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Effect of Concentration, Temperature, Time on Liquid-Liquid Diffusion

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Abstract: *The objective of this study was to investigate the effect of concentration, time, and temperature on liquid- liquid diffusion mechanism. Different concentration of the solute (10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%) in given solvent at different time and various temperature (35^0C, 40^0C, 50^0C, 60^0C) were applied at same concentration. During experiment, mark the porous pot and fill this solution in them to nearly equal height for interval of 1hour. Changes of sample used to determine mass transfer between them. The experimental data was used to determine diffusion coefficient. Diffusion coefficient value changes with concentration, time, and temperature. Diffusion was found to be strongly dependant on temperature. Knowledge of diffusion coefficient at different condition may lead to predict the amount of solute (acetic acid) into solvent (water). These finding may also be used for further optimization studies in different industrial application.*

Keywords: *acetic acid, concentration, diffusion.*

1. INTRODUCTION

Liquid-liquid diffusion plays an important role in chemical engineering. If any aqueous solution containing substances of different molecular weight is kept separated from a more dilute solution of these substances by means of a semi permeable membrane, the concentration gradient thus established causes the substances to diffuse through the membrane from the more concentration to the dilute solution at varying rates of transfer. At the same time water will more through the membrane in the direction opposite to the movement of the solution. Although the liquid diffusion coefficient is known to vary with concentration. At relatively low concentration. Ficks second law of diffusion can be said to apply in the form of

$$\frac{\partial C}{\partial t} = \frac{D}{\delta}\frac{\partial^2 C}{\partial y^2}$$

Get integrated

$$\frac{N}{(A-t)} = \frac{D_1}{\delta}(C_1 - C_2)$$

Where,

Where, N/t = mass transfer per unit time (kg)

A- Area for mass transfer (m^2)

$C_1 - C_2$ - Initial & Final Concentration

D_L – Liquid diffusion

δ - Effective film thickness

$$\Delta C_{ln} = \frac{(C_1-0)-(C_2-C_3)}{\ln\frac{(C_1-0)}{(C_2-C_3)}}$$

The diffusion can be considered as though an element dr of the annulus of the cell then

$$\frac{N}{t} = \int_{r_1}^{r_2}\frac{dr}{2\pi r h} = D_L(\Delta C)_{ln}$$

$$D_L = \frac{N}{2\pi t h(\Delta C)_{ln}}\ ln\frac{r_2}{r_1}$$

2. EXPERIMENTAL PROCEDURE

Prepare four to five different concentration of the solute in the given solvent (acetic acid in water) 10%, 20%, 30%, 40%, 50% .Mark the different porous pots and fill these solution in them to nearly equal height 0.15m. Keep these pots in the respective container and fill the outer container with distilled water to the height of inner solution 0.15 m. Start the stop clock and take out the samples of the outer container at the intervals of 1 hour until reasonable steady condition of concentration is

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determined. Values of C_1, C_2, and C_3 are noted at a known time. Also measure the dimension of each cell for their r_1 is outer radius 0.035 m, r_2 is inner radius 0.032 m and h is height 0.14 m values. You may have to wait for 24 hours for the steady to come. Determine the diffusion coefficient values and plot them as a function of initial concentration (C_1).
Experiment was carried out at various concentration and temperature for different time.

Table-1. Diffusion coefficient for acetic acid + water at room temperature

Sr.No.	C_1 kmol/m^3	C_2 Kmol/m^3	C_3 kmol/m^3	D_L *10 ^{10} m2/s
1.	3.15	2.55	0.6	2.55
2.	4.5	3.3	0.75	2.32
3.	7.2	5.7	1.2	2.21
4.	8.7	6.2	2.4	2.1
5.	9.4	7.9	3.1	1.8
6.	10.6	8.7	3.7	2.4
7.	11.9	9.4	4.6	3.2
8.	12.4	11.1	5.2	5.1
9.	14.9	12.4	6.7	6.7

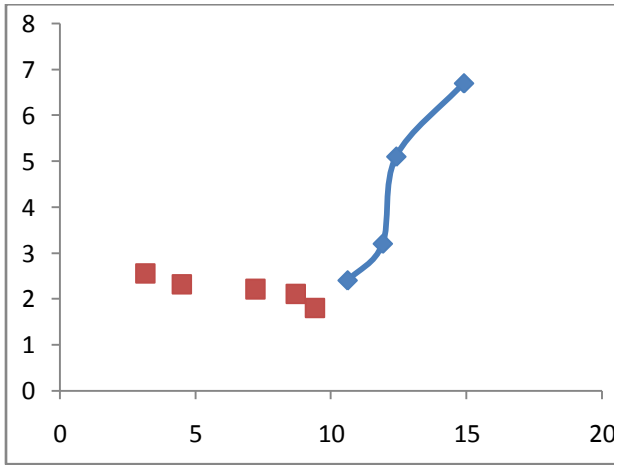

Figure-1: Diffusion Coefficient for various concentrations for acetic acid + water system

Table-2: Diffusion coefficient for acetic acid water at various temperatures.

Sr. No	Temp. (T) ^{0}C	C_1 kmol/m^3	C_2 Kmol/m^3	C_3 kmol/m^3	D_L *10^10m^2/s
1.	35	3.3	2.94	0.36	10.4
2.	40	3.3	2.7	0.66	21.46
3.	50	3.3	2.52	0.9	32.37
4.	60	3.3	2.31	1.2	41.2

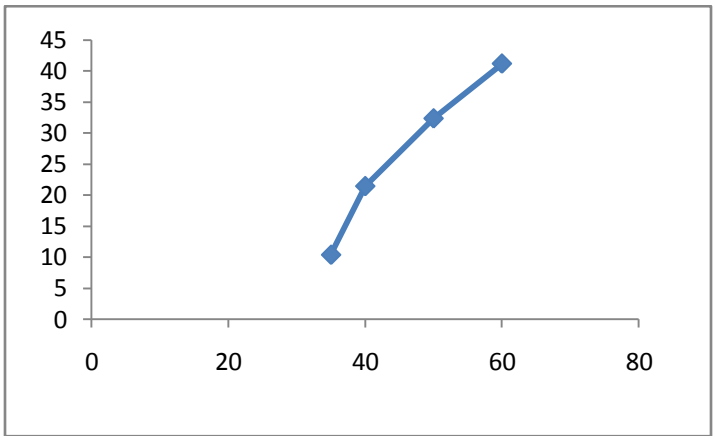

Figure-2: Diffusion Coefficient for various temperatures at same concentration for acetic acid water system

3. RESULT AND DISCUSSION

Diffusion coefficient of the binary system (acetic acid + water) at various concentrations and various temperatures at same time were measured. Results are shown in fig 1 and 2. A minimum difference was necessary to obtain an accurate concentration against time curve.

Effect of concentration on liquid at same time and same temperature – diffusion coefficient decrease a little with concentration and was slightly different shape. The result as shown in fig 1. If the concentration of acetic acid increases, diffusion coefficient was decreases a little first then was increases.

Effect of concentration on liquid at various temperature - If the temperature was increases at same concentration then diffusion was increases.

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