# Diffusion coefficients of UAE Jet fuel in air using harsh environment condition

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***Abstract*—**Vapor diffusion of aviation jet fuel (JET A-1) in air was measured in harsh environmental condition. . The diffusion coefficient of JET A-1 was equal to $5.55\times10^{-7}$ $m^2/s$ at operating temperature of 50 °C. The main physical properties of JET A-1 were measured and compared with other light oil products. It is believed that the diffusion of aviation fuel in air is affected by temperature, vapor pressure, and density. The diffusivity coefficient can be regarded as one of the main factor that needs to be mentioned in risk assessment of this material and especially in harsh environment countries

***Keywords*—** Diffusivity coefficient, jet fuel, risk assessment, vapor pressure.

## I. Introduction

MOLECULAR diffusion can be defined as macroscopic transport of mass, independent of any convection within the system [1]. The diffusivity of the vapor of a volatile liquid in air can be conveniently determined by Winklemann's method in which liquid is contained in a narrow diameter vertical tube, maintained at a constant temperature, and an air steam is passed over the top of the tube to ensure that the partial pressure of the vapor is transferred from the surface of the liquid to the air stream by molecular diffusion. Usually the diffusion occurs from high concentration regions to low concentration regions. There are different factors that affect diffusion such as temperature, pressure and molecular weight. The diffusion occurs faster in high temperature, low pressure, and low molar mass.

Another way of expressing the diffusion rate is by using the term "flux". Flux is an amount of a species that passes per time through a unit area. The flux can be easily found through the Fick rate equation:

$$J_{A,z} = -D_{AB}\frac{dc_A}{dz} \quad \text{........ (1)}$$

It is very essential to know the diffusion rate since it can predict the time needed for certain species to transfer in a medium. Thus, the diffusion rate can have several applications and importance in life. The diffusion rate (flux) depends on $D_{AB}$ , so its essential to identify how does $D_{AB}$ affect the flux. In general, it is assumed that the higher the temperature, the higher the diffusion rate will be, since an increase in temperature represents an increase in the average molecular speed, diffusion occurs faster at higher temperatures. The transfer theory where molar mass transfer rate $N_A$ is related to the diffusion coefficient D by the following formula [2] and [3]:

$$N_A = D * \left(\frac{CA}{L}\right) * \left(\frac{CT}{CBM}\right) \quad \text{........... (2)}$$

In addition, the evaporation of liquid is considered with mass transfer rate in the following formula:

$$N_A = \left(\frac{\rho}{M}\right)\left(\frac{dL}{dt}\right) \quad \text{............(3)}$$

By equating equation (1) and (2), then integrating between L to $L_0$ and 0 to t gives the following formula:

$$L^2 - L0^2 = \left(\frac{(2MD)}{\rho}\right)\left(\frac{C_A C_T}{C_{BM}}\right)t \quad \text{......... (4)}$$

By rearranging equation (3) to be similar to format of linear equation y = xm+b, it will be as follows:

$$\frac{t}{L-L0} = \left(\frac{\rho_L C_{BM}}{2MD\, C_A C_T}\right)(L - L_0) + \left(\frac{\rho_L C_{BM}}{MD\, C_A C_T}\right)L_0 \quad \text{..... (5)}$$

The plot of

$\frac{t}{L-L0}$ $VS\ (L - L_0)$ Showed a slope S which is:

$$S = \left(\frac{\rho_L C_{BM}}{2MD\, C_A C_T}\right)$$

After substitution:

$$D = \frac{\rho_L C_{BM}}{slope\ 2MC_A C_T} \quad \text{........(6)}$$

Where:

$$C_A = \left(\frac{P_V}{P_A}\right)C_T \quad C_{BM} = \frac{C_{B1} - C_{B2}}{\ln\frac{C_{B1}}{C_{B2}}} \quad \text{----- (7)}$$

$$C_{B1} = C_T \quad C_{B2} = \left(\frac{P_A - P_V}{P_A}\right)C_T \quad \text{---(8)}$$

$$C_T = \left(\frac{1}{Kmol\ Vol}\right)\left(\frac{T_{abs}}{T_s}\right) \quad \text{---- ( 9)}$$

This paper studies the diffusion coefficient of jet fuel into air at harsh environment of 50°C.

Diffusion coefficients, along with other parameters, are required inputs to some environmental transport or risk assessment models [3]. Literature values are sometimes available for these parameters, although, often the literature values are determined at 25 °C. A diffusion coefficient of jet fuel is not available in any literature at any temperature.

Jet fuel is refined from crude oil. It is a mixture of many different hydrocarbons. Jet A-1 is a kerosene grade of fuel suitable for most turbine engine aircraft. It is produced to a stringent internationally agreed standard with flash point above 38°C (100°F) and a freeze point maximum of -47 °C. Jet A-1

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