دراسة الخواص الميكانيكية والريولوجية لبوليمر بولي اكريلك اسيد لمحاليل بولي اكريلك اسيد

خالدة حسين حبيب الميالي
قسم الفيزياء ،كلية التربية للبنات ، جامعة الكوفة

الخلاصة

عين معامل الامتصاص ،وسرعة الموجات فوق السمعية، وكذلك معامل الامتصاص، وزمن الاسترخاء، وسعة الاسترخاء ،واللزوجة، والانضغاطية لبوليمر بولي اكر يلك أسيد المذاب في الماء وبنسب وزنيه مختلفة باستخدام تقنية الموجات فوق السمعية ذي تردد (26kHz) وفي درجة حرارة 30 ℃ .

أظهرت النتائج ان كل من قيم السرعة واللزوجة ومعامل الامتصاص، وزمن الاسترخاء، وسعة الاسترخاء تزداد بزيادة التركيز لمحاليل لهذا البوليمر وبالعكس فان قيم الانضغاطية تتناقص بزيادة التركيز وهذه النتيجة تقترح وجود اندماج داخلي بين جزيئات البوليمر وجزئيات المذيب وكذلك بين جزيئات البوليمر أنفسها.

Ultrasonic and Viscosity Studies of Poly (Acrylic Acid) Solutions

K. H.H. AL-Mayali
Department of Physics, College of Education for Girls, University of Kufa

Abstract

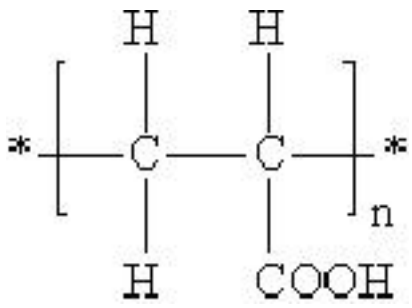
Ultrasonic absorption, velocity, viscosity, adiabatic compressibility, relaxation time and relaxation amplitude measurements are reported on different concentrations of poly(acrylic acid) solutions in common solvent water using pulsed ultrasonic apparatus technique operating at 26 kHz and 30 ℃.

Results show an increase of velocity, viscosity, and absorption coefficient ،relaxation time and relaxation amplitude values with the increasing concentrations of the poly(acrylic acid) solutions, which might be the result of structural fluctuations of polymer molecules such as the segmental motions of the polymer chains. In contrast the compressibility decreases with the increasing concentration of this polymer. This study suggests there is an association between polymer and solvent molecules and also there is association between polymer molecules itself.

Introduction

Poly(acrylic acid) is an unsaturated carboxylic acid. It readily undergoes polymerization and addition reactions from the monomer -$CH_2CH(CO_2H)$- .

PAA is innoxious and soluble in water, it can be used in situations of alkaline and high concentration without scale sediment. PAA can disperse the microcrystals or microsand of calcium carbonate, calcium phosphate and calcium sulfate. PAA is used as scale inhibitor and dispersant for circulating cool water system, papermaking, weave, dyeing, ceramic, painting, etc.



PAA can be used as a scale inhibitor and dispersant in circulating cool water systems in power plants, iron & steel factories, chemical fertilizer plants, refineries and air conditioning systems. Dosage should be in accordance with water quality and equipment materials[1,2].

Ultrasonic absorption and velocity measurements provide useful information on the behaviour of polymers in solutions. It is, therefore, important to obtain fundamental information on how this important and valuable polymer acts in asolution, especially in water[3,4].

Experimental

Poly(acrylic acid) a fine white powder has a molecular weight of 2,000g. Its solutions were prepared by adding a known weight of the polymer to a fixed volume of water, it was stirred for at least 20 hrs, at the temperature 30°C . The ultrasonic velocity measurements were obtained by using the pulsed ultrasonic technique of sender-receiver type (PHYWE-WEST GERMANY) Ultrasonic generator with constant frequency of 26kHz [5]. The temperature is maintained at 30 ^{o}C circulating water from a thermostat with a thermal stability of $\pm$ 0.05^{o}C through the double wall jaket of the ultrasonic experimental cell. The viscosity of solutions was measured at 30 ^{o}C by using an Ostwald viscometer, the method of measurement was described elsewhere[6]. The accuracy of the viscosity measurement was $\pm$0.015%.

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 were determined by using the following equations (5, 6, 7).

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

$$\tau = \frac{4\eta}{3\rho v^2} \quad \ldots(2)$$

$$\frac{\alpha}{f^2} = \frac{8\pi\eta}{3\rho v^3} \quad \ldots(3)$$

$$\frac{\eta}{\eta_o} = \frac{\rho t}{\rho_o t_o} \quad \ldots(4)$$

$$v = \frac{X}{T} \quad \ldots(5)$$

$$Z = \rho v \quad \ldots(6)$$

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

Results and Discussion

The variation of the viscosity, ultrasonic velocity, absorption coefficient, relaxation time, relaxation amplitude and specific acoustic impedance of Poly(acrylic acid) solutions with composition were shown in figures 1, 2, 3, 4, 5 and respectively 6 .

From these figures it is clearly evident that the values of these properties are increasing with the increasing concentrations of this polymer. Figure (7) shows the results for the adiabatic compressibility of ultrasonic waves at 26 kHz and 30 ℃ as a function of poly(acrylic acid) concentrations .

The interaction causing association between defferent concentrations of Poly(acrylic acid) and water may be responsible for the increase in velocity, viscosity, relaxation time and relaxation amplitude [7,8,9]. The increase in the values of the acoustic attenuation with the increase in the concentration can be attributed to modification in the nature of the intermolecular interactions. These measurements suggest the formation of a more rigid structure with the increase of poly(acrylic acid) concentration, possibly due to the polymer-water hydrogen bonding at sites on the polymer's carboxyl(CO_2H) group. The behaviour observed in the poly(acrylic acid) aqueous solutions was observed in other polymer-water solutions [10].

The attenuation of ultrasonic energy depends on viscosity, thermal conductivity, scattering and inter molecular processes, the thermal conductivity and scattering effects are known to be negligible [4,7] therefore, the inter molecular is responsible for the increase of the high values of the acoustic attenuation [7,9,11], indicating an increase in the overall size of the molecule in the path of ultrasonic waves as a result of complex formation between several polymer macromolecules and solvent molecules [4, 12].

Considering viscosity as a relaxation phenomenon, the increase in the value of viscosity versus concentration of solute supports the complex formation [4,7].

In Figure 7,at 1,5,10% and 15% poly(acrylic acid) concentration, the adiabatic compressibility of poly(acrylic acid) aqueous solutions increase, from 20%, compressibility suddenly decreases with concentrations. This could be interpreted in terms of change in the structure of water and in the interaction between the polymer and water. This relaxation phenomenon in poly(acrylic acid) aqueous solutions might be the result of structural fluctuations of polymer molecules, such as the segmental motion of polymer chains and this behaviour suggests the formation of more structures [9,7,13].

Conclustion

This study shows that intermolecular processes are responsible for the relaxation and indicating an increase in the overall size of the molecules in the path of ultrasonic waves as a result of complex formation between Poly(acrylic acid) and solvents molecules. An ultrasonic relaxation in poly(acrylic acid) aqueous solutions, which may be the result of structural actuations of polymer molecules, such as the segmental motions of the polymer chains, was observed for the first time.

References

1.Blmeer, F., (1971), “Fundamental of polymer Sciences”, Joho wily and sons, Inc..

2.Shaghayegh J. and Hamid M., (2005), “ A Study on Swelling and Complex Formationof Acrylic Acid and Methacrylic Acid Hydrogels with Polyethylene Glycol” ،“Iranian Polymer Journal”,14 (10):863-873.

3.Hiroyasu, N.; Tatsuro, M. and Shinobu, K. (2004), “Ultrasonically induced birefringence in polymer solutions”, “ Pure Appl. Chem. ”,. 76(1): 97–104.

4.Hassun, S. and Rahman, K., (1989)Ultrasonic Study of Moleculare association of high Impact Polystyrene Solutions in Toluene (1990)Iraqi J. Sci. 30:3-24.

5.Blitz, J. (1967).Fundamental of Ultrasonic 2nd eedion,

6.Khalida, H.H.; Alaa, F. and Salh, H. (2006) Study of Temperature Effect of some Rheological and Electrical Properties of Poly isobutylene ,Journal of Babylon University”, 13(3):530-538.

7.Khalida, H. H., (2004), Study of Structural and Visco-Relaxation of Polycarbonates Solutions by Ultrasonic Technique”,“Journal of Al-Qadisiya of Pure Sciences 9(3):118-122.

8.Massoumeh, F. (2006) Density Dependence of the Viscosity and Excess Volume of Aqueous Solutions of Polyvinylpyrrolidone”, “Acta Chim. Slov.,

53:219–222 .
9.Syal ,V.K.;Anita ,Ch. and Suvarcha, Ch.. (2005), Ultrasonic velocity, viscosity and density studies of poly (ethylene glycols)(PEG - 8,000, PEG - 20,000) in acetonitrile (AN) and water (H2O) mixtures at 250C, J. Pure Appl Ultrason 27: 61-69.
10.Jong ,R.B. (2002) Ultrasonic Velocity and Absorption Measurements in Binary Solutions, Journal of the Korean Physical Society, 41(1):171-174.
11.Rajulu, A.V. and Redlody, R.L., (2000) Miscibility Studies of Polystyrene Blends as Measured by Viscosity, Ultrsonic, and Refractiv Index Methods, J. Polymeric Mater, 5:467.
12.Maffezzoli, A.; Tarziq, A. and Cannoletta, D.(1999) Ultrasonic Characterization of the Kineties of Water Sorption in Hydrogels, Macromol Symp. 138(144): 149-154.
13.Hassun, S.K. and Isa, S.O. (1989) Visco-Relaxation Study of Poly (Vinyl alcohol) aqueous Solution (A Method for the Determination of Molecular Weight)",“British polymer Journal, 21: 333.

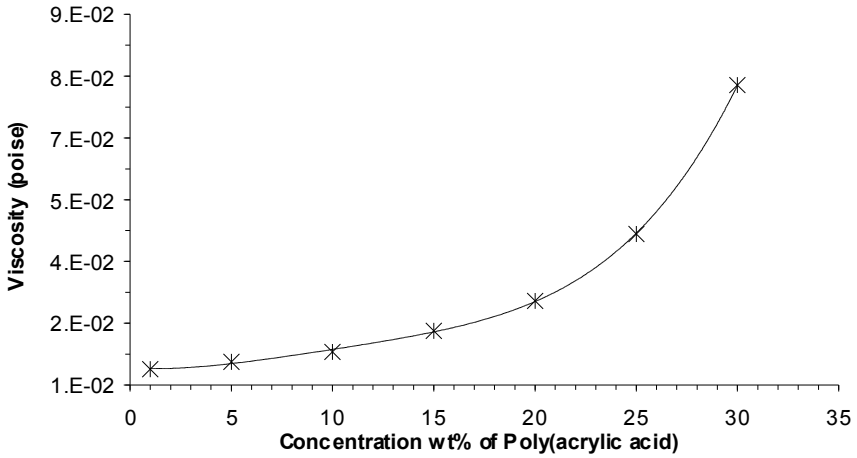


Fig.(1): The variation of Viscosity with Concentration of Poly(acrylic acid) at 30 ◦C .

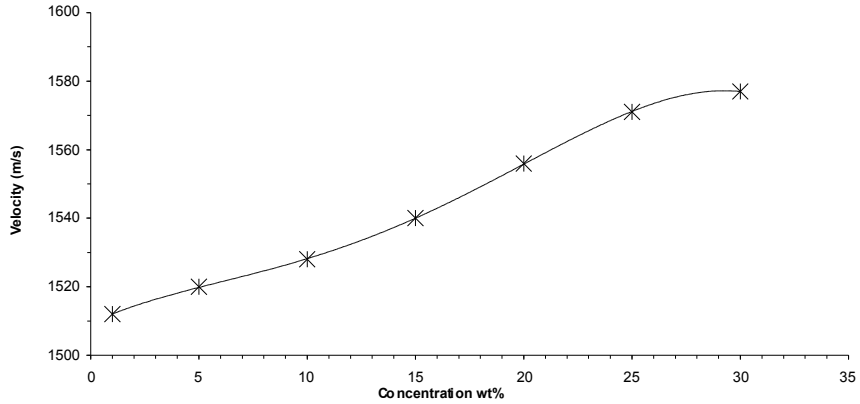


Fig.(2) The variation of Velocity with Concentration of Poly(acrylic acid) at 30 °C .

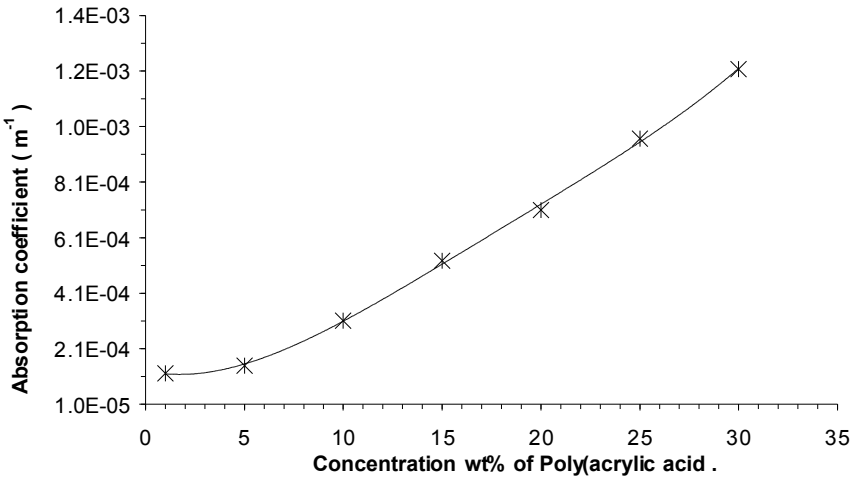


Fig.(3): The variation of absorption coefficient of ultrasonic waves with the Concentration of Poly(acrylic acid) at 30 °C .

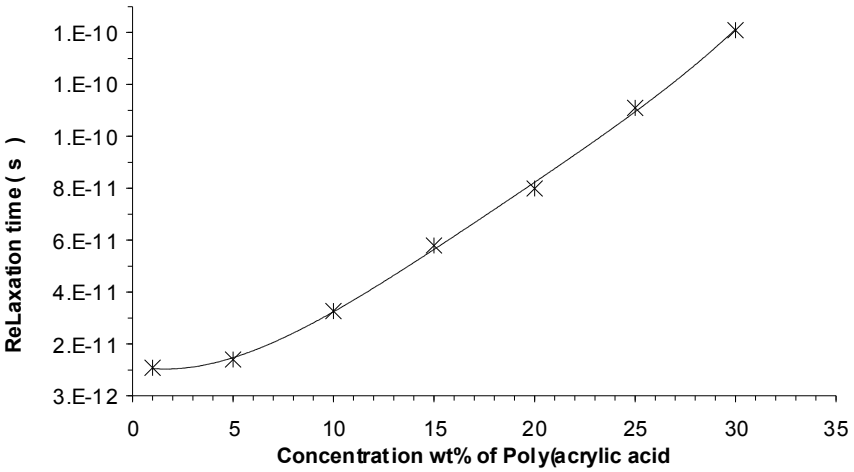


Fig.(4): The variation of relaxation time with the Concentration of Poly(acrylic acid) at 30 °C .

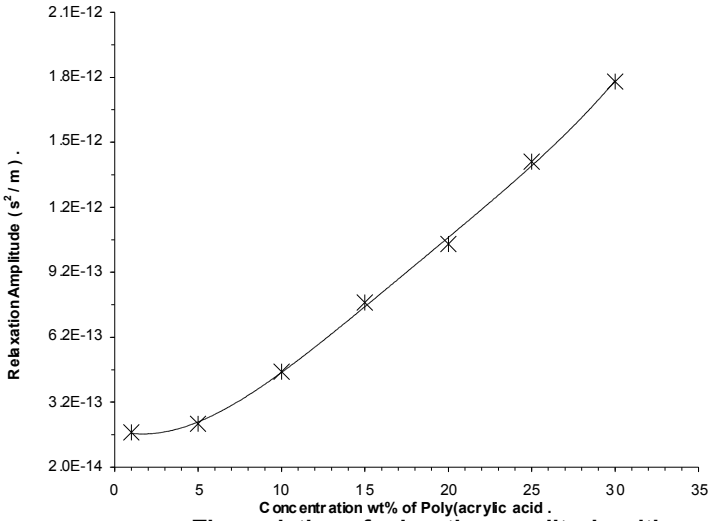


Fig.(5) The variation of relaxation amplitude with the Concentration of Poly(acrylic acid) at 30 °C .

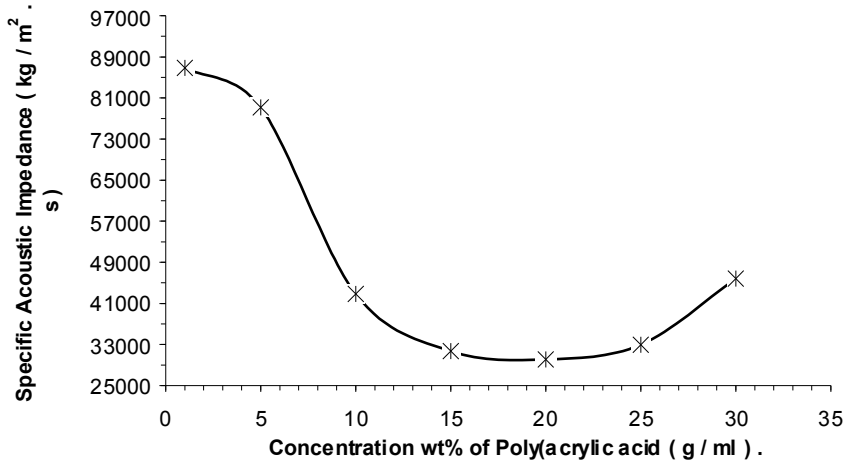


Fig.(6): The variation of specific acoustic impedance with the Concentration of Poly(acrylic acid) at 30 °C .

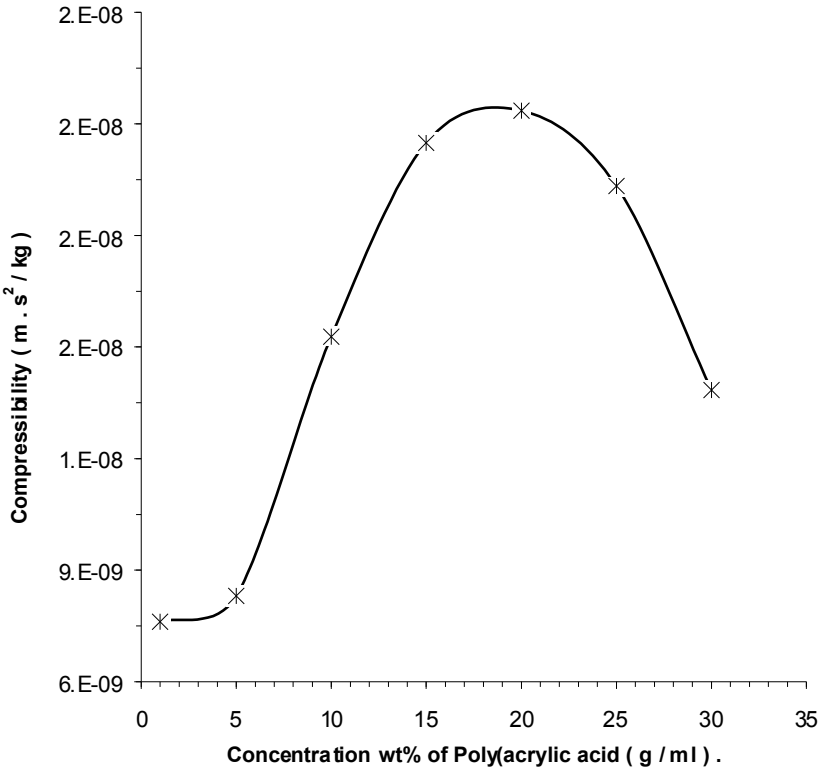


Fig.(7): The variation of compressibility with the Concentration of Poly(acrylic acid) at 30 °C .