EXPERIMENT No. 9

Kinetic Study in a PFR and calculation of CSTR volume connected in series

Objective:

(a) To find the rate constant of reaction between sodium hydroxide and ethyle acetate in study in a PFR and CSTR connected in series
(b) Predict the final conversion from CSTR
(c) Plot $\frac{1}{-r_A}$ versus conversion (X_A) and design the series reactors

Chemicals:

(i) Succinic Acid (N/50), (ii) NaOH (N/20), (iii) $CH_3COOC_2H_5$ (N/10) and (iv) Phenolphthalein indicator

Apparatus:

(1) SS Reactors (PFR and CSTR)
(2) Constant Temperature Water Bath
(3) Stop Watch and
(4) Conical flasks

Theory:

Rate Equation: $$-r_A = k_1 C_{A_0}^2 (1 - X_A)(M - X_A)$$

Mole Balances:

In PFR,

$$\frac{V_1}{F_{A_0 PFR}} = \int_0^{X_{A_1}} \frac{dX_{A_1}}{-r_{A_1}} = \frac{1}{k_1 (M-1) C_{A_0}^2} \times ln \frac{(M - X_{A_1})}{(1 - X_{A_1})} \quad (1)$$

In CSTR

$$\frac{V_2}{F_{A_0 CSTR}} = \frac{X_{A_2} - X_{A_1}}{-r_{A_1}} \quad (2)$$

Procedure:

Reaction: Saponification of ethyle acetate with NaOH.

$$CH_3COOC_2H_5 + NaOH \rightarrow CH_3COONa + C_2H_5OH$$

(88) (40) (82) (46)

(B) (A)

1. Calibrate each rotameters with the respective fluid.
2. Fix a feed rate for inlet streams. $F_A = F_B$ (say 1-2 LPH).
3. Allow the two reactant streams NaOH (A) and Ethyle Acetate (B) to enter the PFR first CSTR at equal feed. Determine C_{A0} and C_{B0}.
4. Collect the samples from PFR and CSTR outlets.
5. Analyze the samples by N/50 Succinic Acid.
6. Change the flow rate of each stream maintaining $F_A = F_B$ and repeat the above steps for 3 flow rates
7. Estimate the unreacted NaOH at the outlet of both the PFR and CSTR by titration or by measuring conductance of the solution
8. Determine the rate constant k_1 from the mole balance of PFR (Reactor 1)
9. Plot $\frac{1}{-r_A}$ versus conversion (X_A) and design the CSTR (Calculate Volume of CSTR) graphically by plotting

N.B.:

1. $C_{A_0} = \frac{v_A}{v_A+v_B} C'_{A_0}$ and $C_{B_0} = \frac{v_B}{v_A+v_B} C'_{B_0}$
2. Volume of CSTR = 2.4 L