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Effect of adding magnesium oxide on the rheological properties of xanthomonaspolymer

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ABSTRACT

In this study the effect of Magnesium oxide (MgO)on the rheological properties of xanthan cellulose gum (Xn) including different type of viscosity have been studied at room temperature, different type of viscosity were calculated forxanthan cellulose gum dissolved in distilled water of different concentrations (0.1, 0.2,…,0.5)% g/mL before and after adding (0.25and 0.5)gMgO for all concentrations. The shear viscosity, relative viscosity, specific viscosity, reduced viscosity, intrinsic viscosity, viscosity average molecular weightand effective molecular radius are calculated. All these viscosities depend on density and concentration. The results show that all these viscosities are increasing with the increase of the polymer concentration before and after adding MgO.

KEYWORDS

Xanthan cellulose gum solution;
Magnesium oxide;
Rheological properties.

INTRODUCTION

Xanthan gum, is one of the most important microbial polysaccharides producedby Xanthomonas campestrisand by other Xanthomonasspecies. This naturalpolysaccharide is an industrial biopolymer of great commercial significance. Due to rheologicalproperties of xanthan solutions, like high viscosity at low concentrations, pseudoplasticityand stability over a wide range of temperatures, pH values and electrolyte concentrations,this polymer is used in food, cosmetics, pharmaceuticals, paper, paint, textilesand adhesives, as well as in the oil and gas industry[1]. The xanthan functionality is a direct consequence of its unique chemical structure. Xanthan is a heteropolysaccharide with a very high molecular weight, consisting of Dglucosyl,D-mannosyl and D-glucuronyl acid residues in a molar ratio of approximately2:2:1 and variable proportions of O-acetyl and pyruvyl residues. The variations in thecultivation media compositions and environmental conditions, as well as in the Xanthomonasstrains used for the production are the factors that can influence the structure andmolecular weight of this biopolymer[2].

Magnesium oxideMgO is semiconductor represents an important class of functional metal oxides with a broad range of properties. They also find tremendous application in catalysis, refractory industries, electronics, cosmetics and wastewater remediation[3]. MgO performs excellently in high temperature, particularly in the creation of electrical insulation. Other properties of MgO include effective corrosion resistance and that it

is transparent to (IR) light. It has a high thermal and low electrical conductivity[4]. The MgO is very suitable material for insulation application due to their low heat capacity and high melting point. MgO is soluble in water and ammonia, but it is insoluble in alcohols. MgO can be appeared in white to grey powder[5].

THEORETICAL PART

The density (ρ) and the shear viscosity of the xanthan cellulose gum solution before and after adding MgO for all concentrations have been measured by the volume method and viscometer respectively, furthermore ether types of viscosities were theoretically determined by the equations (1, 2, 3, and 4).

Relative viscosity (η rel.) is the ratio of the viscosity of the polymer solution to the viscosity of the pure solvent at the same temperature or the ratio of the two efflux times and is given by the Jones-Dole equation[6]:

$$\eta \text{ rel.} = (\eta_s / \eta_o) \quad (1)$$

Where η_s is shear viscosity, η_o is the viscosity of distilled water.

The specific viscosity (ηsp.) and the reduced viscosity(η red.) were calculated by the equations[7]:

$$\eta \text{ sp.} = (\eta \text{ rel.} - 1) \quad (2)$$

$$\eta \text{ red.} = \eta sp. / c \quad (3)$$

Where (c) is the concentration of solutions. The intrinsic viscosities have been obtained by the intersection to y-axis as(c) goes to infinity dilution of graph between reduced viscosity and concentration, which represented the practical value of intrinsic viscosity before and after adding MgO. The intercept values of these curves are shown in TABLE (1). The intrinsic viscosity can be theoretically calculated by using Philippoff equation as follows:

$$\eta rel. = [1 + [\eta]]^8 \text{ Philippoff equation} \quad (4)$$

The relation between intrinsic viscosity [s] and relative viscosity was determined by Arrhenius equation as follows[8]:

$$\ln \eta rel. = [\eta] C \text{ Arrhenius equation} \quad (5)$$

Viscosity average molecular weight has been calculated by the following equation[9]:

$$[\eta] = k M^a_v \quad (6)$$

Where (k) and (a) are constants depend on the type of the polymer, for (Xn) these values obtained from Table of the special of polymers were (a=0.8, $k=2.85\times10^{-4}$)[10].

The effective molecular radius (r) has been calculated by the following equations[11]:

$$\eta \text{ rel} = 1 + 6.3\times10^{24} r^3 \text{ cm} \quad (7)$$

$$\text{slope} = 6.3\times10^{24} r^3 \quad (8)$$

$$r_o = \sqrt[3]{\text{slope}/6.3*10^{24}} \quad (9)$$

Where slope equals the value between relative viscosities against concentration.

EXPERIMENTAL PART

The materials used in the research are xanthan cellulose gum and Magnesium oxide(MgO).

Preparation of solutions

Xanthan cellulose gum with purity (99.8%) and (MgO) with purity (99.9%) of high viscosity. The xanthan cellulose gum solutions have been prepared by dissolving a known weight of xanthan gum powder in distilled water (500 mL) under stirring at (70ÚC) for (60 min). The xanthan gum concentrations were (0.1, 0.2,…, 0.8) % g/mL, then (MgO) added with weight (0.25and 0.5)% g to all xanthan cellulose gum concentrations. The resulting solution was stirred continuously for (15 min) until the solution mixture became a homogeneous.

RESULTS AND DISCUSSION

It will be discussed rheological properties in this research as follows:

Rheological properties

Density is a physical property of matter that expresses a ratio of mass to volume. Density for all solutions of polymer Xn before and after addition MgO has been measured at room temperature. The density is increasing with the increase of polymer concentration as shown in (Figure 1),because of increased the mass of the solution and the swelling made in the polymer chains as a result of soluble in distilled water and higher molecular weightof par-

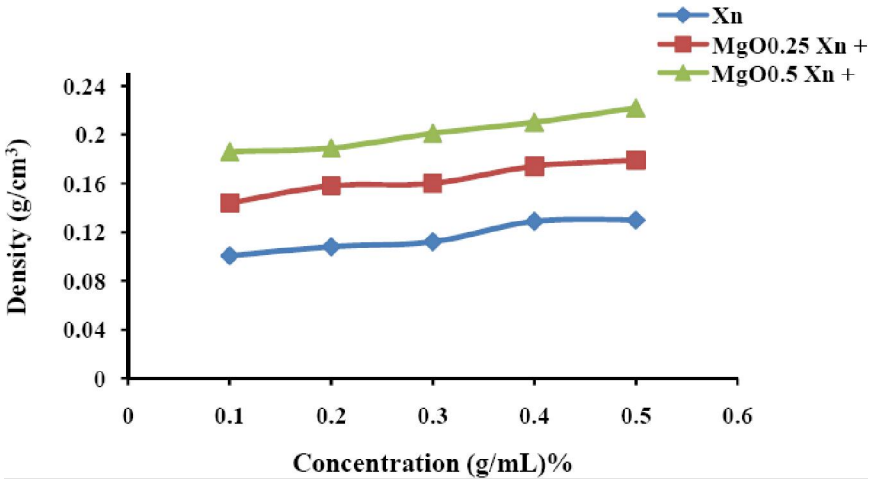

Figure 1 : Density due to concentration

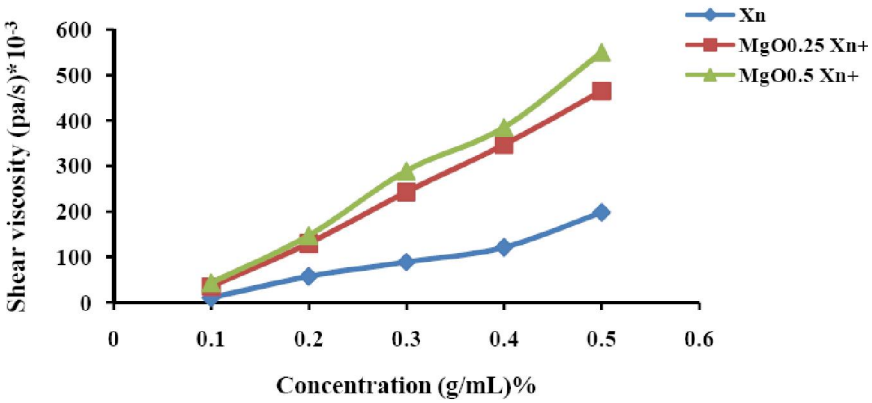

Figure 2 : Shear viscosity due to concentration

ticular polymers[12].

Shear viscosity is increasing with concentration as shown in (Figure 2). This attributed to the mechanism that hydrogen bonding of water that attached to oxygen sites, this leads to salvation sheaths and increase in the size of the molecules.

The values of the shear viscosity increase after addition of MgO, the reason is due toattractive forces between molecules of the solution after the addition, so this is leads to diverging of particle in mixing and occupy it a greater volume. This is leading to increase the values of shear viscosities[13].

The relative,specific and reduced viscosities of the polymer solutions before and after addition of MgOhave been found by using the equations (1,2and 3). The dependence of these viscosities of Xn solutions and its additive on concentration has been shown in Figures (3,4 and 5). These viscositiesare respectively possess the same behaviors of shear viscosity because they are derived from it.

Adding MgO made enhancement for these viscosities because the viscosity describes a fluid's internal resistance between molecules so when we add MgO there will be more molecules, the additional forces between molecules lead to an additional contribution to the shear stress[14].

The intrinsic viscosities of the samples were calculated by plotting a graph between reduced viscosities against the concentration. The extrapolation of the slope as concentration goes to zero equal to the intrinsic viscosity values, as shown in Figure (5). Figure (5) shows that the intersection points of reduced viscosities with (y-axis) for Xn before and after adding MgO. The intrinsic viscosity believed to represent the effective volume of the molecule in solution[15]. The theoretical intrinsic viscosities were calculated by using Philippoff equation (4) and Arrhenius equation (5). The comparison between experimental values and the theoretical values obtained by these two equations as shown in TABLE (1).

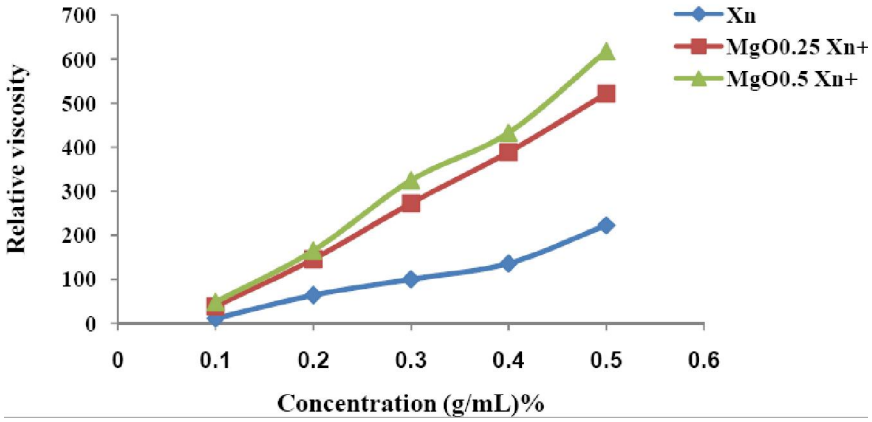

Figure 3 : Relative viscosity due to concentration

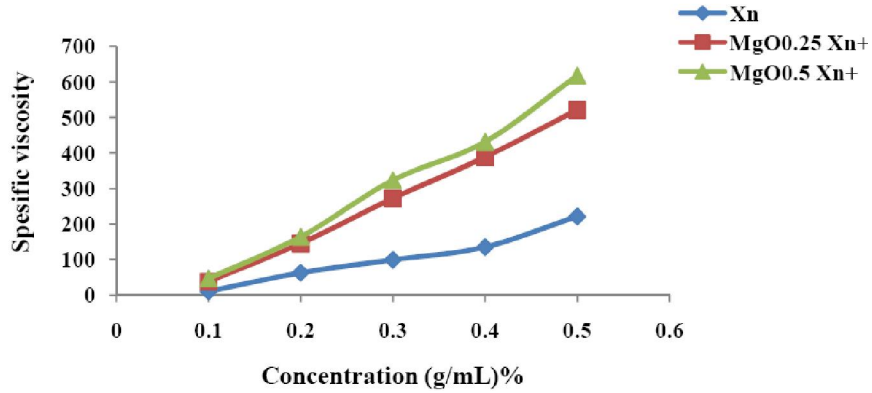

Figure 4 : Specific viscosity due concentration

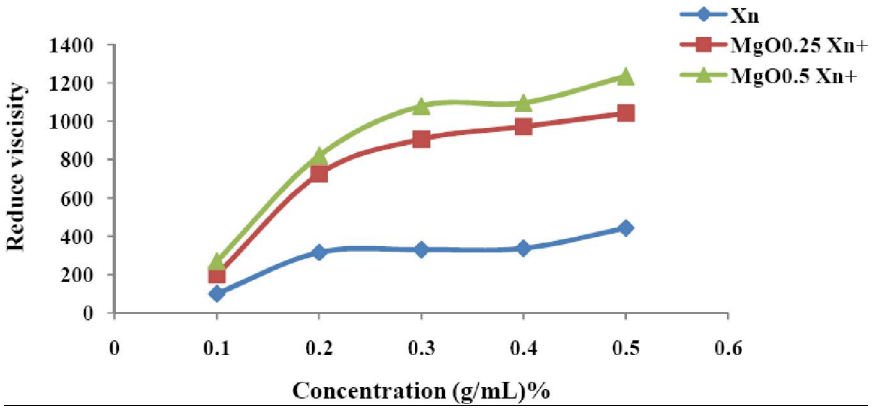

Figure 5 : Reduce viscosity due to concentration

The results shows a good agreement between experimental and theoretical intrinsic viscosity values with acceptable experimental errors. This behavior of the viscosity with concentration was attributed to the structural change associated with a liquid polymer solution and probably indicating entanglement interaction[16].

Viscosity average molecular weights before and after adding MgO were calculated by using equation(6). The values of viscosity were taken experimentally from the known values of intrinsic viscosity and the constants (k and a) depending on the polymer type as shown in the following TABLE (2). The constant (k) obtained from Tables and the constant (a) is (0.8)[17], also from Tables, for good solvents. The values of (k) were measured by using equation (7). 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 as shown in TABLE (2).

The results show that viscosity average molecular

TABLE 1 : Theoretical and experimental values of intrinsic viscosity

Polymer	Intrinsic Viscosity [?](mL/g)		
	Theoretical		Experimental
	Arrhenius	Philippoff	
Xn	18.5	19	18
Xn+0.25g MgO	37	37	36
Xn+0.5g MgO	43	43	42

TABLE 2 : Theoretical and experimental values of viscosity average molecular weight ($[(M)]_v$)

Polymers	The constant (K) × 10^{-4}	Theoretical		Experimental
		Arrhenius Equation	Philippoff equation	
Xn	2.85	1036116.49	1071237.89	1001231.61
Xn +0.25gMgO	3.67	1794023.86	1794023.86	1733621.10
Xn+0.5g MgO	3.89	2015573.16	2015573.16	1957152.25

TABLE 3 : Effective molecules radius for concentration

Effective molecules radius (r) (cm)	
Polymers	High Concentration ×10^{-5}
Xn	1.787
Xn + 0.25g MgO	3
Xn+ 0.5g MgO	4.326

weights are increasing after the addition of MgO, the reason is that molecular weight is defined as the product of the molecular weight of the monomer by the degree of polymerization, since the adding led to increase the size of the polymeric chains then increase molecular weight, so the viscosity average molecular weight increased. This result is the same behavior of researchers on their study about cellulose derivatives[15,16].

Effective molecular radius for high concentration increasedafter adding MgO as shown in TABLE (3). The reason for this behavior is same explained shear viscosity and the cause of these increments is generated gel compounds, so change the volume of chains that appears as random coils, then increasing the effector molecules radius and this is agreement with reference[17].

CONCLUSIONS

The adding MgO to Xn increases the density.

The increasing of concentration led to increase the viscosity and thus can be used as thicker colloid blenders in coating processes, oil drilling and pumping processes for reducing the friction of fluids because of its pseudo plasticity characteristic.

There is a good linear correlation between density and the concentration of solutions.

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