

Study the Effect of adding PAAM on Some Physical Properties of PVA Polymer

Prof.Dr.Abdul-Kareem J. Al-Bermany (Corresponding author)
Babylon University / Facility of Science /Physics Department /Advanced polymer laboratory
E-Mail: dr.abdulkaream@yahoo.com
Asia Hussein Kadhim E-Mail: asia.almousawi@yahoo.com

Abstract:
Some of physical properties of dissolves Polyvinyl Alcohol (PVA) in distilled water had been studied at different concentrations (0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6%, 0.7%, 0.8% and 0.9%) (gm. /ml) before and after adding (1, 1.5) gm. Of Polyacrylamide (PAAM) for all concentrations these are (Rheological and Electrical properties). The Rheological properties such as shear Viscosity, relative Viscosity, Specific Viscosity and reduced Viscosity are measured. The results show that all these properties are increasing with the increase of the polymer concentration before and after adding except reduced Viscosity is decreasing with the increase of the polymer concentration before adding. The electrical conductivity have been investigated at (293K.). Results also shows that adding (PAAM) polymer to (PVA) enhances the conductivity, then the molar conductivity and degree of dissociation were calculated and it depending on the values of density, concentration and type of solute and solvent.
Keywords: (PVA) solution, (PAAM) solution, Rheological properties, Electrical properties.

1. Introduction:

PVA is a water-soluble synthetic polymer, due to the characteristics of easy preparation, good biodegradability, excellent chemical resistance, and good mechanical properties, polyvinyl alcohol is used mainly as a solution in water but its solubility in water depends on its degree of polymerization and degree of hydrolysis of its precursor (poly vinyl acetate)[1]. PAAM is a polymer (-CH2CHCONH2-) formed from acrylamide subunits. It can be synthesized as a simple linear-chain structure or cross-linked. Polyacrylamide is not toxic [2]. It is highly water-absorbent, forming a soft gel when hydrated, used in such applications as polyacrylamide gel electrophoresis and in manufacturing soft contact lenses. In the straight-chain form, it is also used as a thickener and suspending agent. More recently, it has been used as a sub dermal filler for aesthetic facial surgery. One of the largest uses for polyacrylamide is to flocculate solids in a liquid. This process applies to water treatment, and processes like paper making. Polyacrylamide can be supplied in a powder or liquid form, with the liquid form being sub categorized as solution and emulsion polymer [3].The rheological properties of the PVA solutions are affected by effectiveness of the physical bonding solvent systems the physical state of water is very important to rheological responses because free water forms hydro-gel structure The rheological properties of the PVA solutions are affected by effectiveness of the physical bonding solvent systems the physical state of water is very important to rheological responses because free water forms hydro-gel structure [4].Polyvinyl alcohol (PVA) is a good insulating material with low conductivity and hence is of importance to microelectronic industry. It electrical conductivity depends on the thermally generated carriers and also on the addition of suitable dopants [5, 6]. PVA is semi crystalline, water soluble, and low electrical conductivity material, PVA exhibits certain physical properties resulting from crystal-amorphous interfacial effects, electrical conductivity of PVA can be tailored to a specific requirement by the addition of suitable doping material. Depending on the chemical nature of the doping substances and the way in which they interact with the host matrix, the doping alters the physical properties to different degrees [7].The equivalent conductivity is the quantity defined so as to describe the contribution of an ion to electric conductivity, it converges to a finite value in the infinite dilution limit, and it is dependent on the concentration of the electrolyte reflecting the interaction between ions. The equivalent conductivity is usually a decreasing function of concentration because higher concentration stands for the stronger effects of inter ionic interaction. When the dielectric constant of the solvent is low, however, some electrolyte solutions show a minimum in the equivalent conductivity, that is, the equivalent conductivity first decreases with concentration in the dilute regime, followed by the increase in the higher concentration regime. The equivalent conductivity minimum has long been elucidated in terms of the static association models [8]. Polymer blending is a well-known technique used for the modification of desired properties of polymers because it uses conventional technology at low cost [9].The purpose of this research was to study the effect of adding PAAM on the physical properties of PVA to enhance its different applications.

2. Experimental:

2.1 Preparation of Solutions:

PVA (Gerhard Buchman –Germany) with assay (99.8%) and PAAM product by (British Drug House-Germany) with assay (99.9%) of high Viscosity. The PVA solutions were prepared by dissolving a known weights of PVA powder in affixed volume (500 ml) of distilled water under stirring at 70°C for (30 min). The PVA concentrations were (0.1%, 0.2%, 0.3 %, 0.4%, 0.5%, 0.6%, 0.7%, 0.8% and 0.9%) gm. /ml; then PAAM was added with different weights (1, 1.5) gm. to all PVA Concentrations. The resulting solution was stirred continuously for (30 min.) until the solution mixture became a homogeneous.

2.2 Density and Rheological measurements:

The density of the solution (ρ) was determined by the density bottle method and the viscosity measured before and after adding (PAAM) for all concentrations using Ostwald viscometer with accuracy of ± 1.05%, the method of measurement has been described by [10], The Shear viscosity had been calculated by the following equation[11]:

$$\frac{\eta_s}{\eta_0} = \frac{t_s \rho_s}{t_0 \rho_0} \quad \text{..............................} \quad (1)$$

Where (ρ) and (η_s) are the solution density and the shear viscosity respectively, (ρ_0) and (η_0) are density and viscosity of distilled water respectively, Relative viscosity (η_{rel}) was calculated by the following equation [12]:

$$\eta_{rel} = \frac{\eta_s}{\eta_o} = \frac{t_s}{t_o} \quad \text{........................} \quad (2)$$

The specific viscosity (η_{sp}) and reduced viscosity (η_{red}) were calculated by following equations [12], where (C) is the concentration:

$$\eta_{sp} = \frac{(\eta_s - \eta_0)}{\eta_0} = \eta_{rel} - 1 \quad \text{........................} \quad (3)$$

$$\eta_{red} = \frac{\eta_{sp}}{C} \quad \text{........................} \quad (4)$$

2.3 Electrical measurements:

The conductivity was measured using (DDS – 307 microprocessor conductivity meter -England) as shown in (Fig.1), the calibration was made and the correction factor taken account in measuring the samples, all conductivities values obtained for PVA before and after adding PAAM.

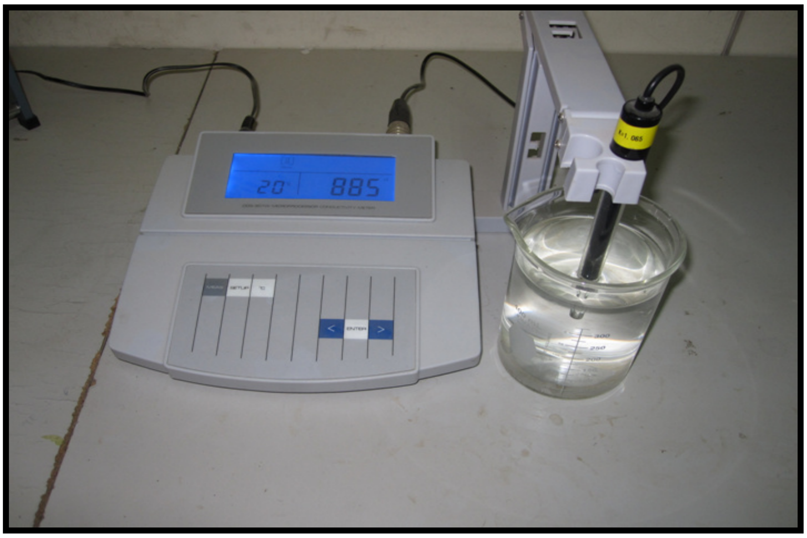

Figure (1) microprocessor conductivity meter

The molar conductivity (Λm) is defined as the conductivity of an electrolyte solution (σ) divided by the molar concentration of the electrolyte(Cm), and so measures the efficiency with which a given electrolyte conducts electricity in solution, it calculated by[12,13]:

$$\Lambda_m = \frac{\sigma}{C_m} \quad \text{.................} (5)$$

The degree of dissociation (D.D) was calculated by the following equation [14]:

$$D.D = \Lambda_m / \Lambda_0 \quad \text{.................} \mathbf{(6)}$$

Where (Λ_0) is the extrapolation of molar conductivity to infinite dilution the limiting value of the molar conductivity.

3. Results and Discussion:

3.1 Rheological properties:

Density is increasing with the increase of polymer concentration as shown in (Fig.2), since the density defined as mass per unit volume. Shear Viscosity is increasing with concentration as shown in (Fig.3) this attributed to the mechanism that hydrogen bonding of water attached to oxygen sites, this leads to salvation sheaths and increase in the size of the molecules, so its viscosity [15] furthermore water act as plasticizer reduce tensile strength and increase its chains [16].Relative, specific and reduce viscosities show in (Fig.4), (Fig.5) and (Fig.6) respectively possess the same behaviours of shear viscosity because they derived from it as shown in equations (2, 3 and 4) .Adding PVA increased these viscosities, this attributed that there are intermolecular interactions and network formation between the two types of molecules as a result of adding PAAM so increasing the size of macromolecules and attributed that PVA molecular weight is lower than PAAM which has high molecular weight, and adding PAAM to PVA increased the friction between the two types of molecules in a solution therefore the solutions have new conformation and configuration that lead to increase viscosity. The exponential behaviour of viscosity with concentration was attributed to the structural change associated with liquid polymer solution and probably indicating entanglement interaction [12].

3.2 Electrical properties:

The measured conductivity of all polymer solutions for different concentrations were plotted in (Fig.7), this shows that PAAM enhances the PVA conductivity by giving them higher values of conductivity so PAAM made PVA polymer semi conductive, this attributed to the fact that PAAM increases the ions in the solution and reducing the number of dipole moment of the PVA and water molecules then there will be ionic conduction which make conductivity increases [17]. The molar conductivity of all samples was shown in (Fig.8) were decreasing with increasing concentrations, this can be attributed to the fact that the dielectric constant of the mixtures increases owing to the stronger hydrogen-bonding interactions [13] and in dilute concentrations it has higher values than that in high concentration , this attributed that there is no intermolecular interactions occurs , the electrostatics repulsing leads to a reduction of intermolecular bonding and increase of polymer dimensions whereas higher concentration lead to inhibition of intermolecular bonding [18]. The extrapolation of this plot to infinite dilution gives the limiting value of molar conductivity; this is the value of when the ions are so far apart that they do not interact [18,19], Ostwald of dilution indicates that complete dissociation when the dilution approach infinite therefore the dilute solution may be represented as strong electrolyte [20] the value of degree of dissociation has the range $0 \leq D \leq 1$ for strong electrolyte D=1 and for weak electrolyte D=0[21], (Fig.9) shows that adding PAAM to PVA solution made these solutions to be stronger electrolyte rather than PVA alone , according to PAAM ionic characteristics and figure also shows that these two curves obey Ostwald law of dilution for aqueous solutions, degree of dissociation of a weak electrolyte is proportional to the square root of dilution[22].

4. Conclusion:

- This study shows that intermolecular processes and the associated state of water in the solvent systems had a significant effect on the physical properties of PVA solutions such as rheological responses. Adding PAAM made enhancement to the shear Viscosity with concentration because the increasing in the size of the molecules.
- The results show that is new polymer after adding PAAM according to new values of viscosity, so new polymer can be used in industries that need high viscosity as a thicker materials use in painting and other.
- Adding PAAM lead to increase the conductivity of the blend so we can increasing its conductivity when increasing the addition of PAAM so it can be used in electrical circuits with in sensing range of electrical conductivity.
- The result of degree of dissociation indicates when adding PAAM the blend behaves as electrolyte.

5. References:

[1] Jayanta Chakraborty, Jayashri Sarkar, Ravi Kumar and Giridhar Madra “Ultrasonic Degradationof Polybutadiene and Isotactic Polypropylene”, Polymer Degradation and Stability, Elsevier, 85(1),555-558,(2004).
[2] Daughlon, Christian G. (23 June 1988). "Quantitation of Acrylamide (and Polyacrylamide): Critical review of methods for trace determination/formulation analysis & Future-research recommendations" (PDF). EPA Environmental Sciences Division homepage. The California Public Health Foundation. Retrieved 2010-06-30.
[3] Wisconsin Department of Transportation. Madison, WI. “Polyacrylamide as a Soil Stabilizer for Erosion Control." January 2001. Report No. WI 06-98.
[4] Song Ie Song, Byoung Chul Kim, “Characteristic rheological features of PVA solutions in water-containing solvents with different hydration states”, Polymer (45), 2381–2386, (2004).
[5] Bassler, H. Phil. Mag. B., 50: 347, (1984).
[6] Simmons, J.G., J. Phys. D, 4: 613 , (1971).
[7] G. Vijaya Kumar. and R. Chandramani, "Doping and Irradiation Dependence of Electrical Conductivity of Fe3+and Ni2+ Doped Polyvinyl Alcohol Films, ACTA PHYSICA POLONICA A, Vol. 117, No. 6**,** (2010).
[8] T. Yamaguchi, T. Matsuoka, and S. Koda,“Dynamic mechanism of equivalent conductivity minimum ofelectrolyte solution” J. Chem. Phys. (2011).
[9] Kaplan, 1998 Kaplan DL , Biopolymers from renewable resources New York: Springer (1998).
[10] Ehssan .D. Jawad ,”Gamma radiation effect in some physical properties of polymer zanthan cellulose “M.Sc. thesis, Baghdad university (2004).
[11] Abdul-Kareem Jawad Rashid ,Rawaa Mizher,Burak Yahya Kadem, "Study the rheological and mechanicalproperties of PVA/NH4Cl by ultrasonic” ,chemistry and material research ,iiste, Vol.1, No.1 , (2011).
[12]Abdul-Kareem.J.Rashid, Shaymaa .H.Nawfal ,“Enhancement Rheological and Electrical Properties of PolyvinylAlcohol by adding Methyl Cellulose”,Advances in Physics Theories and Applications,Vol.17 .(2013).
[13] Al-Bermany K. “a study of the physicals properties of some cellulose derivative polymers” Ph.D.thesis, Al-Mustansirya University, Iraq.(1995).
[14] Danial and Alberty,“physical chemistry” 3th Edition mc .Grew Hill,(2007).
[15] Subhi K. Hassun, Kadhim H. Hussain and Najiba A. Hassan, “Visco- Relaxation Studies ofPolystyrene Solutions in Different Solvents by Ultrasonic” , Acta Polymerica, 41(8),438-441.(1990) .

[16] Al-Bermany K.J. "Enhancement of mechanical properties using gamma radiation for HECpolymer" , Journal of college of Education ,Babylon university,1(5).10-15.(2010) .
[17] E.Foled, M.Iring and F.tudds"degradation of HDPE and LLDPE in closed mixing chamber",polymer Bulletin J.Vol20, no.1.(1988) .
[18] Barthel, J.M.G., Krienke, H., Kunz, W.: Physical Chemistry of Electrolyte Solutions. Springer,Darmstadt (1998).
[19] A.J. Bard and L.R. Faulkner, "Electrochemical Methods: Fundamentals and Applications,"Wiley, New York,(1980).
[20] Zhou, H.; Rivas, G.; Minton, A."Macromolecular crowding and confinement: biochemical,biophysical, and potential physiological consequences". Annual review of biophysics, (2008) .

[21] A.K.J. Al- Bermany, "Babylon Univ. Journal.", Vol. 8, No. 3, (2003).

[22] J. H. Ibrahim ," Effect of Gamma Radiation on Physical Properties of Styrene Butadiene Rubber", Journal ofBabylon University,Vol.17, No.1,(2009).

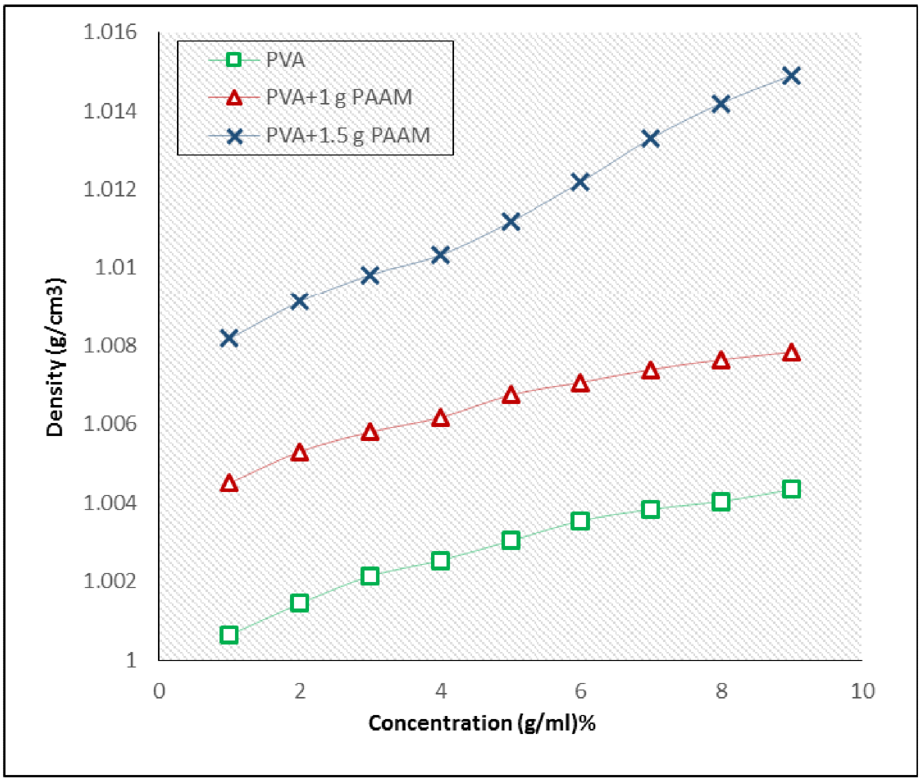

Figure (2) the density of samples due to their concentration before and after adding PAAM

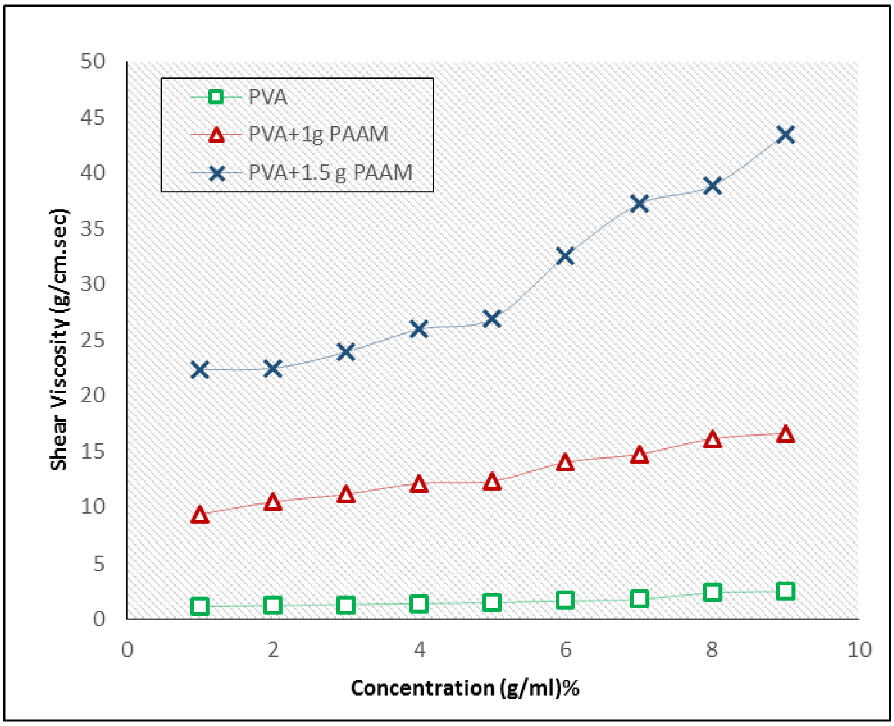

Figure (3) the shear viscosity of samples due to their concentration before and after adding PAAM

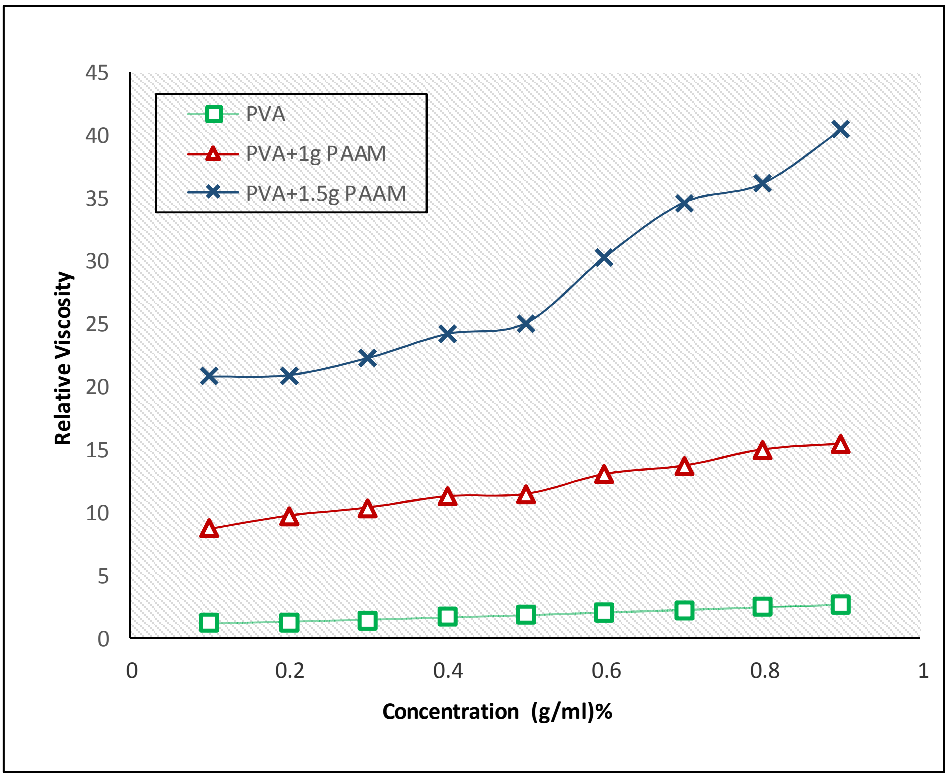

Figure (4) the relative viscosity of samples due to their concentration before and after adding PAAM

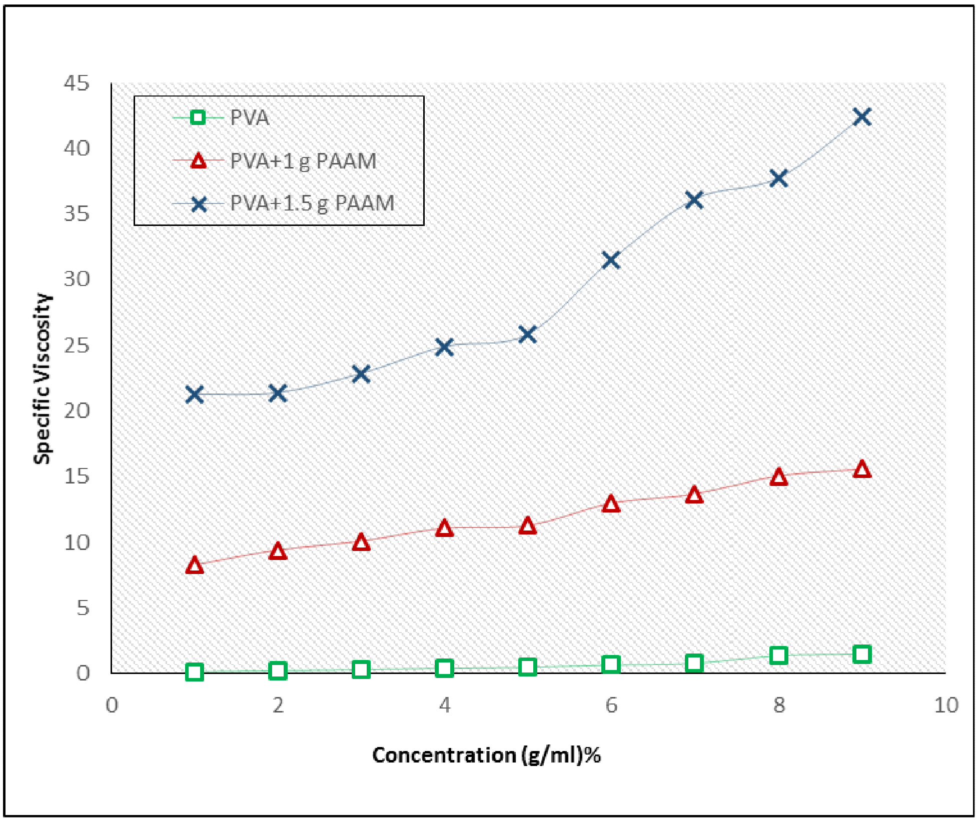

Figure (5) the specific viscosity of samples due to their concentration before and after adding PAAM

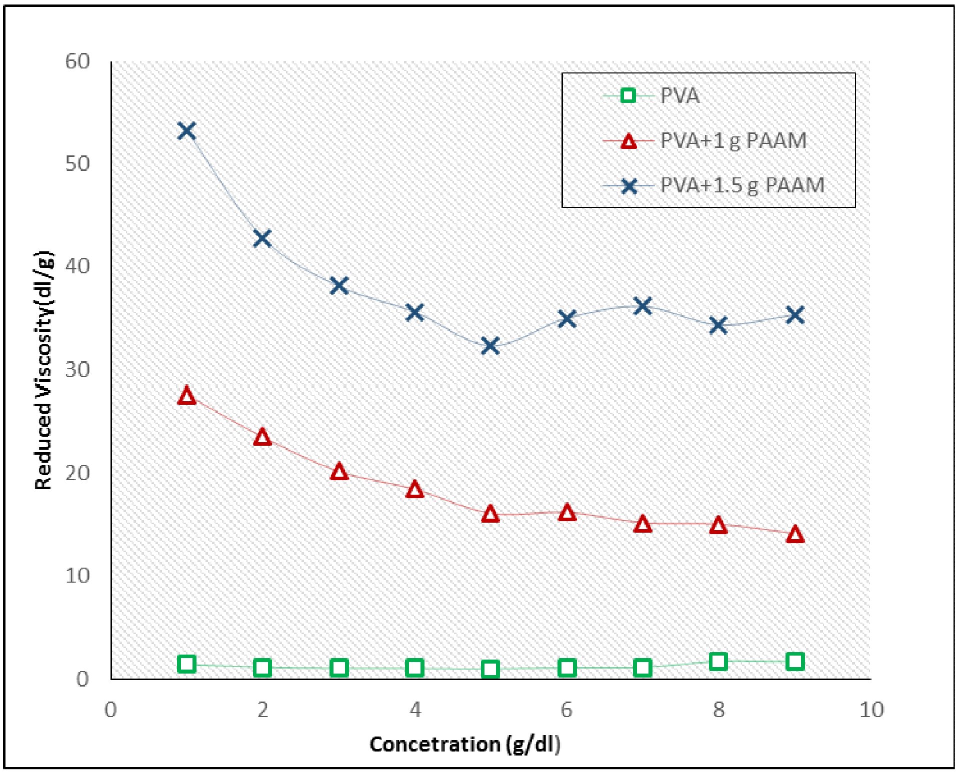

Fig. (6) the reduced viscosity of samples due to their concentration before and after adding PAAM

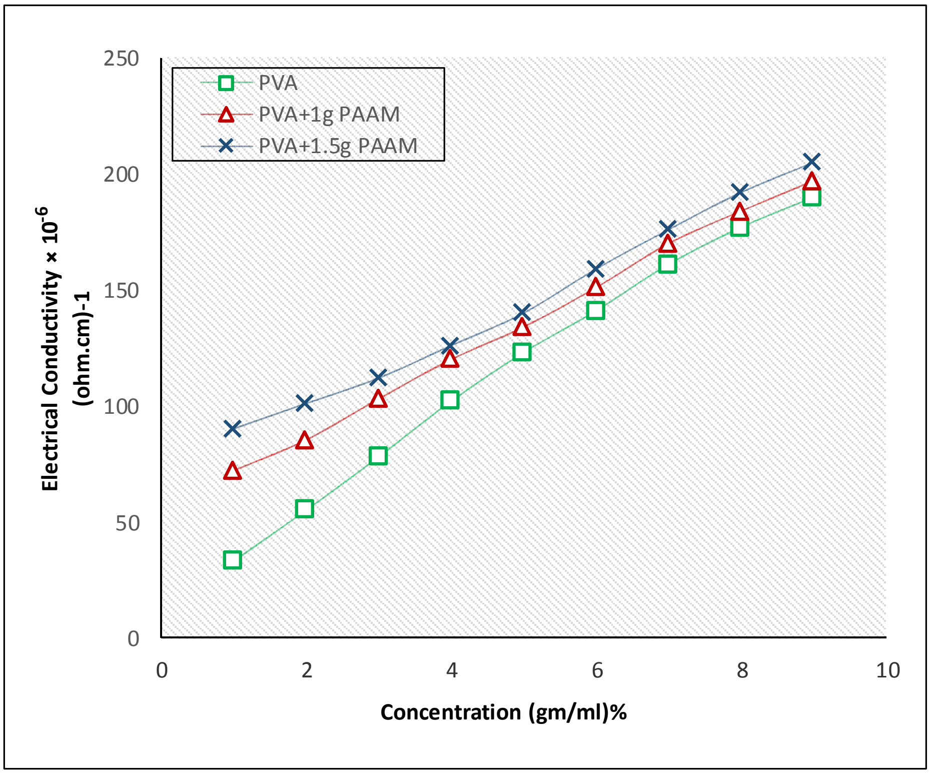

Figure (7) the Electrical conductivity of samples due to their concentration before and after adding PAAM

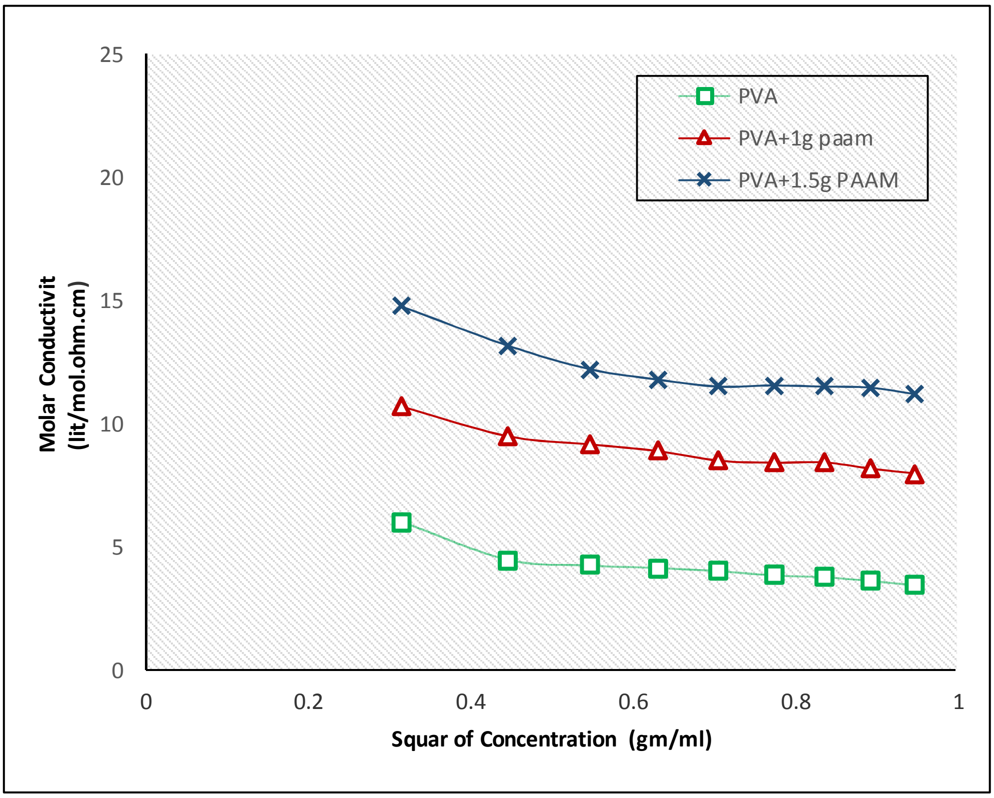

Figure (8) Molar conductivity of samples due to their concentration before and after adding PAAM

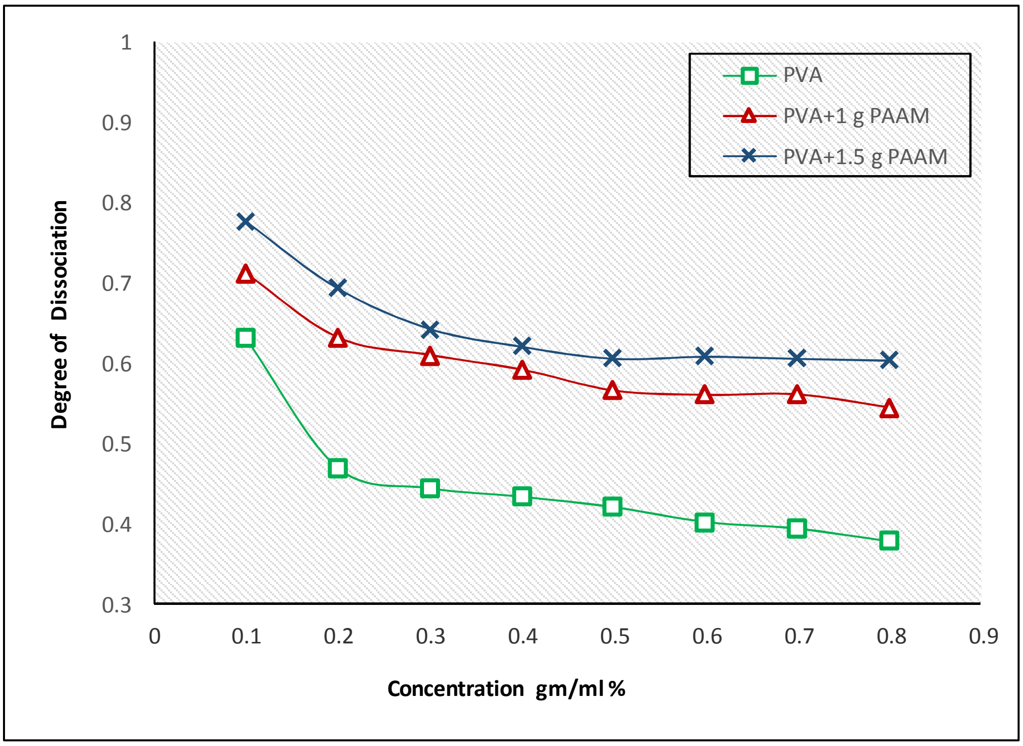

Figure (9) the degree dissociation of samples due to their concentration before and after adding PAAM