Workshop 09: External and internal diffusion effects

Lecture notes for chemical reaction engineering

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2024-03-24

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The irreversible gas-phase reaction

$$A \xrightarrow{cat} B$$

is carried out adiabatically over a packed bed of solid catalyst particles. The reaction is first order in the concentration of A on the catalyst surface

$$-r'_{As} = k' C_{As}$$

The feed consists of 50% (mole) A and 50% inerts, and enters the bed at a temperature of 300 K. The entering volumetric flow rate is 10 dm^3/s (i.e., 10,000 cm^3/s). The relationship between the Sherwood number and the Reynolds number is

$$Sh = 100 Re^{1/2}$$

As a first approximation, one may neglect pressure drop. The entering concentration of A is 1.0 M. Calculate the catalyst weight necessary to achieve 60% conversion of A for

(a) isothermal operation.

(b) adiabatic operation.

Additional information:

- Kinematic viscosity: $\mu/\rho = 0.02 cm^2/s$
- Particle diameter: $d_p = 0.1 cm$
- Superficial velocity: $U = 10 cm/s$
- Catalyst surface area/mass of catalyst bed: $a = 60 cm^2/g - cat$
- Diffusivity of A: $D_e = 10^{-2} cm^2/s$
- Heat of reaction: $\Delta H^\circ_{Rx} = 10,000 cal/gmol A$
- Heat capacities: $C_{pA} = C_{pB} = 25 cal/gmol \cdot K, C_{pS}$ (solvent) $= 75 cal/gmol \cdot K$
- $k'(300K) = 0.01 cm^3/s \cdot g - cat$ with $E = 4000 cal/mol$