

Exercise problem: calculate breakthrough time

An adsorption process is designed to remove traces of xylene (0.1 mole/m³) from nitrogen gas using a 1.2 meter long silica column bed at 1.0 atm and 0°C. Nitrogen does not absorb at all. Calculate the breakthrough time using following data:

$$\rho_{\text{adsorbent}} = 2100 \text{ kg}_{\text{adsorbent}}/\text{m}^3$$

$$\epsilon_e = 0.43$$

$$\epsilon_p = 0.48$$

$$K_d = 1.0$$

$$A_c = 0.1 \text{ m}^2$$

$$Q = 0.008 \text{ m}^3/\text{minute}$$

$$q = 0.2 * c$$

q is in mole_solute/kg_adsorbent

c is in mole_solute/m³

$$V_{\text{inter}} = \frac{Q}{\epsilon_e A_c}$$

$$u_s = \frac{V_{\text{inter}}}{1 + \left(\frac{1 - \epsilon_e}{\epsilon_e} \right) * (K_d \epsilon_p) + \left(\frac{1 - \epsilon_e}{\epsilon_e} \right) * (1 - \epsilon_p) * \rho \left(\frac{\Delta q}{\Delta c} \right)}$$

Unit of q
mol solute/kg adsorbent

Unit of c
mol solute/m³

$$\text{Breakthrough time} = t_{\text{saturation}} - t_{\text{in}} = \frac{L}{u_s}$$