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Acoustical Properties of (Chitin/nano-TiO_2) Bio Polymer Composite Gel

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Abstract

Ultrasonic (U/S) properties of (Chitin (Ch)/TiO_2) nano-composite gel have been studied. The concentrations of Chitin polymer that dissolved in (500 mL) from N-N dimethyl- acetamide and (5% LiCl) at RT. for (0.5 hrs.) were (0.1, 0.2,…, 0.8 g/mL)% respectively, then TiO_2 added as (0.25 and 0.5) g for each concentrates of polymer. All U/S measurements have been made at (f =25 kHz) frequency.

The results show that all U/S properties enhanced after the addition of TiO_2, and this property used in U/S devices.

Keywords: TiO_2, Chitin, Ultrasonic Properties and Nano Materials.

الخلاصة

درست الخصائص فوق الصوتية للمتراكب النانوي الجلاتيني (Chitin (Ch)/TiO_2). تراكيز بوليمر كيتين المذاب في (500 مل) من N–N dimethyl– acetamide and (5% LiCl) عند درجة حرارة الغرفة لمدة (نصف ساعة) كانت (0.1،0.2،...،0.8 غم/مل)% على التوالي، بعد ذلك اضيف TiO_2 بنسب (0.25 و 0.5) غم لكل تراكيز البوليمر. تمت جميع القياسات عند التردد (25 كيلو هيرتز). اظهرت النتائج ان جميع الخصائص فوق الصوتية تحسنت بعد إضافة TiO_2، واستخدمت هذه الخاصية في الأجهزة فوق الصوتية.

الكلمات المفتاحية: ثاني أوكسيد التيتانيوم، كيتين، الخصائص فوق الصوتية، المواد النانوية.

1. Introduction

The propagation of ultrasonic (U/S) waves in pure liquids and its additives (composites or blends) has been interested in the structure and molecules interaction studying. The U/S studies are very important to describe the liquid theory of matter. The U/S velocity of polymer indicates to the polymer nature, therefore the scientist concerned to study of polymer solutions [Kulkarni1 and Khadke, 2016].

Nano-particles, mostly added as a composite to polymers to enhance its properties, but each nano type depends on the treatments of surface and method used [Abdulazeez *et al.*, 2016].

Chitin (polysaccharides or carbohydrate polymers) is a biopolymer found in crab or lobster shells in some (krill or clam) mollusks shells. It is also found in cockroaches, spiders and beetles, also insert in many medical and industrial applications according to its molecular weight (> 10^6 Dalton) [James, 1999].

2. Practical Part

This part concern on the method material preparations and measurements

2.1 Preparation of composite solution

Chitin and TiO_2 were purchased from British Drug House (BDH) Inc. company. Composite solutions prepared by the mixing of liquid method. Chitin concentration that dissolved in (500 ml) from N-N dimethyl- acetamide and (5% LiCl) at RT. for (0.5 hrs.) then (0.25 and 0.5) g from TiO_2 added for each concentrates of chitin. Homogeneous viscous solution gel appear after (1 hrs.) hot plate stirrer at (55ºC).

2.2 U/S measurements

U/S measurements have been made practically by using (SV-DH-7A/SVX-7) device at (25 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).

2.3 Theoretical computations:

All theoretical calculations has been concluded by these equations:

The velocity (V) of U/S wave calculated by [Bidwell, 1901]:

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

Where (X) represent the distance between receiver and sender and (t) is a delay time.

From Laplacian equation, the mean stress or compressibility (β) calculated as [Rao *et al.* 1981]:

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

Where (ρ) is the density of matter:

Young modulus (K) calculated by [Rao *et al.*, 1981]:

$$K = \rho v^2 \quad \text{..... (3)}$$

The impedance of acoustic of a medium (Z) calculated by [Nikam and Hasan, 1993]:

$$Z = \rho v \quad \text{..... (4)}$$

The coefficient of absorption (α) calculated by Lambert – Beer law [Zong and Liu, 2011]:

$$A/A_o = e(-\alpha x) \quad \text{..... (5)}$$

The amplitude of relaxation (D) calculated by [Josef and Herbert, 1990]:

$$D = \alpha / f^2 \quad \text{..... (6)}$$

The transmittance (T) calculated by [Dipak, 2001]:

$$T = I / Io \quad \text{..... (7)}$$

3. Results and discussions

The density of composite gel measured practically at RT. Figure (1) represent the density of solution increased because the colloidal forms across linked among molecules of chitin and TiO_2 that occupied the vacancies between chitin molecules, also the density increased normally by increasing of concentration [Li *et al.*, 2017].

It is a clear from Figure (2) that, the U/S wave velocity of chitin 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]. Figures (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 [Oudry *et al.*, 2009].

The compressibility of a pure chitin and its additives were calculated theoretically, and the result shows that the compressibility is inversely proportional with concentration, Figure (5), and this is because propagation 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 proportional to compressibility. From Figure (6), the bulk modulus increases with concentration similar to reference [Khelladi *et al.*, 2009]. Impedance of specific acoustic, Figure (7) is also directly increase with concentration depending on theoretical equation and density is very small as compare as velocity. U/S absorption coefficient, Figure (8) also directly proportional with concentration, and this is because U/S absorption coefficient depends on concentration [Abdul-Kareem *et al.*, 2015].

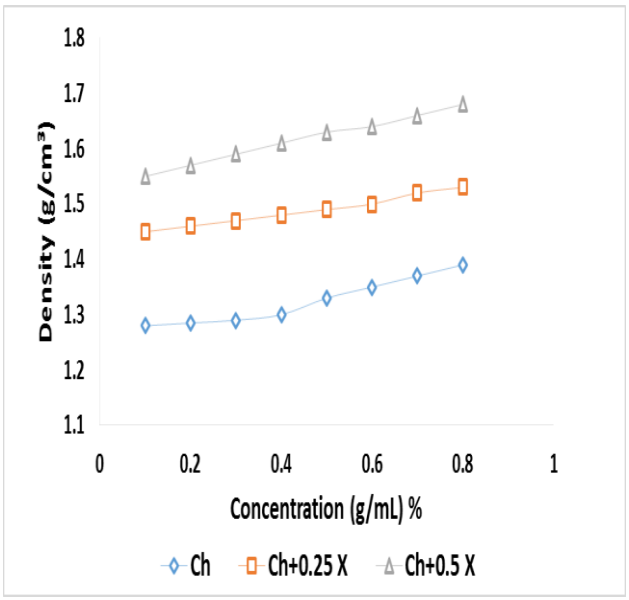

Fig. (1): Density vs. concentrations

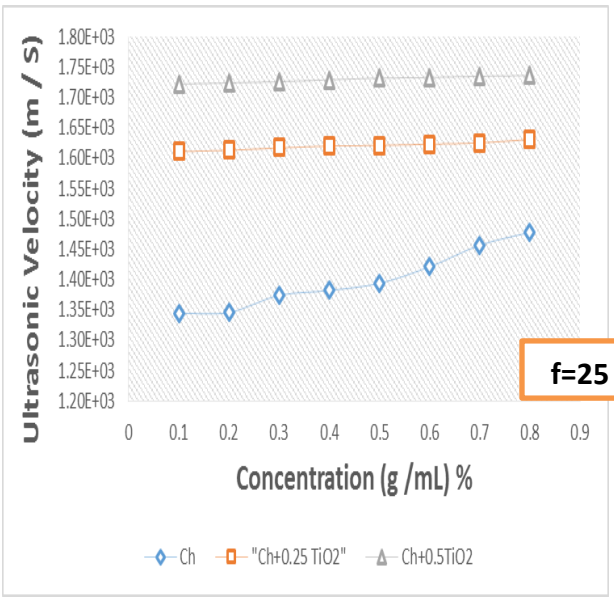

Fig. (2): Ultrasonic velocity vs. concentrations

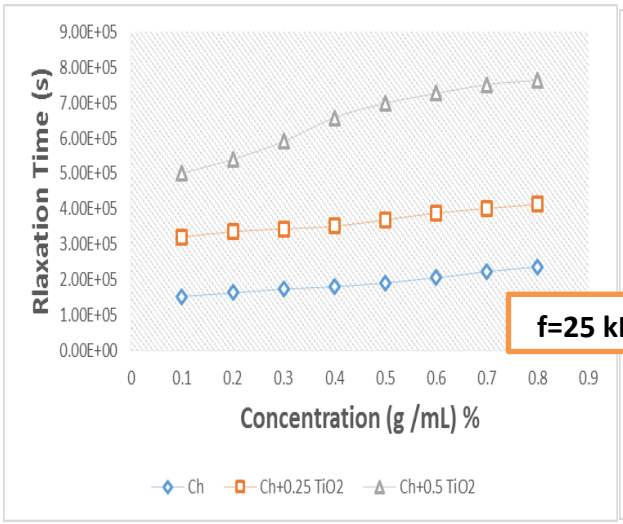

Fig. (3): Relaxation time vs. concentrations

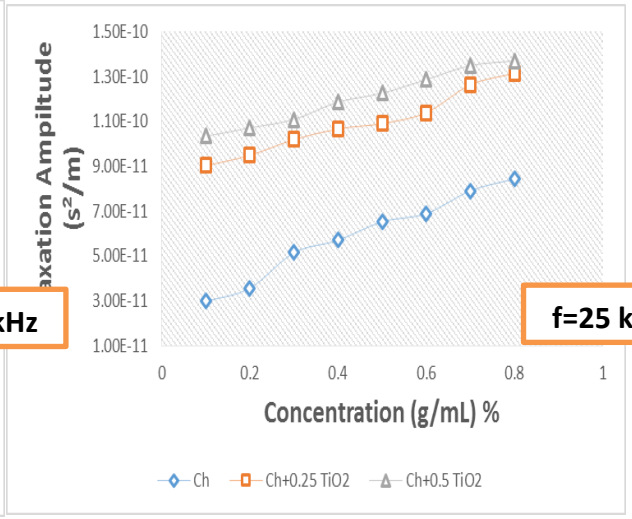

Figure (4): Relaxation amplitude vs. concentrations

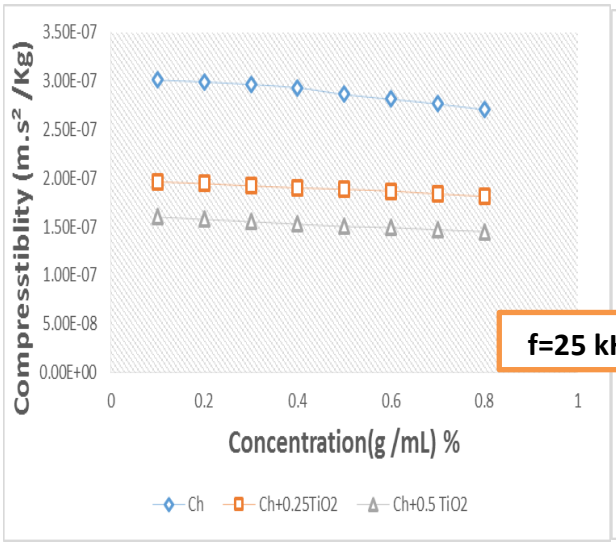

Fig. (5): Compressibility vs. concentrations

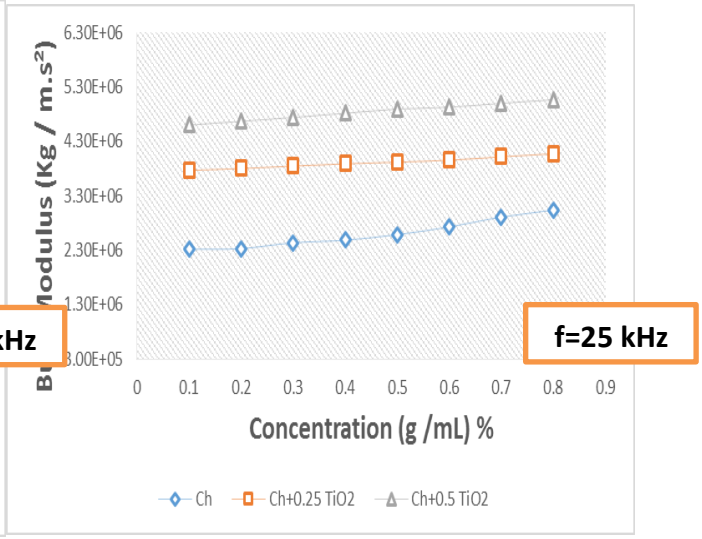

Fig. (6): Bulk modulus vs. concentrations

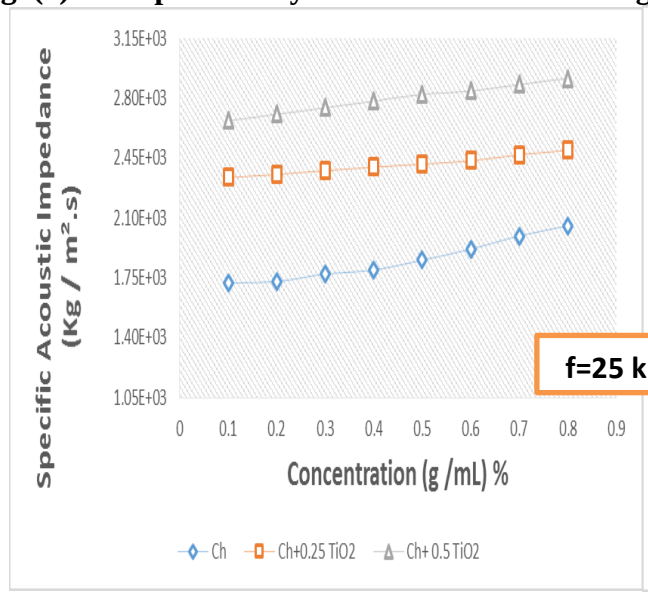

Fig. (7): Specific acoustic impedance vs. conc.

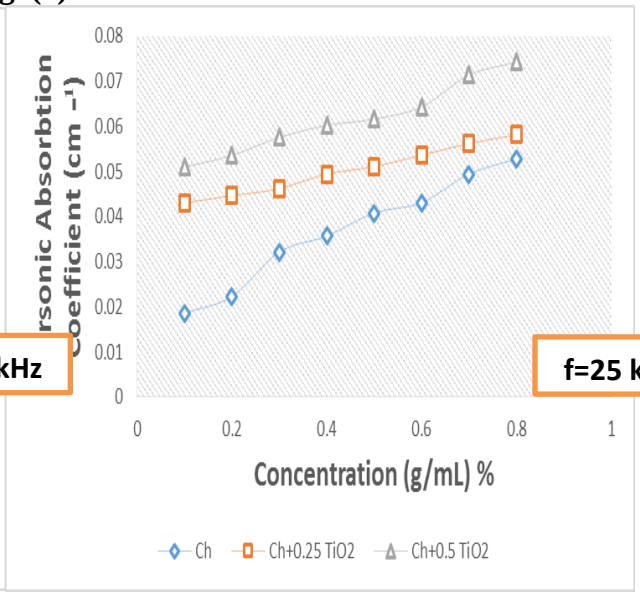

Fig. (8): Ultrasonic absorption coefficient vs. conc.

4. Conclusions:

1- (Chitin/ nano-TiO_2), suitable for using in the coating.
2- (Chitin/ nano-TiO_2) gel success as U/S gel instead of industrial sonar gel.
3- New gel can be used as resistant materials against environment.
4- The composite is harmless to human skin (primary cell wall component of animals).

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