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Enhancement Rheological and Electrical Properties of Polyvinyl Alcohol by adding Methyl Cellulose

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Abstract:

In this study the effect of methyl cellulose on the properties of aqueous solutions including density, viscosity and electrical conductivity have been investigated at (293K.), different type of viscosity and electrical properties were measured for polyvinyl alcohol dissolved in distilled water of different concentrations (0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6%, 0.7% and 0.8%)gm./ml before and after adding (1and 2) gm. of methyl cellulose for all concentrations. The shear viscosity, relative viscosity, specific viscosity, reduced viscosity, intrinsic viscosity and Viscosity Average Molecular weight are measured, all the viscosities depend on density and concentration, The results show that all these properties are increasing with the increase of the polymer concentration before and after adding MC , Results also shows that adding MC polymer to PVA enhances the conductivity, the conductivity measured at room temperature (293 K.), then the molar conductivity and degree of dissociation were calculated and it depending on the values of density, concentration and type of solute_ solvent .

Keywords: Polyvinyl Alcohol solution, Methyl cellulose solution, Rheological properties, Electrical properties.

1. Introduction

In this study polyvinyl alcohol (PVA) and methyl cellulose were prepared, for such materials, it has been shown that the properties of the final material are strongly dependent on the dispersion of any filler within the host polymer, such dispersion is determined by both the fundamental chemical interactions that occur within the system and by imposed processing conditions [1]. 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 [2]. 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), 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 [3]. 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, 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), [4]. major applications Paper and textile sizing, oxygen resistant films, adhesives, emulsifier, colloid stabilizers, base/coatings for photographic films, food wrappings, desalination membranes, electroluminescent devices, and cement coatings[5]. MC is non ionic linear polysaccharide derived from cellulose[3]. it is an important industrial polymer with a wide range of applications in flocculations, drug reduction, detergents, textiles, papers, foods, roiling oil and drugs [4]. MC is water – soluble synthetic polymers. MC is used primarily because it has high viscosity, it is non-toxic, and is non-allergenic[6] . MC has a wide range of applications due to its low cost[7] Because of its polymeric structure and high molecular Wight; it can be used as filler in bio- composite films. MC commonly use for increasing production of oil from its original traps in oil drilling[8] . solvent effects might therefore be expected to influence the ultrasonic relation behavior, the absorption of ultrasonic in liquid polymer systems is governed by local modes of motion and cooperative whole molecule movement because of the strong intermolecular interaction within the polymer it should be possible to observe cooperative motion in the ultrasonic range. Polyvinyl alcohol has high tensile strength and flexibility, as well as high oxygen and aroma barrier properties. However these properties are dependent on humidity, in other words, with higher humidity more water is absorbed, the water which acts as a plasticizer, will then reduce its tensile strength, but increase its elongation and tear strength.

2. Experimental:

2.1 Preparation of Solutions:

PVA (Gerhard Buchman –Germany) with assay (99.8%) and MC product by (Messina) with assay (99.8%) of high viscosity[9] .The PVA solution was prepared by dissolving a known weights of PVA powder in affixed volume (500 ml) of distilled water under stirring at 70oC for (30 min). The PVA concentrations were (0.1%, 0.2%, 0.3 %, 0.4%, 0.5%, 0.6%, 0.7% and 0.8%) gm./ ml ; then MC was added with different weights (1 and 2 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 viscosity measurements:

The density of the PVA solution (ρ) was determined by the density bottle method and the shear viscosity measured before and after adding methyl cellulose for all concentrations using Ostwald viscometer with accuracy of ± 1.05% [10,11], elsewhere different types of viscosity were determined before and after the adding methyl cellulose by the equations (1, 2, 3 and 4) [8-11], The shear viscosity had been calculated by the following equation [7,8,10]:

$$\eta_{shear} / \eta_o = (t\,\rho) / (t_o\,\rho_o) \;\ldots\ldots\; (1)$$

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 ($\eta_{rel.}$) can be analyzed by the Jones-Dole equation [12]:

$$\eta_{rel.} = (\eta_{shear} / \eta_o) = 1 + \eta_{red.} \;\ldots\ldots.(2)$$

Where (c) is the concentration of solutions and($\eta_{red.}$) is the reduced viscosity [13].. The specific viscosity (η_{sp}) and the reduced viscosity($\eta_{red.}$) was calculated by the equations:

$$\eta_{spe.} = (\eta_{rel.} - 1) = \eta_{red.}\, c \;\ldots\ldots\ldots..\; (3)$$

$$\eta_{red.} = \eta_{spe.} / c \qquad \ldots\ldots\ldots\ldots.\; (4)$$

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 MC. The intercept values of these curves are shown in table (1).

The intrinsic viscosity can be calculated by using philippoff equation as follow [11] :

$$\eta_{rel} = \left[1 + [\eta]\frac{C}{8}\right]^{8} \quad \ldots\ldots.\ (5) \quad \text{Philipp off Equation}$$

The relation between [ɳ] and relative viscosity was determined by Arrhenius, so its called Arrhenius equation as follows [11]

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

Viscosity Average Molecular weight had been calculated by the following equation [10]:

$$[\eta] = KM_v^a \quad ...... (7)$$

3.2 Electrical measurements:

The conductivity was measured using (DDS – 307 microprocessor conductivity meter -England) [14], the calibration was made and the correction factor taken account in measuring the samples, all conductivities values obtained for PVA and after adding (MC), the figure shows conductivity meter.

4.2 Theoretical calculation:

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 [15, 16]:

$$\Lambda_m = \sigma/c...... (8)$$

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

The degree of dissociation (D) is calculated by the following equation [17]:

$$D=\Lambda_m/\Lambda_o ... (9)$$

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

3.Results and Discussion:

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 [6, 18]. The properties of the MC and PVA molecules in the hydration co-sphere depend on the nature of solute species, the interactions between molecules and solvent can be classified into three types of interactions [12, 14]:

The nature of interactions occurring between water molecules are define by the solvent–solvent interactions and this provides information regarding solute–solvent interactions between PVA molecules and ions of the MC with water molecules. They stated that the primary solvation consists of PVA molecules which hydrogen bond to the hydroxyl groups [18].

Relative viscosity, specific viscosity and reduced viscosity as show in figure (3), figure (4) and figure (5) Relative, specific, reduced, and intrinsic viscosities 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[14,15], the theoretical intrinsic viscosities were calculated by using philippoff equation and arrhenius equation [11]. 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[12].

Intrinsic Viscosity $[\eta]$ (dl/gm.)			
Polymer	Theoretical		Experimental
	Arrhe.Equ.	Philip.Equ.	
PVA	0.17	0.188	0.18
PVA+1gm MC	5.7	6	5.9
PVA+2gm MC	6.8	7.2	7

Table(1) shows comparison between the theoretical and experimental values of Intrinsic Viscosity

Viscosity Average Molecular weights before and after adding MC 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 and shown in the following table (2).

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 philippoff and arrhenius equations and experimental values obtained by using intrinsic viscosity.

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

Viscosity Average Molecular weight (M_v)					
Polymer	a	K	Theoretical		Experimental
			Arrhe.	Philip.	
PVA	0.5	3×10^{-4}	321111.1111	392711.1111	360000
PVA+1gm MC	0.8	1.57×10^{-4}	501151.4648	534336.0768	523227.3642
PVA+2gm MC	0.8	1.51×10^{-4}	656016.793	692391.5384	680223.0838

2.3 Electrical properties:

The measured conductivity of all polymer solutions for different concentrations were plotted in figure (6), this shows that MC enhances the PVA conductivity by giving them values of conductivity so MC made PVA polymer semi-conductive, this attributed to the fact that MC 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 increase [16]. 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 [17] 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 [16]. 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 [12, 17, 19], Ostwald of dilution indicates that complete dissociation when the dilution approach infinite therefore the dilute solution may be represented as strong electrolyte [20,21] the value of degree of dissociation has the range $0\leq D\leq1$ for strong electrolyte D=1 and for weak electrolyte D=0 , figure (8) shows that adding MC to PVA solution made these solutions to be stronger electrolyte rather than PVA alone , according to MC 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, 23]

4.Conclusion:

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 salvation sheaths and increase in the size of the molecules so its viscosity so it can be used as thicker colloid blend in coating process.
3. adding MC lead to increase the conductivity of the blend so we can increasing its conductivity when increasing the addition of MC so it can be used in electrical circuits with in sensing range of electrical conductivity.
4. the result of degree of dissociation indicates when adding MC the blend behaves as electrolytes.

5.References:

1. Martin Reading*, Alun S. Vaughan 2009 “Rheological, thermal and electrical properties of poly(ethylene oxide) / boehmite nanocomposites” Annual Report Conference on Electrical Insulation and Dielectric Phenomena, University of Southampton, USA, IEEE.
2. G. Vijaya Kumar¤ and R. Chandramani, Doping and Irradiation Dependence of Electrical Conductivity of Fe^{3+} and Ni^{2+} Doped Polyvinyl Alcohol Films, ACTA PHYSICA POLONICA A, Vol. 117, No. 6,(2010).
3. Song Ie Song, Byoung Chul Kim 2004, Characteristic rheological features of PVA solutions in water-containing solvents with different hydration states, Polymer (45) Elsevier .
4. T. Yamaguchi, T. Matsuoka, and S. Koda 2011 “Dynamic mechanism of equivalent conductivity minimum of electrolyte solution” J. Chem. Phys.
5. Matt Petrowsky and Roger Frech 2008 “Concentration Dependence of Ionic Transport in Dilute Organic Electrolyte Solutions” J. Phys. Chem. B, 112 (28) .
6. M. Delsignore, H. Farber, S. Petrucci 1985 “Ionic conductivity and microwave dielectric relaxation of lithium hexafluoroarsenate (LiAsF6) and lithium perchlorate (LiClO4) in dimethyl carbonate” J. Phys. Chem., 89 (23) .
7. Abdul-Kareem Al-Bermany, Burak Yahya Kadem, Rawaa Mizher Obiad, Lamis F. Nasser, Study of some mechanical and rheological properties of PVA/FeCl3 by ultrasonic, International journal of Advanced Scientific and Technical Research Issue 1, Vol. 2, (2011).
8. Abdul-Kareem Al-Bermany, Rawaa Mizher Obiad, Burak Yahya Kadem, Study the Rheological and Mechanical Properties of PVA/NH4Cl by Ultrasonic, Chemistry and Materials Research, IISTE, Vol. 1, No.1, (2011)
9. Messina incorporated “product data”, Travis suite 520 Data, Texas. p. 22,1998.
10. Illiger S R, Rao K.P. and Demappa, T.(2008), Miscibility Studies of HPMC/PVA Blends in Water by Viscosity, Density, Refractive Index and Ultrasonic Velocity Method, *Carbohydrate Polymer* .
11. Najim, K., Hassan, S.(2005), Visco- Relaxation Studieds of Polystyrene Solutions in Different Solvents by Ultrasonic ,*British polymer J.*, Vol.66,192.
12. Hemayat Shekaari · Amir Kazempour, 2011, Solution Properties of Ternary D-Glucose +1-Ethyl-3-methylimidazolium Ethyl Sulfate+Water Solutions at 298.15 K, J Solution Chem (2011) .
13. Seuver, A.M., Mathlouthi, M.: Solution properties and solute-solvent interactions in ternary sugar–salt–water solutions. Food Chem ,(2010).
14. Zhuo, K., Liu, H., Tang, J., Chen, Y., Wang, J.: Interactions of sodium halides with sugars in water: a study of viscosity and 1H spin-lattice relaxation time. J. Phys. Chem. B 113, (2009).
15. The best test preparation for the GRE Graduate Record Examination Chemistry Test. Published by the Research and Education Association, 2000, ISBN 0-8789-600-8. p. 149.
16. Al-Bermany K. (1995) “a study of the physicals properties of some cellulose derivative polymers” Ph.D. thesis, Al-Mustansirya University, Iraq.

17. Barthel, J.M.G., Krienke, H., Kunz, W.: Physical Chemistry of Electrolyte Solutions. Springer, Darmstadt (1998).

18. Youngs, T.G.A., Hardacre, C., Holbrey, J.D.: Glucose solvation by the ionic liquid 1,3- dimethylimidazolium chloride: a simulation study. J. Phys. Chem. B 111, (2007).

19. A.J. Bard and L.R. Faulkner, "Electrochemical Methods: Fundamentals and Applications,"Wiley, New York, 1980.

20. Alberty R.A.(1983) "Physical chemistry" John W. and Sons Inc.

21. Zhou, H.; Rivas, G.; Minton, A. (2008). "Macromolecular crowding and confinement: biochemical, biophysical, and potential physiological consequences". Annual review of biophysics .

22. Minton, A. P. (2001). "The influence of macromolecular crowding and macromolecular confinement on biochemical reactions in physiological media". The Journal of biological chemistry 276 (14) .

23. J. H. Ibrahim ," Effect of Gamma Radiation on Physical Properties of Styrene Butadiene Rubber", Journal of Babylon University,Vol.17, No.1,2009.

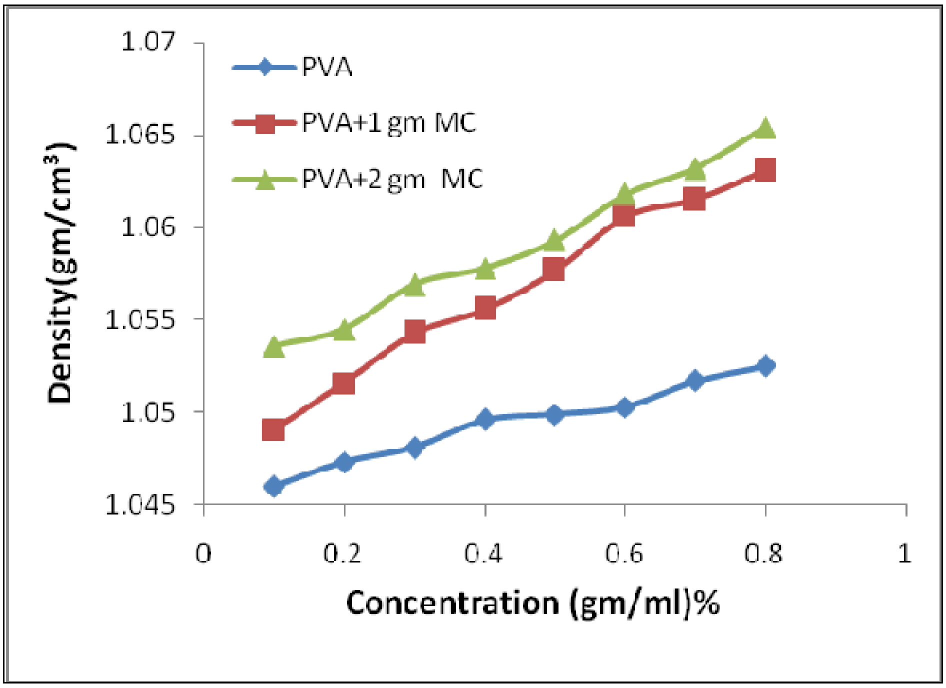

Fig. (1) The density of samples due to their concentration before and after adding MC

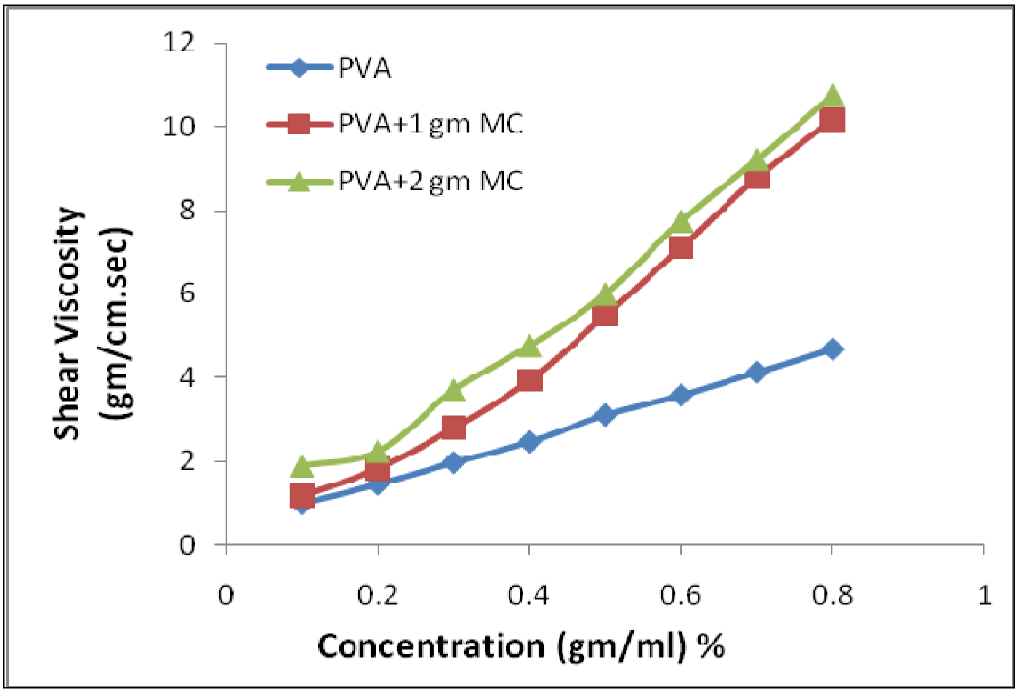

Fig. (2) The shear viscosity of samples due to their concentration before and after adding MC

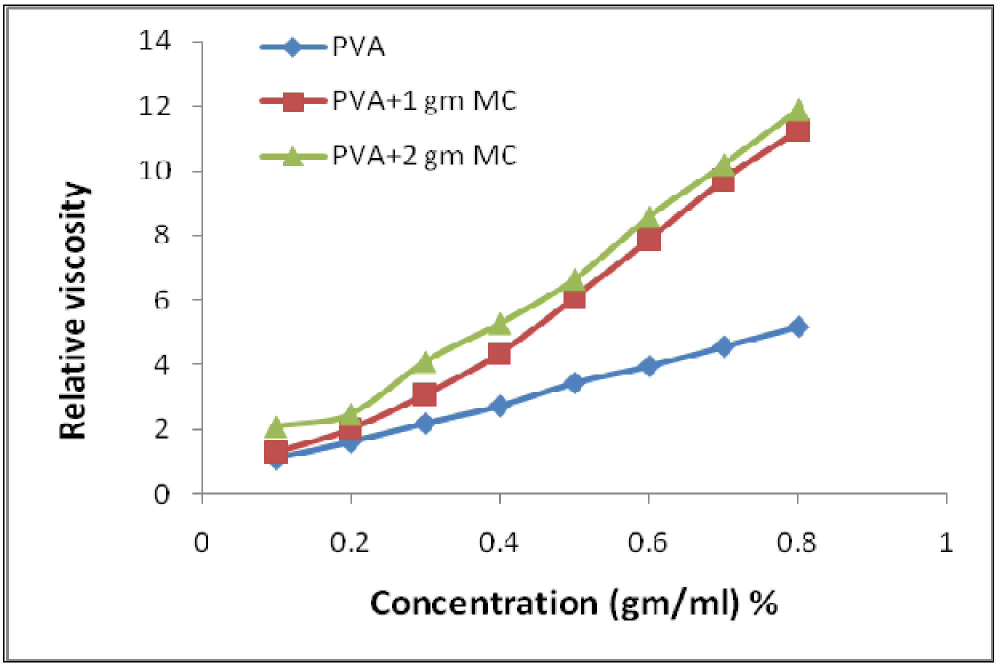

Fig. (3) The relative viscosity of samples due to their concentration before and after adding MC

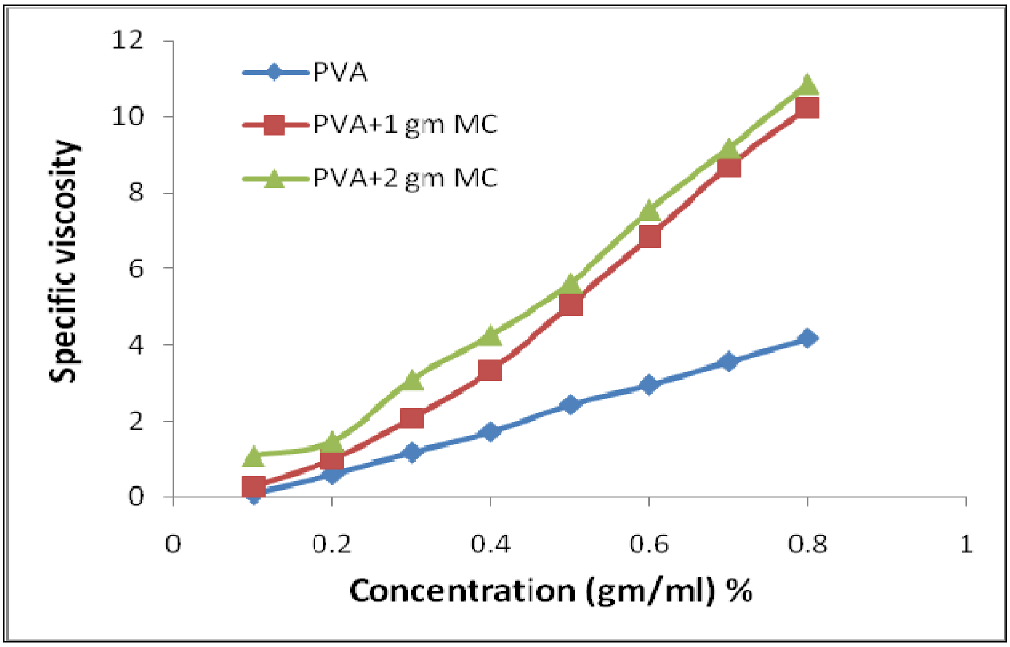

Fig. (4) The specific viscosity of samples due to their concentration before and after adding MC

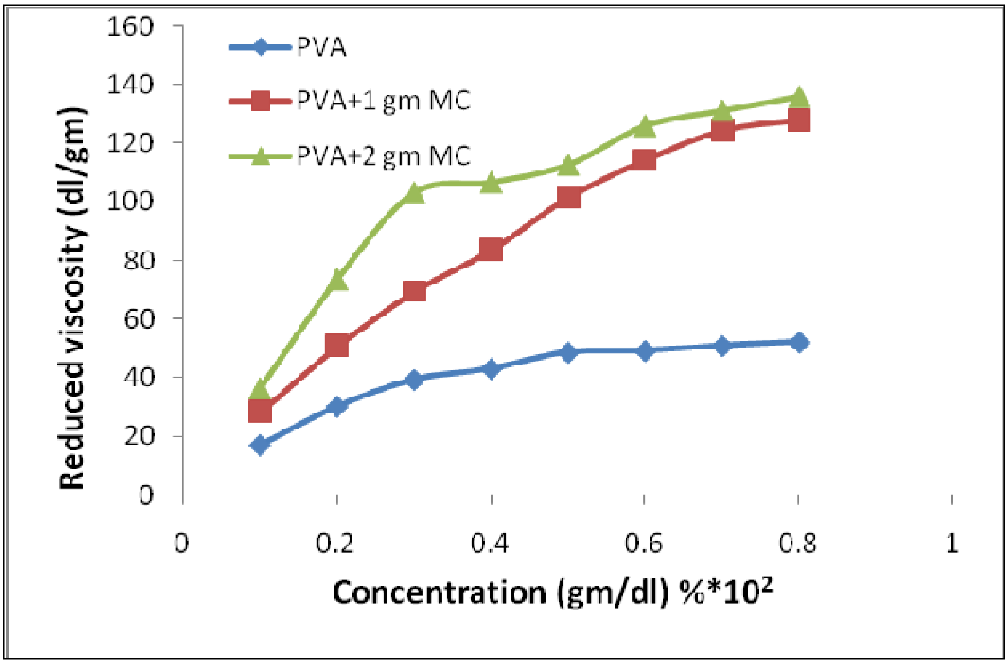

Fig. (5) The reduced viscosity of samples due to their concentration before and after adding MC

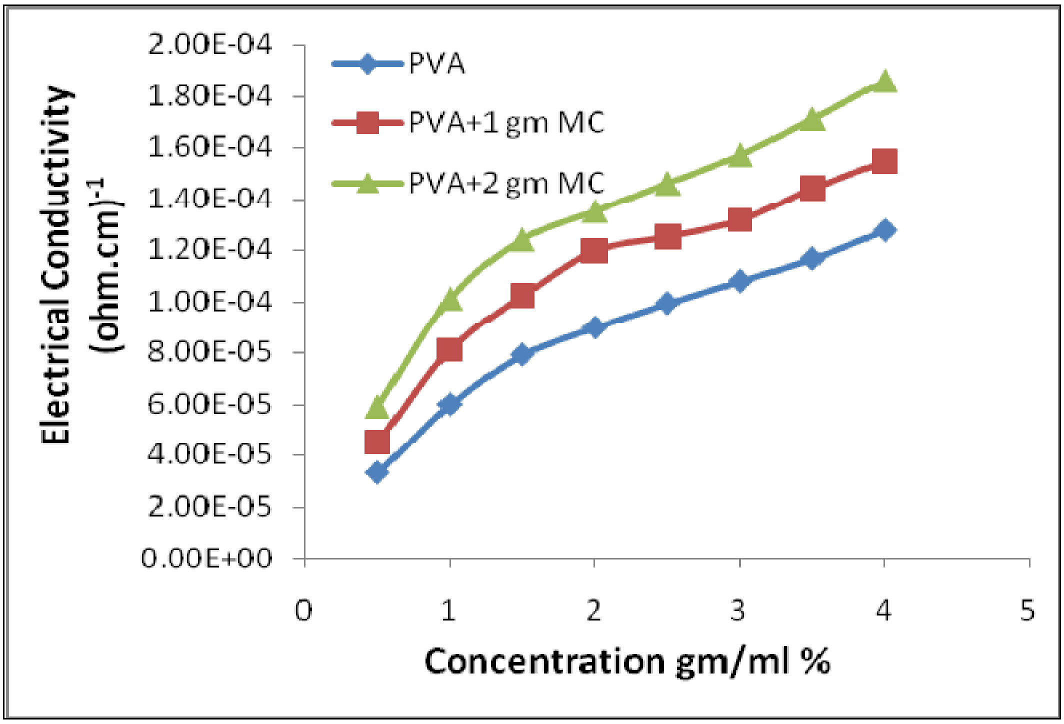

Fig. (6) The Electrical conductivity of samples due to their concentration before and after adding MC

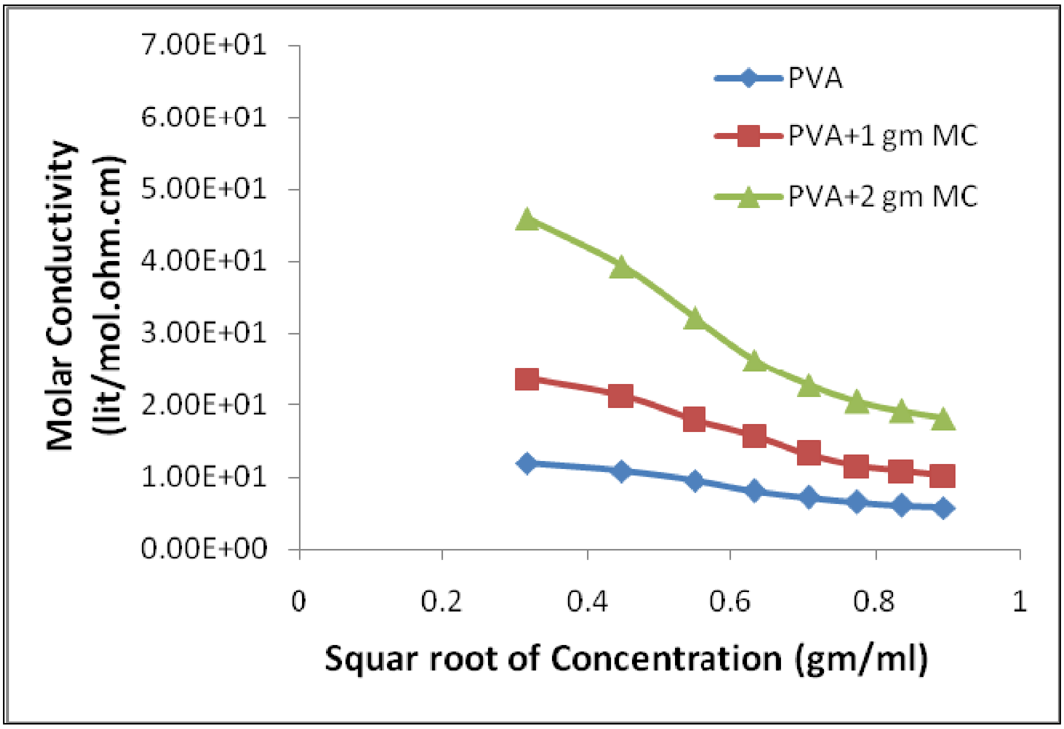

Fig. (7) Molar conductivity of samples due to their concentration before and after adding MC

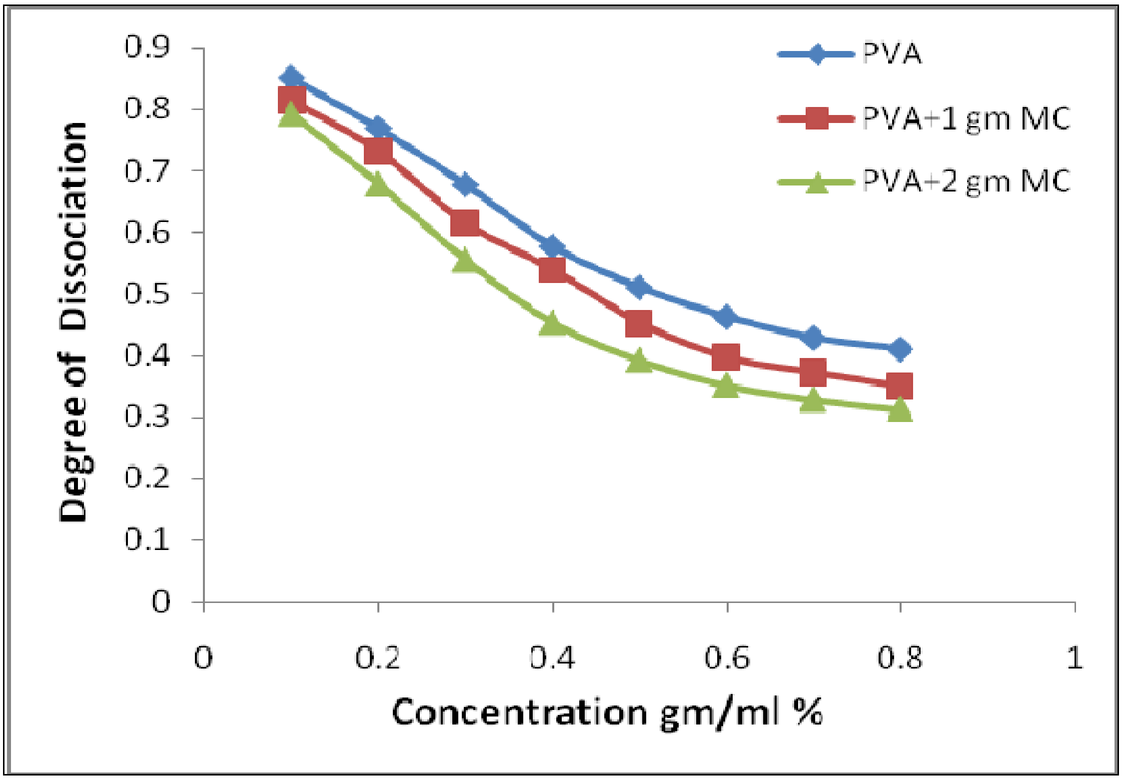

Fig. (8) the degree(D) of samples due to their concentration before and after adding MC

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