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Ultrasonic study of PVA and PVA / PAAM film composites prepared by casting method

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Abstract:
The PVA/PAAM composite membranes of poly vinyl alcohol and Polyacrylamide were prepared by casting method, the appropriate weights of PVA were variable (0.25, 0.5, 0.75, 1 and 1.25 gm) dissolved in (25ml) of distilled water under stirring and heat (70◦C) for (30 min.) then different weights (0.15 and 0.3 gm.) of PAAM were added to each PVA . In order to evaluate the mechanical properties of PVA and PVA/ PAAM composite the ultrasonic measurements were performed at the samples. These properties are velocity of ultrasonic waves, absorption coefficient of ultrasonic waves, relaxation amplitude, specific acoustic impedance, bulk modules and compressibility. The results show that all these properties are increasing with the increase of the polymer thickness except compressibility is decreasing with increase the thickness; results also show that when adding PAAM these properties have higher values than those before increasing except compressibility is decreasing. Results also show that adding PAAM polymer to PVA enhances these properties as a result of high values after addition.
Keywords: polyvinyl alcohol; Polyacrylamide; mechanical properties; casting method.

1. Introduction:

The sol-gel casting method is widely used in the preparation processes for inorganic/organic composites. The advantages of the sol-gel method are that the synthesis process is done at room temperature and organic polymer can be introduced at the initial stage in which the particles of solution kept in the homogeneous dispersed state [1]. Polyvinyl alcohol has high tensile strength and flexibility, as well as high oxygen and aroma barrier properties. However these properties are depend 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 [2].PAAM is highly water-absorbent, forming a soft gel when hydrated, used in such applications as polyacrylamide gel electrophoresis and in manufacturing soft contact lenses. In the straight-chain form, it is also used as a thickener and suspending agent. More recently, it has been used as a sub dermal filler for aesthetic facial surgery. One of the largest uses for polyacrylamide is to flocculate solids in a liquid. This process applies to water treatment, and processes like paper making. Polyacrylamide can be supplied in a powder or liquid form, with the liquid form being sub categorized as solution and emulsion polymer [3]. 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 [4]. The purpose of this research was to investigate the physical properties of PVA with PAAM films by ultrasound wave at fixed frequency (25 KHZ) and study the effect of adding PAAM on the physical properties of PVA to enhance its different applications.

2. Experimental:

2.1 Sample Preparation:

PVA (Gerhard Buchman –Germany) with assay (99.8%) and PAAM product by (British Drug House-Germany) with assay (99.9%) of high Viscosity. The PVA/ PAAM composite membranes were prepared by casting method, the appropriate weights of PVA were variable (0.25, 0.5, 0.75, 1 and 1.25 gm.) dissolved in (25ml) of distilled water under stirring and heat (70◦C) for (30 min.) then add the PVA with different weights (0.15 and 0.3 gm) for each PVA weight, the resulting solution was stirred continuously until the solution mixture became a homogeneous viscous appearance at room temperature for (30 min.). The PVA/PAAM composite polymer membranes are obtained by leaving the mixture solution in a petre dish at room temperature for 2 weeks and then the composites samples were in the circle shape with (5 cm) diameter and the density of the samples were measured by the weight method.

2.2 Ultrasonic Measurements:

Ultrasonic measurements were made by pulse technique of sender receiver type (SV-DH-7A/SVX-7 velocity of sound instrument – Korea), as shown in Fig. (1). below the measurements were made at fixed frequency (f =

25KHz), the receiver quartz crystal mounted on a digital variable 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 (A_o) and the pulses height on oscilloscope (CH2) represents the receiver ultrasonic wave's amplitude (A).

Figure (1) the Ultrasonic measurements system

Theoretical calculation:

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

$$V = X / t \quad \ldots\ldots \quad (1)$$

Where (t) is time that the waves need to cross the samples and (x) is the thickness of the sample. The absorption coefficient (α) was calculated from Lambert – Beer law [6]:

$$A/A_o = e\,(-\alpha x) \quad \ldots\ldots \ (2)$$

Where (A_o) is the initially amplitude of the sound waves, (A) is the wave amplitude after absorption.

Attenuation is generally proportional to the square of sound frequency so the relaxation amplitude (D) was calculated

from the following equation [7]:

$$D = \alpha / f^2 \ldots\ldots\ldots (3)$$

The specific acoustic impedance of a medium (Z), it was calculated by equation [8]:

$$Z = \rho\, v \ \ldots\ldots\ (4)$$

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 [9]:

$$k = \rho\, v^{2} \ldots\ldots\ (5)$$

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 [10]:

$$\beta = (\rho\, v^2)^{-1} \ \ldots\ldots\ (6)$$

3. Results and discussions:

The PVA was using as matrix and PAAM was using as filer using casting method. The density of PVA/PAAM films is shown in Fig.(2), it is increasing when adding PAAM, since the PAAM has high viscosity so it has high density; and when PAAM added to PVA there will be interaction causing association between the three type of molecules (PVA molecules, PAAM molecules and solvent molecules) this interaction causing entanglement action then increase the density[11].Ultrasonic velocity is increasing with increasing PAAM as shown in Fig.(3); ultrasonic velocity increases the greater the focus and the reason for that is that the interaction led to the union of two types of polymer particles and the solvent , which led to formation of large molecules (Macromolecular) as a result of entering solvent molecules within the polymer molecules , which leads to swelling of these molecules that work on transfer mechanical waves from the source of the turmoil on the board of beams , resulting in increased speed . And Fig.(3) also note that the values of the speed of ultrasound increases with increasing proportions of PAAM added, and the reason for that is shaped lattice jellyfish, which leads to the

convergence of polymer particles and reduce the spaces between the particles PVA within the lattice, and thus become the medium well for the transfer of ultrasound[12]. Fig.(4) shows that absorption coefficient is increasing with thickness this attributed to the fact that when polymer concentration increase there will be more molecules in sample 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[13]. Adding PAAM enhances absorption coefficient by increasing its values. The relaxation amplitude is increasing with thickness as shown in Fig. (5), since it depend on the absorption coefficient as related in equation (3). Specific acoustic impedance shown in (Fig.6) is increasing with thickness this behavior same to that given by [14] and 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. The bulk modulus is increasing with thickness as shown in Fig.(7) ; this behavior same to that give by [15]. The compressibility of samples was calculated using Laplace equation (6), the results in Fig. (8) Shows that the compressibility are decreasing with increasing thickness this could be attributed that the 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 sound wave propagation [16,17].
We used PVA/PAAM gel as past in medical sonar and it gives good vision.

4. Conclusion:

- This study shows that adding PAAM to PVA as fillers increase the density of the composites.
- Add PAAM led to increase the speed of ultrasound, so it can be used as good medium for the transfer ultrasound both in medical and other applications.
- Add PAAM led to a decrease in the values of compressibility the composite become more tolerant it can be used in the external environment.
- Add PAAM led to increased absorption coefficient of ultrasound so this composite can be used as coated material for such instrument that want be detect by sonar under sea like submarines.
- Also can be used good absorber material for teaching room and different factories to reduce sound noises from their instruments.
- PVA/PAAM has been used as a gel in medical sonar and give good vision so it can be used as substituted gel instate of that imported gel.

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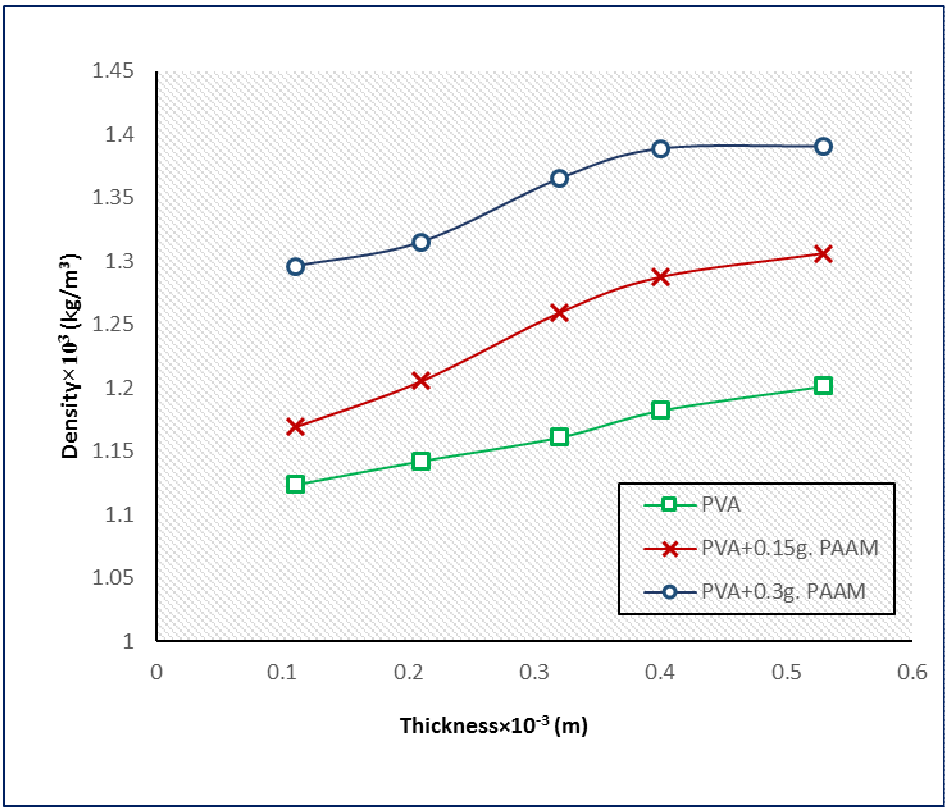

Fig. (2) The density vs. thickness

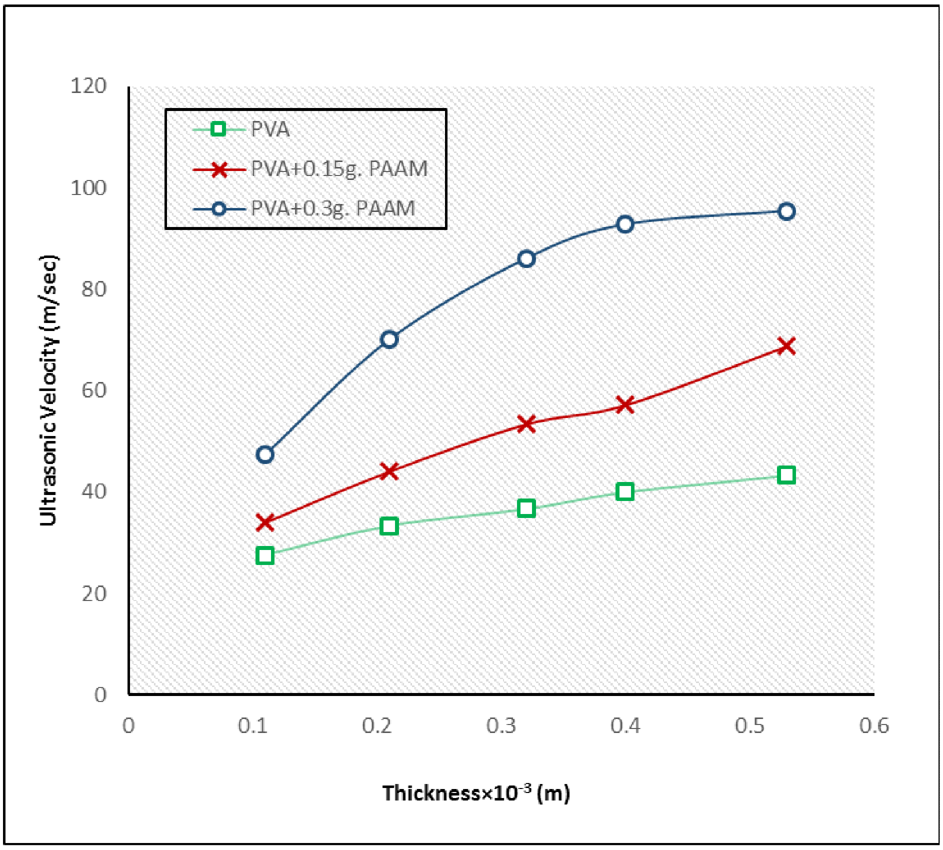

Fig. (3) Velocity vs. thickness

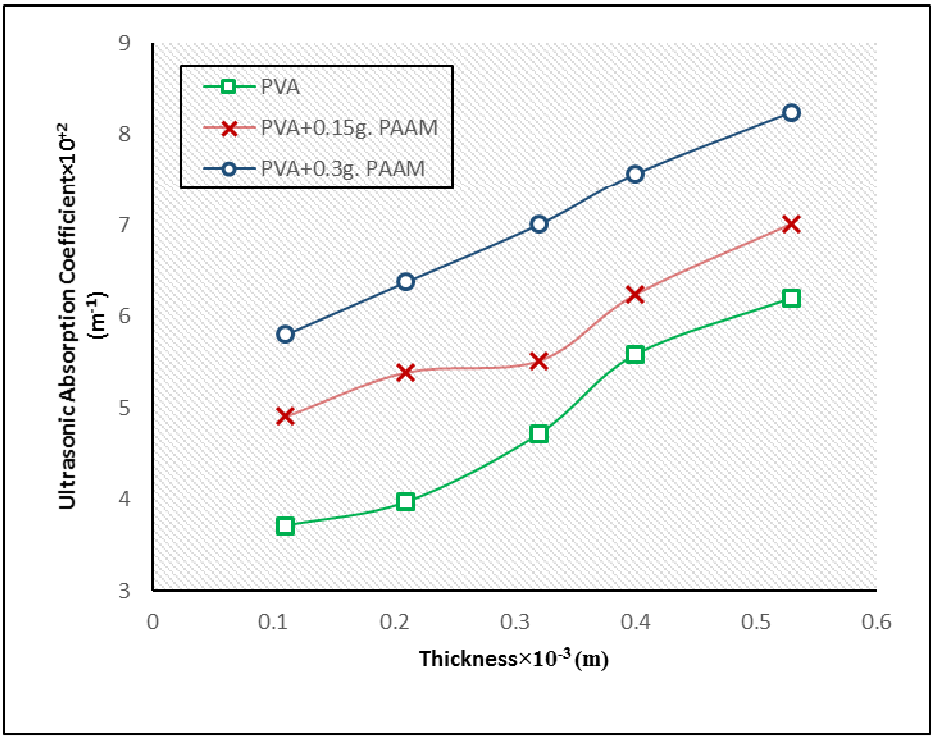

Fig.(4) The absorption coefficient vs. thickness

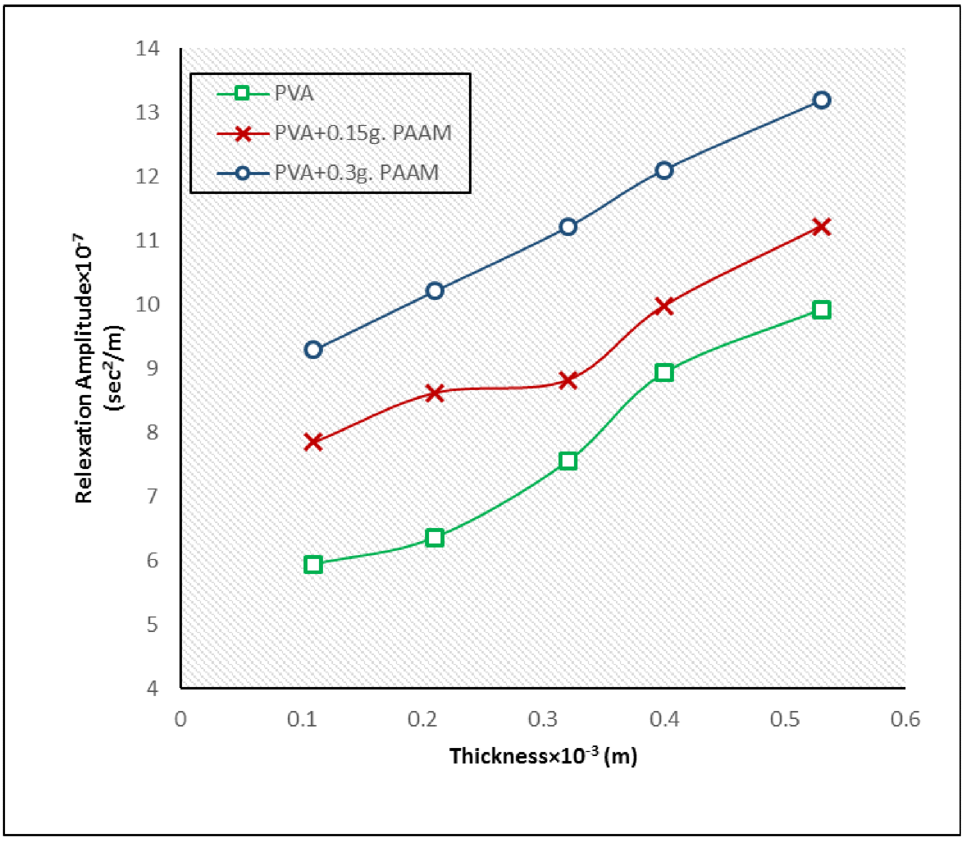

Fig .(5) relaxation amplitude vs. thickness

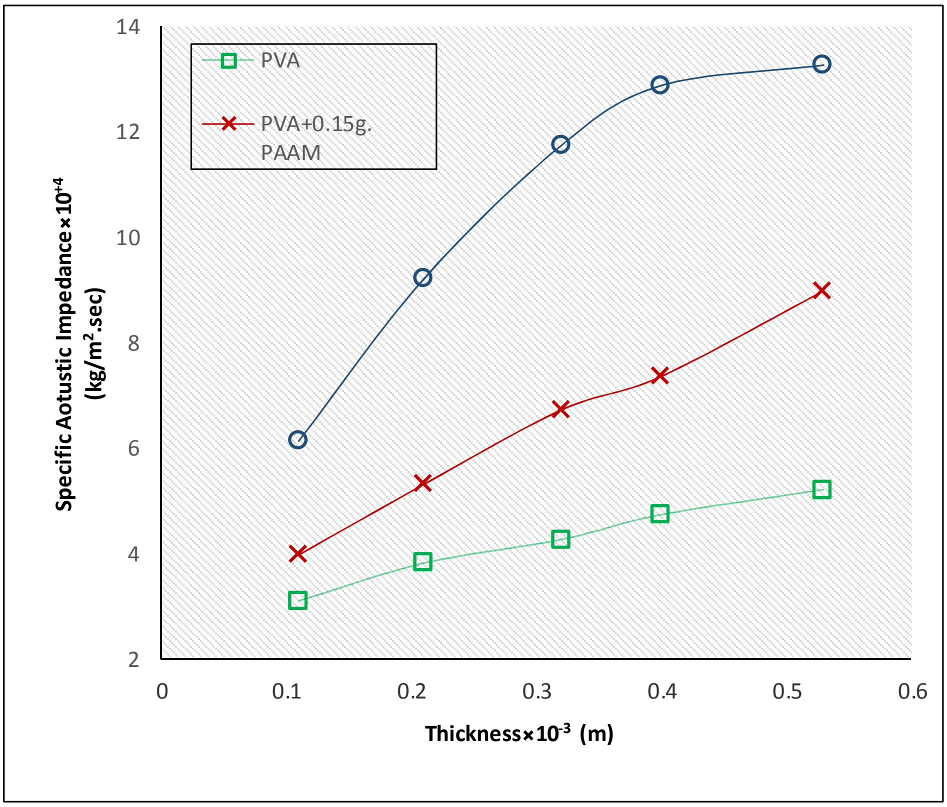

Fig.(6) specific acoustic impedance vs. thickness

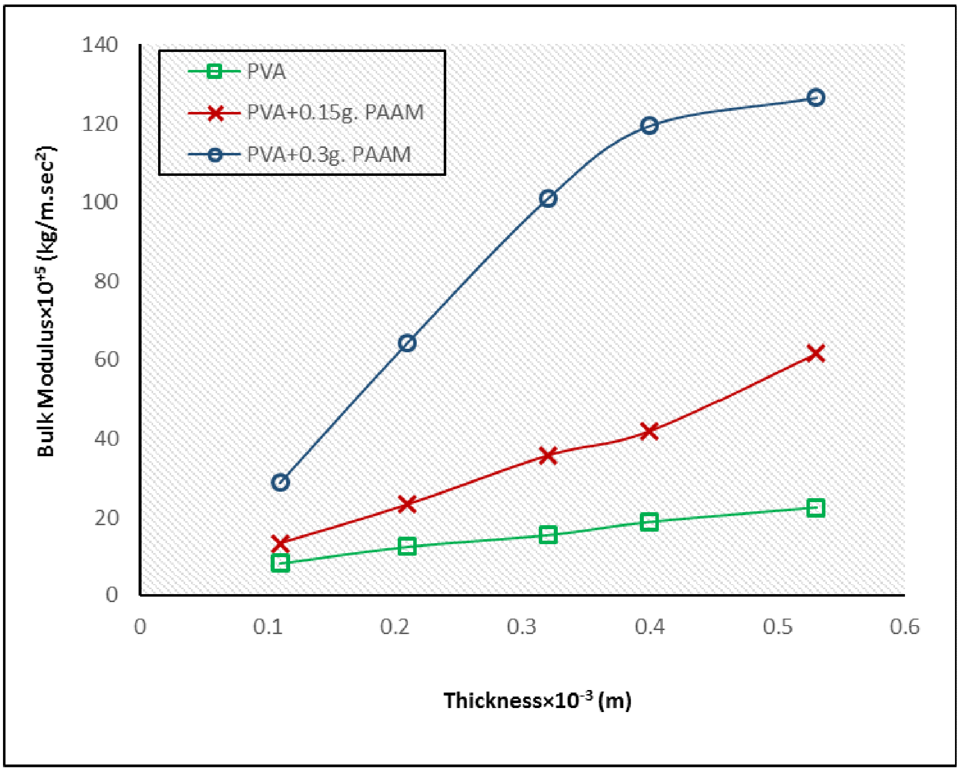

Fig.(7) Bulk modulus vs. thickness

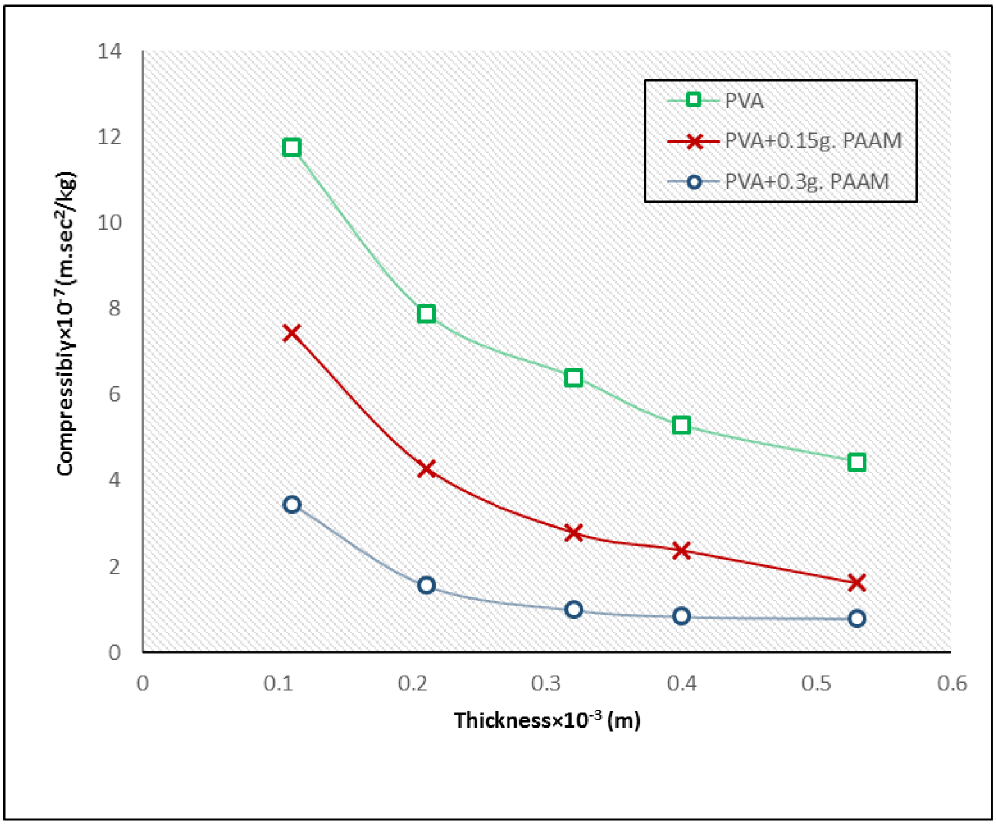

Fig.(8) Compressibility vs. thickness