Prepare and Study Some Mechanical and Electrical Properties of KAl(SO4)2.12H2O as Aqueous Solutions

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Abstract
Some of physical properties of KAl(SO4)2.12H2O dissolves in distilled water had been studied at different concentrations (0.05% , 0.075% , 0.1% , 0.125 and 0.15 gm./ml) such as (mechanical and electrical properties), the mechanical properties such as ultrasonic velocity had been measured by ultrasonic waves system at frequency 25 KHz, other mechanical properties had been calculated such as absorption coefficient of ultrasonic waves, relaxation time, relaxation amplitude, specific acoustic impedance, compressibility and bulk modules. The electrical properties such as electrical conductivity, molar conductivity and degree of dissociation were measured by conductivity meter, The results show that the specific acoustic impedance and bulk modules are increasing with the increase of the concentration , absorption coefficient of ultrasonic waves ,compressibility, relaxation time, relaxation amplitude and shear viscosity are decreasing with increase the concentration, also The results show that the conductivity is increasing with increase the concentration.
Keywords: KAl(SO4)2.12H2O solution, Electrical properties, Mechanical properties, ultrasound technique.

1. Introduction

This materials is used in many industrial fields that are related to human life, it can be used as a purifying factor for irrelevant objects that are found in drinking water as it (i.e. crystal) melts with water thus producing Tri-Alominium Ion which forms a hydroxide with water having a foam –like quality that causes the irrelevant objects in water to go down the water container, thus it can be removed by mechanical methods [1].
In addition to the above uses, the crystal is used as a purifying factor for injuries and it helps to keep the skin in a smooth condition in certain illness conditions or surgeries. It can also be used to produce Alominium that is an important factor in making parts of airplanes and as an element in producing Alomia (Alominium oxide) that is used as a dying element for satellite dishes and other similar objects [2].
some of mechanical properties of different materials were carried by some workers using ultrasonic technique[10]. The purpose of this research was to investigate the physical properties of KAl(SO4)2.12H2O as aqueous solutions by ultrasound wave at fixed frequency (25 KHZ) and know its ability to industrial applications.

2. Experimental:

1.2 Preparation of Solutions:

We prepared KAl(SO4)2.12H2O with assay (99.8%). and different solutions were prepared by dissolving a known weights of The KAl(SO4)2.12H2O powder in affixed volume (500 ml) of distilled water under stirring for (10 min). The KAl(SO4)2.12H2O concentrations were (0.05% , 0.075% , 0.1% , 0.125 and 0.15 gm./ml) . The resulting solution was stirred continuously for (10 min) until the solution mixture became a homogeneous.

2.2 Ultrasonic measurements:

Ultrasonic measurements were made by pulse technique of sender-receiver type (SV-DH-7A/SVX-7 velocity of sound instrument) with constant frequency (25 KHz), the receiver quartz crystal mounted on a digital vernier scale of slow motion, the receiver crystal could be displaced parallel to the sender and the samples were put between sender and receiver. The sender and receiver pulses (waves) were displaced as two traces of cathode ray oscilloscope, and the digital delay time (t) of receiver pulses were recorded with respect to the thickness of the samples (x). The pulses height on oscilloscope (CH1) represents incident ultrasonic wave's amplitude (A0) and the pulses height on oscilloscope (CH2) represents the receiver ultrasonic wave's amplitude (A).

Generator and Receiver of Ultrasonic Waves

3.2 Theoretical calculation:
The absorption coefficient (α) was calculated from Lambert – Beer law[3]:

$$A / A_0 = e^{(-\alpha x)} \cdots\cdots\cdots (1)$$

Where (A_0) is the initially amplitude of the ultrasonic waves,(A) is the wave amplitude after absorption and (x) is the thickness of the sample.
The ultrasonic wave velocity (V) was calculated using the following equation[4]:

$$V = x / t \cdots \cdots \cdots (2)$$

Where (t) is time that the waves need to cross the samples (digital obtained from the instrument). Attenuation is generally proportional to the square of sound frequency so the relaxation amplitude (D) was calculated from the following equation[5] where (f) is the ultrasonic frequency:

$$D = \frac{\alpha}{f^2} \cdots \cdots \cdots (3)$$

The acoustic impedance of a medium (Z), it was calculated by equation[6,7]:

$$Z = \rho V \cdots \cdots \cdots (4)$$

Bulk modulus (K) is the substance's resistance to uniform compression, it is defined as the pressure increase needed to decrease the volume; it was calculated by Laplace equation[8] :

$$K = \rho V^2 \cdots \cdots \cdots (5)$$

Compressibility (B) is a measure of the relative volume change of a fluid or solid as a response to a pressure (or mean stress) change, it was calculated by the following equation[9]:

$$B = (\rho V^2)^{-1} \cdots \cdots \cdots (6)$$

The relaxation time (τ) was calculated from the equation[10]:

$$\tau = 4\eta_S / 3\rho V^2 \cdots \cdots \cdots (7)$$

the viscosity of the samples was measured by knowing absorption coefficient using the equation: [11]

$$\eta_{shear} = 3\, \alpha\, \rho\, v^3 / 8\, \pi^2\, F^2 \ldots\ldots (8)$$

4.2 Conductivity measurements:
The conductivity was measured using (DDS – 307 microprocessor conductivity meter -England) [12], the calibration was made and the correction factor taken account in measuring the samples, all conductivities values obtained for KAl(SO4)2.12H2O, the figure shows conductivity meter.

5.2 Theoretical calculations:

The molar conductivity (Λ_m) is defined as the conductivity of an electrolyte solution divided by the molar concentration of the electrolyte, and so measures the efficiency with which a given electrolyte conducts electricity in solution, it calculated by [13, 14]:

$$\Lambda_m = \sigma/c\ldots\ldots(9)$$

Where σ is the conductivity and (c) is the molar concentration.
The degree of dissociation (D) is calculated by the following equation [15]:

$$D= \Lambda_m/\Lambda_o \ldots (10)$$

Where Λ_o is the extrapolation of molar conductivity to infinite dilution the limiting value of the molar conductivity.

3. Results and Discussion:

1.3 Mechanical properties:

Since there is no interaction or network formation between the two types of molecules (solvent and solute) because of absence of bonding attachments. The solute molecules dispersion through the solvent with out bonding this lead to molecules to have free movement inside solution then allow ultrasound waves passes with out changes shows in (Fig.1)[16]. (Fig.2) shows that absorption coefficient is increasing with concentration this attributed to the fact that when KAL(SO4)2.12H2O concentration increase there will be more molecules in solution this lead to more attenuation against wave propagation, the attenuation can be attributed to the friction and heat exchange between the particles and the surrounding medium as well as to the decay of the acoustic wave in the forward direction due to scattering by the Particles, this behavior same to that give by [11] for other materials, Compressibility of samples was calculated using Laplace equation no. (6), the results in Fig. (3) show that the compressibility are increasing with increasing concentration this behavior same to that given by [17.18] for other materials; this could be attributed that ultrasonic waves propagation made molecule to be each close together, this change confirmation and configuration of these molecules. bulk modulus is decreasing with concentration as shown in(Fig.4) because The compressibility is increasing with the increase of concentration (Fig.3) There are inverse proportionality between compressibility and bulk modulus .

Specific acoustic impedance shown in (Fig.5) is decreasing with concentrations this behavior same to that given [18] for other Materials. Ultrasonic relaxation amplitude was calculated by using equation no.(3) and shown in (Fig.6) and Ultrasonic relaxation time was calculated by using equation no. (7) Shown in (Fig.7) these values are increasing with concentration, this behavior is the same to that given by [6] for other materials ,and attributed to the fact that ultrasonic energy depends on viscosity ,thermal conductivity, scattering and intermolecular processes .Thermal conductivity, scattering are known to be negligible , so viscosity is responsible for the increase of relaxation amplitude for this reason absorption coefficient commonly known as visco- absorption [11] Shear Viscosity shown in (Fig .8) is increasing with concentration, this attributed to the mechanism that hydrogen bonding of water attached to oxygen sites, this leads to salvation sheaths and increase the size of the molecules.

2.3 Electrical properties:

The measured conductivity of all KAL(SO4)2.12H2O solutions for different concentrations were plotted in figure (9), this shows that increases the ions in the solution and reducing the number of dipole moment of the

KAL(SO4)2.12H2O and water molecules then there will be ionic conduction which make conductivity increase [16]. The molar conductivity of all samples were shown in figure (10) and decreasing with increasing concentrations, this can be attributed to the fact that the dielectric constant of the mixtures increases because of the stronger hydrogen-bonding interactions [14] and in dilute concentrations it has higher values than that in high concentration , this attributed that there is no intermolecular interactions occurs , the electrostatics repulsing leads to a reduction of intermolecular bonding and increase of KAL(SO4).12H2O dimensions whereas higher concentration lead to inhibition of intermolecular bonding [15]. The extrapolation of this plot to infinite dilution gives the limiting value of molar conductivity; this is the value when the ions are so far a part that they do not interact [12, 17, 18], Ostwald of dilution indicates that complete dissociation when the dilution approach infinite therefore the dilute solution may be represented as strong electrolyte [20,21] the value of degree of dissociation has the range $0\leq D \leq 1$ for strong electrolyte D=1 and for weak electrolyte D=0 [15] , figure (11) shows that KAL(SO4).12H2O stronge electrolyte, according to KAL(SO4).12H2O ionic characteristics and figure also shows that this curve obey Ostwald law of dilution for aqueous solutions.

4. Conclusions:

1. ultrasonic absorption coefficient increases with increasing concentration so it can be used as coated materials for moving bodies in order to detect by ultrasonic technique .
2. the shear Viscosity increases with concentration because of the increasing in the size of the molecules, so it reduce tensile strength and increase its chains viscosity which is responsible for the increase of relaxation amplitude.
3. this composite has good mechanical properties so it may use as resistant materials against environment.
4. the conductivity increases when concentration is increasing so it can be used in electrical circuits with sensing range of electrical conductivity.

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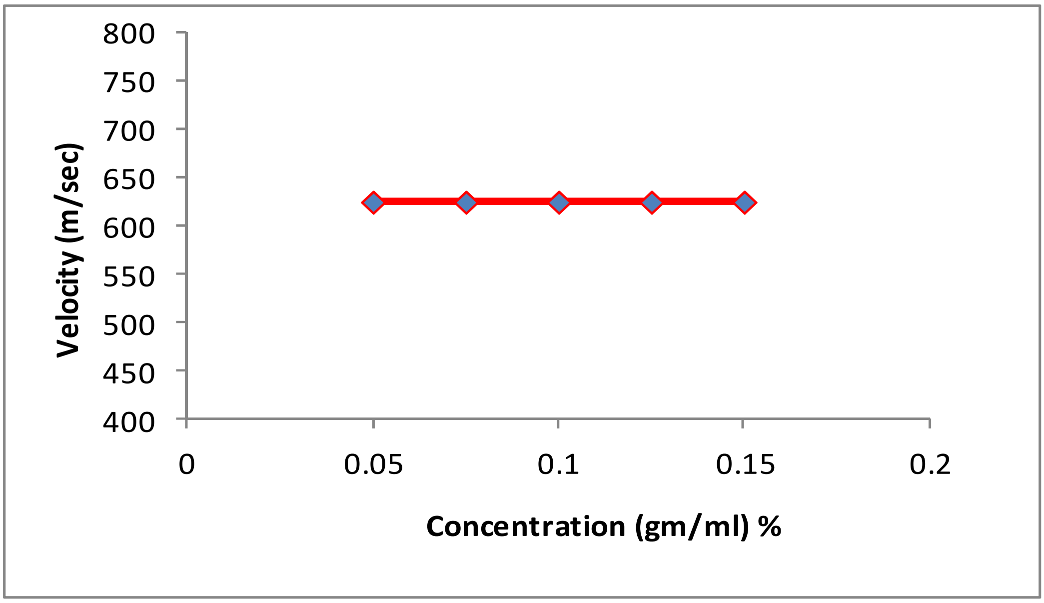

Figure.1. Velocity due to concentration

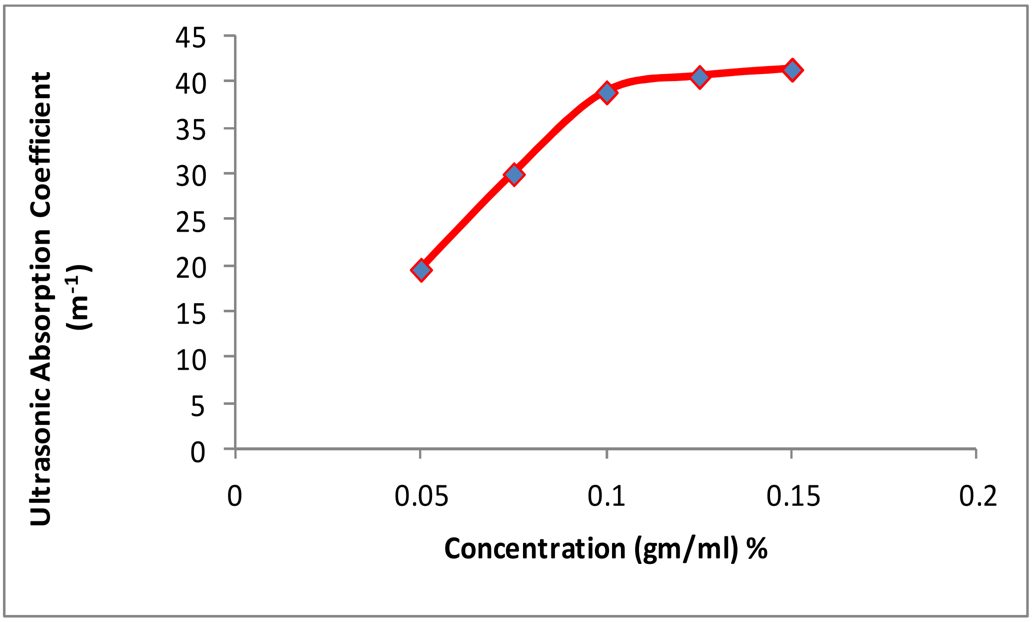

Fig.2. Absorption coefficient due to concentration

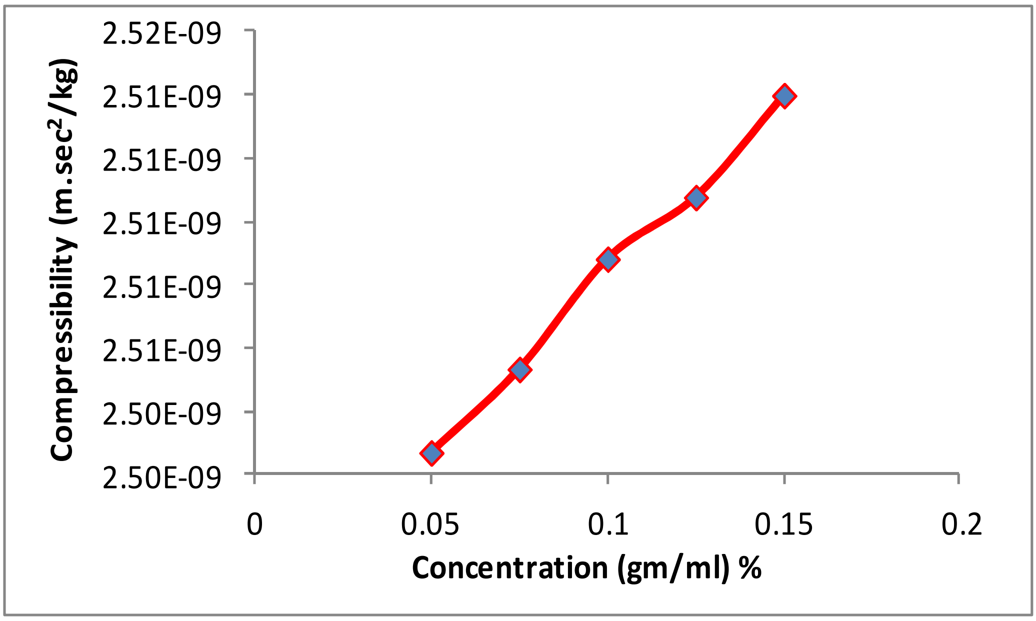

Fig.3. Compressibility due to concentration

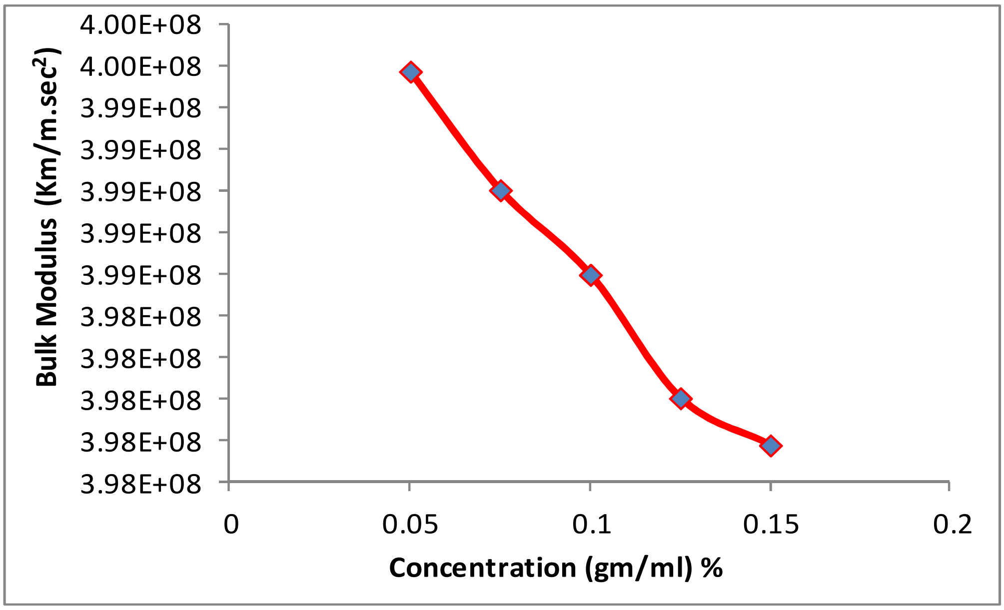

Fig.4. Bulk Modulus due to concentration

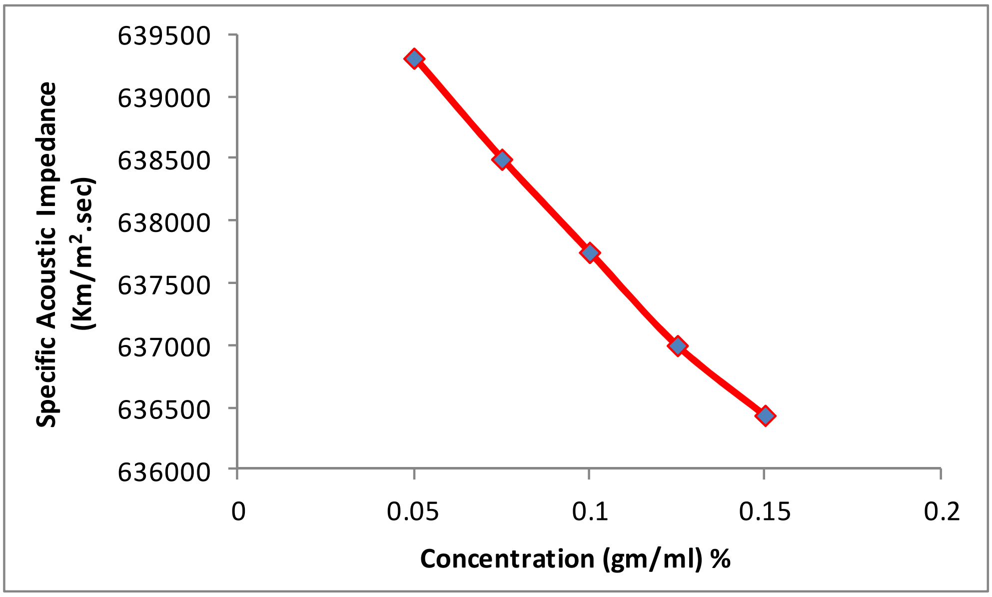

Fig. 5. Specific Acoustic impedance due to concentration

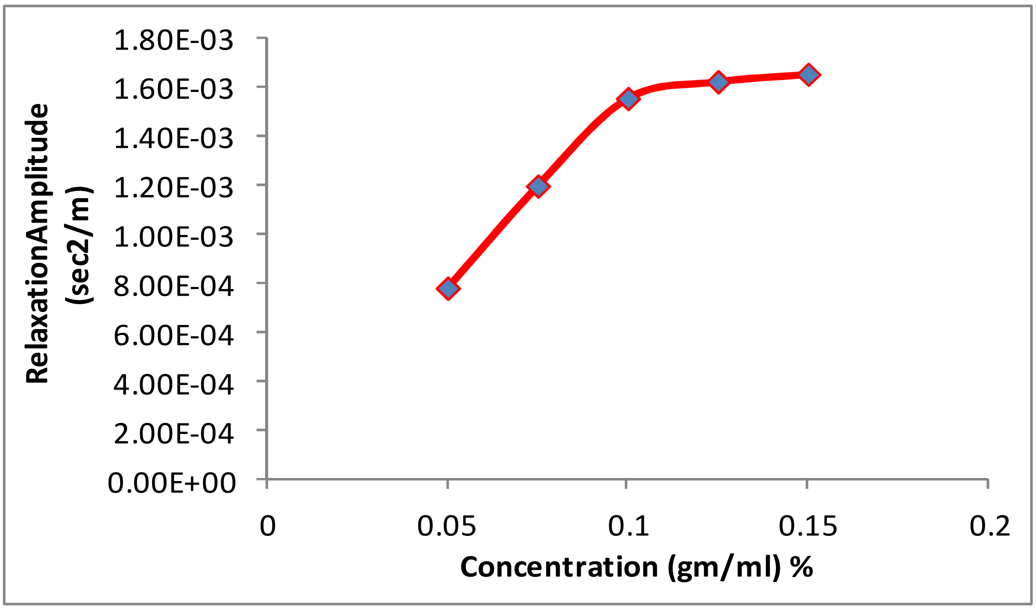

Fig.6. Relaxation amplitude due to concentration

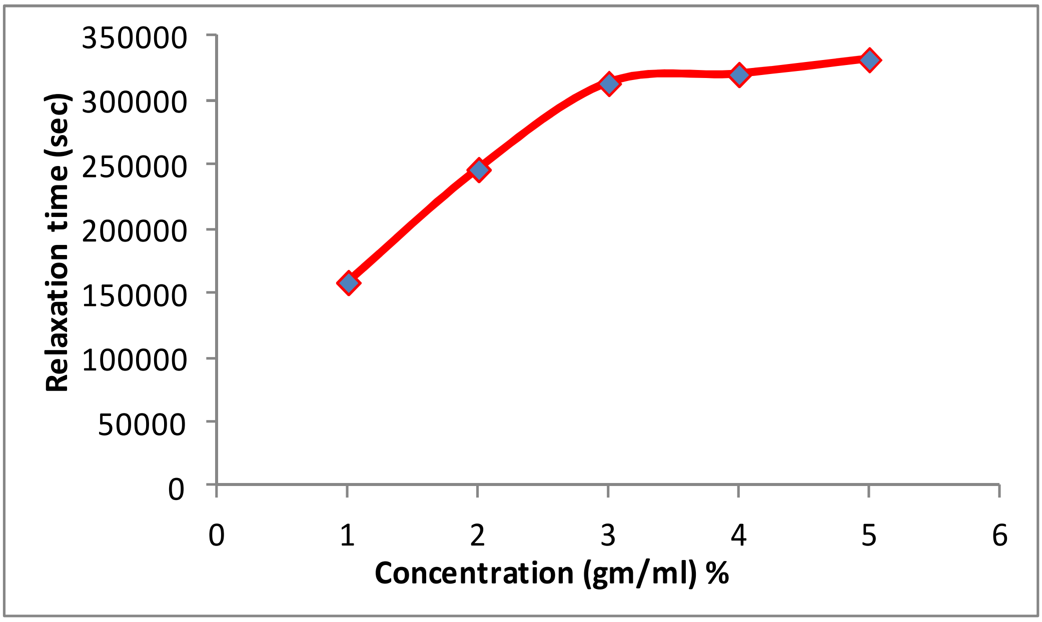

Fig.7. Relaxation time due to concentration

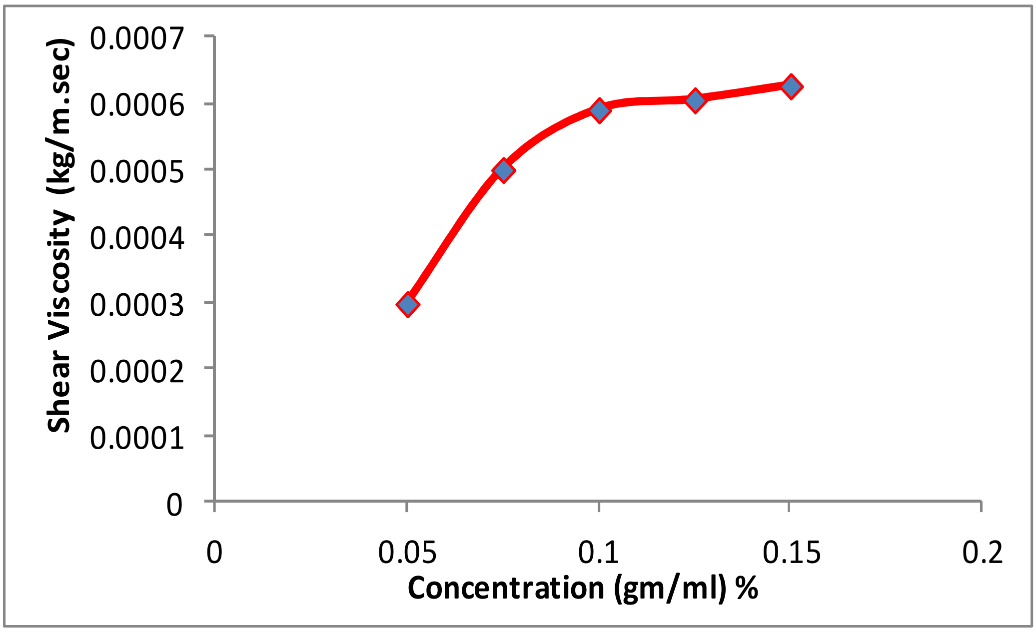

Fig.8. Shear Viscosity due to concentration

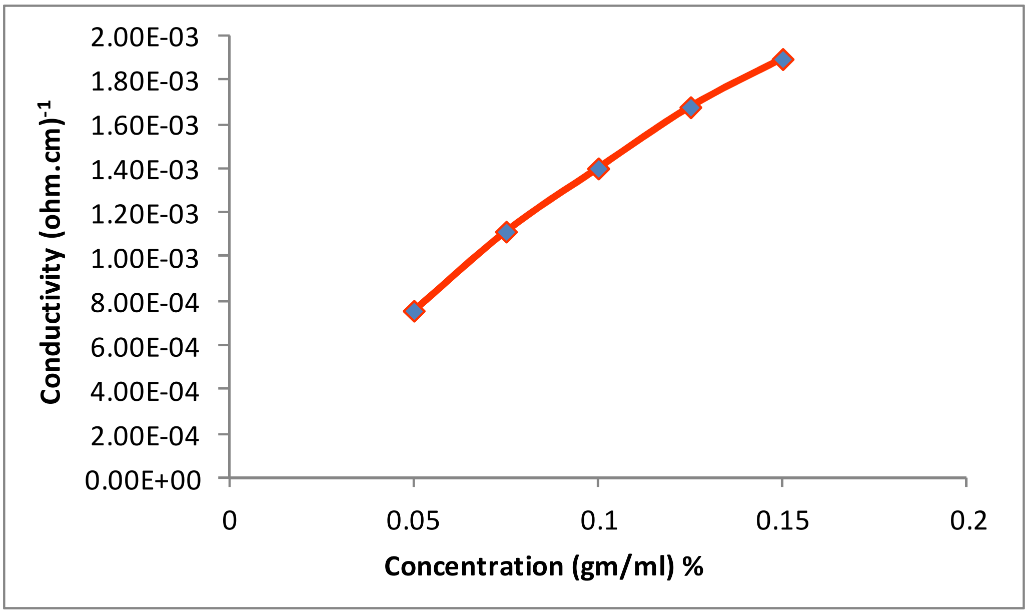

Fig.9. Electrical Conductivity due to concentration

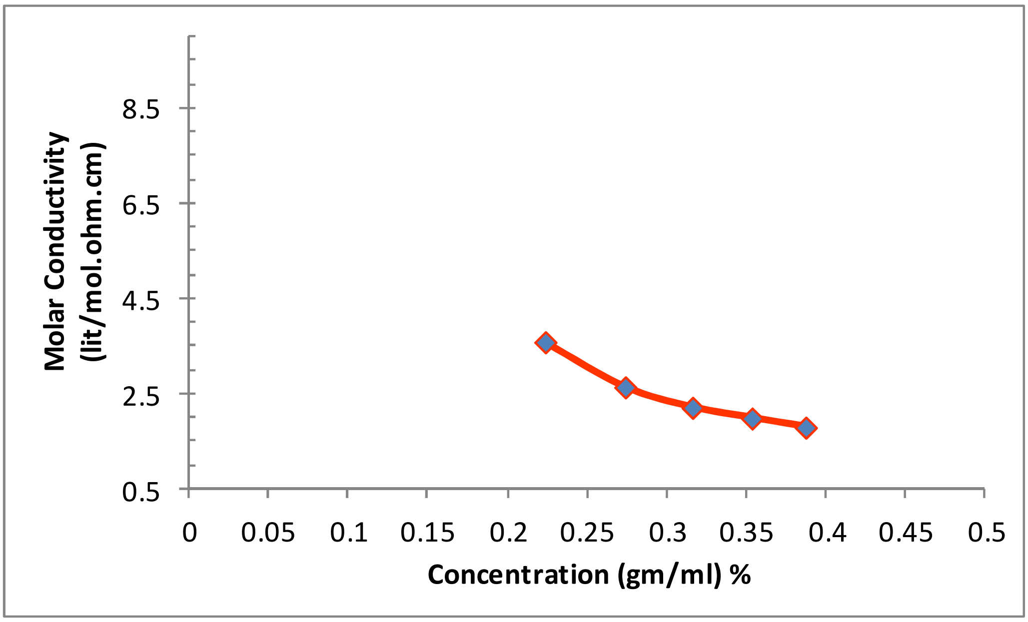

Fig.10. Molar Conductivity due to concentration

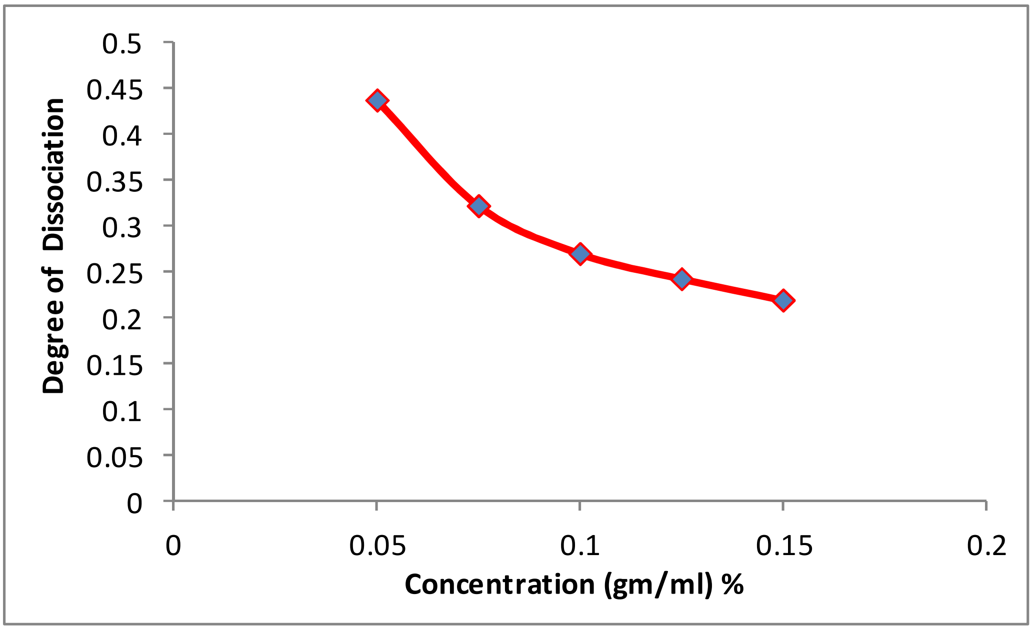

Fig.11. Degree of Dissociation due to concentration

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