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Enhancement Mechanical Properties of Polyvinly Alcohol by adding Methyl Cellulose using ultrasonic technique

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Abstract:
Some of physical properties of polyvinyl alcohol dissolves in distilled water had been studied at different concentrations (0.1%, 0.2%, 0.3%, 0.4%, 0.5% , 0.6%, 0.7%, 0.8%) gm./ml) before and after adding (1and 2) gm of MC for all concentrations , 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 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 MC these properties are increasing except compressibility is decreasing. Results also shows that adding MC polymer to PVA enhances these properties as a result of high values after addition.
Keywords: PVA solution, MC solution, mechanical properties, ultrasound technique.

1. Introduction

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), [1]. major applications Paper and textile sizing, oxygen resistant films, adhesives, emulsifier, colloid stabilizers, base/coatings for photographic films, food wrappings, desalination membranes, electroluminescent devices, and cement coatings[2]. MC is non ionic linear polysaccharide derived from cellulose[3]. it is an important industrial polymer with a wide range of applications in flocculations, drug reduction, detergents, textiles, papers, foods, roiling oil and drugs [4]. MC is water – soluble synthetic polymers. MC is used primarily because it has high viscosity, it is non-toxic, and is non-allergenic[5] . MC has a wide range of applications due to its low cost[6] Because of its polymeric structure and high molecular Wight; it can be used as filler in bio- composite films. MC commonly use for increasing production of oil from its original traps in oil drilling[7] . 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. 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 polyvinyl alcohol (PVA) with methyl cellulose (MC) as aqueous solutions by ultrasound wave at fixed frequency (25 KHZ) and study the effect of adding MC on the physical properties of PVA to enhance its different applications.

2. Experimental:

2.1 Preparation of Solutions:

PVA (Gerhard Buchman –Germany) with assay (99.8%) and MC (Messina) with assay (99.8%) of high viscosity[11] .The PVA solution was prepared by dissolving a known weights of PVA powder in affixed volume (500 ml) of distilled water under stirring at 70oC for (30 min). The PVA concentrations were (0.1%, 0.2%, 0.3 %, 0.4%, 0.5%, 0.6%, 0.7% and 0.8%) gm./ ml ; then MC was added with different weights (1 and 2 gm.) to all PVA Concentrations. The resulting solution was stirred continuously for (30 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

2.3 Theoretical calculation:

The absorption coefficient (α) was calculated from Lambert – Beer law[12]:

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

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[13]:

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

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[14] 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[15]:

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

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[16] :

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

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[17]:

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

The relaxation time (τ) was calculated from the equation[18]:

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

3. Results and Discussion:

(Fig.1) 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 [15], this behavior same to that give by [19] for other polymers, adding MC enhances absorption coefficient by increasing its values. This attributed as we explained that adding MC increased the viscosity of the solution this means that there were more flexibility for these polymer chains in solution as a result of adding MC 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 MC[20]. Ultrasonic velocity is increasing with increasing MC 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 [21].and Adding MC 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 [22]. The compressibility is decreasing with the increase of concentration (Fig.3) and attributed to the fact that in Laplace equation no. (6) There are inverse proportionality between compressibility and ultrasonic velocity [23, 24]. Ultrasonic relaxation time was calculated by using equation no. (7) Shown in (Fig.4) and the relaxation amplitude shown in (Fig.5) calculated from equation no.(3) their values are increasing with concentration, this behavior same to that give by [19] for other polymers, also (Fig.4) Shows that relaxation time increased when adding MC this attributed to the fact that ultrasonic energy depends on viscosity thermal conductivity[25], scattering and intermolecular processes , thermal conductivity and scattering effects are known to be negligible [26] Specific acoustic impedance shown in (Fig.6) is increasing with concentrations this behavior same to that given by [27] for other polymers and attributed to the equation no. (4) 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.7) ; this behavior same to that give by [28].(Fig.6) shows that adding MC increased acoustic impedance because MC polymer chains fills the valances by swallowing water molecules and be closer to PVA macromolecules that increasing Specific acoustic impedance.

4. Conclusion

1. Adding MC polymer to PVA enhances the ultrasonic absorption coefficient as a result of high values after addition so it can be used as coated materials for moving bodies in order to detect by ultrasonic technique .

2. Adding MC polymer increases the ultrasonic velocity so the blend can be use as good medium for transferring ultrasonic waves in such medical instruments.

3. Adding MC reduced compressibility this lead to increase interaction between polymer molecules this cause enhancement for mechanical properties against environments .

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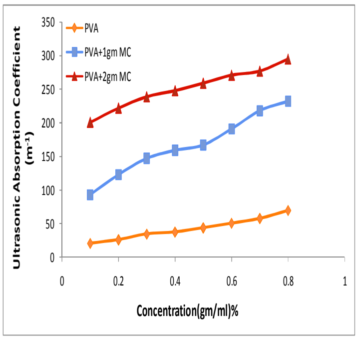


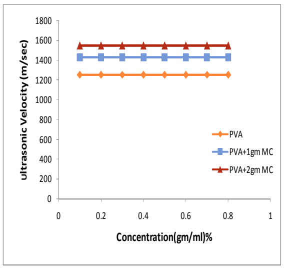
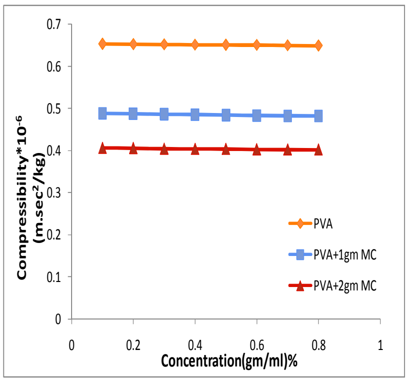


Fig.1. Absorption coefficient due to concentration

Figure.2. Velocity due to concentration



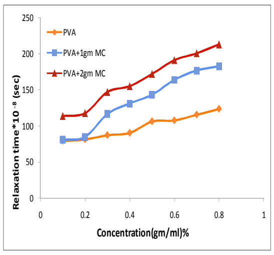
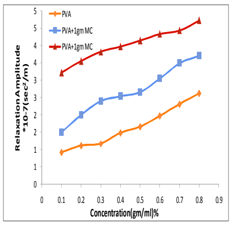


Fig.3. Compressibility due to concentration

Fig.4. Relaxation time due to concentration



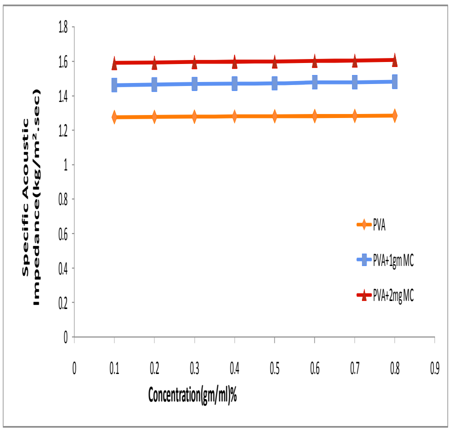


Fig.5. Relaxation amplitude due to concentration

Fig. 6.Acoustic impedance due to concentration

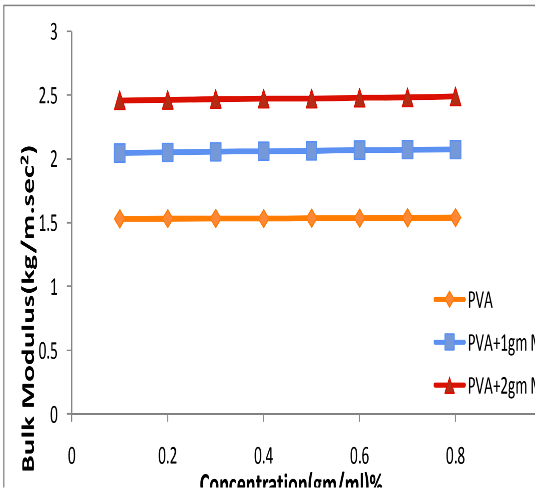


Fig.7. Bulk Modulus due to concentration