

How may Improved Locally Sourced Gum Arabic Compare with Other Polymers ormulation of Polymers from Locally Sourced Polysaccharides for Application in Polymer Fflooding

ABSTRACT

The oil industry is experiencing a paradigm shift where the use of green chemicals is being encouraged in order to address environmental issues often associated with the use of synthetic chemicals such as hydrolysed polyacrylamide, mainly used to reduce the mobility of water in enhanced oil recovery, which as well as the fact that most of these synthetic polymers like hydrolysed polyacrylamide which is used to reduce the mobility of water in enhanced oil recovery; are all imported chemicals. Thus, this brings the need to locally source polymers locally source for polymers to viably support that are viable so as to increase indigenous oil production for the oil industry.

Gum Arabic is a viscosifier mostly found in the northern part of Nigeria. Different concentrations of the Gum Arabic were analysed as to study their rheology and understand as well as the effect of salinity on them in order to have a sense of which will determine their degree of resistance as this is a criteria for assessing polymer flooding. However, the stability of Gum Arabic was further enhanced by the introduction of Carboxyl Methyl Cellulose (CMC) at varying concentrations to showdetermine its effect on the solution viscosity. From the results, it can be concluded that increased viscosity was as a result of the modification of Gum Arabic by CMC whichand this could be related to increased bonding between Gum and with CMC.

Keywords: Gum Arabic; CarboxylMethyl Cellulose (CMC); Polymer; Viscosity; Salinity.

INTRODUCTION

Polymer flooding has been carried out for the past 40 years in many marginal oil fields and its effectiveness has been proved to be successful in several fields. The general expectation from polymer flooding is to obtain about 50% ultimate recovery with averagely 15 to 20% incremental recovery over secondary water flooding process (Rellegadla, 2017). Both naturally derived polymers like xanthan gum and synthetic polymers such as the partially hydrolyzedhydrolysed polyacrylamide (HPAM) have been used basically for the purpose of viscosifying water for polymer flooding. Typical synthetic polymers are partially hydrolyzedhydrolysed polyacrylamide (HPAM) whoseand its derivatives have been used for most large-scale field production simply mostly because it is less costly (Chang, 2011). One The commercial bio-polymer used in oilfield applications s but not frequently so,used as like the HPAM due to its higher cost is xanthan gum (Sun, 2012).

HPAM in produced water (Back produced water) after polymer flooding in oilfield causes serious environmental problems such as difficulty in oil - water separation: ; the treatment of back produced water from polymer flooding (PWPF) with HPAM is more difficult to separate than oily wastewater without HPAM (Zhang, 2010; Bao, 2010; Deng, 2002) because the HPAM residual component dissolved in water increases the viscosity of wastewater whileand also HPAM is equally absorbed onto the oil/water interface, making the separation process much more difficult to attain (Duan, 2014).

Chemical cost of a polymer flooding process is a function of the polymer selected for flooding. For instance, although chemical cost as well as the treatment cost is said to be higher for

xanthan gum solutions compared **withto** polyacrylamide solutions, Xanthan's cost is stable when compared to the fluctuating cost of polyacrylamide polymer. **P**The polyacrylamide is actually synthesised from petroleum products and their costs in the market are very sensitive to **the the price of crude oil prices**. (Rellegadla, 2017). Thus, there is **the** need to manufacture shear resistant, **also** temperature resistant chemicals, **and as well as** environmentally friendly biopolymers that are less costly than xanthan gum as **this is aa** sure way of generating **highermore** recovery while reducing cost.

Gum Arabic, **also known as Acacia Senegal**, is presently one of the oldest **of** polysaccharides **and** mostly found in the northern part of Nigeria **also known as Acacia Senegal**. It is produced as tear-drop-shaped globules exudates from bark wounds of Acacia trees (Glicksman, 1973). Due to the presence of ionic charges on the backbone of the polymer chains, the viscosity of solutions of gum Arabic is based on changes in pH **Q**. Viscosity is low at low pH and **highalso** at high pH **and** reach**inges** a maximum **ofat** about **a pH of** 6-8. It occurs **mainlyjorly** as a mixture of calcium magnesium and potassium salts of arabic acid and is composed of the following carbohydrates **including, this include**: galactose, arabinopyranose, arabinofuranose, rhamnose, glucuronic acid and 4-O methyl glucuronic (Anderson, 1966). The gum is **a** highly water soluble **polysaccharide**. It is principally used in the food and pharmaceutical industries as **stabilizerstabiliser**, thickener, suspens**ording** and bind**ering agent** in the manufacture of confections, dairy products, beverages, cotton-seed oil emulsion and tablets (Nahla, 2000). The composition of sugars within Gum Arabic is shown in **the** Equation 1.

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Carboxyl methyl cellulose (CMC) is the most popular and cheapest cellulose derivative, It is an anionic and **also** a water-soluble natural polymer that is well known as a safe and biodegradable polymer, which is widely used in the food industries as food additives, **and, in oil exploration, and** paper, **and**, textile industries **among otherse.t.c** due to its high viscosity (Ibrahim, 2014). CMC is **synthesizesynthesised** by reacting cellulose with sodium hydroxide in the presence of sodium chloroacetate.

In line with Nigerian Oil and Gas Industry Content Development Act, 2010, which seeks to increase indigenous participation in the oil **and** industry by prescribing minimum threshold for the use of local services and materials **as well asand** promot**esing** the transfer of technology and skills to Nigerian staff and labour **in the industry**, this work investigates the use of Gum Arabic (locally sourced) as a suitable polymer in enhanced oil recovery **aswhile** CMC was added to determine **its the** effect on **Gumits** stability at increased water salinity.

MATERIALS

AND

METHOD

DIn this analysis, different concentrations of Gum Arabic (Figure 1) from 10,000ppm, 30,000ppm to 50,000ppm were **separately** dissolved **usingin** 500ml of water. The solution was stirred gently to achieved homogeneity in order to avoid the formation of fish eye **which, this** was then allowed to hydrate for a period of 24hrs. Rheological characterisation was carried out using Fann Viscometer to determine the rheology **of Gum solution** at different Speeds from (600, 300, 200, 100, 6.) **rpm** to 3rpm. The stability of the solutions were further analysed **after addition ofusing** NaCl (1wt%). The concentration of CMC **utilizedutilised** in the formulation was increased from 1wt% to 1.4wt% to study the effect of CMC on the viscosity with respect to salinity after another 24hrs. The rheological study **equally** captured the investigation of CMC alone as well as when blended with Gum Arabic.

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I do not see errors for each bar. How many samples were picked for each treatment(category)? Was sampling done only once for each treatment?



Figure 1: Gum Arabic

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Readers could also use a photo of CMC and of the blends for the purposes of visual comparison.

RESULTS AND DISCUSSION

From Figure 2, it is obvious that increasing the Gum Arabic's concentration improved the solution's viscosity at higher concentration of 50,000ppm just like some other polysaccharides such as like Xanthan gum and, Guar gum among others e.t.c that show very good rheology at increasing concentrations (Chatterji, 1981; Eiroboyi, 2018). **Though**, Gum Arabic's viscosity did not show much appreciable rheology at low concentration of the gum alone., **T**his could be as a result of the nature of its molecular structure. Also, the effect of salt affected the viscosity, this is because of the fact that the gum is polyelectrolyte hence its interaction with NaCl.

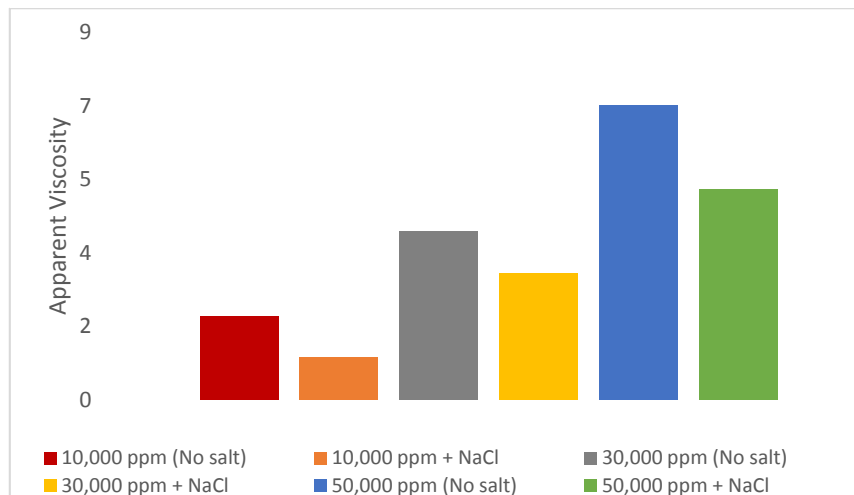


Figure 2: The Effect of salinity on Gum Arabic at increasing concentration

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Figure 3 displays the rheological behaviour of Carboxymethyl Cellulose at increasing concentrations as well as in the presence of NaCl. **CMC at However, in this case it was used an additive in the formulation. The results show that 1wt% of CMC** was very viscous, even more viscous at increasing concentration of 1.4wt%. This particular analysis was necessary to actually ascertain if there was synergy between the polymers after blending. Both **CMC at 1wt% and 1.4wt%** reflected reduction in viscosity in the presence of 1wt% NaCl.

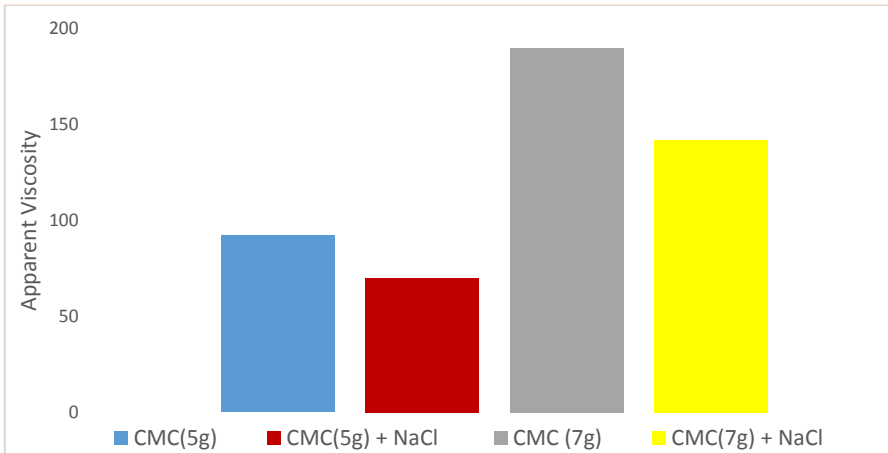


Figure 3: The effect of salinity on CMC at increasing concentration

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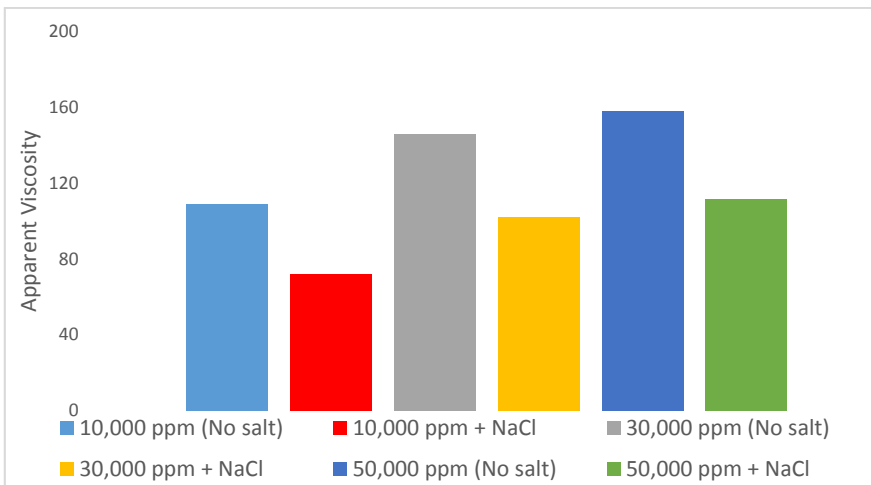


Figure 4: The Effect of salinity on a blend of Gum Arabic and 1wt% of CMC at increasing concentration

and 1wt% of CMC

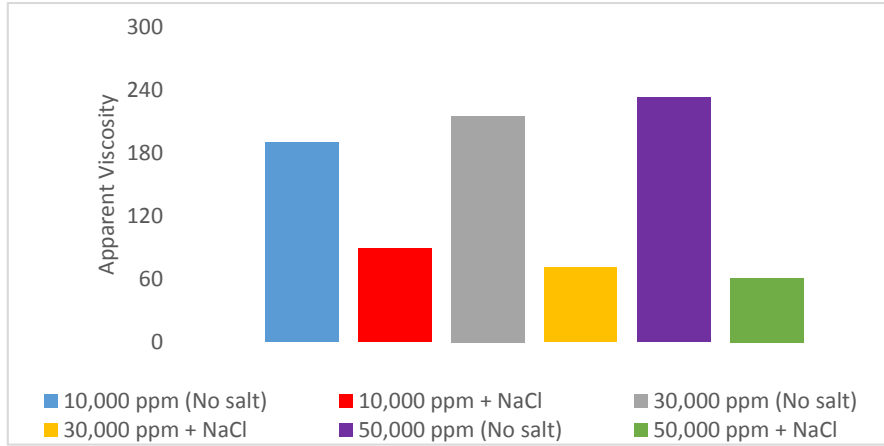
The presence of CMC in the solution strongly interacts with Gum Arabic solution increasing the viscosity considerably. From Figure 4, 50,000ppm reflected the highest viscosity. **than other lower concentrations,** This could be as a result of increased intermolecular entanglement **fromof** both the molecular chains of Gum Arabic and CMC. When compared with the viscosity of the gum alone (Figure 2) and the viscosity of CMC alone (Figure 3), the resultant blend in Figure 4 displayed **synergy** upon blending. **Although,** the reduction in viscosity

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Without error bars it is difficult to really assess significant differences.

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Without error bars it is difficult to really assess significant differences.

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How do you mean? Do you mean homogeneity? Synergy is not the same as homogeneity. Do you mean homogeneity?

based on a result of the effect of salinity was equally obvious., This is because of the nature of the ionic status of both polymer chains.



Comment [8]:
Unacceptable explanation. Are you sure both are ionic? Did you measure the surface ions or electrostatic forces on the surface of both Gums and CMC? Gums may have an ionic surface but certainly not CMC. Was the degree of substitution of cellulose with carboxymethyl absolute? Did cellulose not harbour free hydroxyls which may make CMC polar just as charged ions may make Gums polar. All things being equal, CMC is expected to be neutral.

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Without error bars it is difficult to really assess significant differences.

Figure 5: The Effect of salinity on a blend of Gum Arabic and 1.4 wt% of CMC at increasing concentration

and 1.4 wt% of CMC

Gum blended with The presence of increasing concentration of 1.4wt% of CMC shown in Figure 5 without the influence of salinity increased the solution's viscosity more than that blended with 1wt% CMC (Fig. 5). However, the resistance provided by increase in Gum Arabic concentration did not improve resistance when the concentration increased. This behaviour could be related to the fact that the presence of increased CMC concentration increased the anions present within the solution such that in the presence of NaCl, there was increased reaction with NaCl, thereby reducing the electrostatic repulsion increasingly on the polymer chains which eventually decreased the viscosity.

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Which anions? Where might these anions be coming from? Free hydroxyls in CMC may make CMC polar but not anionic.

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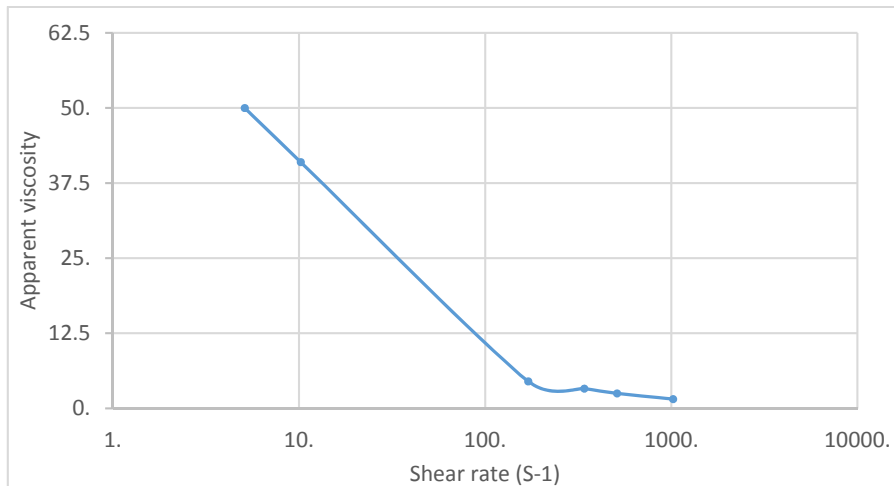


Figure 6: Viscosity-shear rate behaviour

Figure 6 depicts that the viscosity reduces with increasing shear rate, **this** (reflecting Gum Arabic's shear thinning behaviour).

CONCLUSION

During polymer flooding, one of the characteristics of a polymer is its ability to remain stable in the presence of high salinity as such the injected solution must maintain its viscosity for a longer duration. From the experimental analysis,

- It is obvious that Gum Arabic at increasing concentration with CMC was able to produce increased viscosity which is a requirement in polymer flooding though Gum Arabic as a polymer alone is **of a** low viscosity polymer.
- Gum Arabic **solution** with CMC, especially at increasing concentration of CMC **and Gum Arabic solution** did not produce adequately **the** stability against salinity for the solution.
- **A**The experiment analysis proved that attraction and repulsion of **molecular charges on molecular backbone** are responsible for the resultant solution viscosity especially because both polymers are ionic.
- **The**is reduced viscosity **ction** could be related to the increase in **anions** from the polymers in solution because both of them are **polyelectrolytes** and as such would interact strongly with the cations of NaCl solutions thereby decreasing the electrostatic repulsion of the polymer chains in solution.
- In the use of Gum Arabic, **non-ionic** additives **that are non-ionic** would **suffice** better **serve** than ionic **polymer ones** in **in saline environments** **the face of high salinity**.

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Yet to be proven in your paper.

Comment [14]:
Unacceptable assertion. Refer to above cautions.

Comment [15]:
CMC does not or is not shown to be with anions.

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CMC is not proven to be electrolytic. Refer to earlier admonitions.

NOMENCLATURE

CMC – CarboxylMethyl Cellulose

HPAM – Hydrolysed Polyacrylamide

NaCl – Sodium Chloride Salt

PPM – Pounds per million

Cp – Centipoise

PWPF - Produced water from polymer flooding

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