ml of the supplied NaOH solution by the standard succinic acid solution to get C'_{A_0} gmol/liter
- (vi) Calculate X_A from C_A for various $\tau = \frac{V_R}{v_0}$
- (vii) Plot $f(X_A)$ against τ and determine the rate constant from the slope.

N.B. $C_{A_0} = \frac{v_A}{v_A + v_B} C'_{A_0}$ and $C_{B_0} = \frac{v_B}{v_A + v_B} C'_{B_0}$

