

Enhancement Mechanical Properties of Carboxymethyle Cellulose by Adding Polyacrylamide using Ultrasonic Technique

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Abstract
The CMC/PAAM composite membranes were prepared by casting method, the appropriate weight of CMC was variable (0.2,0.3,0.4,0.5 and 0.6 gm) and dissolved in (25ml) of distilled water under stirring and heat (70◦C) for (40 min.) then add the PAAM with different weights (0.05, 0.1 gm) for each CMC weight. In order to evaluate the mechanical properties of CMC/PAAM composite the ultrasonic measurements were performed at the 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 composite were measured using oscilloscope ,then we calculated absorption coefficient and the transmittance ratio of the sound. It was found that there is significant relationship between ultrasonic velocity and material properties also results show that adding PAAM effects on the density then on the absorption of the ultrasonic waves inside the composites samples.
Keywords: Carboxymethyle cellulose, Polyacrylamide , Mechanical properties, ultrasound technique.

1. Introduction

CMC is 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, 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].

Polyacrylamide (PAAM), are polymer-based materials used to facilitate erosion control and decrease soil sealing by binding soil particles, especially clays, to hold them on site. In addition, these types of materials may also be used as a water treatment additive to remove suspended particles from runoff. PAAM increases the soil's available pore volume, thus increasing infiltration and reducing the quantity of storm water runoff that can cause erosion. Suspended sediments from PAAM treated soils exhibit increased flocculation over untreated soils. The increased flocculation aids in their deposition, thus reducing storm water runoff turbidity and improving water quality[4].

Polyacrylamide is a polymer that is formed from units of acrylamide, a known neurotoxin. However, polyacrylamide itself is non-toxic, but is a controversial ingredient because of its potential ability to secrete acrylamide. Polyacrylamide is used in wide range of cosmetic products (moisturizers, lotions, creams, self-tanning products, etc.). The Food and Drug Administration (FDA) allows Polyacrylamide (with less than 0.2% acrylamide monomer) to be used as a film former in the imprinting of soft-shell gelatin capsules. The Cosmetics Ingredient Review (CIR) Expert Panel allows the use of 5 ppm acrylamide residues in cosmetic products. Polyacrylamides were first used as an implantable carrier for sustained delivery of insulin to lengthen the life of diabetic rats. Since then, various drug delivery systems based on polyacrylamide have been developed [5]. It is also used as a carrier for other bioactive macromolecules and cells to produce the desired effects [6]. Polyacrylamide-chitosan hydrogels are biocompatible and are used for sustained antibiotic release[7][8].

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[9]. The purpose of this research was to investigate the Mechanical properties of Carboxymethyle cellulose with Polyacrylamide (PAAM) by ultrasound wave at fixed frequency (25 KHZ) and study the effect of adding PAAM on the Mechanical properties of CMC to enhance its different applications.

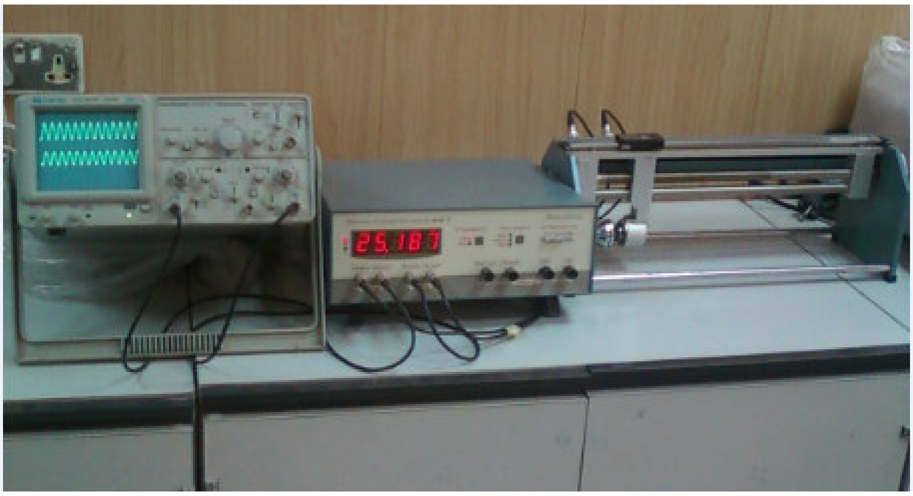
2. Experimental:

2.1 Preparation of Solutions:

The CMC/ PAAM composite membranes were prepared by casting method, the appropriate weight of CMC was variable (0.2, 0.3, 0.4, 0.5 and 0.6 gm) dissolved in (25ml) of distilled water under stirring and heat (70 C^{O}) for (40 min.) then add the PAAM with different weights (0.05, 0.1 gm) for each CMC weight, the resulting solution was stirred continuously until the solution mixture became a homogeneous viscous appearance at room temperature for (40 min.). The CMC/PAAM composite polymer membranes are obtained by leaving the mixture solution in a petredish at room temperature for 3 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) 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).



2.4 Theoretical calculation:

The ultrasound wave velocity (V) was calculated using the following equation [10]:

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

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 Laplace equation where (ρ) is the density [11]:

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

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 [12, 13]:

$$K = \rho v^2 \quad \ldots\ldots. (3)$$

The acoustic impedance of a medium (Z) was calculated by equation [14]:

$$Z = \rho v \quad \ldots\ldots.. (4)$$

Absorption coefficient (α) was calculated from Lambert – Beer law [15]:

$$A/A_o = e\,(-\,\alpha\, x) \;\ldots\ldots\; (5)$$

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 [16]:

$$D = \alpha / f^2 \;\ldots\ldots\ldots\; (6)$$

Transmittance (T) is the fraction of incident wave at a specified wavelength that passes through a sample was calculated from the following equation [17]:

$$T = I / Io \;\ldots\ldots\; (7)$$

3. Results and discussions

The composite membranes density were measured by the weight method at room temperature (296.15 K.), figure (1) shows that the density of the membrane increase because its molecules which are heavier than CMC molecules occupied the vacancies between polymer macromolecules displaying CMC molecules from their position and because density is mass per unit volume so increasing the density with increasing the concentration[18].

Ultrasonic velocity is increasing with increasing CMC 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 [19].and Adding PAAM 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 [20].

Compressibility of samples were calculated using Laplace equation no. (2), figure (3) 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 [21,22] this compression fills the vacancies between polymer molecules and restricted the movement of these molecules this lead to reduce the elasticity of the composite as shown in figure (3) And the bulk modulus is increasing with concentration (Fig.4) ; this behavior same to that give by [23]. Specific acoustic impedance shown in (Fig.5) is increasing with concentrations 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. (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 , this behavior same to that give by (Al-Bermany E. 2004& Hassun and Rahman 1990) for other polymers(24,25), adding PAAM enhances absorption coefficient by increasing its values. The relaxation amplitude are increasing with concentration as shown in figure (7) since it depend on the absorption coefficient as related in equation no (6).

The transmittance are decreasing with increasing concentration as shown in figure (8) this attributed that the polymer molecules absorbed the sound waves according to Lambert-Beer Law which is biased on concentration[26].

4. Conclusion

1-The density and velocity results show this composite is good medium to transfer ultrasound waves.

2-Adding PAAM 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.

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

4-this composite has good mechanical properties so it may use as resistant materials against environment.

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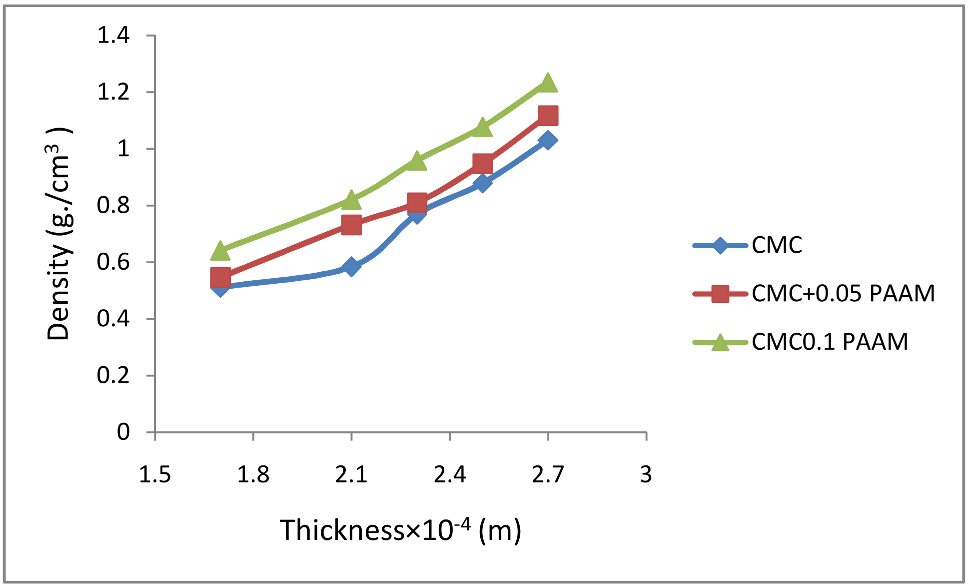

Figure.1. Density due to Thickness

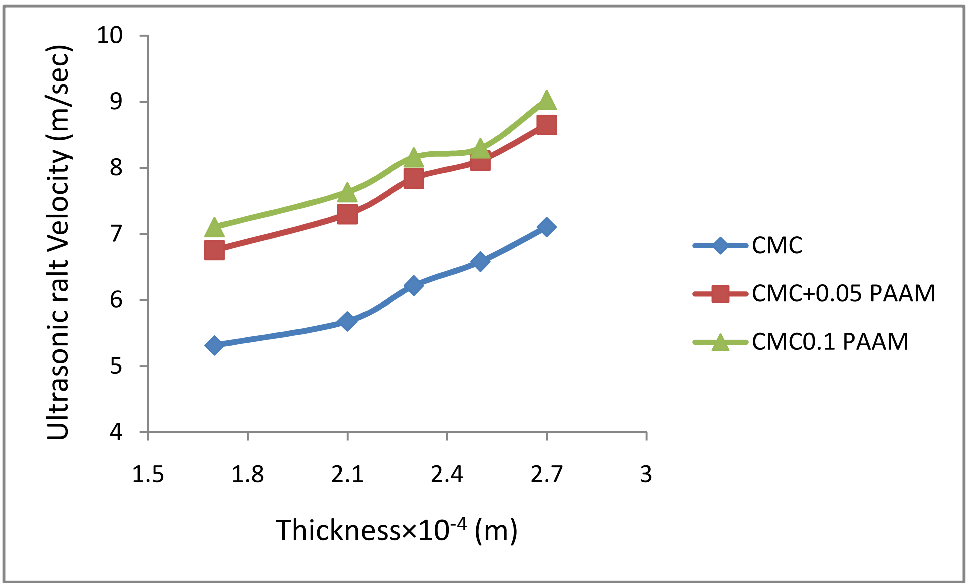

Figure.2. Velocity due to Thickness

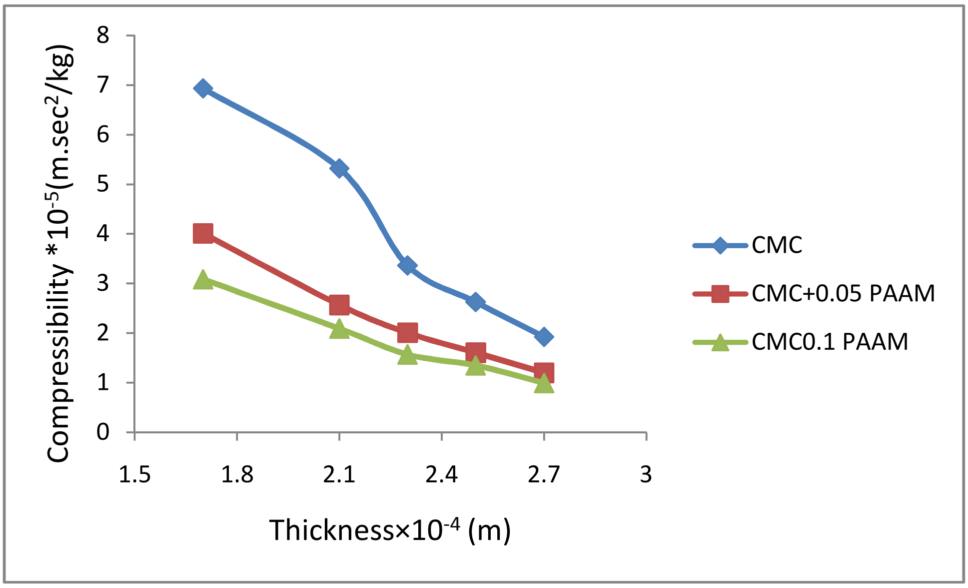

Figure.3. Compressibility due to Thickness

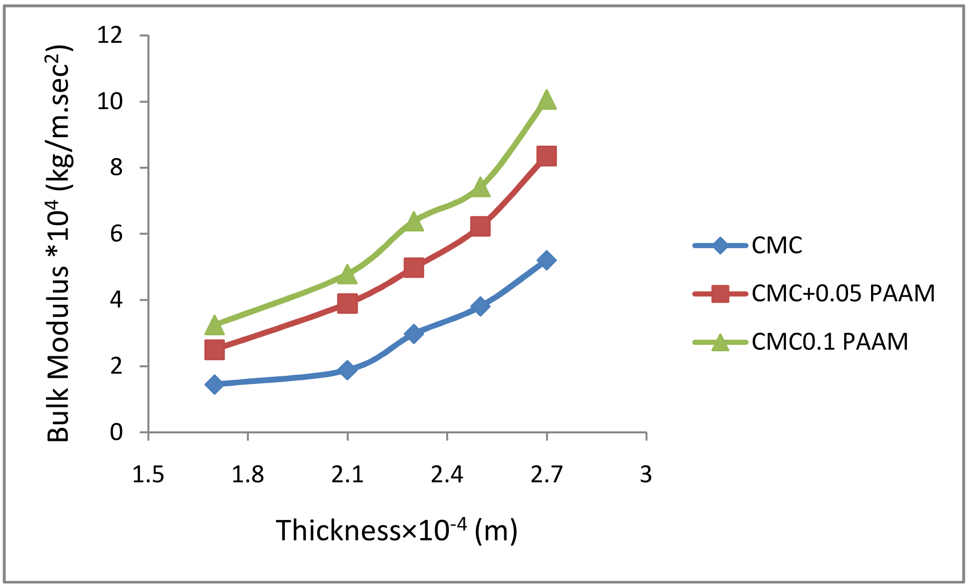

Figure.4. Bulk Modulus due to Thickness

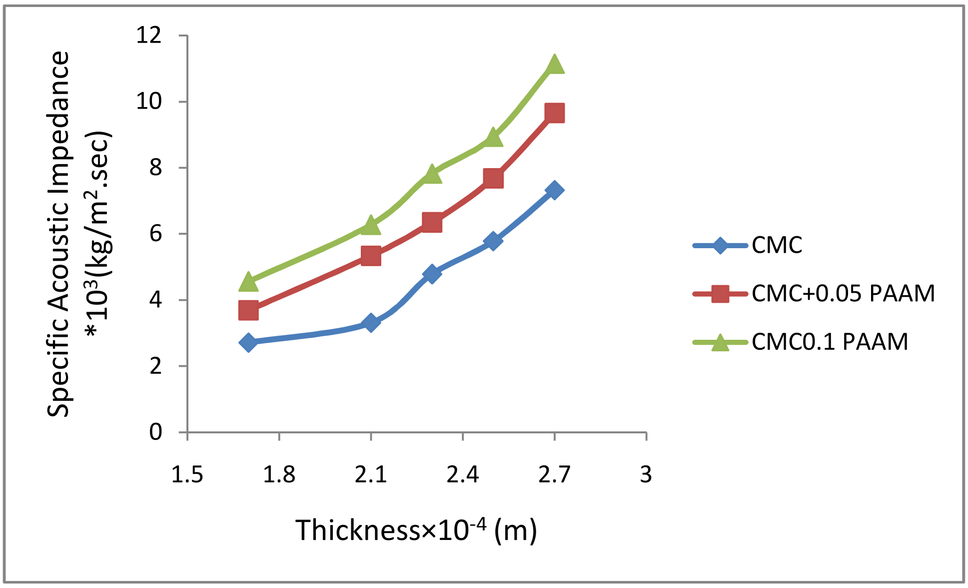

Figure.5.Acoustic impedance due to Thickness

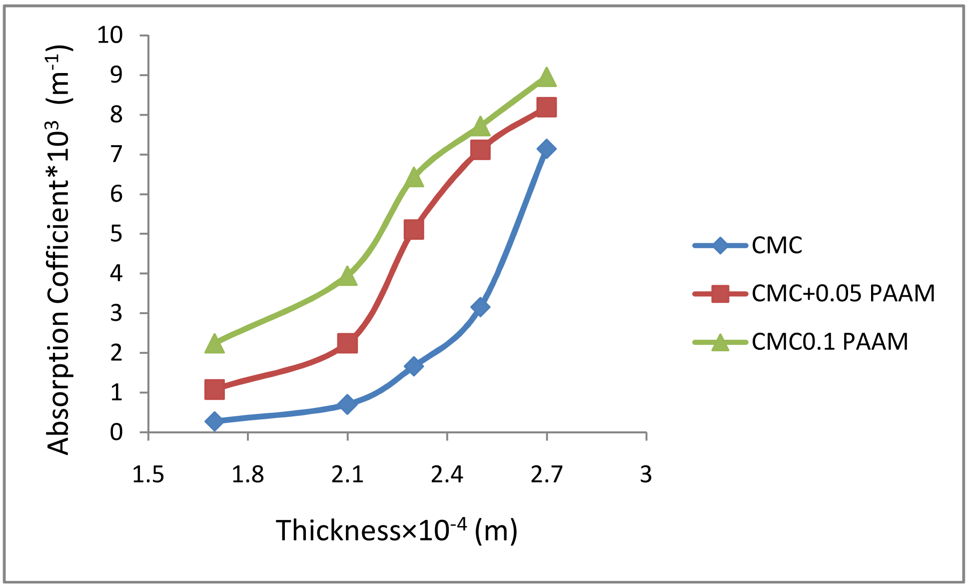

Figure.6. Absorption coefficient due to Thickness

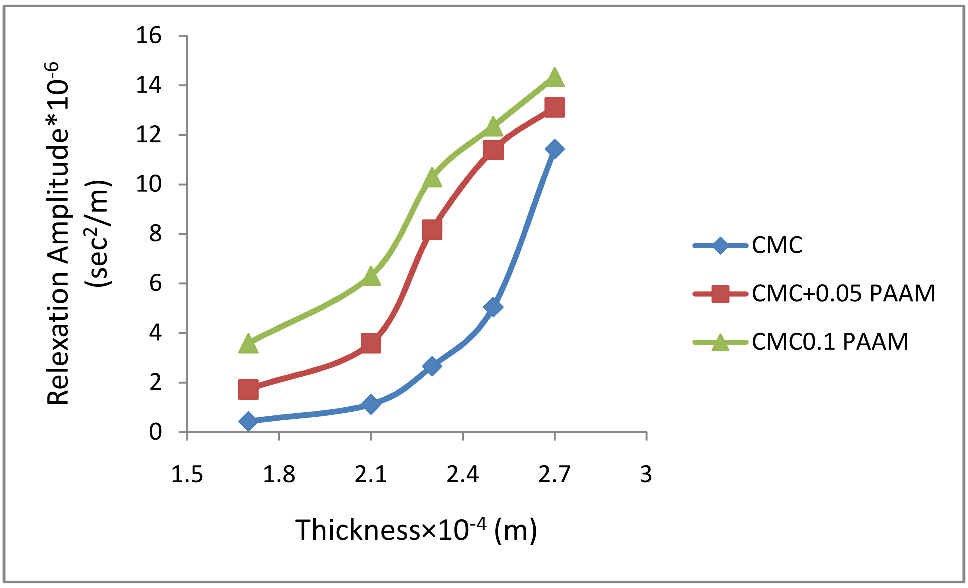

Figure.7. Relaxation amplitude due to Thickness

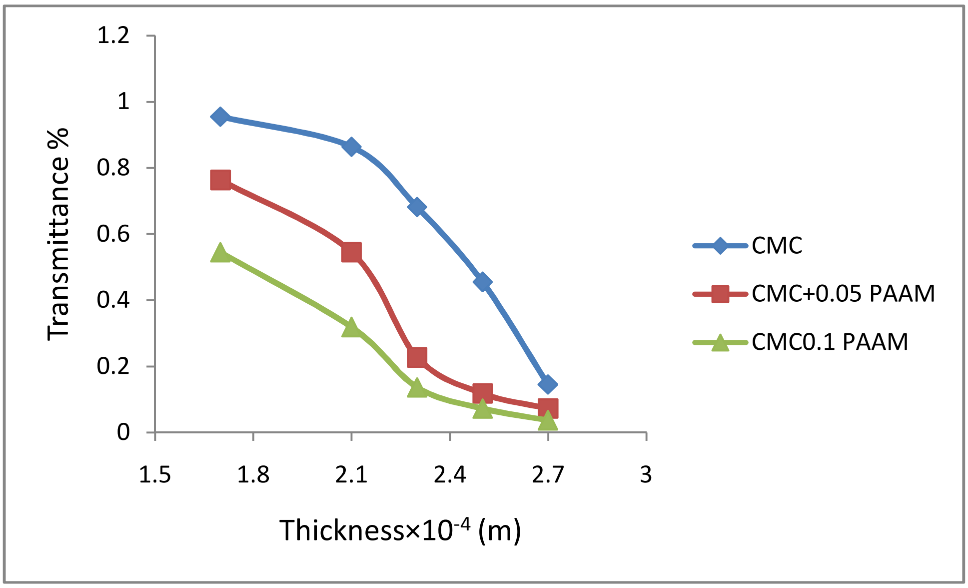

Figure.8. The transmittance due to Thickness