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Mechanical Ultrasonic Properties of (Poly(Methylene Oxide)-TiO_2) Polymer Composite Gel

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Abstract: Mechanical Ultrasonic U/S properties of (poly(methylene oxide)/TiO_2) composite gel have been measured. Concentrations of poly(methylene oxide) polymer that dissolved in 250 mL from phenol at 331 K. For (0.5 h) were (0.1, 0.2, …, 0.8 g/mL)%, furthermore (0.25 and 0.5 g) from TiO_2, respectively, added for each polymer concentrates. All measurements have been made at (f = 30 kHz) frequency. The results indicate that all U/S properties enhanced after TiO_2 adding and this property can be enhanced the using of poly(methylene oxide) in many mechanical devices.

Key words: Poly(methylene oxide), TiO_2, mechanical properties, ultrasonic waves, composite gel, polymer

INTRODUCTION

The propagation of mechanical Ultrasonic waves (U/S) in liquids or fluids such as (composites, blends and collides) has been interested in the studying of structure and molecules interactions. The studies of U/S are very important to describe the liquid theory of matter. The velocity of U/S waves of polymer indicates to the polymer nature (Kulkarni ad Khadke, 2016).

The nano-particles, mostly added to polymers to conform a composite to enhance its properties but each nano types depend on the treatments of surface and method.

Poly(methylene oxide) resin has been widely used in mechanical, automotive, plumbing, appliance, industrial and electrical conponents along with its copolymer resins. It is continuing to replace die-cast zinc, brass, aluminum, steel and other metals in the various end-use industries (Allan and Yong, 1999).

MATERIALS AND METHODS

Practical part: This part concern on the method material preparations and measurements.

Preparation of composite solution: Poly(methylene oxide) and TiO_2 were purchased from Sigma Aldrich Ltd. company. Composite solutions prepared by the mixing of liquid. Poly(methylene oxide) concentration that dissolved in 250 mL from phenol at 331 K. for (0.5 h) then (0.25 and 0.5 g) from TiO_2 added for each concentrates of poly(methylene oxide). Homogeneous gel appear after (1.5 h).

U/S measurements: "U/S measurements have been made practically by using (SV-DH-7A/SVX-7) device at (30 kHz) frequency. The U/S waves have been applied to the tested sample that lying in the region between the sender and receiver. The receiver converts U/S pulses to the electrical pulses received by digital oscilloscope device. The apparent signal in first channel contains positive peak represent incident U/S wave or initial Amplitude (A_o) and the negative part in second channel refers to receiver Amplitude (A)".

Theoretical calculations: All theoretical calculations have been calculated by, the Velocity (V) of U/S mechanical waves calculated by Wilson and Gibbs (1901):

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

Where:
X = The distance between receiver and sender
t = Time of delay

The compressibility (β) calculated from Laplacian Eq. 2 (Rao *et al*., 1981):

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

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where, (ρ) is the density of matter. Young (elasticity) modulus (K) calculated by Rao *et al.* (1981):

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

Impedance of acoustic of a medium (Z) calculated by Nikam and Hasan (1993):

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

Coefficient of absorption (α) calculated by Lambert-Beer law (Wu and Liu, 2010):

$$A/A_0 = e(-\alpha x) \quad (5)$$

Amplitude of relaxation (D) calculated by Josef and Herbert:

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

Transmittance (T) calculated by Basu (2001):

$$T = I/I_O \quad (7)$$

RESULTS AND DISCUSSION

"The density of composite gel measured practically at 331 K. Figure 1 shows that the density of solution gel increased because the colloidal forms across linked among molecules of poly(methylene oxide) and TiO_2 that occupied the vacancies between poly(methylene oxide) molecules also the density increased normally by increasing of concentration" (Li *et al.*, 2017).

"It is a clear from Fig. 2 that the U/S wave velocity of poly(methylene oxide) increased with increasing of concentration this behavior return to structural relaxation that happens in the associated composite. A fluid at rest has internal structure similar to solid but when the waves propagate result various periodic causes flow of molecules between vacancies in the lattice during compression and return to original location during rarefaction. The U/S wave velocity directly proportion with concentration before and after addition because U/S waves cause interaction between polymer molecules and additive, lead to increase the velocity (Upmanyu and Singh, 2014). Figure 3 and 4 show the relaxation time and amplitude also increase against concentrations according to theoretical equations and the increasing of polymer chain leads to increase the fraction between the composition layers that tested by moment of inertia factor (Fig. 5-7).

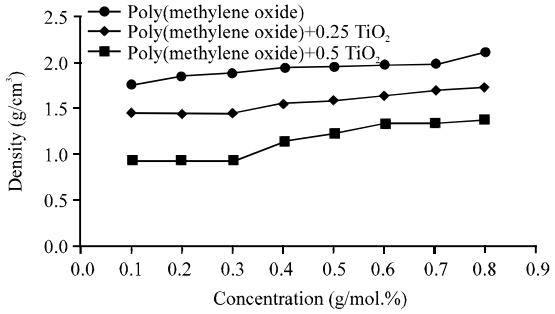

Fig. 1: Density vs. concentrations

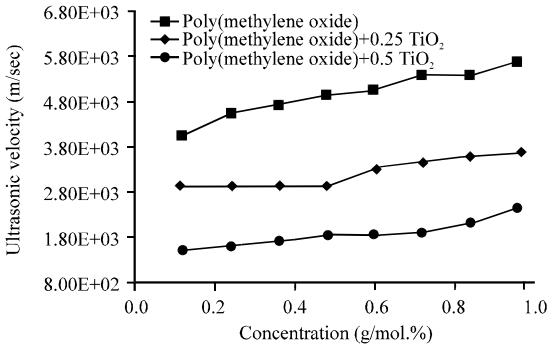

Fig. 2: Ultrasonic velocity vs. concentrations

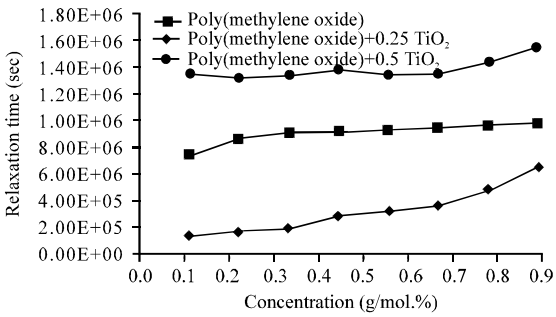

Fig. 3: Relaxation time vs. concentrations

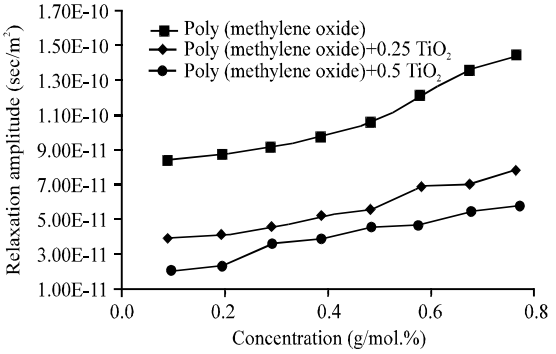

Fig. 4: Relaxation amplitude vs. concentrations

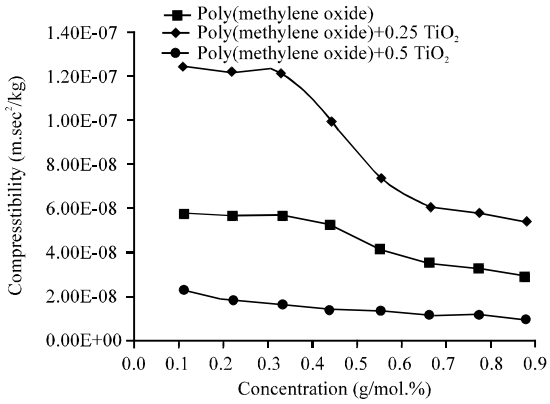

Fig. 5: Compressibility vs. concentrations

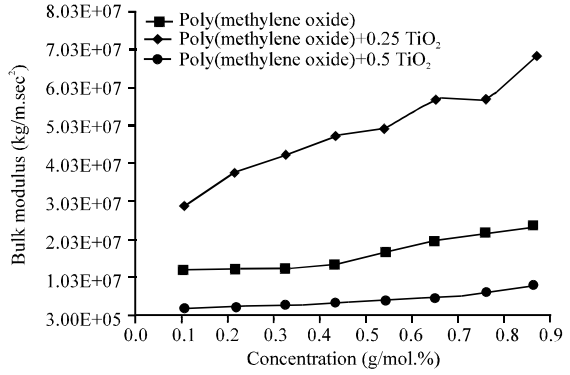

Fig. 6: Bulk modulus vs. concentrations

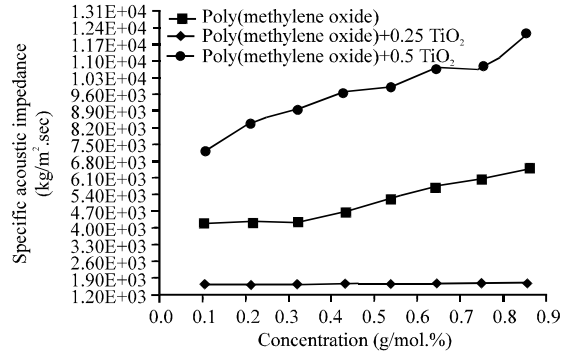

Fig. 7: Specific acoustic impedance vs. conc

"The compressibility of a pure poly(methylene oxide) and its additives have been calculated theoretically and the result shows that the compressibility is inversely proportional with concentration, Fig. 5 and this is because the propagation of U/S waves made a random polymer chain conformation or randomly coiled in addition of U/S wave make a compression lead to reduce the elasticity of composition (Ravichandran and Ramanathan, 2010) in addition of the velocity of U/S wave is inversely

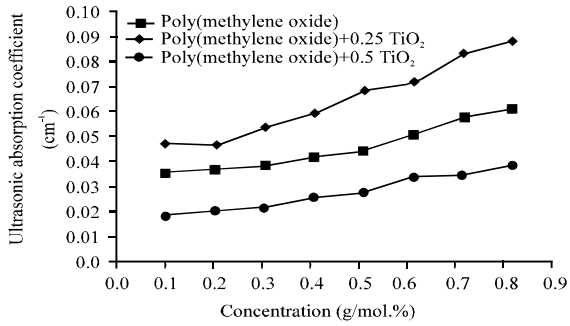

Fig. 8: Ultrasonic absorption coefficient vs. conc

proportional to compressibility. From Fig. 6, the bulk modulus directly proportional with concentration similar to reference (Khelladi *et al*., 2009). Impedance of specific acoustic, Fig. 7 is also directly increase with concentration depending on theoretical equation and density is very small as compare as velocity. U/S absorption coefficient, Fig. 8 also directly proportional with concentration and this is because U/S absorption coefficient depends on concentration (Abdali *et al*., 2015)".

CONCLUSION

Poly(methylene oxide) resin is a highly crystalline polymer characterized by its metallic qualities of hardness, strength and stiffness. It also has good lubricity properties under a wide variety of enviromental conditions of moisture and heat, good fatigue resistance a low coefficient of friction and springiness. It has good chemical resistance to most solvents. It cannot, however, beam proofed. The composite gel is best medium to U/S transformation.

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