Study of Rheological and mechanical properties of polymeric Blend (Arabic Gum /PVP)

دراسة الخصائص الريولوجية والميكانيكية لخليط من بوليمر (صمغ عربي- PVP)

Fadwa H.A. AL-Shaaer
College of Education for girls, Physics Department, Kufa University

ABSTRACT

Miscibility characteristics of blend, carbohydrate polymer (Arabic gum) and Poly (vinyl pyrrolidin) (PVP) in common solvent water were studied at different weight percentage by ultrasonic wave velocity, viscometry, and density techniques at 30°C. The acoustical parameters such as, relaxation amplitude (α/f^2), absorption coefficient (α), relaxation time (τ), acoustical impedance (Z) and adiabatic compressibility (β), are calculated. The results are interpreted in terms of molecular interaction between the components of the mixtures.

الخلاصة

تم دراسة خواص خليط من بوليمر (صمغ العربي) وبولي فاينل بيرلدين (PVP) المذابين في الماء بنسب وزنية مختلفة حيث قمنا بقياس سرعة الأمواج فوق السمعية واللزوجة والكثافة بدرجة حرارة (30ºC). وقد تم احتساب بعض الخواص الميكانيكية كسعة الاسترخاء (α/f^2) و معامل الامتصاص (α) وزمن الاسترخاء (τ) و الممانعة الصوتية (Z) و الانضغاطية الاديباتيكية (β). النتائج المتحققة فسرت على أساس حدوث تفاعل على المستوى الجزيئي بين مكونات الخليط.

INTRODATION

The blending of polymers is one of the simplest means to obtain a variety of physical properties from the constituent polymers. The gain in newer properties depends on the degree of compatibility or miscibility of the polymer at molecular level. The polymer blends are formed by combining two or more polymers by mechanical or chemical methods of intimate mixing. The resulting polymeric systems often exhibit properties that superior to any one of the component polymers alone. There has been great deal of interest in the studies of these systems generally known as polymeric alloys[1,2]. However, the manifestation of superior depends on the miscibility of polymers on the molecular scale. The miscibility results in altogether different morphology of the blends ranging from single phase system to tow or multiphase system[3].

Ultrasonic techniques are powerful and effective tool for investigation of polymer solution properties and behavior of polymer chains in an ultrasonic field. It provide a wealth of information about molecular interactions, nature and strength of interactions[4-6].

In this work we are going to investigate a blend of Arabic gum dissolved in water and Poly vinyl pyrrolidin (PVP) solution at different concentration by using ultrasonic techniques.

EXPERIMENTAL

Arabic gum, a complex slightly acidic (carbohydrate natural polymer), Its structure is complex and has not yet been fully explained, Its solutions were prepared by adding a known weight of it to a fixed volume of Water, it was stirred for at least 2 hrs, at 30°C and then mixed with poly vinyl pyrrolidin (PVP), synthetic polymer, at different concentration (0.01- 0.1)%. The ultrasonic velocity measurements were obtained using the pulsed ultrasonic technique of sender-receiver type (PHYWE-WEST GERMANY) Ultrasonic interferometer working at 5MHz frequency. The temperature is maintained at 30°C circulating water from a thermostat with a thermal stability of ± 0.05°C through the doudle wall jaket of the ultrasonic experimental cell. The viscosity of solutions has been measured at 30°C by using an Ostwald viscometer with accuracy of was ±0.015%, the method of measurement has been described elsewhere[7].

THEORETICAL CALCULATION:

Theoretical values of adiabatic compressibility (β) relaxation time (τ), relaxation amplitude (α/f^2), viscosity (η), absorption coefficient (α), and specific acoustic impedance (Z) for the solutions have been calculated using the following equations(1-6) [8, 9,10].

$$\beta = \frac{1}{\rho v^2} \qquad \text{.........................}(1)$$

$$\tau = \frac{4\eta}{3\rho v^2} \qquad \text{.........................}(2)$$

$$\frac{\alpha}{f^2} = \frac{8\pi^2\eta}{3\rho v^3} \qquad \text{.........................}(3)$$

$$\frac{\eta}{\eta_o} = \frac{\rho t}{\rho_o t_o} \qquad \text{.........................}(4)$$

$$v = \frac{x}{T} \qquad \text{.........................}(5)$$

$$Z = \rho v \qquad \text{.........................}(6)$$

Where η and η_o are the viscosity for the solution and solute respectively, ρ and ρ_o the densities of the solution and solute respectively, ν the ultrasonic wave velocity in solution, t and t_o the flow times of solution and solute respectively. τ is the delay time of ultrasonic waves and x is the crystal moving distance.

RESULTS AND DISCUSSION

Experimental data of density, viscosity and ultrasonic velocity of the prepared solution show an increase with increasing concentration of synthetic polymer PVP which dissolved in aqueous solution (figs.1-3). Increases in density, viscosity and velocity with PVP concentration indicated increases in cohesion forces due to powerful intermolecular interaction. The interaction may due to hydrogen bonding between natural and synthetic polymer. The changes in density and ultrasonic velocity with concentration are not appreciable like viscosity, because molecular motion is affected by polymer-solvent and polymer –polymer interactions. The non liner increases in viscosity indicated structural changes due to polymer-solvent interaction[2, 5, 8].

In order to understand the nature of polymer-solvent interaction various acoustical parameters such as specific acoustic impedance, adiabatic compressibility, Absorption coefficient, relaxation amplitude and relaxation time were calculated. Variation of acoustical parameters with concentration of polymer-solvent system furnishes a valuable wealth information on molecular interactions occurring in the solutions and hence the structural changes[4, 10].

The linear increases of acoustical impedance with PVP concentration (fig.4) and decreasing of adiabatic compressibility (fig.5) supported that the molecules are fully compressed due to electrical forces of the solution molecules and orientation of the natural polymer molecules around the synthetic polymer molecule. This is also supported by the fact that intermolecular free length is found to decreases with increase in synthetic polymer concentration [2, 4].

The variation of absorption coefficient, relaxation amplitude and relaxation time with concentration (figs.6-8) show decreasing and then increasing at high concentration, this may be attributed to the structural fluctuations of polymer molecules, such as the segmental motion of the polymer chains which are influenced by density, viscosity and ultrasonic wave velocity[11].

CONCLUSION

This study show that there is a good miscibility between the natural polymer (Arabic gum) and the synthesis polymer (pvp) which can be attributed to a strong intermolecular interaction yields between the two polymers (polymer-polymer interaction) and formation of hydrogen bonds between the polymers and the solvent (polymer-solvent interaction).

The acoustical waves cause a structural fluctuation in the polymer molecules which may be result from the segmental motion of the polymer chains.

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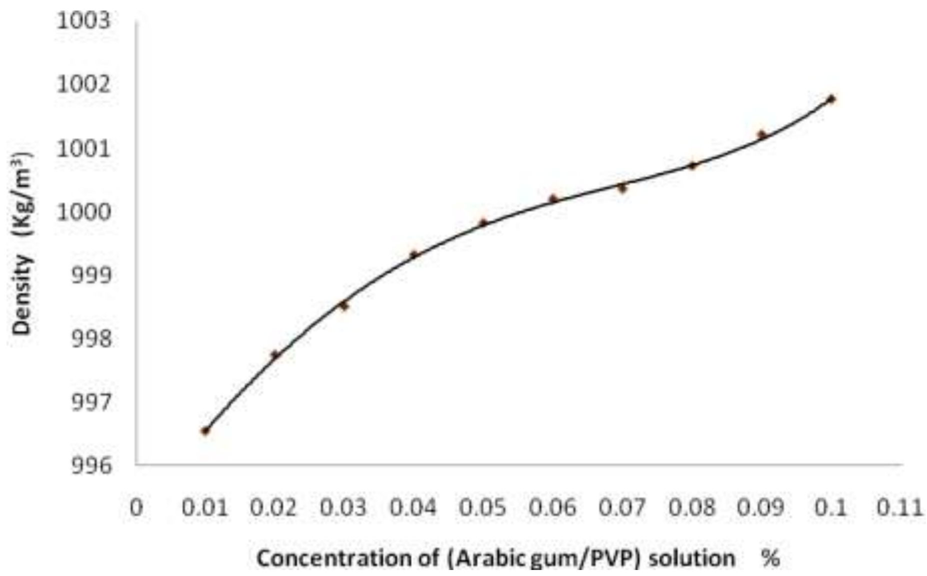

Fig. 1 The variation of density Vs concentration of Arabic gum-pvp aqueous solution.

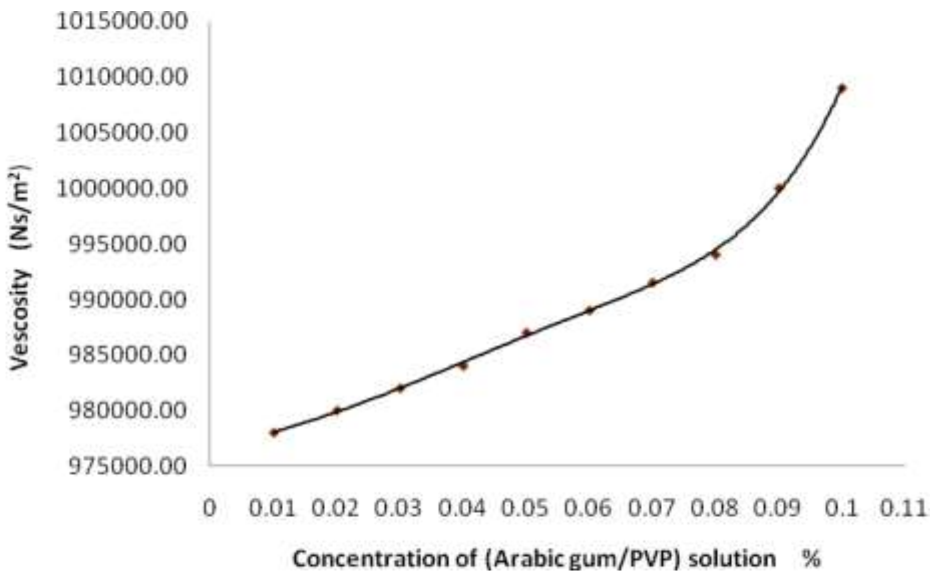

Fig. 2 The variation of viscosity Vs concentration of Arabic gum-pvp aqueous solution.

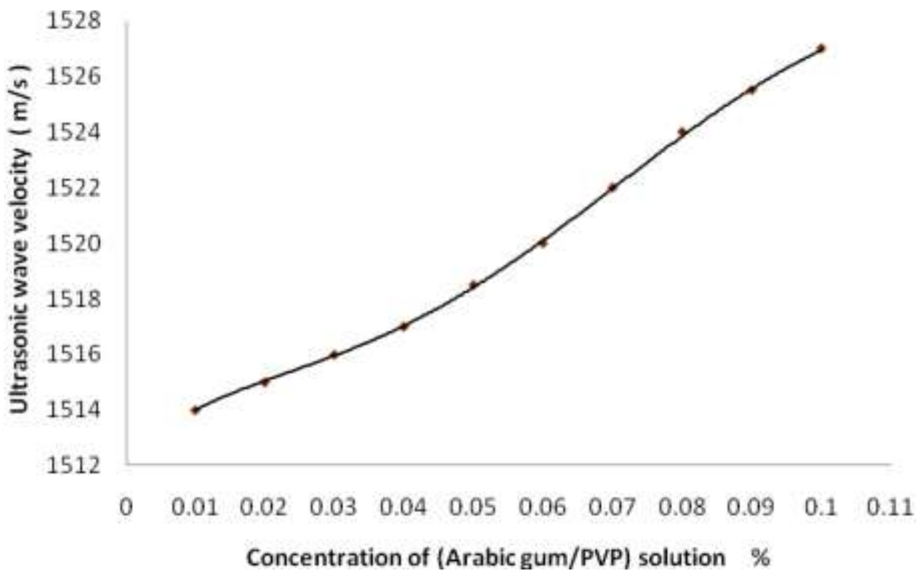

Fig. 3 The variation of ultrasonic wave velocity Vs concentration of Arabic gum-pvp aqueous solution.

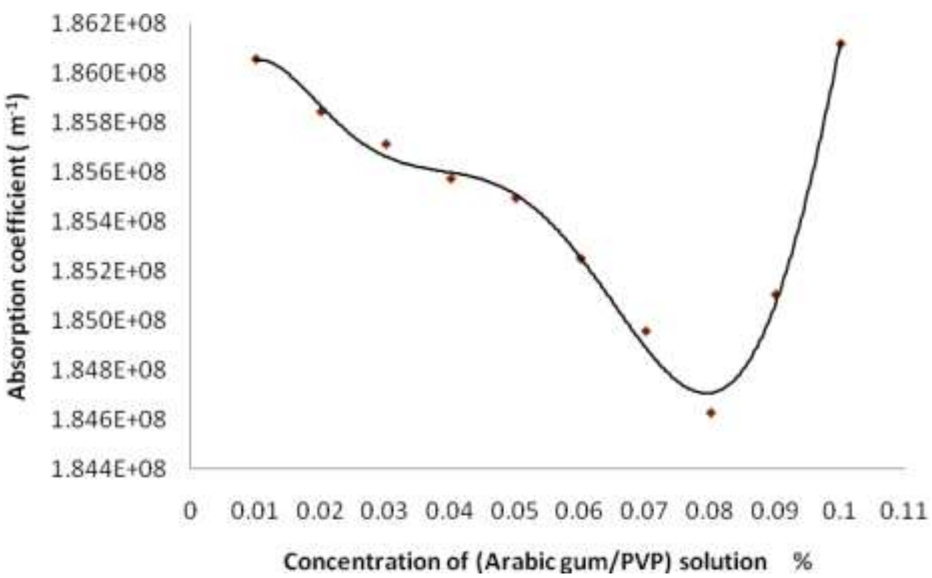

Fig. 4 The variation of absorption coefficient Vs concentration of Arabic gum-pvp aqueous solution.

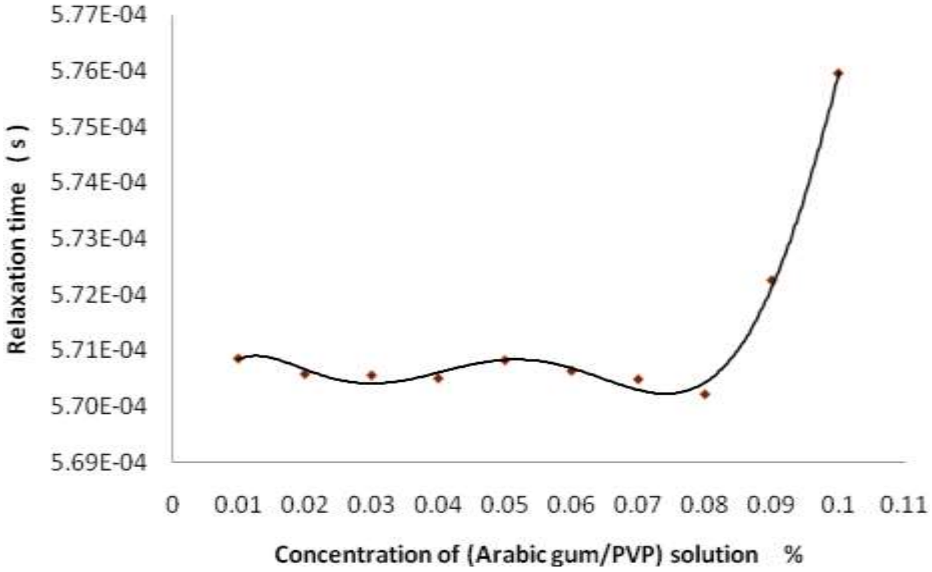

Fig. 5 The variation of relaxation time Vs concentration of Arabic gum-pvp aqueous solution.

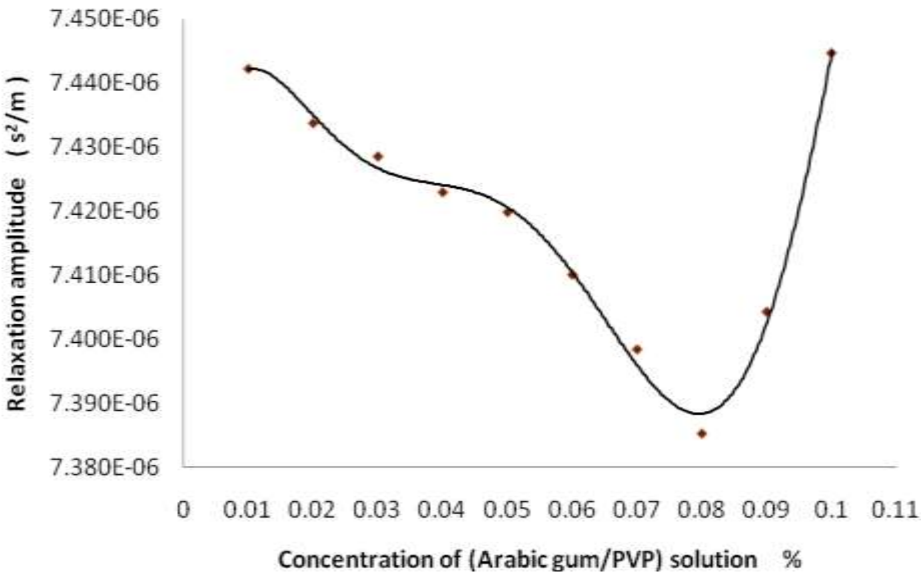

Fig. 6 The variation of relaxation amplitude Vs concentration of Arabic gum-pvp aqueous solution.

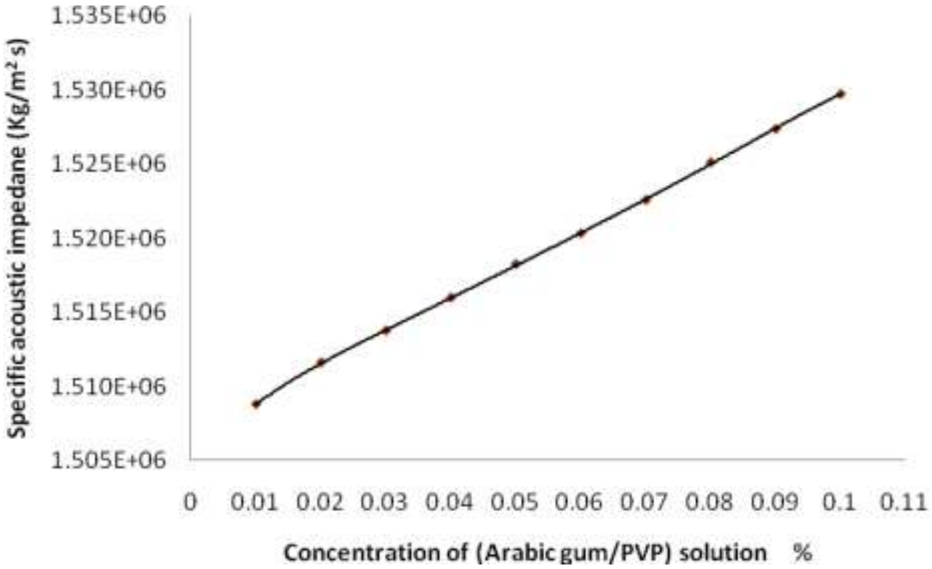

Fig. 7 The variation of specific impedance Vs concentration of Arabic gum-pvp aqueous solution.

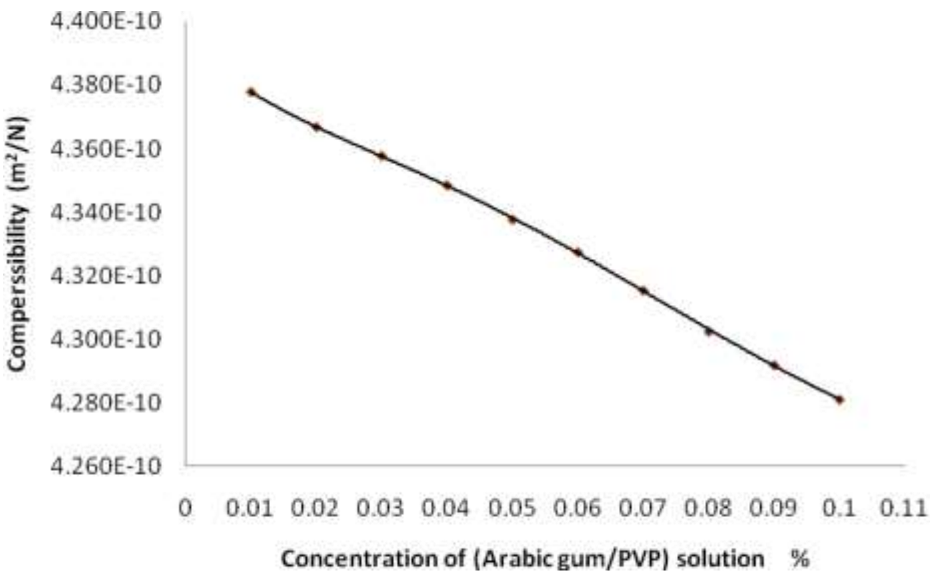

Fig. 8 The variation of compressibility Vs concentration of Arabic gum-pvp aqueous solution.