http:// www.ijcps.net

International Journal of Chemical and Petroleum Sciences

ISSN 2253-0932

INTRODUCTION OF COTTON GUM AS A NATURAL POLYMER TO ENHANCED OIL RECOVERY

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ABSTRACT

Polymer flooding as an enhanced oil recovery (EOR) method is widely utilized to improve water flooding and plays an important role during EOR process. Partial hydrolyzed poly acryl amide (HPAM) as one of the well known polymers is used in order to have a decrease water/oil mobility ratio in oil reservoirs. As this polymer is decomposed at reservoirs having high temperature and high salinity, the use of this polymer is limited. This study introduces cotton gum as a new natural polymer which can be used for polymer flooding. Cotton gum as a polysaccharide is obtained from the natural cottons. To compare this polymer with HPAM, related experiments including thermal decomposition and viscosity tests in same conditions were conducted and our experiments confirm that this polymer shows a good resistance against high salinities and temperatures.

Keywords: *Polymer Flooding, Cotton Gum, Salinity, Viscosity.*

1. INTRODUCTION

Polymers are added to the injected water through a reservoir to Improve Oil Recovery (IOR). The main purpose of polymer injection as an EOR chemical method is to decrease the mobility of the injected water by increasing the solution viscosity and decreasing the rock permeability to the injected water. An increased viscosity of the injection fluid allows better profile control. The amount of oil gained through injected water in water flooding sweep is not efficient for the reason that injected water has a finger like movement in the oil bank because of water viscosity which is less than oil. Therefore, water can easily move through oil and high mobility of injected water causes sweep efficiency of oil to be decreased. To solve this problem, a water-soluble polymer is used to reduce the effects of finger such as movement of injected water. By solving polymers into water, water viscosity is increased dramatically and causes mobility of water to be less than oil and

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sweep efficiency of oil will increase during EOR process.Surfactants are added to injection water to 'wash out' more oil in the reservoir. Polymers increase sweep efficiency by improving the mobility ratio. Surfactants, enhance microscopic recovery by reducing capillary forces (S. H., Yang 2007). Polymers increase the viscosity of injection water, whilst surfactants reduce interfacial tension between oil and water. Polymer solutions are used in oil reservoirs, so that they can sweep a larger area of oil-bearing zone and delay breakthrough time as well (Zeynali, M.E., et al 2004). During a standard water flooding, breakthrough comes up slightly fast then water fingering occurs in the oil bunk causing by high mobility of water; as a result, its sweep efficiency decreases (Perry A., et al 1982, Du Y., 2004). Polymer is added to injection water and increases viscosity of the solution owing to its high molecular weight, which leads to reducuction of fingering effect, therefore sweep efficiency will be improved (Alban N., and Gubitta J., 1999). Hydrolyzed poly acryl amide (HPAM) and Xantan Gum, which are synthetic and natural polymers respectively, are usually used in polymer flooding, both in field and in pilot projects. In 1964, Pye and Sandi claimed that polymer flooding can increase oil recovery compared to water flooding. They stated that partially hydrolyzed poly acryl amide (HPAM) can reduce the mobility of displacing water by increasing its viscosity and improving the sweep efficiency of flooding process (Detling, K.D., 1994). Fouling and Wang (2006) used high concentration of HPAM polymer solution during flooding studies for Canadian oil fields and illustrated the promising effect of HPAM to increase recovery factor up to 21% of the Original Oil in Place (Standford, B.B., 1964, Fulin, Y., et al 2006). Zhang and Halliburton (2006) studied the effect of Alkaline-surfactant-polymer (ASP) flooding during EOR process of a Chinese oil field and stated that combination of these materials can improve oil recovery significantly compared to polymer flooding alone (Zhang, G., and Seright R.S., 2007) . The main objective of this work is to introduce a natural polymer in order to be used in polymer flooding process. In this study temperature and salinity effect as important parameters for polymer flooding on cotton gum solution will be evaluated.

2. MATERIAL AND METHODS

2.1. Preparation and protection of plant sample

Inflorescences of plant species Gossypium hirsutum were collected from botanical garden in Fars Provinces in Iran (during the crop season of 2012). Plant sample was kept in paper pockets carried to the laboratory and thoroughly rinsed.Then inflorescences were put in suitable medium away from the direct sunlight and were air dried carefully.The tissues of the dried plants were milled and the resulting fine powder screened with a mesh sieve and kept in the laboratory until the extracting time.

2.2. Preparation of plant aqueous extract

5 grams of the powdered dried plant were placed in closed 250 cc glass jar and then 100 ml of sterilized distilled water was added to the powder. The stock suspension was placed on a shaker at 350 rpm for 24 hours. Then it was passed through filter layers. The stock suspension was placed in Rotary evaporator for extraction and evaporation of the solvent. The resulting extract was placed in oven in temperature 55 °C. Finally the resulting powder was put in sterilized micro tubes and stored at about 4°C in the refrigerator (Abdolmaleki, M., et al 2011).

2-3. Laboratory Measurement Procedure

To investigate the effect of salinity and temperature on this polymer solution, a number of experiments in different conditions were conducted. Cotton gum solutions were made in different concentrations, and the viscosity of each solution was accurately measured in the same condition. In next step, NaCl solutions with different concentrations were added to the solution in order to make a solution with required salinity. Hydrolysis is a chemical process in which a molecule is cleaved into two parts by the addition of a water molecule, in other words, the partial hydrolysis of polymers greatly increases the polarity of the molecules, the resulting polar groups on the polymer molecules are strongly inhibited by others (other molecules) and provides a good distribution in dilute aqueous solutions leading to an increase in viscosity of the solution.To evaluate the effect of temperature on cotton gum polymer solutions in various concentrations, the solutions were heated up to 250 °C, and it was observed that Cotton gum solution could sustain temperature up to 250 °Cwithout missing its property within 24 hr and our experiments indicate that this polymer is stable at high temperatures. Related experiments were done for HPAM solution in the same condition and as it was observed that thermal decomposition of HPAM takes place above 250 0 F. In this work, in order to hydrolyze cotton gum, NaOH (0.5 and 1 N) at high concentrations has been used. In fact, by adding small amount of NaOH, poly-ionic property of solution will increase and dissolves rapidly in water and produces a viscous solution.

3. RESULTS AND DISCUSION

3.1. The effect of Temperature on Effectiveness of Cotton Gum Solution

Temperature ranges, in which polymers remain stable without degradation are very sensitive to the type of polymer. It is believed that most polymers will be decomposed at high temperatures and so miss their applicability. Reservoirs with temperature higher than 65 0 C should be avoided for using HPAM because it decreases their viscosity dramatically at that temperature. To evaluate temperature effect on cotton gum solution, some other experiments were done. As are shown in Figure (1) to Figure (5), these figures illustrate the effect of temperature at different concentrations with various hydrolyzed degrees which were determined based on a standard back titration method. To determine the degree of hydrolysis, a weighed portion of prepared sample is dissolved in water and then solution was acidified with 0.1 N hydrochloric acid to a pH = 3. The acidified solution was back titrated with 0.1 N standard solution of sodium hydroxide to pH = 7. Our experiments show that cotton gum solution can withstand up high temperatures without losing its viscosity owing to its stable structure. The obtained results, show when the made solution is heated up to high temperature in the downstream direction, stability of solution, such as viscoelastic parameter will be sustained

3.2. The Effect of Salinity on Efficacy of Solution

As Figure(6) illustrates, the relative viscosity of HPAM becomes constant at some salinity level for Polydactyl Amide solutions which are widely used in oil reservoirs, so it is concluded that HPAM is not a good candidate for the reservoirs with high salinity. Generally, it has been proved that the concentration of anions such as Na+, Ca2+ and Mg2+ effects are imposed on oil reservoirs to improve their recovery factor. The major drawback of salinity in concentration of Na+ anion on HPAM flooding is HPAM efficiency reduction (Fig 6). Therefore HPAM should be used for reservoirs with low brine concentration only. In fact, at the reservoirs with having salinity degree higher than 100000 ppm, HPAM solution will lose its viscosity properties and could not be a good candidate in EOR process. As observed, Cotton gum as a natural polymer compared to HPAM, shows a high resistance against high salinity up to 2 Molar of NaOH and could be used for reservoir with high salinity. As expected, experimental results confirmed that with adding NaCl to cotton gum solution, its viscosity not only decreases with increasing salinity, but increases the viscosity significantly and therefore this polymer will be stable at high salinity. It is important that cotton gum is not decomposed at high concentrations of NaCl because viscosity property of such solution by adding NaCl is maintained. Maximum viscosity has been observed at concentration 2 Molar NaCl. Therefore, in oil reservoirs with high salinity, this polymer could act as water shut off and it can be used). In contrast, As can be shown from Figure (7) to Figure (10) Cotton solution shows a resistance against high salinities compare to HPAM as commercial polymer which is widely used (Figure. 6). Consequently, Cotton gum can be a good candidate for polymer flooding processes in reservoirs with high salinity concentration.

3.2.1. Equations of salinity

For 1000 ppm: $\mu=18.53C-3.431$
For 1500 ppm: $\mu=19.66C-2.118$
For 2000 ppm: $\mu=20.40C-0.511$
For 2500 ppm: $\mu=20.58C+1.348$

According to experiential data and related equations, it is found that with decreasing of salinity concentration, solution viscosity will decrease and with increase of salinity concentration viscosity will increase, too. As it is observed viscosity associated with salinity linearly

4. CONCLUSION

This study concerns salinity and temperature effects on Cotton Gum solution as a new natural polymer compared to HPAM in the same conditions for the sake of improving oil recovery process. Experiments are designed to study the salinity, and temperature effects on cotton gum solution. Taking everything into consideration, the following deductions are obtained:
Cotton Gum solution as a natural polymer is able to withstand in high salinities as well as keeping its stability at high temperatures. As our experiments confirmed, this natural polymer acts as a viscoelastic and could increase water viscosity remarkably and although it shows good resistance against high salinity. It increases water viscosity in high salinity, which is an important advantage in polymer flooding processes for oil reservoirs with high salinity and high temperature.

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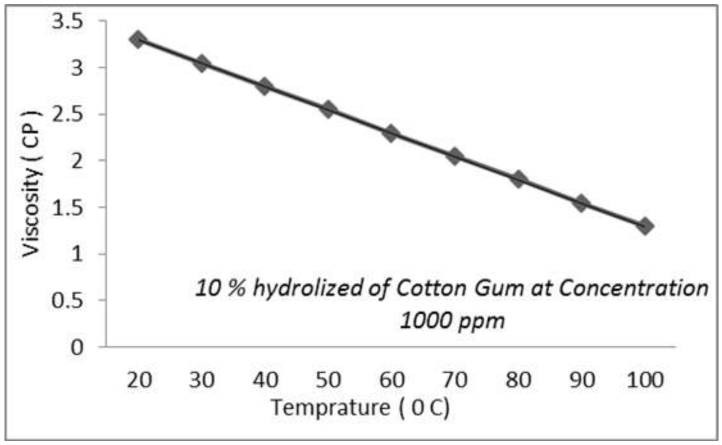

Figure.1. Effect of temperature on viscosity of cotton gum solution at Concentration 1000 ppm, with 10 % hydrolyzed degree.

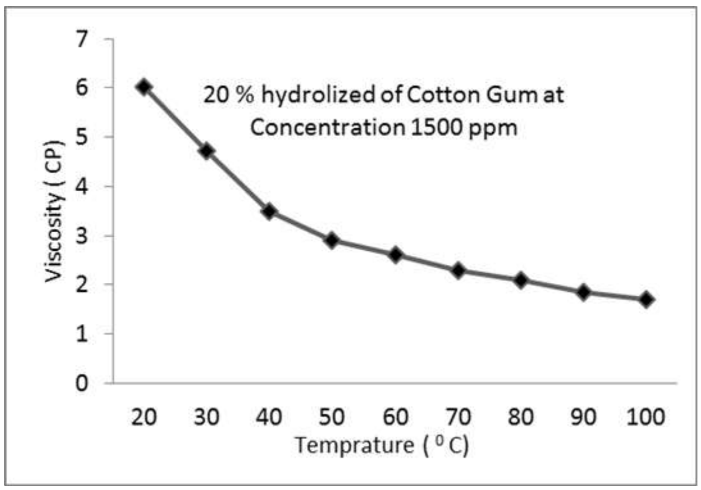

Figure.2. Effect of temperature on viscosity of cotton gum solution at Concentration 1500 ppm, with 20 % hydrolyze degree.

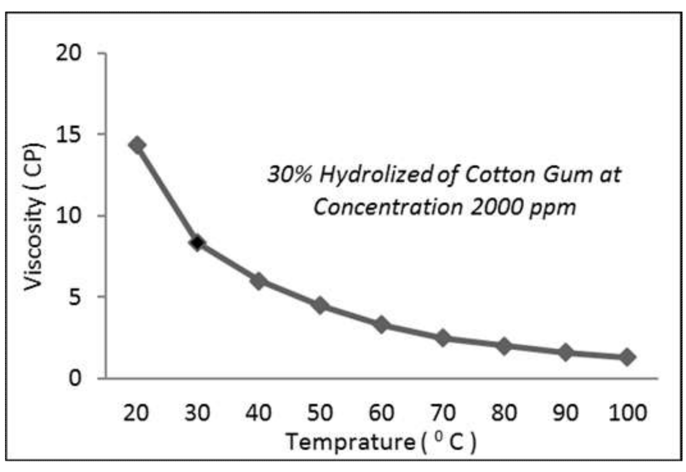

Figure.3. Effect of temperature on viscosity of cotton gum solution at Concentration 2000 ppm,With 30 % hydrolyzed degree.

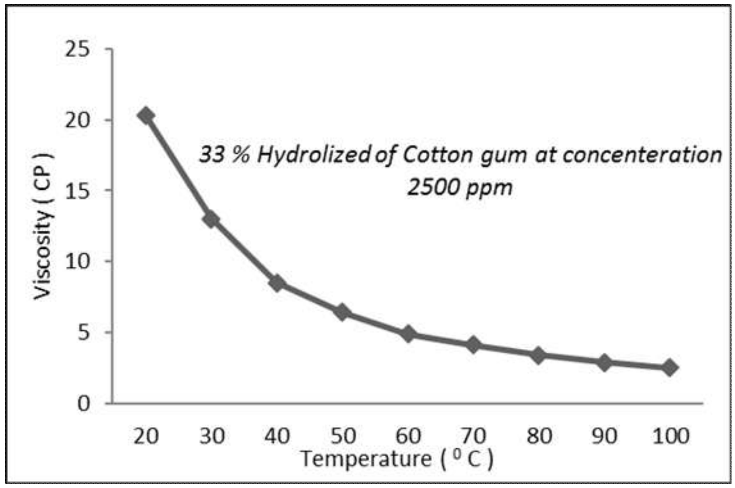

Figure.4. Effect of temperature on viscosity of cotton gum solution at Concentration 2500 ppm,with 33 % hydrolyzed degree.

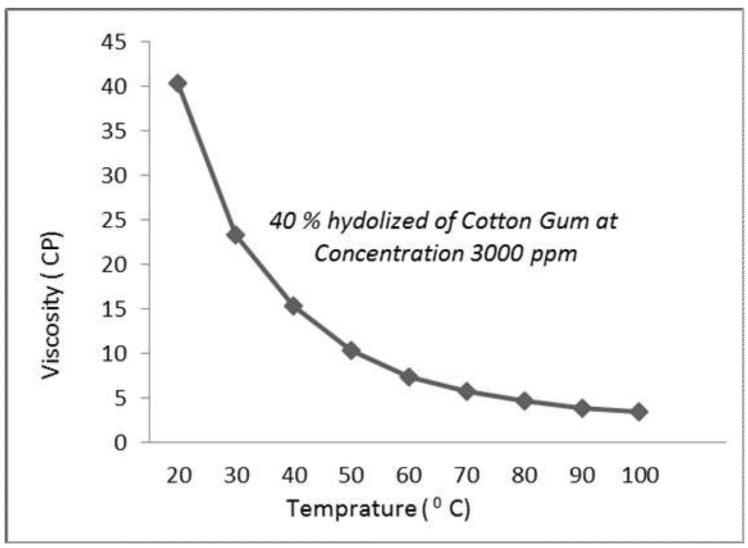

Figure.5. Effect of temperature on viscosity of cotton gum solution at Concentration 3000 ppm, with 40 % hydrolyzed degree.

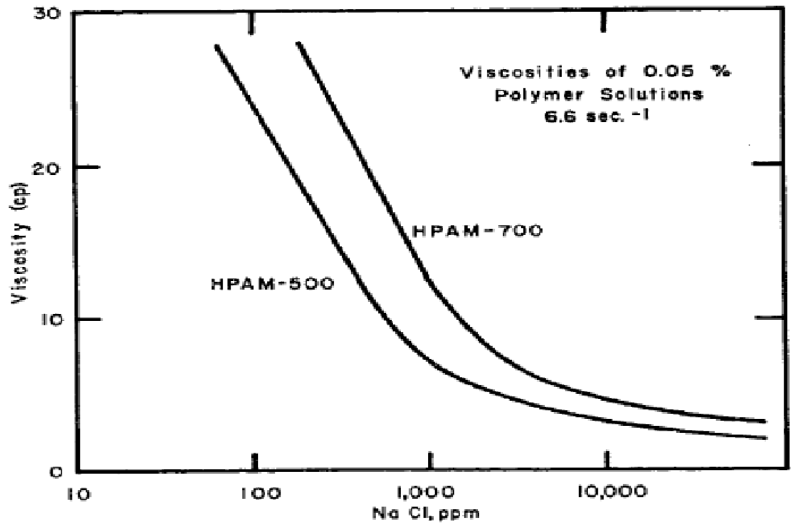

Figure.6. Effect of brine salinity on viscosity of 0.05 polymers solution (Alban N., and Gubitta J., 1999).

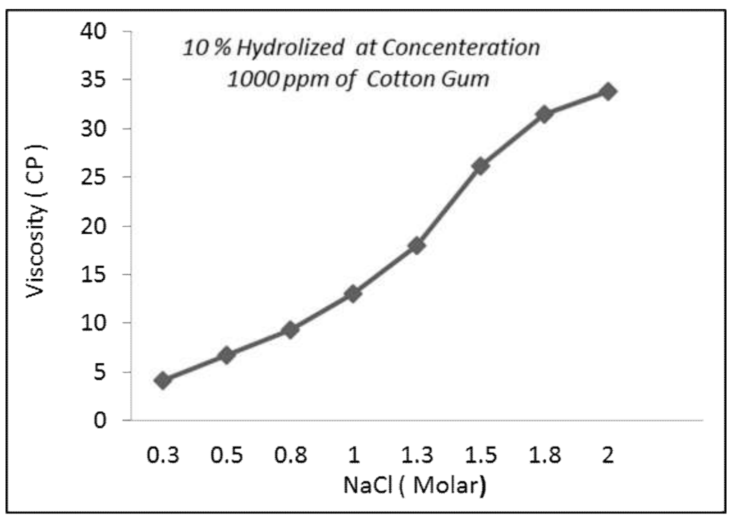

Figure.7. Effect of NaCl on viscosity of cotton gum solution at Concentration 1000 ppm, with 10 % hydrolyzed degree.

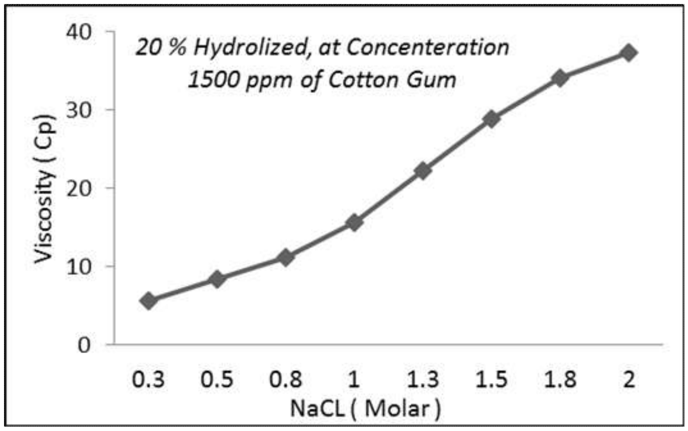

Figure.8. Effect of NaCl on viscosity of cotton gum solution at Concentration 1500 ppm, with 20 % hydrolyzed degree.

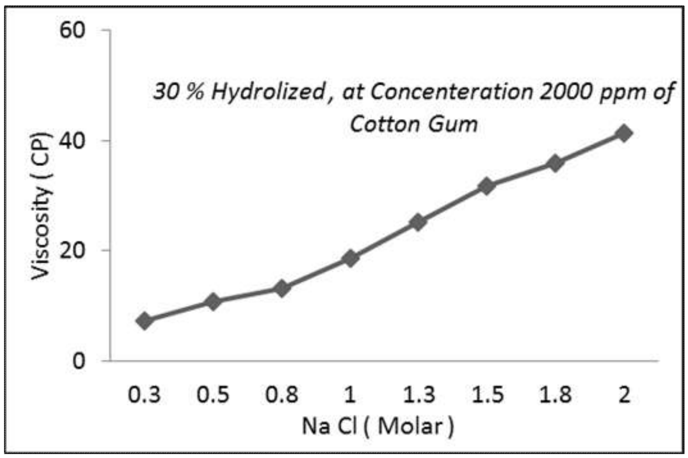

Figure.9. Effect of NaCl on viscosity of cotton gum solution at Concentration 2000 ppm, with 30 % hydrolyzed degree.

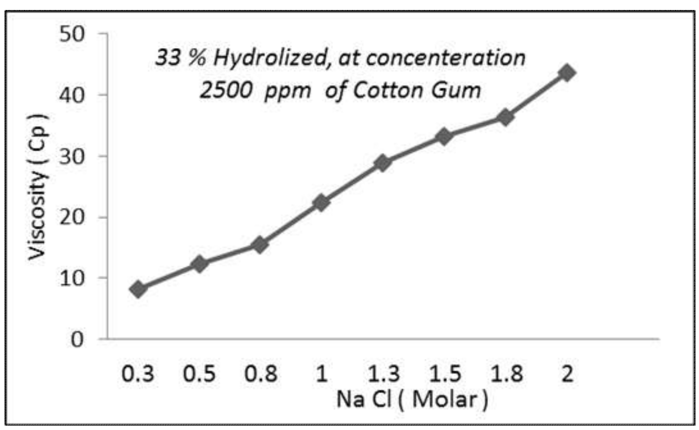

Figure.10. Effect of NaCl on viscosity of cotton gum solution at Concentration 2500 ppm, with 33 % hydrolyzed degree.