CEN 3313

MASS TRANSFER

Assoc. Prof. Ayşe Karakeçili

Assoc. Prof. Berna Topuz

Diffusion Coefficients for Gases

Experimental determination of diffusion coefficients:

- **Two-bulb method,** where sampling for $c2(t)$ with the help of following relations can be used to obtain diffusion coefficient

$$\frac{c_{av} - c_2}{c_{av} - c_2^0} = \exp\left[-\frac{D_{AB}(V_1 + V_2)}{(L/A)(V_2V_1)}t\right]$$

If c_2 is obtained D_{AB} can be calculated

where,

$$c_1 + c_2 = c_1^0 + c_2^0$$

$$c_{av} = \frac{V_1c_1^0 + V_2c_2^0}{V_1 + V_2}$$

Prediction of diffusion coefficients:

Chapman–Enskog correlation :

$$D_{AB} = \frac{1.8583 \times 10^{-7}}{\sigma_{AB}^{2}\Omega_{D,AB}}\left(\frac{T^{3/2}}{P}\right)\left(\frac{1}{M_A}+\frac{1}{M_B}\right)^{1/2}$$

Semi-Emprical method of Fuller

$$D_{AB} = \frac{1.0 \times 10^{-7}}{[(\sum v_A)^{1/3} + (\sum v_B)^{1/3}]^2}\left(\frac{T^{3.5/2}}{P}\right)\left(\frac{1}{M_A}+\frac{1}{M_B}\right)^{1/2}$$

(Nonpolar gases and polar-nonpolar mixtures)

(sum of structural volume increments)

CONVECTION MASS TRANSFER

Convection mass transfer that occurs at the surface of a volatile surface or liquid due to the motion of a gas over the surface.

Concentration boundary layer is the region of the fluid in which concentration gradients exists,

Thickness (δ_c) is defined as the value of y for which;

$$\frac{C_{A,s}-C_A}{C_{A,s}-C_{A,\infty}} = 0.99$$

CONVECTION MASS TRANSFER

Molar flux; $N_{A,s} = -D_{AB} \left.\frac{\partial C_A}{\partial y}\right|_{y=0}$

at the surface

$N_{A,s} = k\,\underbrace{(C_{A,s} - C_{A,\infty})}_{\text{molar concentration difference}}$

k; convective mass transfer coefficient (m/s)

$$k = \left.\frac{-D_{AB}\frac{\partial C_A}{\partial y}}{(C_{A,s} - C_{A,\infty})}\right|_{y=0}$$

Local and Average Convection Coefficients

$If\ C_{A,s} \neq C_{A,\infty}$ → **Convection occurs**

Surface molar flux and convection mass transfer coefficient both vary along the surface

Total mass transfer rate $N_A = k_{avg}\ A_s\ (C_{A,s} - C_{A,\infty})$

$$k_{avg} = \frac{1}{A_s}\int k\ dA_s$$

$$k_{avg} = \frac{1}{L}\int k\ dx$$

References

1. Geankoplis, C.J., Transport Processes and Separation Process Principles, Prentice-Hall, Pearson Education, 2003

2. Incropera F. P., Dewitt D. P. , Bergman T.L., Lavine A.S., Fundamentals of Heat and Mass Transfer, John Wiley & Sons Inc.

3. Middleman S., An Introduction to Mass and Heat Transfer: Principles of Analysis and Design, John Wiley, High Education, 1997.

4. Cussler E.L., Diffusion : Mass Transfer in Fluid Systems, Cambridge University Press, 3rd Edition, 2009.

5. Bird R.B., Stewart W.E., Lightfoot E.N., Transport Phenomena, John Wiley & Sons, 1960.