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Study the Effect of adding PVA on Some Physical Properties of CMC Polymer as aqueous solutions

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Abstract
Some of physical properties of Carboxy methyl cellulose dissolves in distilled water had been studied at different concentrations (0.1%, 0.2%, 0.3%, 0.4% ,0.5 ,%,0.6 %,0.7% and 0.8%) gm./ml) before and after adding (0.5, 1 ,1.5) gm. of PVA for all concentrations, the Rheological properties such as shear, relative reduced and Specific Viscosity are measured; the mechanical properties such as ultrasonic velocity had been measured by ultrasonic waves system at frequency 45 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 results show that all these properties are increasing with the increase of the polymer concentration except compressibility is decreasing with increase the concentration; results show that when adding PVA these properties are increasing except viscosity, Relaxation time and compressibility are decreasing. Results also shows that adding PVA polymer to CMC enhances the ultrasonic absorption coefficient as a result of high values after addition.
Keywords: CMC solution, PVA solution, mechanical properties, rheological properties, ultrasound technique.

1. Introduction

CMC is an ionic linear polysaccharide derived from cellulose .it is an important industrial polymer with a wide range of applications in flocculations, drug reduction, detergents, textiles, papers, foods, roiling oil and drugs [1]. CMC is water – soluble synthetic polymers. CMC is used primarily because it has high viscosity, it is non-toxic, and is non-allergenic. CMC has a wide range of applications due to its low cost [2] Because of its polymeric structure and high molecular Wight; it can be used as filler in bio- composite films [3]. CMC is able to improve the mechanical and barrier properties of pea starch-based films [4]; Because of its pronounced visco- elastic and structure-forming properties, the cellulose ether sodium carboxy methyl cellulose (Na-CMC) is employed as a flow enhancer, stabilizer, and also as an agent for binding, suspending and thickening. The physical properties are strongly dependent not only on the molecular weight and concentration of polymer but also the kind of solvent systems [5]. PVA is a water-soluble synthetic polymer, due to the characteristics of easy preparation, good biodegradability, excellent chemical resistance, and good mechanical properties, polyvinyl alcohol is used mainly as a solution in water but its solubility in water depends on its degree of polymerization and degree of hydrolysis of its precursor (poly vinyl acetate), The rheological properties of the PVA solutions are affected by effectiveness of the physical bonding solvent systems the physical state of water is very important to rheological responses because free water forms hydro-gel structure [6] solvent effects might therefore be expected to influence the ultrasonic relation behavior, the absorption of ultrasonic in liquid polymer systems is governed by local modes of motion and cooperative whole molecule movement because of the strong intermolecular interaction within the polymer it should be possible to observe cooperative motion in the ultrasonic range [7]. Polyvinyl alcohol has high tensile strength and flexibility, as well as high oxygen and aroma barrier properties. However these properties are dependent on humidity, in other words, with higher humidity more water is absorbed, the water which acts as a plasticizer, will then reduce its tensile strength, but increase its elongation and tear strength. Acoustic relaxation measurements on other polymers have been reported by several workers [8, 9], ultrasonic technique is good method for studying the structural changes associated with the information of mixture assist in the study of molecular interaction between two species; some of mechanical properties of different polymers were carried by some workers using ultrasonic technique [10]. The purpose of this research was to investigate the physical properties of carboxy methyl cellulose (CMC) with polyvinyl alcohol (PVA) as

aqueous solutions by ultrasound wave at fixed frequency (45 KHZ) and study the effect of adding PVA on the physical properties of CMC to enhance its different applications.

2. Experimental:

2.1 Preparation of Solutions:

CMC- sodium salt (pancreas- Barcelona-Spain) with assay (99.9 %) of high viscosity and PVA (Gerhard Buchman –Germany) with assay (99.8%).The CMC solution was prepared by dissolving a known weights of CMC powder in affixed volume (400 ml) of distilled water under stirring at 70oC for (30 min). The CMC concentrations were (0.1%, 0.2%, 0.3 %, 0.4%, 0.5%, 0.6%, 0.7% and 0.8%) gm./ ml ; then PVA was added with different weights (0.5, 1, 1.5 gm.) to all CMC Concentrations. The resulting solution was stirred continuously for (30 min) until the solution mixture became a homogeneous

2.2 Density and Rheological measurements:

ined before and after the adding of PVA by the following equations [12].The Shear viscosity had been calculated by the following equation [13]: The density of the solutions (ρ) was determined by density bottle method and their viscosities measured before and after adding PVA for all CMC concentrations by using Ostwald viscometer with accuracy of ± 1.05% [11], the method of measurement has been described elsewhere different types of viscosity were determ

$$\frac{\eta_s}{\eta_o} = \frac{t \rho}{t_o \rho_o} \text{.....} \quad (1)$$

Where (ρ) and (ηs) are the solution density and viscosity respectively, (ρo) and (ηo) are density and viscosity of distilled water respectively, Relative viscosity (ηrel) was calculated by the following equation.

$$\eta_{rel} = \frac{t}{t_o} = \frac{\eta_s}{\eta_o} \text{.....} \quad (2)$$

The specific viscosity (ηsp) and reduced viscosity (ηred) was calculated by the equations where (C) is the concentration:

$$\eta_{sp} = \frac{(\eta_s - \eta_o)}{\eta_o} = \eta_{rel} - 1 \text{.....} \quad \text{.....} (3)$$

$$\eta_{red} = \frac{\eta_{sp}}{C} \text{.....} \quad (4)$$

2.3 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 (45 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).

2.4 Theoretical calculation:

The absorption coefficient (α) was calculated from Lambert – Beer law [14]:

$$A/A_0 = e^{(-\alpha x)} \text{ ..... } (5)$$

Where (A0) 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 [15]:

$$v = x / t \text{ ..... } (6)$$

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 [16] where (f) is the ultrasonic frequency:

$$D = \alpha / f^2 \ldots\ldots\ldots (7)$$

The acoustic impedance of a medium (Z), it was calculated by equation [17]:

$$Z = \rho v \ldots\ldots\ldots (8)$$

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 [18]:

$$K = \rho v^2 \ldots\ldots\ldots (9)$$

Compressibility (β) 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 [19]:

$$\beta = (\rho v^2)^{-1} \ldots\ldots\ldots (10)$$

The relaxation time (τ) was calculated from the equation [20]:

$$\tau = 4 \eta_s / 3\rho v^2 \ldots\ldots\ldots (11)$$

3. Results and Discussion:

3.1 Rheological properties:

The density is increasing with the increase of polymer concentration as shown in (Fig.1) since the density defined as mass per unit volume and we adding different weight of polymer to fixed volume of solvent so there are linear increment for density. Shear Viscosity is increasing with concentration as shown in (Fig.2) this attributed to the mechanism that hydrogen bonding of water attached to oxygen sites, this leads to salvation sheaths and increase in the size of the molecules, so its viscosity [21] furthermore water act as plasticizer will reduce tensile strength and increase its chains [22, 23]. Relative, specific and reduced viscosities showed in (Fig.3), (Fig.4) and (Fig.5) respectively possess the same behaviors of shear viscosity because they derived from it as shown in equations (2, 3), adding PVA reduced these viscosities, this attributed that there are intermolecular interactions and network formation between the two types of molecules as a result of adding PVA so decreasing the size of macromolecules and attributed that CMC molecular weight is higher than PVA which has Low molecular weight, and adding PVA to CMC reduced the friction between the two types of molecules in a solution therefore the solutions have new conformation and configuration that lead to reduce viscosity. [24, 25, 26].

3.2 Mechanical properties:

(Fig.6) shows that absorption coefficient is increasing with concentration this attributed to the fact that when polymer 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 [8], this behavior same to that give by [11] for other polymers, adding PVA enhances absorption coefficient by increasing its values. This attributed as we explained that adding PVA reduced the viscosity of the solution this means that there were more flexibility for these polymer chains in solution as a result of adding PVA molecules, and because ultrasonic waves propagate as compression and rarefaction in a medium so there are variation in density medium and there were more attenuation to energy of ultrasound waves when adding PVA [27]. Ultrasonic velocity is increasing with increasing concentration as shown in (Fig.7) this because structural or volume relaxation it occurs in associated liquids such as polymers, a liquid when at rest has a lattice structure similar to that possessed by solid when waves are propagated through it, the resultant periodic changes of wave pressure causes molecules to flow into vacancies in the lattice during compression phase and to return to their original positions in the lattice during rarefaction so when concentration increases the velocity is also increase [28]. Adding PVA increase the velocity, this attributed that ultrasonic waves interact with polymers causing association between the two types of molecules that lead to increase the velocity [26]. The compressibility is decreasing with the increase of concentration (Fig.8) and attributed to the fact that in Laplace equation no. (10) There are inverse proportionality between compressibility and ultrasonic velocity [28, 29]. Ultrasonic relaxation time was calculated by using equation no. (11) Shown in (Fig.9) and the relaxation amplitude shown in (Fig.10) calculated from equation no.(7) their values are increasing with concentration, this behavior same to that give by [11] for other polymers, also Fig.9 Shows that relaxation time reduced when

adding PVA this attributed to the fact that ultrasonic energy depends on viscosity thermal conductivity, scattering and intermolecular processes , thermal conductivity and scattering effects are known to be negligible [18] so viscosity is responsible for the decrease of relaxation time for this reason absorption coefficient commonly known as visco –absorption. Specific acoustic impedance shown in (Fig.11) is increasing with concentrations this behavior same to that given by [30] for other polymers and attributed to the equation no. (8) has only one variable parameter which is velocity and density has very small variations with respect to that of velocity. and the bulk modulus is increasing with concentration (Fig.12) ; this behavior same to that give by [23].Fig.11 shows that adding PVA reduced acoustic impedance because PVA polymer chains fills the valances by swallowing water molecules and be closer to CMC macromolecules that increasing Specific acoustic impedance [31].

4. Conclusion

Adding PVA polymer to CMC enhances the ultrasonic absorption coefficient as a result of high values after addition.

it can be applied as a coated material to object that want to be observed by sonar or such radars.

Small amount of PVA can reduce CMC solution viscosity instead of adding large quantity of water to obtain same results.

When concentration increases the velocity increases there will be complexes molecules were formed in the solution by the effect of peroxide and roots that rebounded to Network formations between polymer chains when adding PVA.

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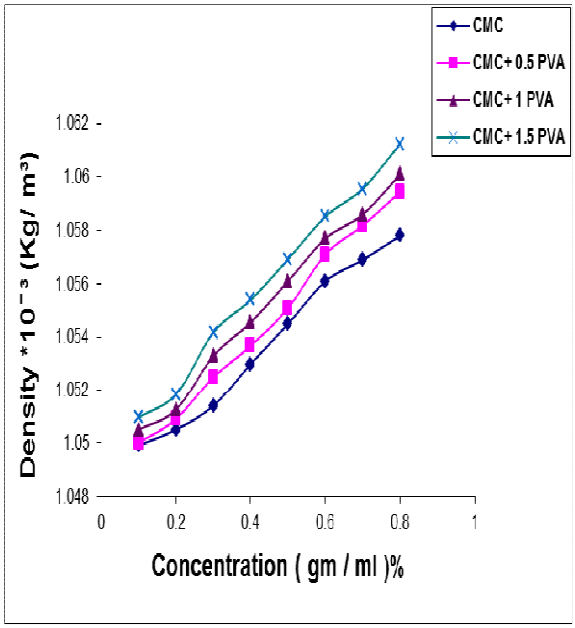

Figure.1. Density due to concentration

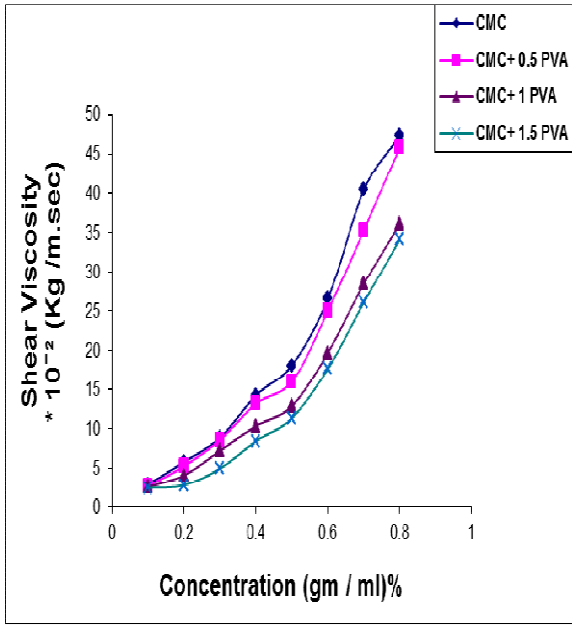

Figure.2. Shear viscosity due to concentration

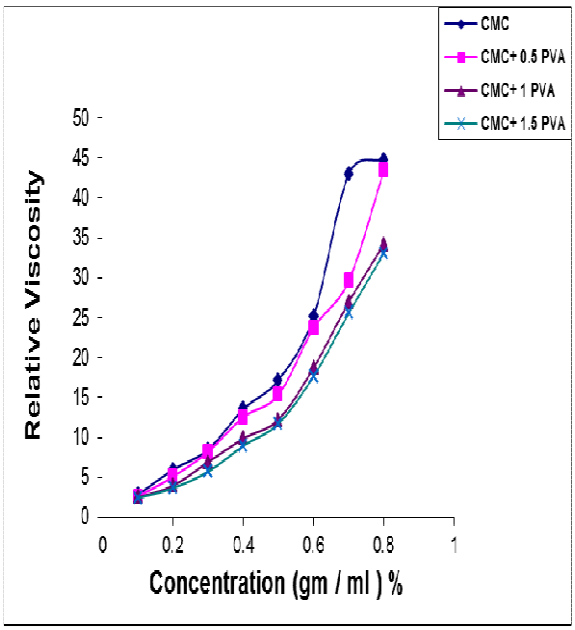

Figure.3. Relative viscosity due to concentration

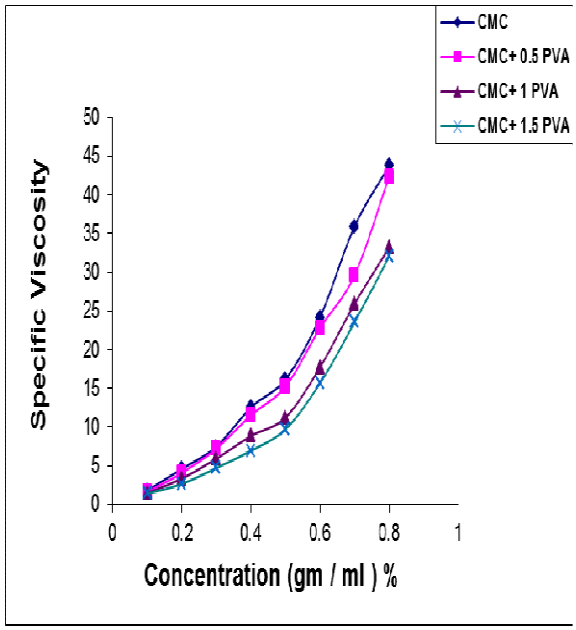

Figure.4. Specific viscosity due concentration

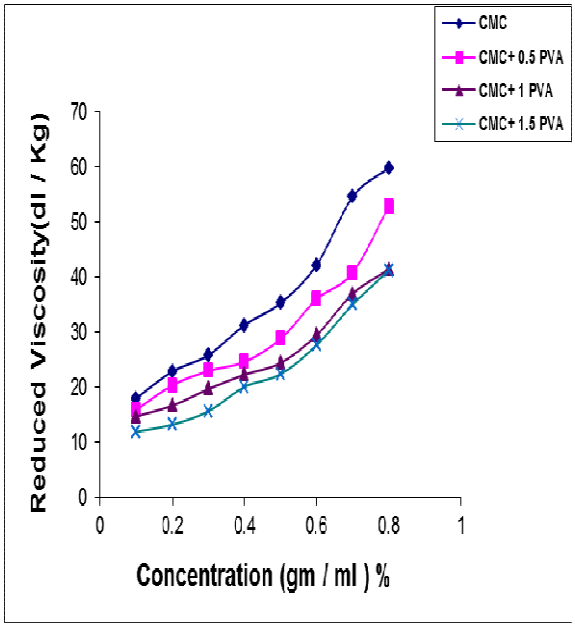

Figure.5. Reduce viscosity due to concentration

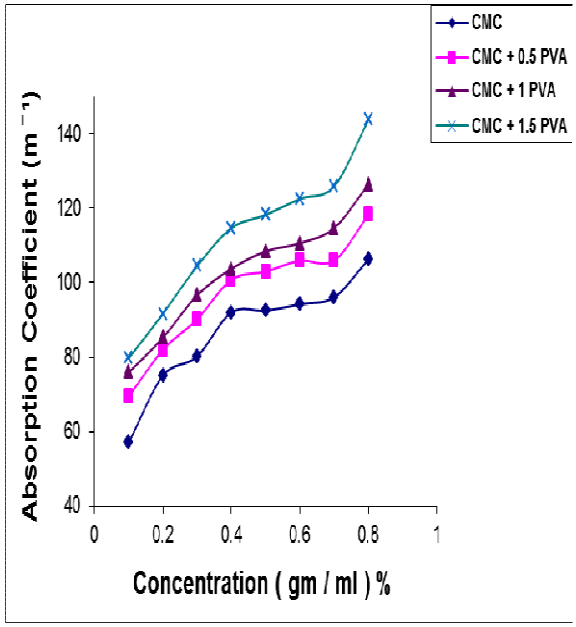

Figure.6. Absorption coefficient due to concentration

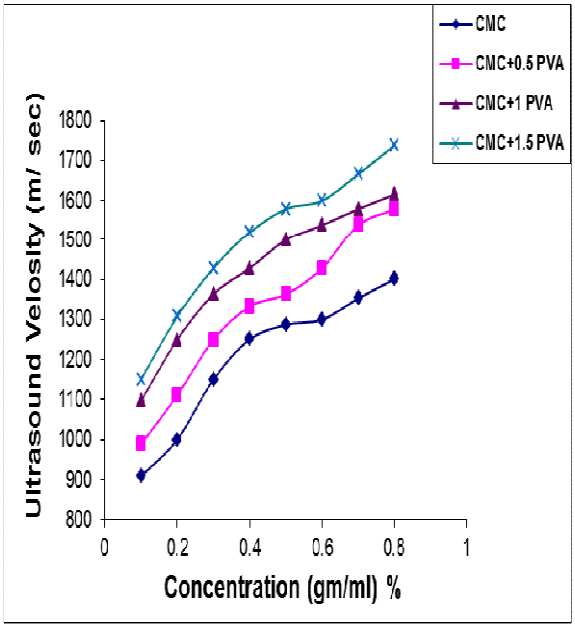

Figure.7. Velocity due to concentration

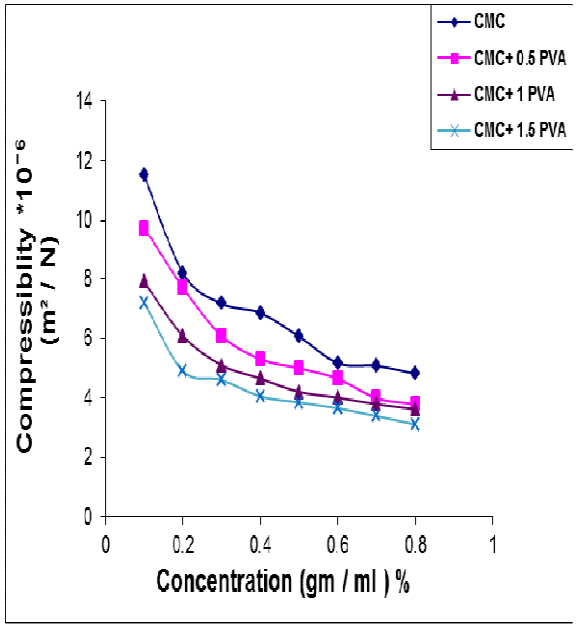

Figure.8. Compressibility due to concentration

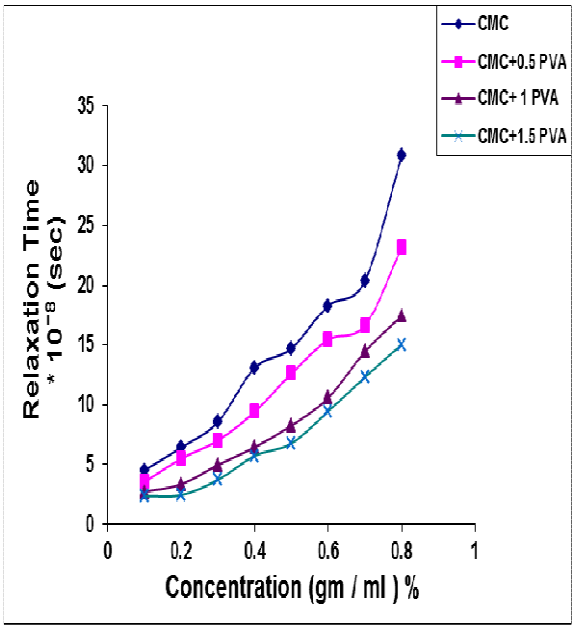

Figure.9. Relaxation time due to concentration

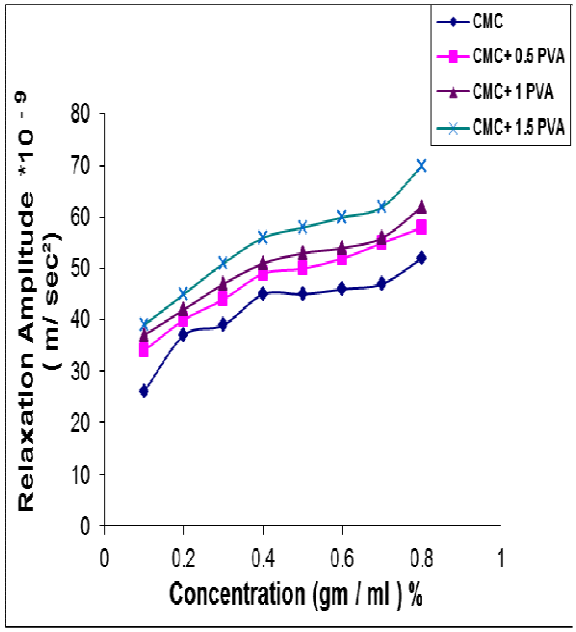

Figure.10. Relaxation amplitude due to concentration

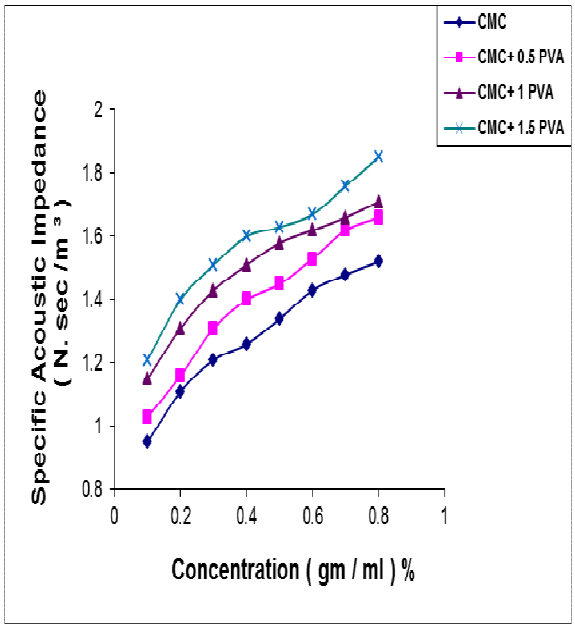

Figure.11.Acoustic impedance due to concentration

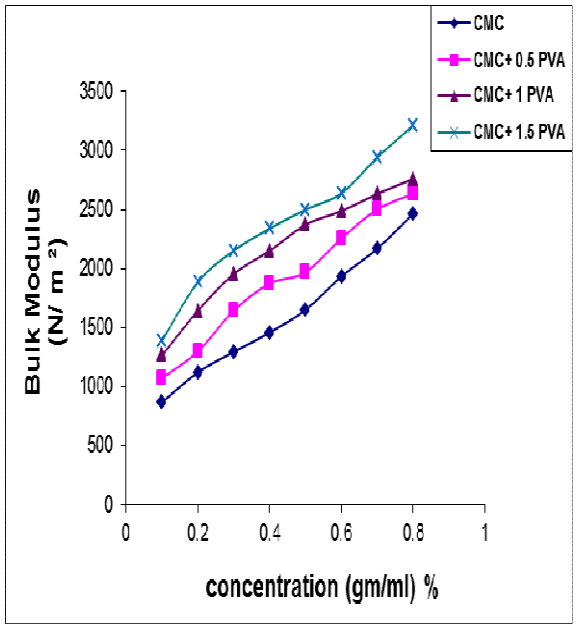

Figure.12. Bulk Modulus due to concentration