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Determination of the Arrhenius Parameters of Mahogany Seed Oil using Viscosity Flow Data

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Abstract:- A more accurate measurement of the physical and physicochemical properties of fluids is very important in understanding mass flow and heat transfer behaviors of (viscous) fluids, in this case, locally produced Khaya Senegalensis (Mahogany) seed oil in Yola, Nigeria. In the present work, we determined the viscosity η, density ρ and graphically correlated three Arrhenius parameters; the Activation Energy (E_a,)theEntropicfactor (A) and the Arrhenius Temperature (T_A). We alsointroduced the Arrhenius Activation Temperature T* for homogenous dimensions. Viscosity measurement in centipoise ranged between 60.70 at 30°C to 9.83 at 80°C while the density measurement varied between 0.9243 g/cm^{3}at 30 °C to 0.9110 g/cm^3 at 80 °C. The Arrhenius parameters of Activation energy (E_a), Entropic factor A, Arrhenius temperature (T_A) and the Arrhenius Activation Temperature T^* are calculated to be 712.5748 J/mole, 3.9551 centipoise, - 62.3630 °C, and 85.7490 °C respectively. The goodness of the above result is supported by the R-squared value of 0.9666. The results show that the model which best fits the relationship between the defined Arrhenius parameters is a logarithmic in nature. All the biodiesel quality parameters examined in the present study showed that Khaya Senegalensis seed oil is a good feed stock for biodiesel production and reveals its usefulness in electric voltage transformers.

Keywords:- *Activation energy, Arrhenius Activation Temperature, Arrhenius temperature, Entropic factor, Arrhenius Parameters and Viscosity*.

I. INTRODUCTION

Viscosity is one of the most important physicochemical properties of pure liquids and their mixtures which is very relevant in optimizing and designing industrial processes. Viscosity being one of the most important factors in transport equations and industries, its parameters are essential for energy and hydraulic calculations of fluid transport. As a result of the above, reliable data must be available with models that can provide an accurate estimation of the viscous behavior of fluids (Haj-Kacem R. B. *et al.*, 2014) in this case, Khaya Senegalensis (Mahogany) seed oil in Yola.

The viscosity of fluids is determined both by collision among particles and by the force fields which determines interactions among molecules. The theoretical description of viscosity is therefore quite complex (Haj-Kacem R. B. *et al.*, 2014). This is why several models have been proposed in the literature essentially based on Eyring theory or empirical or semi-empirical equations that are not always applicable to a large number of mixtures (Ouerfelli N., Bouaziz M., and Herráez J. V. 2013; Herráez, J. V. *et al.*, 2008; Lee L. S. and Lee Y. S. 2001; Qunfang L. and Yu-Chun H., 1999; Macías-Salinas R., García-Sánchez F., and Eliosa-Jiménez G., 2003; F. Belgacem B. M., 2001). On the other hand, excess thermodynamic functions (like enthalpy of hydration) and deviations of analogous non thermodynamic functions (like viscosity) of binary liquid mixtures are fundamental for understanding different types of intermolecular interactions in these mixtures. The viscosity of fluids is determined both by collision among particles and by the force fields which determines interactions among molecules. Many empirical and semi-empirical models have been developed to describe the viscosity of pure liquids and liquid mixtures. This paper aims at contributing to describe the viscosity of Mahogany Seed Oil. In this regard, we intend to use statistical analysis to determine the relationship among the relevant Arrhenius parameters, allowing the reduction of the parameters number and enhancing related calculations in fluid transport. Also, the suggested practical equation is useful when one of the two Arrhenius parameters data is absent. Indeed, it can be used to estimate the non-available value of one parameter using the information provided by the other. In fact, the viscosity Arrhenius energy (E_g) can be related to the enthalpy of vaporization (ΔH^O_{vap}) at the same pressure (Viswanath D. S. *et al.*, 2007) though we didn't delve into that in this paper. In addition, the entropic factor (A) is also closely related to the viscosity of the pure system in vapor state at the same studied pressure (Hichri M. *et al.*, 2013; Das D. *et al.*, 2012, 2013 and Dallel M. *et al.*, 2014).

Ben Haj-Kacem *et al.*, 2014 proposed an empirical power law-type equation called HajKacem-Ouerfelli equation, for modeling the relationship between the two parameters of viscosity Arrhenius-type equation for some pure classical solvents, such as the Arrhenius energy (E_g) or the entropic factor (A) which presents good concordance only for the low and moderate viscous fluids which have not too high values of activation energy (kJ·mol^{-1}) and not too low values of pre-experimental factor ($-17 < \ln(/\text{Pa·s}) < -10$). However, in the present work we used an empirical exponential law-type equation by Arrhenius valid on more extended intervals; In addition, we have tried to give some physical meaning of the proposed equation parameters. We add that the suggested equation is important since it allows rewriting the viscosity Arrhenius-type equation by using a single parameter instead of two and thus it is very useful for engineering data which can permit estimating one non-available parameter when the second is available or can be precisely evaluated by some theories suggested in the literature.

The seed of Khaya Senegalensis (Mahogany) from which the oil was extracted is especially not among the popular cultivars of oil seeds like groundnut, soya bean, palm fruit and palm seed. At least, it is allowed to waste away in the forest. As suggested by Besbes *et al*, (2004) regarding date seed oil, few works so far done on some of these oils were majorly focused on their chemical composition (Adeyeye *et al*; 1990; Ajewole and Adeyeye; 1991, Adeyeye and Ajewole, 1992).Over the years, there has been a spectacular increase in the world demand for both oils and oil meals with attending uptrend in prices (Mielke, 1988). Estimates available on future production indicate that this trend will continue (Kaufman, 1990). During the 20th Century, the non-edible uses of oil seed products declined substantially due to the availability of relatively inexpensive oil derived from fossil reserves (Les and Leegood, 1993). It is, however, now realized that the fossil reserves could be exhausted or become shorter in supply and are not renewable (Boelhauwer, 1983). As such, looking into alternative oil sources from various seeds which abound around us should remain a subject of active investigation. Although such oils are not expected to replace petrochemicals in their entirety (Harwood, 1984), their applications as lubricating oils, emulsifiers, retardant agents or components of cosmetics for example, could be very important. The purpose of this study was to determine some of the physical properties of the Khaya Senegalensis (Mahogany) oil, whether it qualified to be a source vegetable oil raw material and to investigate the possible technological applications, apart from eating, to which the oils could be put. The ability to gather data on a material's viscosity behavior gives manufacturers an important "product dimension" knowledge of a material's rheological characteristics is valuable in predicting pumpability and pourability, performance in a dipping or coating operation or the ease with which it may be handled, processed or used. The interaction between rheology and other product dimensions often makes the measurement of viscosity the most convenient means of detecting changes in colour, density, stability, solid content and molecular weight.

Viscosity is a principal parameter when any flow measurements of fluid such as liquids. Semi solids gases and even solids are made and are usually done in conjunction with product quality and efficiency. Anyone involved with flow characterization, in research or development quality control or fluid transfer, at one time or the other gets involved with some kind of viscosity measurement. It is against the background that we intend to determine the viscosity, density and refractive index of mahogany oil which to the best of our knowledge has not been done. All actual or fluids are compressible and when flowing are capable of sustaining shearing stress on account of friction between the adjacent layers. Viscosity is the inherent property of all fluids and may be referred to as the internal friction offered by a fluid to the flow. For water in a beaker, when stirred and left to itself, the motion subsides after sometime, which can happen only in the presence of resisting force acting on the fluid. The temporary resistance offered by fluids to the shearing stress is called viscosity. Viscosity is that behavior of fluids due to which they oppose relative motion between the adjacent layers. Liquids such as kerosene, alcohol and water etc which flows readily are said to be mobile while liquids such as tar, pitch etc which do not flow readily are said to be viscous. Liquids such as honey, heavy oils, glycerin etc are more viscous than tar.

When a liquid flows in a tube, a viscous force opposes the flow of the liquid. Hence, a pressure difference is applied between the end of the tube which maintains the flow of the liquid. If all particles of the liquid passing through a particular point in the tube move along the same path, the flow of the liquid is called "streamed lined flow". This occurs only when the velocity of flow of the liquid in below a certain limiting value called the critical velocity, the flow is no longer streamed lined but becomes turbulent. In this type of flow, the motion of the liquid becomes zig-zag and edge currents are developed. Reynold's provided that the critical velocity for a liquid flowing, in a tube is (Shukla and Srivastava, 2006);

$$V_c = \frac{k\eta}{\rho a} \qquad (1)$$

Where; ρ = density, η = viscosity, a = radius of the tube, k = Reynold's number whose value for a narrow tube and for water is about 1,000.

When the velocity of flow of the liquid is less than the critical velocity, then the flow is controlled by the viscosity, the density having no effect on it. But when the velocity of flow is larger than the critical velocity, then the flow is mainly governed by the density, the effect of viscosity becoming less important. It is because of the reason that when a volcano erupts, then the lava coming out of it flows speedily in spite of being very thick, rather very viscous. To quantify viscosity, we will imagine our bulk fluid as consisting of a number of very thin layers. In order for the fluid to flow, a force will be required to slide these layers relative to one another. The amount of force (f) required is assumed to be directly proportional to the area (A) of the layers in contact with one another and the velocity difference (v) between the layers. Also, the force is inversely proportional to the distance (d) between the layers. Viscosity (η) can then be introduced as a constant of proportionally, yielding a force equation of the form;

$$f = \eta \frac{Av}{d} \qquad (2)$$

What factors determine whether a given fluid has a high (or low) viscosity? Certainly the strength of intermolecular attractions has an influence; nitro-benzene has a much higher viscosity than regular benzene because the former is capable of dipole-dipole attractions which are considerably stronger than the dispersion forces of attraction present in bulk benzene. Other factors can contribute, such as the size and shape of molecules. For example, long chain molecules like polymers are capable of becoming entangled with each other which causes friction between the hypothetical layers of the fluid which translates into a large viscosity.

Viscosity varies with temperature, generally becoming smaller as temperature is elevated. This trend occurs because the increased kinetic motion at higher temperatures promotes the breaking of intermolecular bonds between adjacent layers. A considerable amount of research has been carried out in an attempt to understand the exact nature of the temperature variation of viscosity. One relatively simple model assumes that the viscosity obeys an 'Arrhenius-like' equation of the form

$$\eta = Ae^{\left(\frac{E_a}{RT}\right)} \qquad (3)$$

Where ,R, E_a, A, and T are the gas constant (8.31 $JK^{-1}mol^{-1}$), the Arrhenius activation energy (it has to be expressed in Joules per mole so as to fit into this equation), the frequency or the entropic(entropic) factor of the Arrhenius equation for the liquid system and T is the temperature measured in Kelvin respectively. The above expression is almost identical to the Arrhenius equation that describes the temperature variation of the rate constant (k) of a chemical reaction, except that equation (3) does not have a negative sign in the exponential which causes the viscosity to get smaller with increasing temperature. Equation (3) can be re-expressed in the logarithmic form as;

$$In\, \eta = \left(\frac{E_a}{R}\right)\frac{1}{T} + In\, A \qquad (4)$$

The plot of the logarithm of shear viscosity η against the reciprocal of absolute temperature (T) for numerous liquid systems is practically linear and the Arrhenius parameters, which are the activation energy (E_a) and the entropic factor (A).Using (either) the graphical (or linear least-squares fitting methods), the slope of the straight line is equal to (E_a/R) and the intercept on the ordinate is equal to (In A). Thus;

$$\text{Activation Energy } E_a = \text{Slope S x Gas Constant R} \qquad (5)$$

And

$$\text{The Pre} - \text{exponential Factor A} = \text{Antilog}\left[\frac{\textit{Intercept on the vertical axis}}{2.30257}\right] \qquad (6)$$

In addition to these two main Arrhenius parameters, we added a third parameter (T_A) called the Arrhenius temperature deduced from the intercept with the abscissa axis:

$$T_A = \frac{-E_a}{R\, In\, A} \qquad (7)$$

Which can simplify the viscosity-temperature dependence following the Eyring (Dean, 1987;Viswanath *et al.*, 2007; Eyring, 1936; Eyring and Hirschfelder, 1937; H. Eyring and John, 1969)form as;

$$In\, \eta = \left(\frac{E_a}{R}\right)\left(\frac{1}{T} - \frac{1}{T_A}\right) \qquad (8)$$

For homogenous dimensions (Glasstone, Laidler and Eyring, 1941), we can as well calculate another parameter termed the Arrhenius activation temperature (T*) as an additional variable for future statistical investigations:

$$T^* = \frac{E_a}{R} \qquad (9)$$

II. METHODOLOGY

A. *Sample, Collection and Preparation*

All the seeds of Khaya Senegalensis (Mahogany) were collected from Michika Local Government Area of Adamawa State during their annual seasons of availability in 2017. The good quality seeds were hand-picked to separate them from bad ones. Since the seed is an oil seed, moisture content was reduced or eliminated by air-drying them under the sun and subsequently preserved in a well aerated cupboard for further processing.

B. *Extraction of the Seed Oil*

Seed decortications were manually done. The decorticated dried seeds were flaked using n-hexane blender. A Soxhlet extractor was used for the extraction with a hexane as the extracting solvent. Activated molecular sieves were added to the oil and left for two days to dry the oil. The dried oil was filtered and stored for physical characterization.

III. METHODS

A. *Viscosity Determination*

The Ostwald viscometer is commonly used for comparing the viscosities of two liquids or the same liquid at different temperatures such a viscometer used in this experience is shown in plate 1

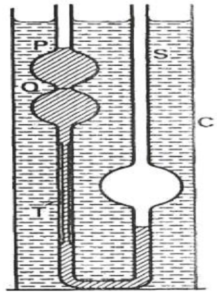

Plate 1. Schematic diagram for measuring viscosity

B. *Procedures*

The mahogany seed oil was introduced at S, drawn by suction above P and the time t_1, taken for the liquid level to fall between the fixed marks P and Q will be observed. The same experiment will be repeated with the same volume of water and the time t_2 for the liquid level to fall from P to Q will be recorded.

Suppose the liquids have respective densities ρ_1, ρ_2 then, since the average head h of liquid forcing it through T is the same in each case, the pressure excess between the ends of T equals $T = h\rho_1 g$, $T = h\rho_2 g$ respectively. If the volume between the marks P, Q is V, then, from Poiseuille's formula, we obtain that;

$$\frac{V}{t_1} = \frac{\pi(h\rho_1 g)a^4}{8\eta_1 L} \qquad (10)$$

Where; a = radius of T, η_1, = the coefficient of viscosity of the mahogany seed oil and L = the length of T. Similarly for the second liquid.

$$\frac{V}{t_2} = \frac{\pi(h\rho_2 g)a^4}{8\eta_2 L} \qquad (11)$$

Dividing equation (2) by (1) we have (Oyekunle *et. al.*, 2007);

$$\eta_1 = \frac{\eta_2 t_1 \rho_1}{t_2 \rho_2} \qquad (12)$$

Where

R_1 and R_2 =Viscosity of the mahogany oil seed and water respectively

t_1 and t_2 = Time taken for the mahogany seed oil and water to fall from P to Q respectively

ρ_1 and ρ_2 = Density of mahogany seed oil and water respectively

Thus, knowing t_1, t_2 and the densities ρ_1, ρ_2, the coefficients of viscosity can be compared. Further, if a pure liquid of a known viscosity such as water is used, the viscosity will be used to measure the coefficient of viscosity of the mahogany seed oil. Since viscosity varies with temperature, the viscometer will be used in a cylinder surrounded by water at a constant temperature. With the aid of an attached water bath, it will be possible to determine the viscosities of the mahogany seed oil with respect to the water at various temperatures (such as 30 °C, 40 °C, 50 °C, 60 °C, 70 °C and 80 °C).

IV. DENSITY DETERMINATION

A pycnometer will be used for determining the density of the mahogany seed oil.

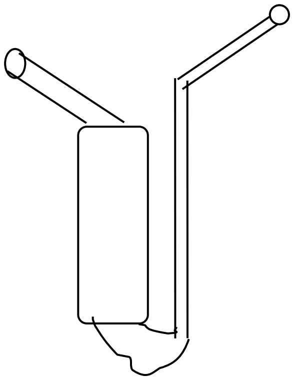

Fig 1:- The Pycnometer

V. PROCEDURES

The pycnometer (100 cm^3) will be washed with soap and rinsed with water, then with small amount of acetone. It will then be dried in an oven. The dried flask and the stopper will be weighed (W_o). The pycnometer will be filled with water (at 20 °C) and weighed (W_1). The water will be emptied and the pycnometer dried. The pycnometer will then be filled with the oil sample and weighed (W_2). The density of the oil sample will be computed as follows (Danbature *et al.*, 2015);

$$\rho = \frac{M_B - M_O}{M_W - M_O} \qquad (13)$$

Where; M_B and M_W = Mass of the Mahogany seed oil and water sample
M_O = Mass of Pycnometer

VI. RESULTS AND DISCUSSIONS

OIL SAMPLE	COLOUR	ODOUR	TASTE	PHASE
Khaya Senegalensis	Light Yellow	Bland	Bitter	Liquid

Table 1. The Observed Colour, Flavour and Physical Condition of the Mahogany Seed Oil at Room Temperature.

Viscosity (CP)	Temperature (°C)
60.70	30
37.75	40
25.30	50
17.26	60
13.31	70
9.83	80

Table 2. Measurement of the Viscosity of the Mahogany Seed Oil in Centipoise (Cp)

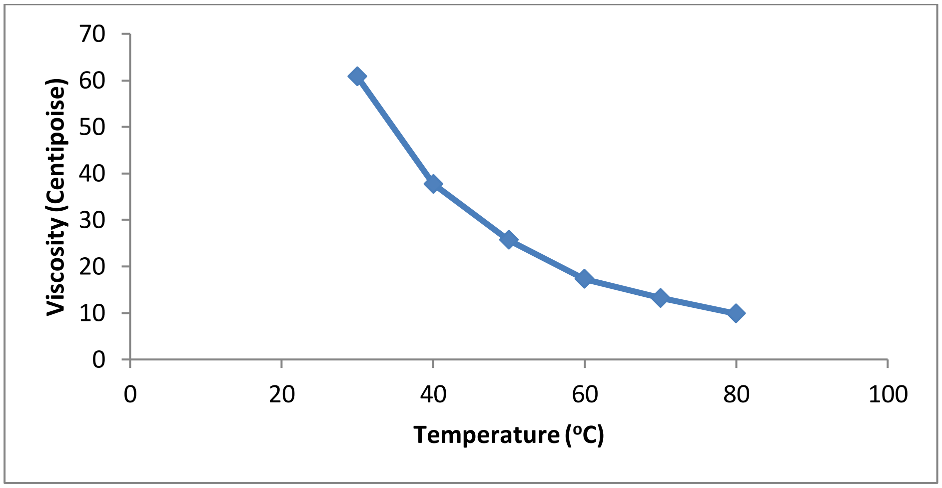

Fig 2:- Variation of Viscosity (Centipoise) of the Mahogany Seed Oil with Temperature (°C)

Density (g/cm^3)	Water (°C)	Temperature (°C)
0.9243	0.7975	30
0.9190	0.6529	40
0.9142	0.5468	50
0.9130	0.4665	60
0.9120	0.4042	70
0.9110	0.3547	80

Table 3. Comparing the Density of Water and that of the Mahogany Seed Oil (g/cm^3)

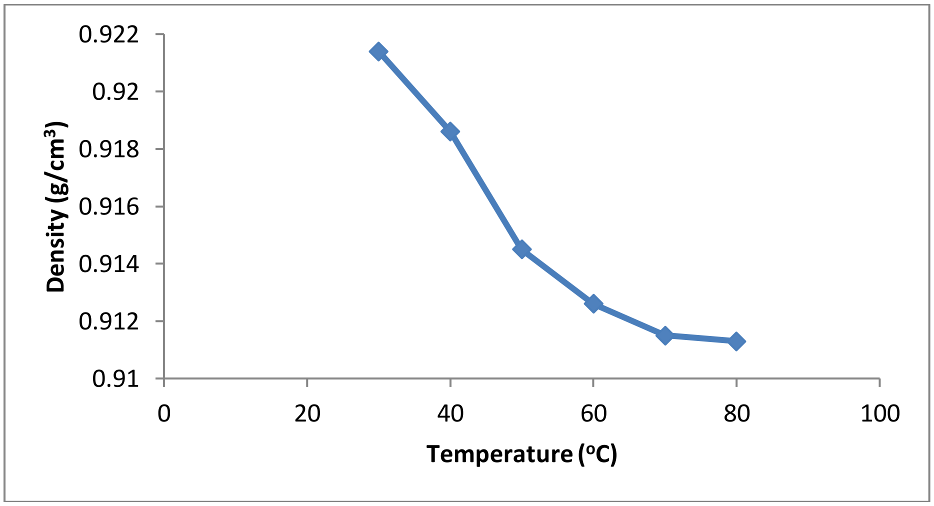

Fig 3:- Variation of Density of the Mahogany Seed Oil with Temperature (°C)

Viscosity η (cP)	In η	Temperature T (°C)	1/T (°C⁻¹)
60.70	4.1059437	30.00	0.033333
37.75	3.63098548	40.00	0.025000
25.30	3.2308044	50.00	0.020000
17.26	2.84839169	60.00	0.016667
13.31	2.58851563	70.00	0.014286
9.83	2.28543893	80.00	0.012500

Table 4. Natural Logarithm of Viscosity and the inverse of Temperature

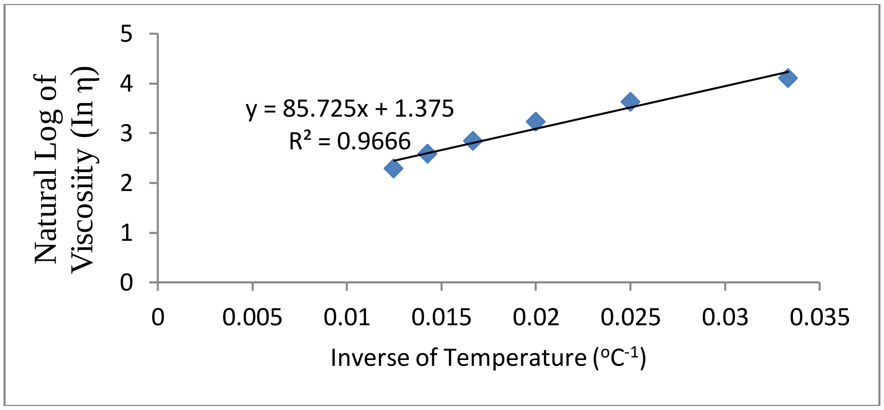

Fig 4:- Natural Log of Viscosity (In η) Versus Inverse of Temperature (°C^{-1})

VII. DISCUSSIONS

Available data of transport properties of liquids are essential for mass and heat flow. As it is one of the important properties of fluids, liquid viscosity needs to be measured or estimated given that it influences the design, handling, operation of mixing, transport, injection, combustion efficiency, pumping, pipeline, atomization and transportation and so forth. The characteristics of liquid flow depend on viscosity which is affected principally by temperature and pressure. It is commonly understood that viscosity or chemical reactions occur more rapidly at higher temperatures. This is because thermal energy dictates direction of motion at the molecular level. As the temperature rises, molecules move faster and collide more vigorously, greatly increasing the likelihood of bond cleavages and rearrangements. Whether it occurs through the collision theory or transition state theory, chemical reactions are typically expected to proceed faster at higher temperatures and slower at lower temperatures. Temperature in the same manner, affects viscosity.

Based on experimental viscosity data of the Mahogany seed oil over different temperature ranges at atmospheric pressure, we were able to determine the Arrhenius parameters such as Activation energy E_a, Entropic factor A, Arrhenius temperature T_A and the Arrhenius activation temperature T^*.Using equations 5, 6, 7 and 9 we were able to calculate the above parameters respectively as 712.5748 J/mole, 3.9551 cP, -62.3630 °C, and 85.7490 °C. The goodness of this result is supported by the R-squared value (0.9666). As observed from the graph plot (Figure 4), practically all the above parameters obey the linear Arrhenius behavior (Equation 4). Also, we found that there is significant statistical nonparametric correlation between the activation energy (E_a) and the entropic factor (A), as well as the Arrhenius temperature (T_A). Results showed that the model which best fits the relationship between the defined Arrhenius parameters is a logarithmic type correlating the activation energy (E_a) to the Arrhenius temperature (T_A). Concerning the hydraulic calculations of fluid transportations and for energy transfer (Aymen *et al.*, 2015), we have reduced the model using single variable without losing significant accuracy. The equation used in the present work allows for redefining the Arrhenius equation by using a single parameter (Ben Haj-Kacem *et al.*, 2012 and Kirkwood *et al.*, 1949) instead of two (Irving, 1977) by using experimental viscosity values at several temperatures. We hereby re-emphasize that this model would be very useful in different fields of physical and chemical sciences. Most interestingly, in engineering data and in estimating one unknown parameter when the second one is available (Das *et al.*, 2012) or evaluated by some relevant theories suggested in the literature (Viswanath *et al.*, 2007).The implication of the exponential term in equations 3 and 4 is that viscosity increases exponentially when the activation energy decreases. Because viscosity with small activation energy does not require much energy to reach the transition state, it should proceed faster than a reaction with larger activation energy.

In chemical reactions, the activation energy obtained above is the minimum energy required for the reaction to take place while the entropic factor expresses the fraction of reactant molecules that possess enough kinetic energy to go into reaction as governed by the Maxwell-Boltzmann law. In other words, the entropic factor is the fraction of molecules that would react if either the activation energy was zero, or if the kinetic energy of all molecules exceeded the activation energy; this is admittedly, an uncommon scenario although barrierless reactions have been characterized by this behavior. The exponential term $e^{\frac{E_a}{RT}}$ in equation 3 counts the fraction of the molecules present in a fluid which have energies equal to or in excess of the activation energy at a particular temperature. Also, the fraction of the molecules able to react will almost double by increasing the temperature by a value as small as 10 ºC and this causes the reaction to almost double as well. The implication of this term in equations 3 and 4 is that the rate constant of a reaction increases exponentially when the activation energy decreases. The rate of a reaction is directly proportional to the rate constant of a reaction, the rate increases exponentially as well. Because a reaction with small activation energy does not require much energy to reach the transition state, it should proceed faster than a reaction with larger activation energy. In addition, the Arrhenius equation implies that the rate of an uncatalyzed reaction is more affected by temperature than the rate of a catalyzed reaction. This is because the activation energy of an uncatalyzed reaction is greater than the activation energy of the corresponding catalyzed reaction. Since the exponential term includes the activation energy as the numerator and the temperature as the denominator, smaller activation energy will have less of an impact on the rate constant compared to larger activation energy. Hence, the rate of an uncatalyzed reaction is more affected by temperature changes than a catalyzed reaction. This form of the Arrhenius equation makes it easy to determine the slope and y-intercept from an Arrhenius plot. It is also convenient to note that the above equation shows the connection between temperature and rate constant. As the temperature increases, the rate constant decreases according to the plot. From this connection we can infer that the rate constant is inversely proportional to temperature.

Physical observations of the Mahogany seed oil sample (Table 1) indicates that the colour is light yellow, had essentially bland odour, a very bitter taste, which convincingly suggest the presence of alkaloids and resins. Other physical parameters of the oil sample such as viscosity and density were also determined and these physical constants are temperature dependent. The viscosity and density values of the oil sample compares closely to those obtained for glycine max (soya bean) by Akanni *et al.*, (2005).The Khaya Senegalensis have comparable viscosity values (table 2) to that obtained for Jatropha curcas by Oyekunle *et al.*, (2007). Also, we are informed that the oil from Jatropha curcas was used by many villagers in some tropical countries such as Mali for driving stationary machineries/engines (SPORE magazine, 1997). Therefore, it is very possible to use the Mahogany seed oil in starting the engines if left overnight since the solidification temperature of the oil sample is quiet below the lowest possible temperature which is about 10ºC in any season (Oyekunle *et al.*, 2007).

The density values (Table 3) for the oil sample are observed to be less than that of water within the given temperature range. This result is in agreement with the values observed for some conventional seed oil such as groundnut oil. Hence, Khaya Senegalensis, can be conveniently applied in inhibiting the vaporization of water in any process especially in arid region where we have acute water shortage. However, the water for which the oils may serve as retardants should not be drinkable one since pre-oxidation of the oils may transfer rancid oil odour to the water. Also, since seed oils are susceptible to bio-degradation unlike fossil fuels, there is little or no fear of possible long-term environmental pollution that may occur due to their use.

Finally, the seed oil yield of about 60% volume per weight is higher than that obtained by Okieimen and Eromosole, (1999); and Abdulhameed *et al.*, (2012). It is also higher than that obtained for soya beans (15 – 21) % and rape seed (>40%) (Okieimen and Eromosole, 1999). This value therefore is considered as reasonable recovery yield. A crop that produces high amount of oil is desirable for biodiesel production as it could be used as a feasible alternative (Jibrail and Kaet, 2013). However, the observed improvement in the oil recovery of mahogany seed could be attributed to the modified method of extraction. Also, the density of mahogany seed oil is higher than that obtained by Abdulhameed *et al.*, (2011) but lower than that reported by Okieimen and Erosomole (1999). The density of mahogany seed oil obtained in this research falls within the European standard of (0.86 – 0.90) g/cm^3 (EN14214).

VIII. CONCLUSION

In the present work, we have used statistical methods to analyze eventual correlation between the Arrhenius parameters for Mahogany seed oil. We found that there is significant statistical nonparametric correlation between the activity energy (Ea) and the entropic factor (A), as well as the Arrhenius Temperature (T_A) and the Arrhenius Activation Temperature T* for homogenous dimensions. Results showed that the model which best fits the relationship between the defined Arrhenius parameters is a logarithmic type correlating the activation energy (Ea) to the Arrhenius temperature (T_A). Therefore, in making hydraulic calculations of fluid transportations and for energy transfer (Ouerfelli, Bouaziz, and Herráez, 2013; Herráez, Belda, Díez, and Herráez, 2008; Irving, 1977; Benson, 1976; Dean, 1987; Glasstone, Laidler, and Eyring 1941; Lee and Lee, 2001; Qunfang and Yu-Chun, 1999; Macías-Salinas, García-Sánchez, and Eliosa-Jiménez, 2003; Belgacem, 2001; Viswanath *et al.*, 2007), we have reduced the model using single variable without losing significant accuracy. We made use of an equation in modeling the relationship between the two parameters of viscosity Arrhenius-type equation, such as the Arrhenius energy (Ea) or the entropic factor (A). The equation allows us to redefine the Arrhenius equation by using a single parameter (Ben Haj-Kacem *et al.*, 2014; Kirkwood, Buff and Green 1949) instead of two (Irving, 1977) by using experimental viscosity values for Mahogany seed oil at several temperatures. We hereby assert that this model would be very relevant in several fields of the physical and chemical sciences. It will also be very interesting for engineering data and will permit estimating one non-available parameter when the second one is available (Das *et al.*, 2012 and Dallel *et al.*, 2014) or estimated by some theories suggested in the literature (Viswanath D. S. *et al.*, 2007; Kirkwood, Buff and Green, 1949; Cummings and Evans, 1992; Eyring, 1936; Eyring and Hirschfelder; 1937; Eyring and John, 1969).We hope that this study opens the way to estimate more accurate values of the proposed equation's parameters, when the nature of fluids is classified separately (high, moderate, low viscous liquids) or solvent characteristics (protic, polar, nonpolar, etc.). In the same way, this correlation may encourage theorists to combine or merge some previously distinct theoretical methods already available. In addition, we hope that it will be useful in large domains of applied physics, chemistry fluid mechanics, and engineering etc.

The dry zone Mahogany (Khaya senegalensis) is an oil rich tree crop that grows well in subharan Africa. Its round, woody, capsular fruit that has four to five valves in which up to 6-18 seeds are embedded. The tree's importance lies mainly on its seed, which contains kernel with oil content of 67%. The seed oil "Mayin daci" (in Hausa language) is used for cooking and in the manufacture of cosmetics and pharmaceutical products in West Africa. The present methods of handling and processing the mahogany seed involves operations that are not only slow and full of drudgery but also wasteful. Improved methods of handling and processing the seed using suitable machines and equipment could be developed if the physical properties are known. The seeds which are commonly found in Adamawa State were sampled and subjected to physical property test at a moisture content of about 12.20% wet basis.

The oil sample in this study could serve as grease for engine parts anywhere in the tropics and at temperatures close to 5ºC such as in temperate regions because the oil was less viscous around such temperature. The seed of Khaya Senegalensis is non-drying oil, consisting of long chain fatty acids, and the extract from the seed may contain bioactive compounds of potential therapeutic and prophylactic significance. It could also be concluded that mahogany seed oil is a good feed stock for biodiesel production. Also, these results would play a very important role in understanding the agronomic properties of the seed when designing processing or handling machine for the seed.

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