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Effect of Polyacrilamide on The Rheological and Electrical properties of Polyethylene glycol

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ABSTRACT

In this work, Some of physical properties of PEG dissolves in distilled water had been studied at different concentrations (0.6%,0.7%,0.8%,0.9%,1%,1.1%,1.2%, and 1.3%) gm./ml) before and after adding (0.25, 0.5, and 1) of PAAm. the Rheological properties such as shear, relative, reduced, specific, intrinsic viscosity and average molecular weight .the electrical properties such as electrical conductivity, molar conductivity and degree of dissociation, are measured; The results show that all these properties are increasing with the increase of the polymer concentration before and after adding PAAm, except molar conductivity and degree of dissociation are decreasing.

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INTRODUCTION

The polymer blend definition of polymeric mixtures as a combination of two or more polymers are polymeric mixtures preparation process mediated by blending polymers in the liquid state or in the solid state or in the molten phase [1]. The aim of the preparation of polymer blends is to get new recipes can not be found in the individual polymers as the preparation of polymeric composites depends largely on the ability blending polymers Polyacrilamide (Miscibility) [2], for example, are mixed polymer Polyethylene glycol with rates a few to get the flexibility of Poly Styrene fragile, as well as the goal of the polymeric mixtures preparation is to get the polymer material has a visual electrical and mechanical properties are good.

2. Experimental:

2.1 Preparation of Solutions:

The PEG solution was prepared by dissolving a known weights of PEG powder in affixed volume (500 ml) of distilled water under stirring at 70C for (30 min). The PEG concentrations were (0.6%, 0.7%, 0.8 %, 0.9%, 1%, 1.1%, 1.2% and 1.3%) g/ ml ; then PAAm was added with different weights (0.25,0.5 and 1 g.) to all PEG concentrations. The resulting solution was stirred continuously for (30 min) until the solution mixture became a homogeneous.

2.2 Density and viscosity measurements:

The density of the PEG solution (ρ) was determined by the density bottle method and the shear viscosity measured before and after adding methyl Poly acrilamide for all concentrations using the viscometer [3,4], elsewhere different types of viscosity were determined before and after adding PAAm by the equations (1, 2, 3 and 4) , The shear viscosity had been calculated by the following equation [5,6,3]:

$$\frac{\eta_{shear}}{\eta_o} = \frac{t \cdot \rho}{t_o \cdot \rho_o} \quad \dots (1)$$

Where (ρ) and (η) are density and shear viscosity of solute respectively, (ρ_o) and (η_o) are density and viscosity of distilled water respectively, (t) and (t_o) are the flow time for solution and distilled water respectively. Relative viscosity (η_{rel}) can be analyzed by the Jones-Dole equation [7]:

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$$\eta_{rel} = \left(\frac{\eta_{shear}}{\eta_o} \right) = 1 + \eta_{red} \quad \dots (2)$$

Where (c) is the concentration of solutions and (η_{red}) is the reduced viscosity [8]. The specific viscosity (η_{spe}) and the reduced viscosity (η_{rel}) was calculated by the equations:

$$\eta_{spe} = (\eta_{rel} - 1) = \eta_{red} \cdot c \quad \dots (3)$$

$$\eta_{red} = \frac{\eta_{spe}}{c} \quad \dots (4)$$

The intrinsic viscosity has been obtained practically its value represent the intersection to y-axis as (C) goes to zero of graph between reduced viscosity and concentration, which represented the piratical value of intrinsic viscosity before and after adding PAAm. The intercept values of these curves are shown in table (1).

The intrinsic viscosity can be calculated by using Philipp off equation as follow [4] :

$$\ln \eta_{rel} = [\eta] C \quad \dots (5) \quad \text{Philipp off Equation}$$

Viscosity Average Molecular weight had been calculated by the following equation [5]:

$$\ln \eta_{rel} = [\eta] C \quad \dots (6) \quad \text{Arrhenius Equation}$$

The relation between $[\eta]$ and relative viscosity was determined by Arrhenius, so its called Arrhenius equation as follows [5]:

$$[\eta] = MK_v^a \quad \dots (7)$$

The Effective molecule radius is found from the eqn. :

$$r = \sqrt[3]{\text{slope}/6.3 \times 10^{24}} \quad \dots (8)$$

3.2 Electrical measurements:

The conductivity was measured using conductivity meter. The molar conductivity (Λ_m) is defined as the conductivity of an electrolyte solution divided by the molar concentration of the electrolyte, and so measures the efficiency with which a given electrolyte conducts electricity in solution, it calculated by [9,13]:

$$\Lambda_m = \frac{\sigma}{C_m} \quad \dots (9)$$

Where σ is the conductivity and (C_m) is the molar concentration.

The degree of dissociation (D) is calculated by the following equation [11]:

$$D = \Lambda_m / \Lambda_o \quad \dots (10)$$

Where Λ_o is the extrapolation of molar conductivity to infinite dilution the limiting value of the molar conductivity.

RESULTS AND DISCUSSION

3.1. Rheological properties:

The densities of the solutions increased with increasing the ionic liquid concentration and there is a good linear correlation between density and concentration of solutions as shown in figure (1). The shear viscosity of the liquids as shown in figure (2) increasing with concentration this attributed to the mechanism that hydrogen bonding of water attached to oxygen sites, this leads to solvation sheaths and increase in the size of the molecules so its viscosity[12,13] Relative viscosity, specific viscosity and reduced viscosity as show in figure (3,4,5) relative, specific, reduced, and intrinsic viscosities respectively were derived from shear viscosity and their theoretical equations consist of one variable, parameter which is the shear viscosity, so all these viscosities in general have the same behavior of increasing shear viscosity with the increase of concentration, therefore the reasons explained shear viscosity behavior corresponding to other viscosities[14,9], the theoretical intrinsic

viscosities were calculated by using Philipp off equation and Arrhenius equation [4]. The comparison between our experimental values and the theoretical values obtained by these two equations are shown in table (1).

The results show a good agreement between experimental and theoretical intrinsic viscosity values with acceptable experimental errors. The exponential behavior of viscosity with concentration was attributed to the structural change associated with liquid polymer solution and probably indicating entanglement interaction [7]. viscosity average molecular weights before and after adding PAAm were calculated by using equation (7). The values of $[\eta]$ were taken experimentally from table (1) and constants K and a depending on the polymer type. The calculated values of the viscosity-average molecular are shown in table (2). The comparison between the theoretical values of viscosity average molecular weights obtained by Philipp off and Arrhenius equations and experimental values obtained by using intrinsic viscosity.

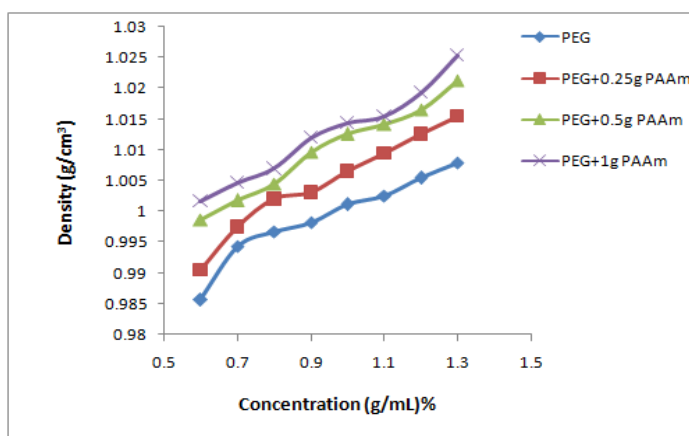


Fig. 1: Density versus concentration for polymeric solution.

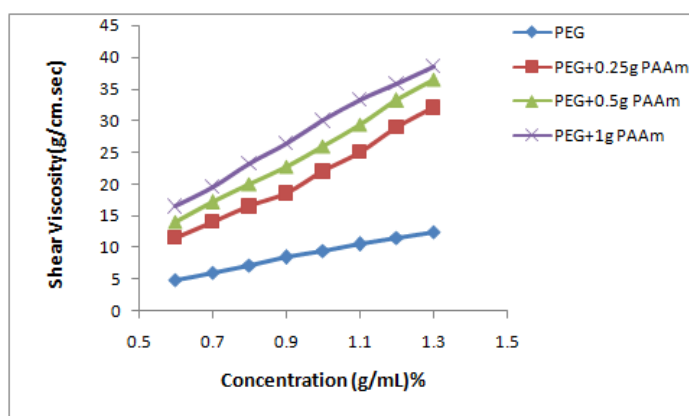


Fig. 2: Shear viscosity versus concentration for polymeric solution

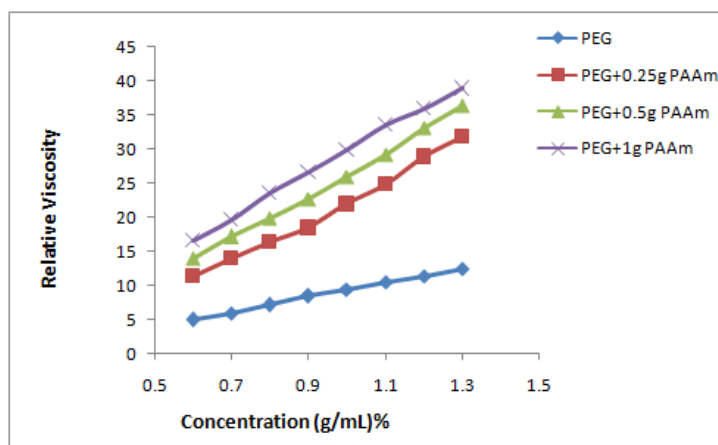


Fig. 3: Relative viscosity versus concentration for polymeric solution.

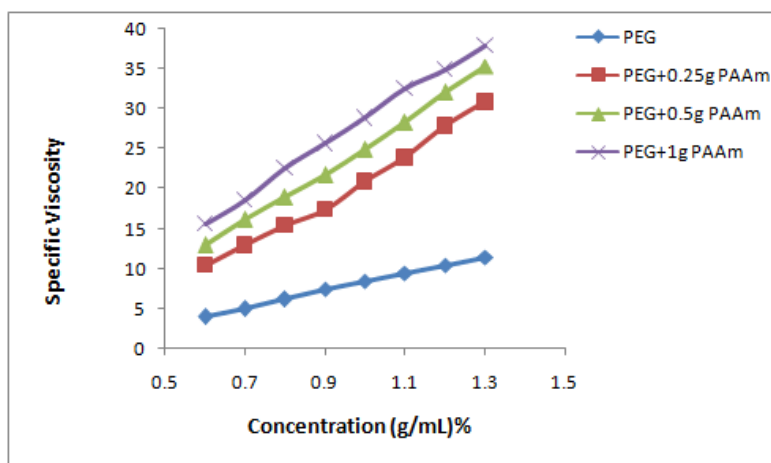


Fig. 4: Specific viscosity versus concentration for polymeric solution.

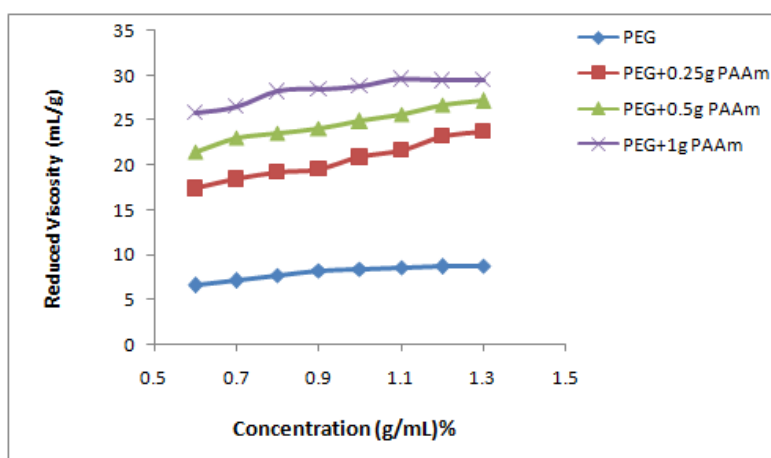


Fig. 5: Reduce viscosity versus concentration for polymeric solution.

Table 1: shows comparison between the theoretical and experimental values of Intrinsic Viscosity.

polymer	Intrinsic Viscosity [η] (mL/g)		
	Theory		Exp.
	Arrhe.	Philip.	
PEG	3.5	3.5	3.8
PEG+0.25g PAAm	9.8	9.8	10
PEG+0.5g PAAm	12	12	12.5
PEG+1g PAAm	18	18	18.5

Table 2: shows comparison between the theoretical and experimental values of Viscosity Average Molecular weight (Mv).

polymer	Viscosity average Molecular weight (Mv)		
	Theory		Exp.
	Arrhe.	Philip.	
PEG	2942.952581	2942.952581	3127.91659
PEG+0.25g PAAm	66849.67446	66849.67446	67938.8883
PEG+0.5g PAAm	128757.6123	128757.6123	132923.8839
PEG+1g PAAm	450324.1762	450324.1762	460303.8866

Table 3: shows values of effective radius before and after Adding PAAm.

Polymer	Effective radius (r) (cm)
PEG	0.812×10^{-8}
PEG + 0.25 g PAAm	1.134×10^{-8}
PEG + 0.50 g PAAm	1.168×10^{-8}
PEG + 1.00 g PAAm	1.171×10^{-8}

3.2. Electrical properties:

The measured conductivity of all polymer solutions for different concentrations were in figure (6), this shows that PAAm enhances the PEG conductivity by giving them values of conductivity so PAAm made PEG 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 PEG and water molecules then there will be ionic conduction which make conductivity increase [10].

The molar conductivity of all samples was shown in figure (7) 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 [11] 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 [10]. 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 [7, 11, 15], Ostwald of dilution indicates that complete dissociation when the dilution approach infinite therefore the dilute solution may be represented as strong electrolyte [16,17] the value of degree of dissociation has the range $0 \leq D \leq 1$ for strong electrolyte $D=1$ and for weak electrolyte $D=0$, figure (8) shows that adding PAAm to PEG solution made these solutions to be stronger electrolyte rather than PEG 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. [18, 19]

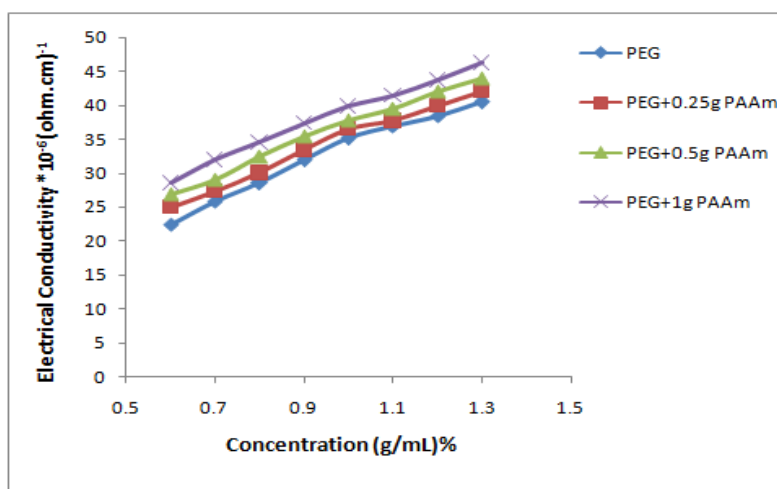


Fig. 6: Electrical conductivity versus concentration before and after adding PAAm.

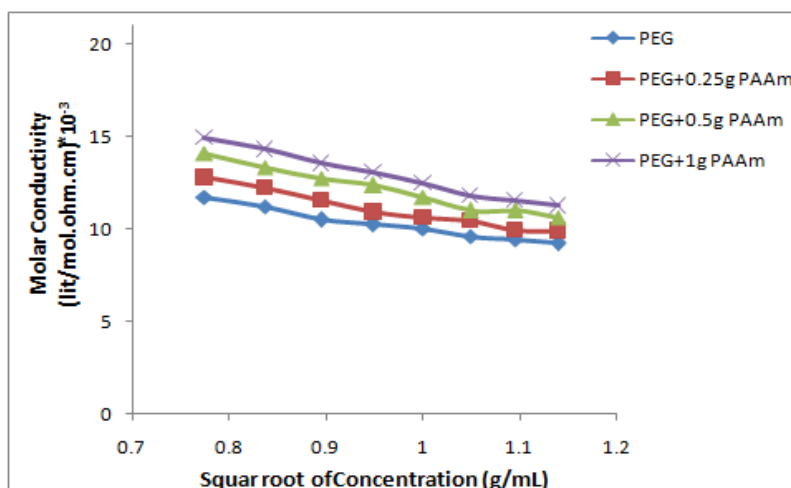


Fig. 7: Molar conductivity versus concentration before and after adding PAAm.

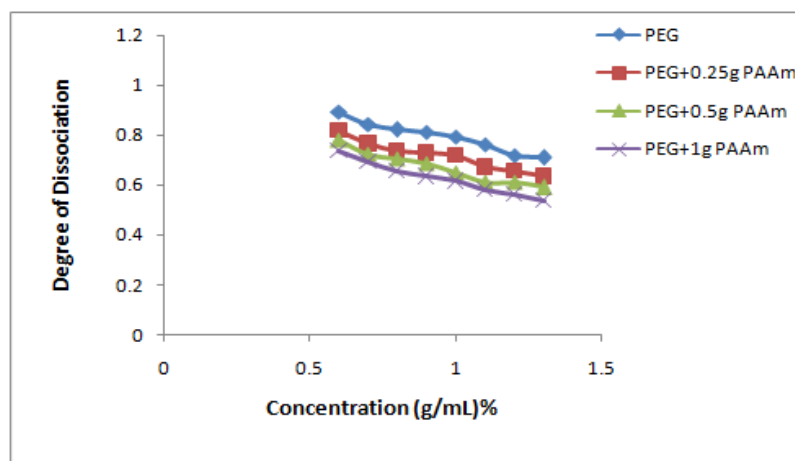


Figure 8: the degree of Dissociation (D) versus concentration before and after adding PAAm.

Table 4: shows values of Molar Conductivity before and after adding PAAm

Polymer	(Λ_o) (lit/mol.ohm.cm) $\times 10^{-3}$
PEG	14
PEG + 0.25 g PAAm	16
PEG + 0.50 g PAAm	18
PEG + 1.00 g PAAm	20

Conclusions:

1. There is a good linear correlation between density and the concentration of solutions.
2. Increasing concentration leads to increasing viscosity because of the mechanism that hydrogen bonding of water attached to oxygen sites, this leads to solvation sheaths and increase in the size of the molecules.
3. Effective radius and Average Molecular weight increasing with the increase of the polymer concentration before and after adding PAAm.
4. 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.
5. degree of dissociation indicates when adding PAAm the blend behaves as electrolytes

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