

Variation of Viscosity and Activation Energy Change of Various Amount of Bi-Solute Mixture in Distilled Water via a Locally Constructed Viscometer

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ABSTRACT

Time of flow, viscosity coefficients,, change in activation energies of distilled water and mixtures of powdered peak milk and glucose in water solutions were determined through a simple constructed capillary viscometer. It was observed that the viscosity coefficients and activation energy change increased linearly with increase in solute concentration in the solvent. Likewise, the activation energy change shows a linear relationship with viscosity at 308 K.

Keywords: Viscosity, Activation energy, Distilled water, Peak milk, Glucose, Mixture, Concentration

INTRODUCTION

Density of a substance, ρ is the ratio of its mass to its volume. Both mass and volume are extensive quantities. They specify how much of the substances are physically present in the mixture. The dimensions of density are $M L^{-3}$, Density is an intensive quantity relating to the nature of the substance. The property varies not only with molecular weight but also with molecular interaction and structure. The density of fluids is an important element for research and in industrial field. Density is used to solve variety of problems such as quality control in the production of industrial liquids or concentration determination in the food and beverages industries, as in measuring sugar and alcohols concentration. Specific applications for density include chemical spill models for substances such as oils or toxic gases. In addition, density

is often required for the estimation of other physical properties; such as molar refraction and viscosity, (Abdollah et al, 2010).

Viscosity, which is also called a viscosity coefficient, is a measure of a fluid's resistance to flow. It is the substance constant indicating the magnitude of the fluidity of a fluid. In general, viscosity is associated only with liquid. Gas also has viscosity, but it is a relatively inviscid fluid, the resistance to flow can be ignored. Almost all liquids are viscous fluids having viscosity. For example, when rotating a drum container filled with water on its vertical central axis, the water that was at rest in the beginning starts moving as it is dragged by the inside wall of the container and then whirls completely together with the container as if it were a single rigid body. This is caused by the force (resistance) generated in the direction of the flow (movement) on the surfaces of the water and the container's inside wall. A fluid that generates this kind of force is regarded as having viscosity, (Dikko, 2014 and Cragoe, 1933).

The activation energy of the original pure liquid should change when a solute molecule is added to it since the addition may change the bond strength of the given liquid or the solvent molecule as the solute molecule tends to occupy the neighboring positions. The change obviously will depend on the type and the concentration of the solute molecule. Thus, the viscosity, μ , is expected to be affected significantly by addition of solute molecules to original solvent, (De and Dikko, 2012).

MATERIALS AND METHOD

The densities (ρ_2) of the various mixtures, the time of flow (t_2) of the mixtures, viscosity coefficients (μ_2) and the change in activation energy (ΔE_a), were determined and recorded in Table (1) under average temperature of 308 K. The densities were determined by measuring the mass (m) of a given volume (v) of the solution and using the relation, $\rho = m/v$. Time t was measured by a digital stop-watch (sport timer) with accuracy of ± 0.01 s. For distilled water the average of three such readings was recorded to be $t_1 = 1542.18 \pm 0.01$ seconds.

The temperature during the experiments was recorded at 308 K. For determination of mass concentration in water we prepared different solutions containing different amounts of powdered peak milk and glucose in a fixed volume (200 cc) of distilled water.

To determine the viscosity coefficient of a given liquid mixture, we need the absolute value of μ_1 of water at 308 K is found to be 7.22 millipoise from Hand book of Physical Constants. (1 millipoise = $10^{-4} \text{kgm}^{-1}\text{s}^{-1}$ (10 poise = 1 Pa.s. = $1 \text{kgm}^{-1}\text{s}^{-1}$) (Cutnell and Johnson, 1995). Using these values of μ_1 , ρ_1 , ρ_2 , t_2 and t_1 from Table (1), the viscosity coefficient μ_2 of solutions are then calculated using the equation, (De and Dikko, 2012) and the values are also given in Table (1).

$$\mu_2 = \frac{\mu_1 \rho_2 t_2}{\rho_1 t_1} \quad (1)$$

In laminar flow, a molecule to go ahead must squeeze past pushing aside the neighboring molecules. To achieve this, the molecule flowing ahead must acquire a definite amount of energy which may be called activation energy, E_a . Then, with Boltzmann factor, the number of molecules having such energy will be proportional to $\exp(-E_a/k_B T)$, (Shiekh *et al*, 2002). The rate of flow and hence fluidity would depend on this number, and the viscosity is given by

$$\mu = B \exp(E_a / k_B T) \quad (2)$$

where B is a constant for a given liquid, k_B is the Boltzmann constant, T is the temperature and E_a the activation energy for viscous flow. The change in activation energy, ΔE_a arising from different concentrations of the solute in the mixture (solution) at constant temperature can be calculated. From equation (2), we can get the change in activation energy as

$$\Delta E_a = K_B T \ln \left(\frac{\mu_2}{\mu_1} \right) \quad (3)$$

where μ_2 is the viscosity of the resulting solution, μ_1 is the viscosity of water, T is the temperature at which μ_2 and μ_1 were determined.

A capillary viscometer type, locally constructed (Fig 1) was used to study some physical changes of water when miscible solutes like powdered Glucose and peak milk are incrementally added to a fixed volume of water. Various equal masses of powdered glucose and peak milk were mixed and added to distilled water and stirred very well to get a homogenous mixture.

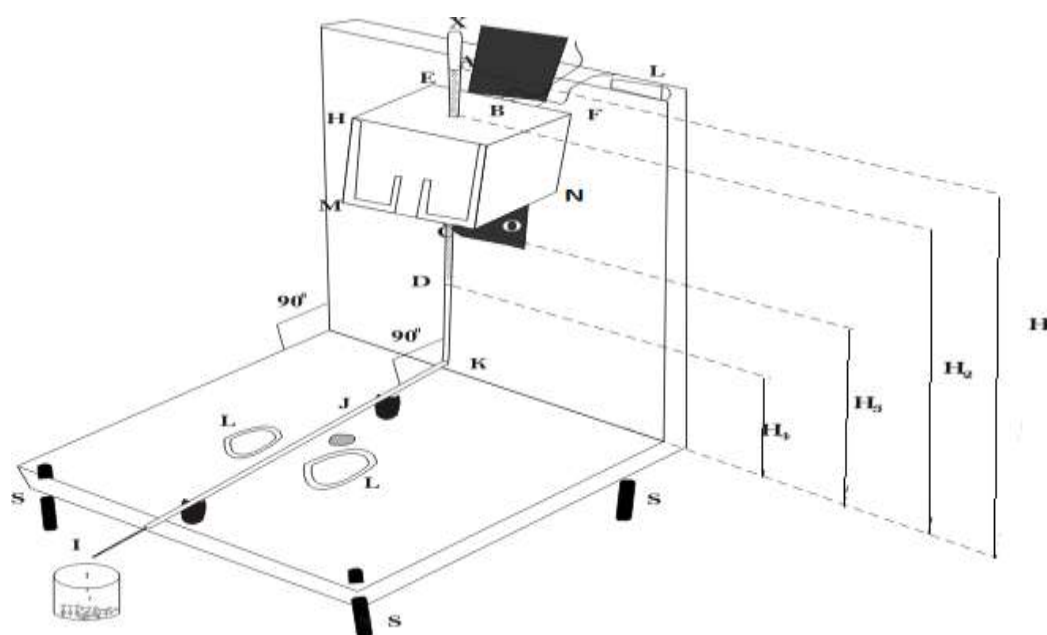


Fig 1 Design of a simple Viscometer (Dikko, 2014)

RESULTS AND DISCUSSION

The densities (ρ_2) of the various mixtures, the time of flow (t_2) of the mixtures, viscosity coefficients (μ_2) and the change in activation energy (ΔE_a), were determined and recorded in Table (1) under average temperature of 308 K.

Table 1

Densities, viscosity coefficients, and activation energy changes of the solution mixtures of various equal amounts of powdered peak and powdered glucose added to 200 cc of distilled water at 308 K

S/N	Vol. of distilled water (cc) ± 0.5	Mass of mixture added (g)	Conc. of Mixture (g/cc)	Density of the sol. ρ_2 (g/cc) ± 0.005	Time of flow t_2 (sec) ± 0.01	Viscosity μ_2 of the sol. (10^{-4} Pa.sec) ± 0.001	ΔE_a (meV) ± 0.001
1	200	4	2	1.008	1556.13	7.421	0.726
2	200	8	4	1.015	1562.17	7.513	1.064
3	200	12	6	1.022	1577.57	7.620	1.432
4	200	16	8	1.029	1589.14	7.730	1.812
5	200	20	10	1.035	1600.63	7.827	2.137
6	200	24	12	1.042	1611.56	7.934	2.508
7	200	28	14	1.048	1622.64	8.034	2.824

From Figure (2&3), the viscosity coefficients and change in activation energies slightly increase with increase in mass per volume concentration. As the concentration increases from 2 g/cc to 14 g/cc, the viscosity coefficient of glucose-paek milk-water mixture increases from 7.421 to 8.034 (10^{-4} Pa.sec), at room temperature.

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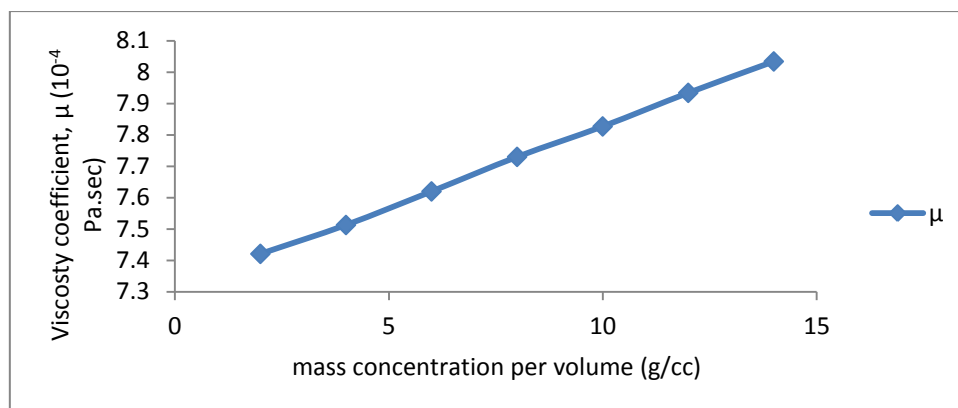


Figure 2: Variation of viscosity with mass per volume conc. For glucose and peak milk in distilled water

Similarly, the change in activation energy of glucose peak milk-water mixture, (Fig 3), increases from 0.726 meV to 2.824 meV. These variations also show a linear trend.

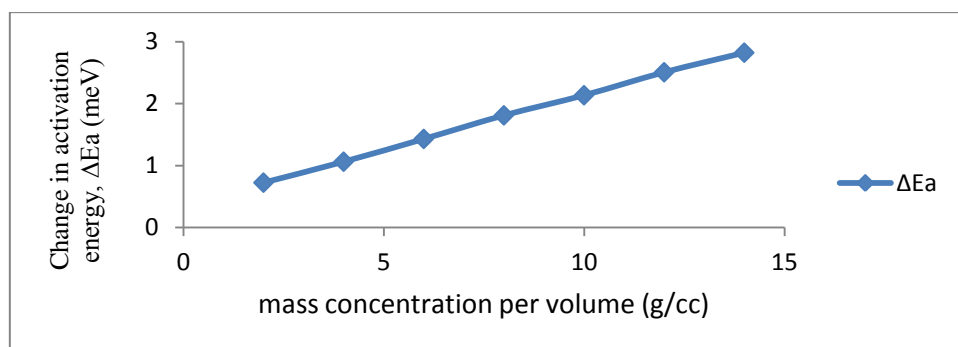


Figure 3: Variations of change in activation energy with mass per volume concentration of glucose and peak milk in water,

Figures (3&4) show that the viscosity and activation energy change increased linearly with the increase in density of the mixture.

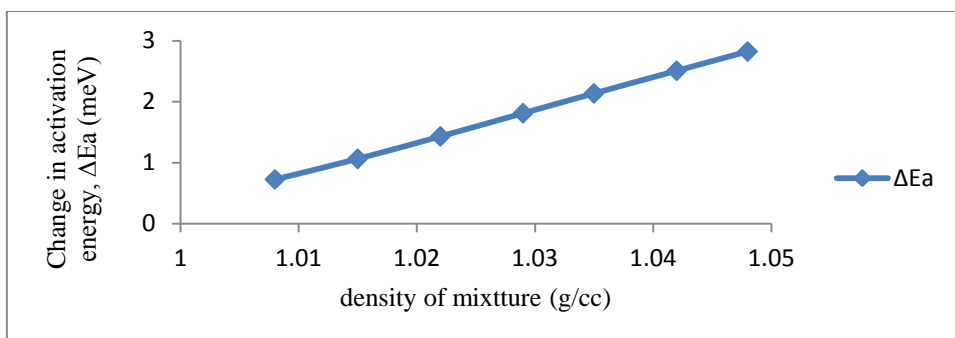


Figure 4 Variations of change in activation energy change with the density of the mixture of glucose and peak milk in water,

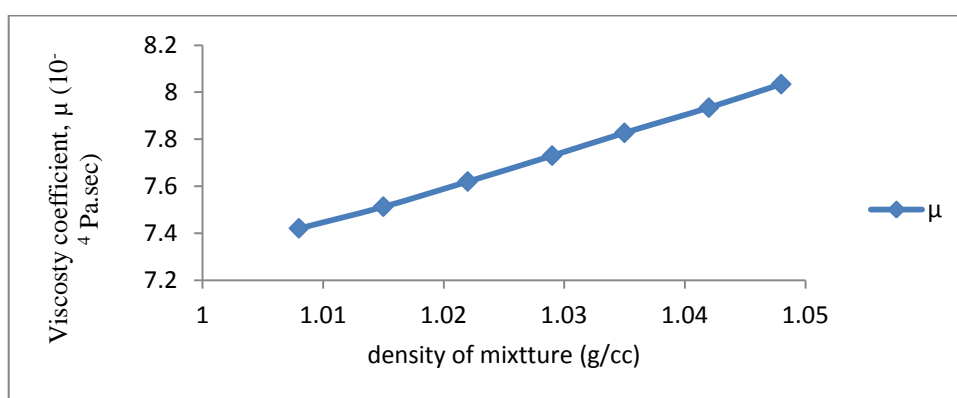


Figure 5: Variations of density of mixture with viscosity of the mixture of glucose and peak milk in water,

Similarly, from Figure (6), the activation energy change varies directly with the viscosity of the solution-mixture

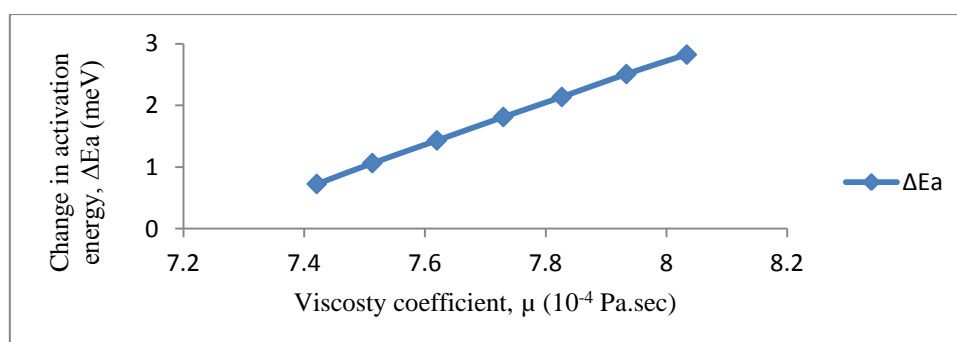


Figure 6: Variations activation energy changes with the viscosity the mixture of glucose and peak milk in water,

CONCLUSION

Viscosity and activation energy change increased linearly with increase in solute concentration in the solvent. The viscosity and activation energy change also increased linearly with increase in density of the solvent. Similarly, the activation energy change varies directly with the viscosity of the solution.

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