

EXPERIMENT No. 9

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

Objective:

- To find the rate constant of reaction between sodium hydroxide and ethyle acetate in study in a PFR and CSTR connected in series
- Predict the final conversion from CSTR
- 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) $\text{CH}_3\text{COOC}_2\text{H}_5$ (N/10) and (iv) Phenolphthalein indicator

Apparatus:

- SS Reactors (PFR and CSTR)
- Constant Temperature Water Bath
- Stop Watch and
- Conical flasks

Theory:

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

Mole Balances:

In PFR,

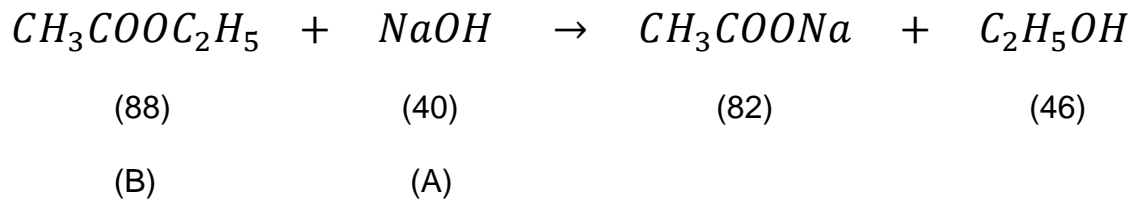
$$\frac{V_1}{F_{A_0 PFR}} = \int_0^{X_{A_1}} \frac{dX_{A_1}}{-r_{A_1}} = \frac{1}{k_1(M-1)C_{A_0}^2} \times \ln \frac{(M-X_{A_1})}{(1-X_{A_1})} \quad (1)$$

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.



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