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Enhancement of Some Mechanical Properties of Polyethylene Glycol by Adding Carboxymethyl Cellulose as a Blends and Applied in Wood Glue

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ABSTRACT

The (PEG/CMC) blends were prepared by liquids mixing method, the appropriate concentrations of PEG were (0.1-0.2 to 0.8 g/mL)% are dissolved in (500 mL) of distilled water under stirring without heat for (20 min.) then added the CMC with two weights (0.25 and 0.5) g for each PEG concentrates at (288 K). In order to evaluate the mechanical properties of (PEG/CMC) blends the ultrasonic measurements were performed at these samples, these properties are ultrasonic velocity, compressibility, acoustic impedance and bulk modulus, were made at fixed frequency (f = 25 kHz), another acoustic mechanical properties were measured and calculated at a same time such as the ultrasonic wave amplitude absorption by using oscilloscope, then calculated the absorption coefficient and the transmittance ratio of the sound. It was found that there is significant relationship between ultrasonic velocity and material properties results show that adding PEG effects on the density then on the absorption of the ultrasonic waves inside the blend samples. Finally applied this blend in various concentrations as additive to imported wood glue and found that increasing the adhesion force after adding comparing with pure. FT-IR test has been made.

***Keywords*:** PEG, CMC, Acoustical Properties, Ultrasonic Technique, Wood Glue, Polyethylene Glycol, Carboxymethyl Cellulose, Wood Glue

1. INTRODUCTION

Acoustic propagation in liquid, liquid mixtures and solutions has been useful in the study of structure and the interactions among liquid molecules. Ultrasonic studies have been found to be useful in describing the theory of liquid state of matter. The propagation of ultrasonic velocity through polymers and their solutions have been attracted the attention of many researchers in the recent past and is serving as an important tool to understand the nature of polymer solutions. Thus the study of polymer solutions, both dilute and concentrated, gives a wealth of information for both academic curiosity and the end uses of polymers [1].

CMC is a negative charge linear polymer and one of the most important cellulose derivatives, which have an immense importance to the industry and also in our everyday life. CMC is a linear, long chain, water soluble and anionic polysaccharide derived from cellulose. In addition, the purified cellulose is a white to cream colored as well as tasteless, odorless, and it is a free-flowing powder. CMC is an important industrial polymer due to its high viscosity, non-toxic, non-allergenic, biodegradability as well as production at lower cost, furthermore, it is a most important water soluble derivative with various applications in paper, food, detergents, cosmetics, and textiles [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].

The propagation of ultrasonic velocity through polymers and their solutions have been attracted the attention of many researchers in the recent past and is serving as an important tool to understand the nature of polymer solutions. Thus the study of polymer solutions, both dilute and concentrated, gives a wealth of information for both academic curiosity and the end uses of polymers [4].

PEG, PEO, or POE refers to an oligomer or polymer of ethylene oxide. The three names are chemically synonymous, but historically PEG has tended to refer to oligomers and polymers with a molecular mass below (20,000 g/mol), PEO to polymers with a molecular mass above (20,000 g/mol) and POE to a polymer of any molecular mass. PEG and PEO are liquids or low-melting solids, depending on their molecular weights. PEGs are prepared by polymerization of ethylene oxide and are commercially available over a wide range of molecular weights from (300 g/mol) to (10,000,000 g/mol). While PEG and PEO with different molecular weights find use in different applications, and have different physical properties (e.g. viscosity) due to chain length effects, their chemical properties are nearly identical.

Different forms of PEG are also available, depending on the initiator used for the polymerization process – the most common initiator is a mono functional methyl ether PEG, or methoxypoly, abbreviated PEG. Lower-molecular-weight PEGs are also available as purer oligomers, referred to as monodisperse, uniform, or discrete. Very high purity PEG has recently been shown to be crystalline, allowing determination of a crystal structure.

Wood glue is an adhesive used to tightly bond pieces of wood together. Many substances have been used as glues. Several wood glues have poor gap - filling ability (they bond tightly to wood, but not to itself) and this property must be treat by testing some materials as additives as polymers.

Therefore, woodworkers commonly use tight - fitting joints that need surprisingly little glue to hold large pieces of wood. Most wood glues need to be clamped while the glue sets.

Epoxy resins and some other glues can be thickened with structural fillers (or with thicker formulations of the resin) to help fill gaps, however it's obviously preferable to try to minimize gaps in the first place [4].

2. EXPERIMENTAL

This part of research include the practical work and some information about the materials, measurements and devices.

2. 1. Preparation of solutions

Polyethylene Glycol (PEG; mol.wt. 6000 Daltons) / Sodium carboxymethylcellulose (CMC, mol.wt. 700000 Daltons) was purchased from Hercules, Inc. (Wilmington, DE) blends membranes were prepared by liquid mixing method, the appropriate concentrations of PEG was variable (0.1-0.2 to 0.8) g dissolved in (500 ml) of distilled water under stirring without heat for (20 min.) then add the CMC with two weights (0.25 and 0.5) g for each PEG concentrates, the resulting solution was stirred continuously until the solution mixture became a homogeneous viscous appearance at (50 ºC) temperature for (40 min.).

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 distance of the samples (x). The pulses height on oscilloscope (CH1) represents incident ultrasonic wave's amplitude (A_o) and the pulses height on oscilloscope (CH2) represents the receiver ultrasonic wave's amplitude (A).

2. 3. Theoretical calculations

The ultrasonic wave velocity (V) was calculated by using the following equation [5]:

$$\mathbf{V = X / t} \text{ ……..…} (1)$$

where (X) is the distance and (t) is a time.

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 Laplace equation where (ρ) is the density [6]:

$$\boldsymbol{\beta = (\rho\, v^2)^{-1}} \text{ …….. } (2)$$

Bulk modulus (K) of a composite is the substance's resistance to uniform compression, it is defined as the pressure increase needed to decrease the volume; it was calculated by [7,8]:

$$\mathbf{K = \rho\, v^{2}} \ldots\ldots\ldots (3)$$

The acoustic impedance of a medium (Z) was calculated by equation [9]:

$$\mathbf{Z = \rho\, v} \ldots\ldots\ldots (4)$$

Absorption coefficient (α) was calculated from Lambert – Beer law [10]:

$$\mathbf{A/A_o = e\,(-\,\alpha\, x)} \ldots\ldots\ldots (5)$$

where (A_o) is the initially amplitude of the ultrasonic waves, (A) is the wave amplitude after absorption and (x) is the thickness of the sample. Attenuation is generally proportional to the square of sound frequency (f) so the relaxation amplitude (D) was calculated from the following equation [11]:

$$\mathbf{D = \alpha / f^{2}} \ldots\ldots\ldots\ldots (6)$$

Transmittance (T) is the fraction of incident wave at a specified wavelength that passes through a sample was calculated from the following equation [12]:

$$\mathbf{T = I / Io} \ldots\ldots\ldots\ldots (7)$$

3. RESULTS AND DISCUSSIONS

The blend membranes density were measured by digital densemeter at room temperature (288 K), (Fig. 1) shows that the density of the membrane increase because its molecules which are heavier than PEG molecules occupied the vacancies between polymer macromolecules displaying PEG molecules from their position and because density is mass per unit volume so increasing the density with increasing the concentration. This increasing behavior suggests, a strong electrolytic nature in which the solute tends to attract the solvent molecules and vice versa [13].

Ultrasonic velocity is increasing with increasing PEG concentration, as shown in (Fig. 2) 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 [14], and Adding CMC 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 [15], also the increasing of molecular weight rustled increasing in polymer chains, this is lead to converge polymer chain and increase density and the result perfect agreement with [16].

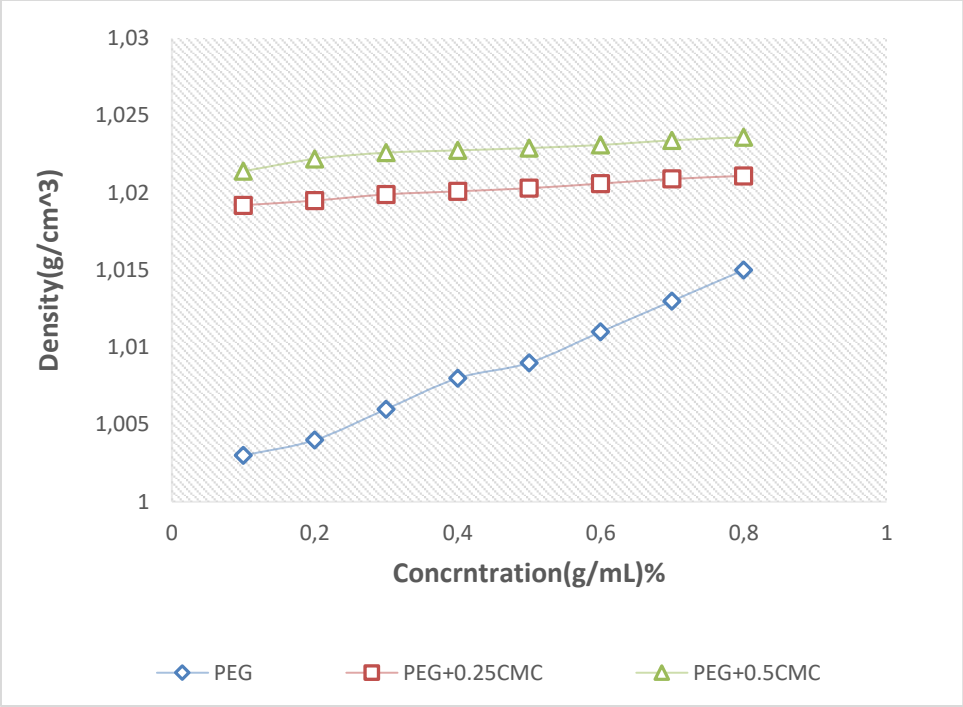

Figure 1. Density and concentrations.

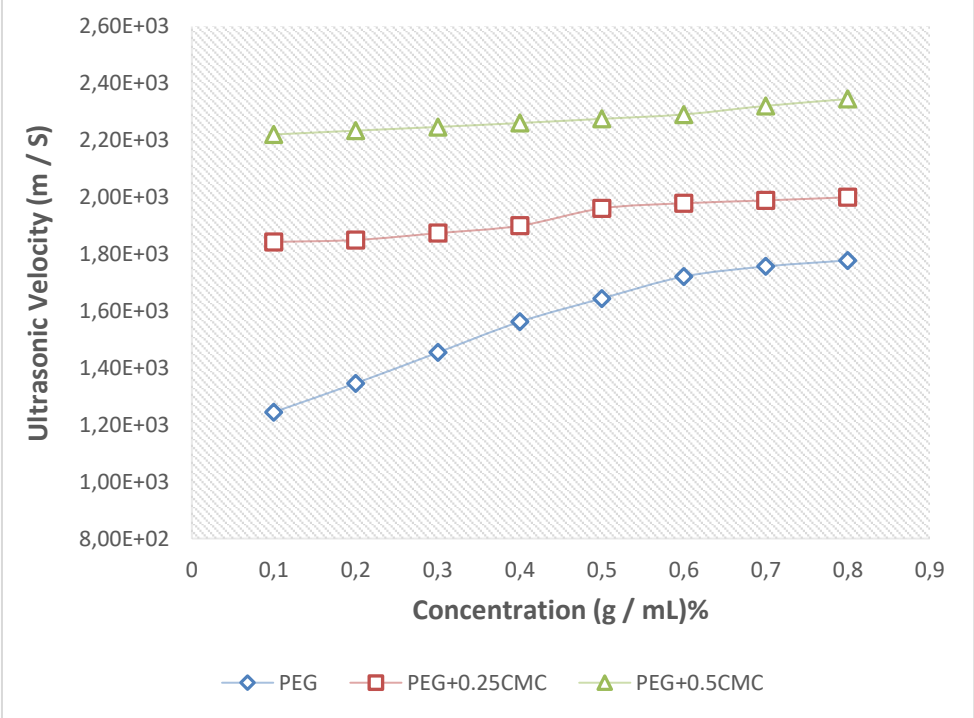

Figure 2. Ultrasonic velocity and concentrations.

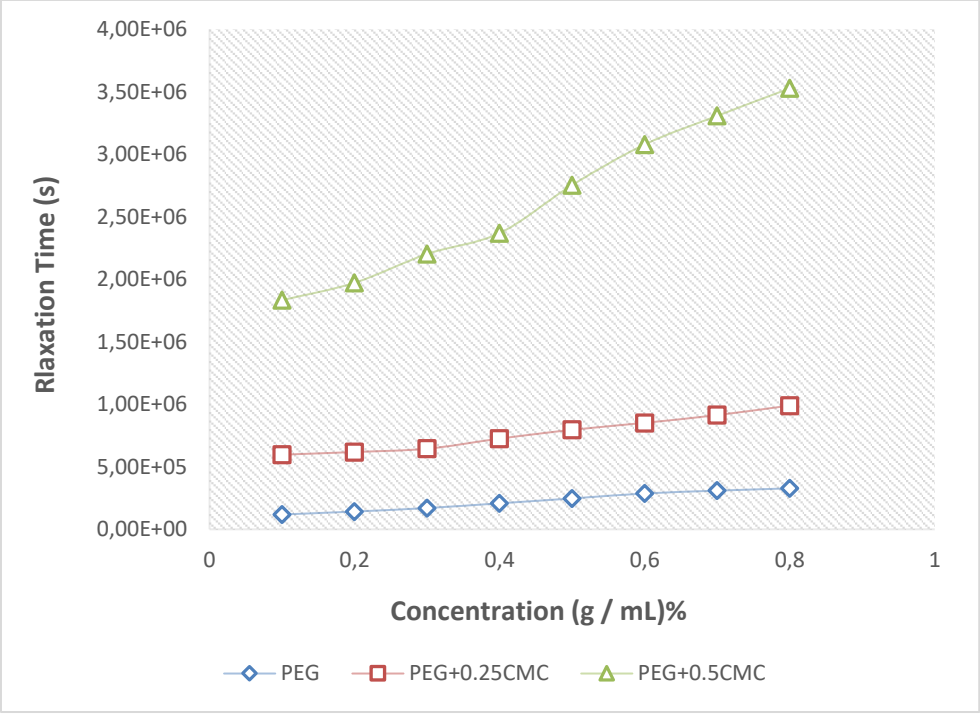

Figure 3. Relaxation time and concentrations.

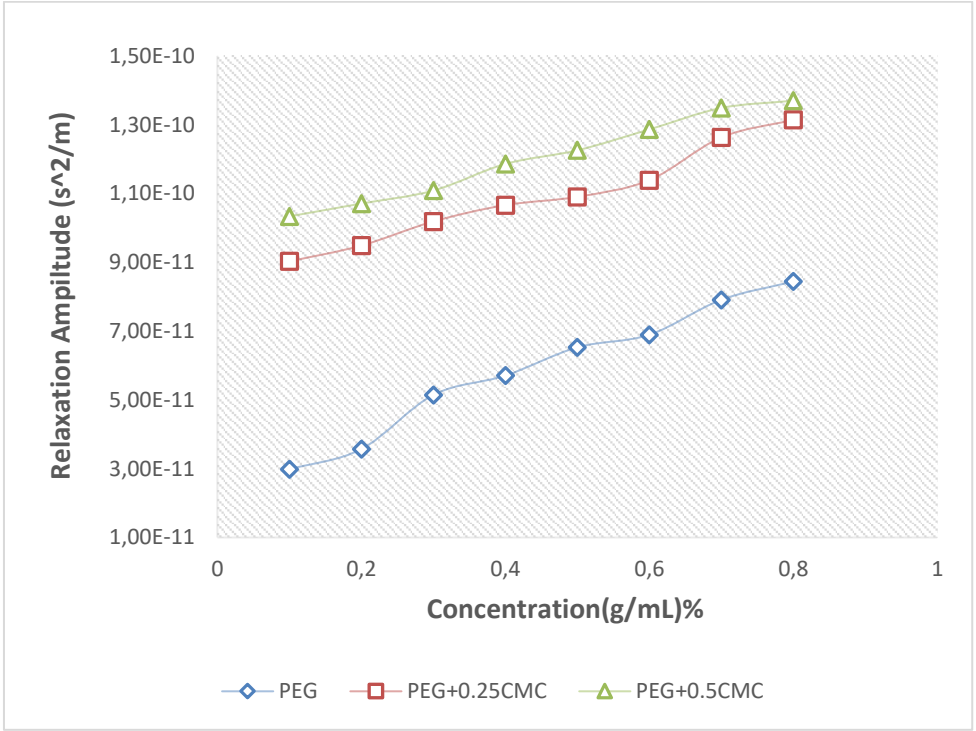

Figure 4. Relaxation amplitude and concentrations.

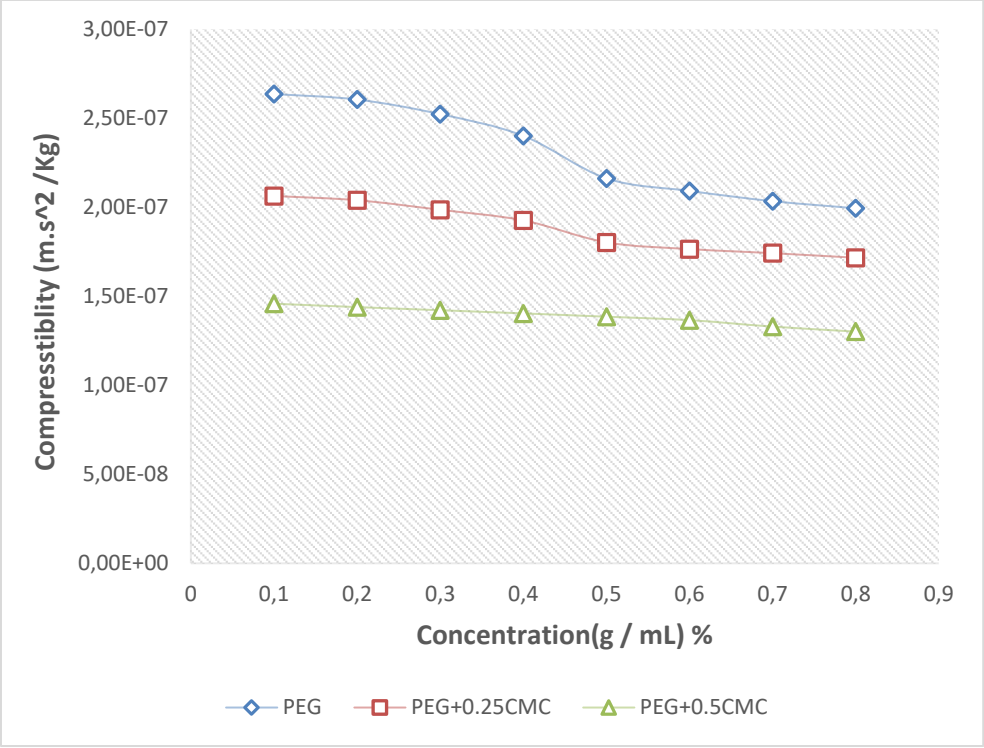

Figure 5. Compressibility and concentrations.

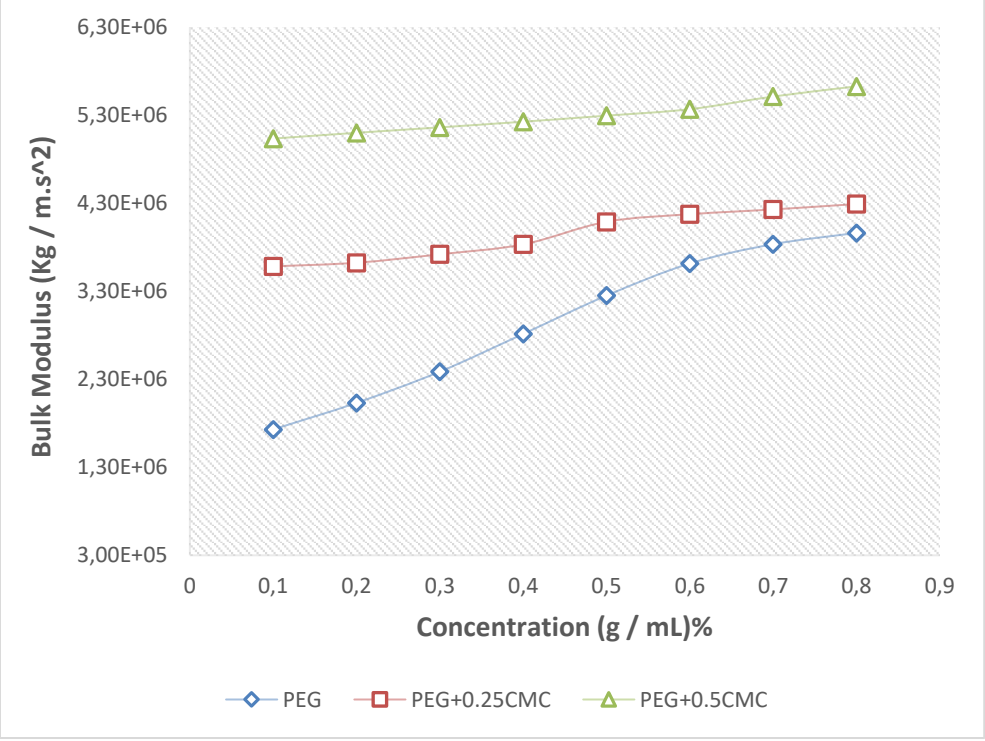

Figure 6. Bulk modulus and concentrations.

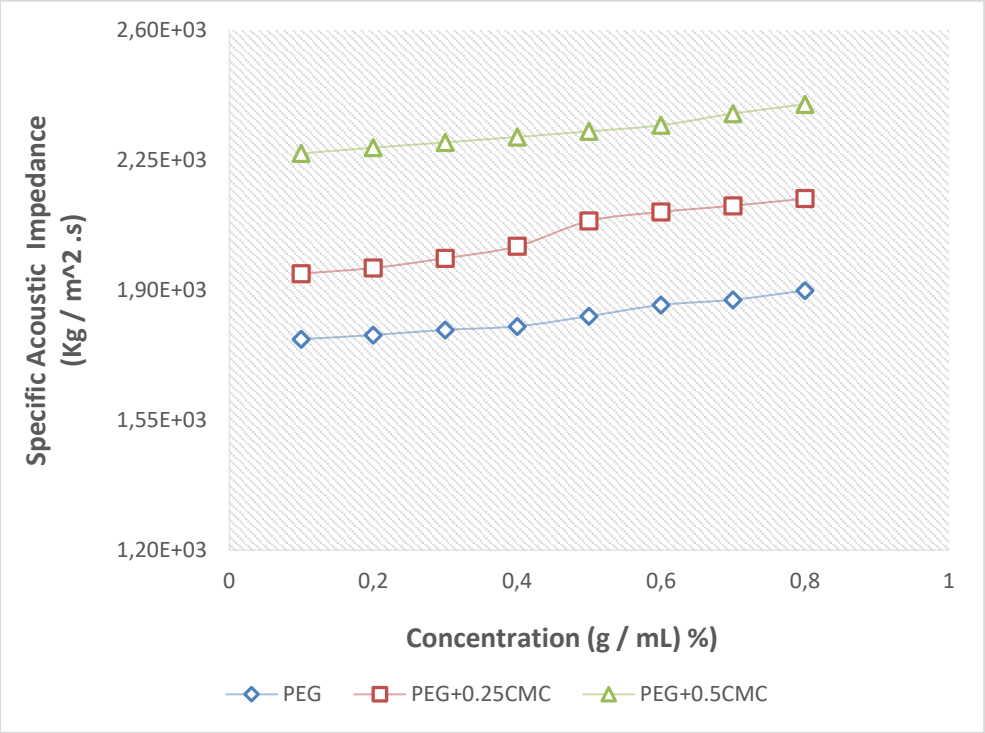

Figure 7. Specific acoustic impedance and concentration.

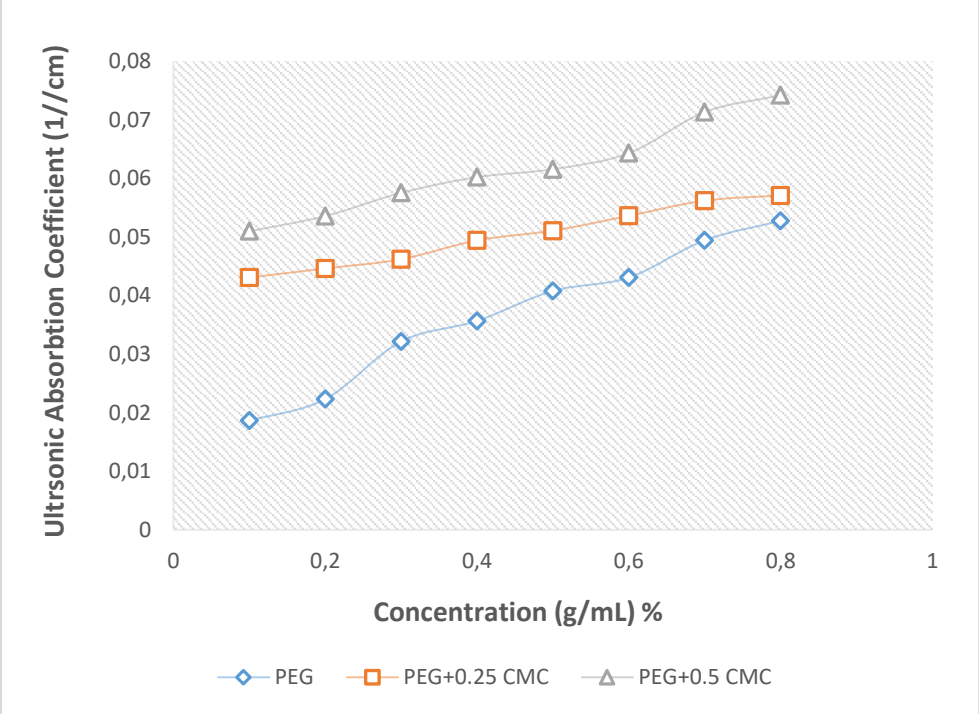

Figure 8. Ultrasonic absorption coefficient and concentrations.

The relaxation time and relaxation amplitude increase when concentrations increase as shown in (Figs. 3 and 4) and this is agreement with theoretical equations in one aspect and the increase of concentration lead to increase polymer chain and increase internal fraction between the layers of liquid and also the relaxation amplitude increase because the moment of inertia is very large and appear clear that relaxation time is increase 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 , this behavior same to that give by [17,18]

Compressibility of samples were calculated using Laplace equation, equation (2), (Fig. 5) shows that the compressibility are decreasing with increasing concentration this could be attributed that ultrasonic waves propagation made polymer chains that randomly coiled to be each close together, this change confirmation and configuration of these molecules, so there are more compression happen of these molecules through ultrasound wave propagation [19] this compression fills the vacancies between polymer molecules and restricted the movement of these molecules this lead to reduce the elasticity of the blend.

The bulk modulus is increasing with concentration (Fig. 6), this behavior same to that give by [20], also theoretical the velocity of ultrasonic waves inversely proportional with compressibility. Specific acoustic impedance shown in (Fig. 7) is increasing with concentrations attributed to the equation (4) has only one variable parameter which is velocity and density has very small variations with respect to that of velocity. show that relaxation time is increase 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, this behavior same to that give by [21].

The transmittance are decrease with increasing concentration, this attributed that the polymer molecules absorbed the sound waves according to Lambert-Beer Law which is biased on concentration, so the cohesives of hydrogen bonds decreased the passing of ultrasonic waves, and theoretical increase when velocity increase, therefore the values of it increased after adding CMC.

Ultrasonic absorption coefficient shown in (Fig. 8), also increase when concentration increase and happen greater after adding CMC, because ultrasonic absorption coefficient perfectly depended on concentration and relaxation structural between polymer molecular and density of medium, therefore increase after addition [21], and in medical can be used this blend to reduced helical adhesion tissue in intestine if kink is happen, and reduced the classification in joints [22].

Fig. (9) shows that the adhesion force of wood glue improvement by adding some cellulose derivative polymer and also increase when concentration increase and this is return to the, when polymer added to the glue the internal structure been in cross link state and also increase the viscosity of blend and the result showed that the upper value in CMC because the cross link depended on molecular weight and the carbon in chain make the structure greater force.

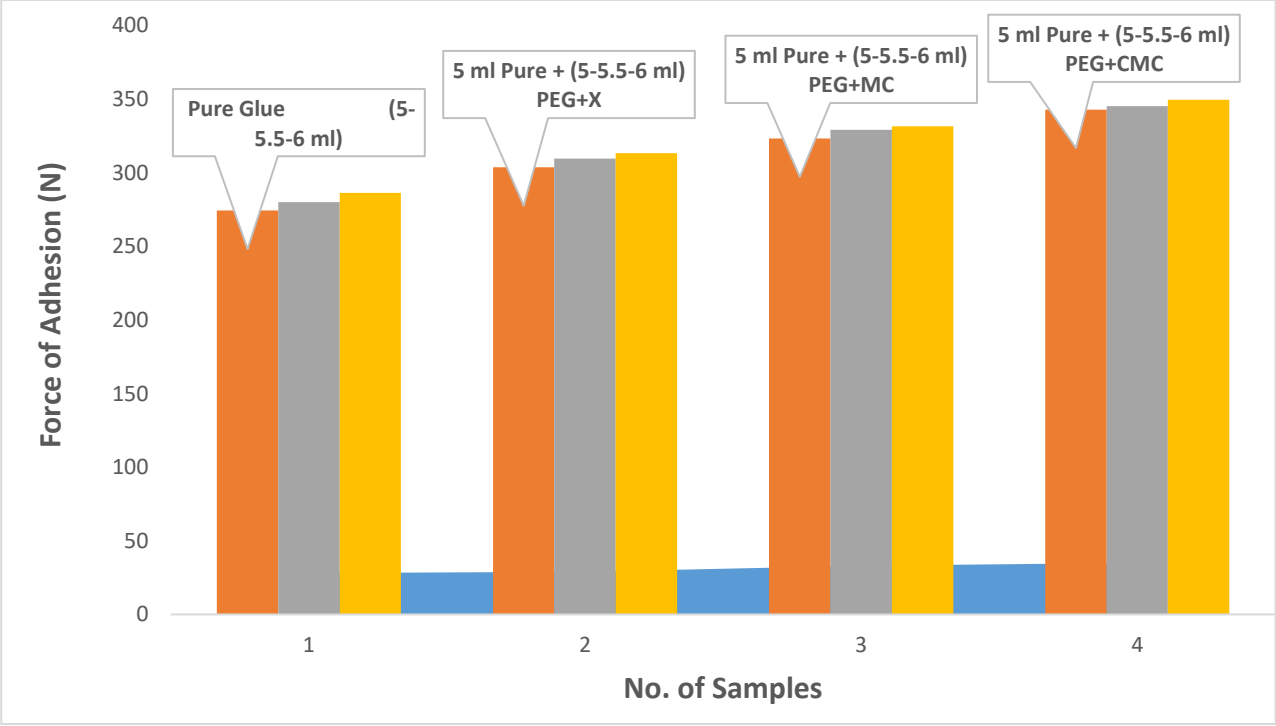

Figure 9. Adhesion Force for all samples.

4. CONCLUSIONS

1) The acoustical properties of PEG polymer are improved when adding CMC.
2) New polymer blend (PEG/CMC) resulted, has high molecular weight can be used in coating.
3) PEG forms aqueous two-phase systems with several polymers including polysaccharides such as dextran, cellulose and hyaluronate. Phase separation of the two polymers depends on the composition of the polymers and the solvent.
4) Ultrasonic velocity depended on the length of polymer chain and concentration.
5) The density and velocity results show this blend is good medium to transfer ultrasonic waves.
6) Adding PEG polymer to CMC enhances the ultrasonic absorption coefficient because of high values after addition, it can be applied as a coated the calcification joints of human to reduce helical adhesion tissue and reduce the limitation of joint.
7) Adding CMC reduced compressibility this lead to increase interaction between polymer molecules this cause enhancement for mechanical properties against environments.
8) This blend has good mechanical properties so it may use as resistant materials against environment.
9) Adding CMC led to increase the ultrasonic velocity of PEG, and this propriety can be used in oil liquid in sonar devices because the blend is harmless to human skin.

10) Adding CMC led to increase the ultrasonic absorption coefficient of PEG, and this propriety can be used as a coating to devices animated undersea equipment for the purpose of discovery.

11) Adding the blends to wood glue increase the adhesion force and improve the adhesion and this property can be used in furniture industry.

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