

# Impacts Of Additives On Rheological Properties Of Rice Husk And Xanthan Gum Modified Drilling Fluid

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**Abstract:** Four (4) samples A, B, C and D were developed using bentonite clay, rice husk, and xanthan gum in different proportions based on their rheological properties and thixotropic property (Gel strength), pH and density values. Additives (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub> and BaSO<sub>4</sub>) were added to the four samples in composition of 1%, 2%, 3% for (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 5%, 10%, 15% for (BaSO<sub>4</sub>) at temperature of 30 °C. FANN 35 viscometer was used to measure their rheological properties and thixotropic property (Gel strength), while pH meter and mud balance were used to measure their pH and density values respectively. The maximum pH, apparent viscosity (AV) and Gel strength in 10 seconds (GS = 10 (sec)) corresponds to 9.1, 51.3 cP and 34.2 (lbf/100 ft<sup>2</sup>) respectively were observed in sample A without chemical additive. From the results obtained the chemical additives had positive impacts on the rheological properties of the drilling fluid samples. Sample A with xanthan gum and bentonite only had most improved viscosity when the chemical additives were added followed by sample B with bentonite (24.5g), rice husk (20g) and xanthan gum (1g). The Gel strength of the samples were increased by the addition of any of the chemical additives, samples A and B still had more improvement than the other two samples. The yield point and plastic viscosity (YP/PV ratio values) results revealed that the carrying capacity of the drilling fluid samples could be increased by the addition of NaOH, NaCl and BaSO<sub>4</sub>. The pH values of all the samples were alkaline close to neutral with addition of the chemical additives. Thus, it could be concluded that drilling fluid with 20g rice husk and 1 g xanthan gum and standard 24.5g bentonite proportion could be improved upon with the addition of any of the chemical additives tested in appropriate quantity for effective performance in drilling operations.

**Keywords:** Rice husk, chemical additives, rheological properties, drilling fluid.

## I. INTRODUCTION

Drilling fluids are mostly used while drilling underground wells. They primarily serve the goal of controlling subsurface pressures in combination with density and numerous other additional pressures operating on the fluid column (annular or surface imposed). Water-based, oil-based, and synthetic-based drilling fluids are typically the three main classifications of drilling fluids utilized in a broader sense. Although oil-based drilling fluid has the inherent benefits of higher temperature stability, superior lubricity, and strong shale hydration inhibitive ability, its widespread use is constrained by its high cost and potential environmental harm. As a result, water-based drilling fluids are more commonly utilized than other drilling fluids due to their low cost, environmental friendliness, and ease of preparation. To retain the necessary qualities during drilling, water-based drilling fluid is primarily made of water, bentonite, polymers, salts, and other ingredients (Zhang *et al.*, 2021). As there is a greater need for energy, there is a greater demand for resource extraction methods that are both more affordable and environmentally acceptable. According to "Oil Field Review" (2012), the drilling process accounts for 80% of the drilling cost and drilling fluid development for 15% to 25%. Drilling move in a regular procession from vertical inclined, horizontal to subsea and deep-sea drilling. All these require adequate and specialized drilling fluid to fulfill the objective looking at the fact that higher the adverse condition the deeper the operations. However, drilling fluids needs to be prepared in such a way that they suit drilling process and reservoir conditions. These reservoir conditions include high bottom hole temperature, highly deviated wells; salts domes across permeable formation and most importantly water sensitive shale must be given special consideration as they compete with drilling operation. Drilling fluids are used to carry drilled solids from the bottom of the hole to the surface, suspend drilled solids and weighting materials when the mud is static, provide a thin impermeable cake to seal pores and other openings in the formation and thereby restrict the movement of fluids,

contain formation pressure, support the weight of casing and drill string, transmit hydraulic horse power to the bit, and assist with evaluation (Growcock & Harvey, 2005; Darley & Gray, 1988).

Drilling fluid selection and design are crucial to achieving all of these properties during drilling operations. A properly designed drilling fluid enables operators to reach the desired geological ore at a lower cost, with improved bit and drill string penetration, easier penetration, faster bit cooling, minimal hole damage, and easier transport of cuttings to the surface at the end of the drilling operation. However, the environmental impact of utilizing the fluid, the expense of the fluid, and the fluid's impact on production from the pay zone must all be taken into account when choosing the fluid (Bilal, 2016). This drilling fluid when in slurry form, they are termed drilling muds. They are made up of chemical components like weighting agent, fluid components like water or oil-water mixture in an emulsion and solid components such as clay, xanthan gum, rice husks which serve as viscosifier and fluid loss control additive.

With an annual consumption of 100,000 tons, this bentonite clay is used in a variety of industrial processes in Nigeria, including the formulation of drilling fluids, adsorbent, carrier material, adhesive, as support and clarifiers etc makes Nigeria a potential source for clay. However, on the other hand rice husk is one of the most available viscosifying agent considering the fact that the quantity of rice produced in Nigeria is about 1Mt/y (Ubwa *et al.*, 2014).

In order to develop and manage the rheological qualities of drilling fluid, materials like rice husks, polyacrylates, xanthan gums, and many other synthetic and natural polymers can be added. High temperatures can cause water-based drilling fluid to lose some of its qualities, which can have an impact on the viscosifying agents and reduce the fluid's velocity (Akinyemi & Alausa, 2020; Ismail *et al.*, 2014). Furthermore, any lack of the rheology of the drilling fluid can lead to inability to disperse solids within it such as the weighting agent or the drill cuttings. This can cause serious problems during drilling operations such as difficulty in removing cuttings, high fluid loss formations, reduction yield and high permeability to water. The use of Sodium hydroxide (NaOH), Sodium Chloride (NaCl), Sodium Carbonate ( $\text{Na}_2\text{CO}_3$ ), Xanthan gum, Rice husk and Bentonite Clay to improve the rheological properties such as viscosity etc. of water-based drilling fluids is paramount in a drilling process. Hence, this study focused on the developing and optimizing the drilling fluid with combination of Sodium hydroxide (NaOH), Sodium Chloride (NaCl), Sodium Carbonate ( $\text{Na}_2\text{CO}_3$ ), xanthan gum, Rice husk and Bentonite Clay. The structure of the rice husks can also be investigated to check the possibility of interaction with xanthan gum and other additives. Despite numerous researches on drilling fluid using different viscosifying agents and other additives to improve the performance of the drilling fluid, there is no single research that combines bentonite clay, rice husks and xanthan gum with other additives to develop drilling fluid. Previous researchers have studied the utilization of xanthan gum as well as rice husk as part of the components of water based drilling fluids (Akinyemi and Fatai 2022, Akinyemi and Lawal, 2022). However, it is well known that a properly designed drilling fluid enables operators to reach the desired. Thus, in this study the effects of addition of chemical additives to carefully selected drilling mud samples prepared in different compositions of bentonite, xanthan gum and rice husk were investigated.

## **II. MATERIALS AND METHOD**

### **2.1 Materials**

The bentonite sample was collected from Ashaka, Funakaye LGA in Gombe State. The Rice Husks was obtained from local rice mills in Kafur LGA Katsina state. The xanthan gum was obtained from Fluka Chemicals AG, Switzerland, while the NaOH, NaCl,  $\text{Na}_2\text{CO}_3$  and  $\text{BaSO}_4$  were analytical products of Central Drug House (CDH) India. The major equipment used for the study were Fann viscometer (FANN 35A), sieve and sieve shaker (Sieve-Tronic), Jaw crusher (DR 80B/4Q), Mud balance (LEUTERT), Homogeniser (L2R-3577), Ball Mill machine (Kera BV), weighing balance (METLAR MT-501).

### **2.2 Methods**

#### **2.2.1 Sample preparation**

The bentonite was surface dried for about one week to dry the moisture content of the clay, while the rice husk was surface dried for about 3 days to remove the moisture content. The dried recipe of the rice husk was later ground in to small size with jaw crusher and ball mill and sieve to an average of 120-125 microns to get the fine particles (Angaji *et al.*, 2013). The blends of the rice bentonite, rice husk and the xanthan gum were prepared into containers in accordance with specifications given in Table 1 to generate samples A to D; the blends were mixed thoroughly with

homogenizer and mixer to obtain a homogeneous mixture. A 350 ml of de-ionized water was poured in to each of the blends in the container and mixed for about 10 mins. These drilling mud samples were left for about 24hrs to age (Ahmed *et al.*, 2012).

Table 1: Drilling Fluid components specifications

| Sample | Bentonite (g) | Rice husk (g) | Xanthan gum (g) |
|--------|---------------|---------------|-----------------|
| A      | 24.5          | 0             | 5               |
| B      | 24.5          | 20            | 1               |
| C      | 24.5          | 10            | 2               |
| D      | 24.5          | 15            | 2               |

### 2.2.2 Determination of rheological properties of drilling mud samples

The rheological properties of the drilling mud samples A to D, which include plastic viscosity, yield point, Thixotropic property (gel strength) and shear stress-shear rate relations were determined using the FANN 35A viscometer as described by Akinyemi and Abdulhadi (2022). The drilling mud sample was poured in to the viscometer cup to the scribed mark and placed on the stand of the viscometer as it was lifted to immerse the rotating sleeve. The rotor speed of 300 and 600 rpm were used throughout the analysis (i.e. two point data approach) (Labe *et al.*, 2015). The plastic viscosity and yield point of the sample was measured using the readings from rotor sleeve speeds of 300 and 600 rpm. Furthermore, the gel strength of the sample was determined using FANN 35SA viscometer for 10 seconds and 10 minute gel strength. The formulated sample was poured into the sample holder and mounted to position and the base lifted until the drilling mud reach the scribe line and the lock screw tightened. The sample was subjected to shear at 600 rpm for 10 seconds and the gear was then set to neutral position. The motor was shut off and waited for 10 seconds and the deflection at 3 rpm was recorded as 10 seconds gel strength in lb/100 ft<sup>2</sup>. The procedure was repeated for the 10 minute gel strength (Hussaini *et al.*, 1983). Yield point was determined by computationally taking the difference between dial readings 300 rpm and plastic viscosity. The same procedure was repeated for samples B to D. To determine the impact of the chemical additives on the rheological properties of the drilling mud samples, the entire procedures were repeated for samples mixed with 3.5 g (1%), 7g (2%), 10.5 g (3%) of NaOH, as set 1, samples mixed with 3.5 g (1%), 7g (2%), 10.5 g (3%) of NaCl as set two, the samples mixed with 3.5 g (1%), 7g (2%), 10.5 g (3%) of Na<sub>2</sub>CO<sub>3</sub> as set 3 and the samples with 17.5g (5%), 35g (10%), 52.5 g (15%) of BaSO<sub>4</sub> additive separately as set 4. The whole procedures were carried out the temperature of 30°C.

### 2.2.3 Determination of Mud Density

The mud density of the drilling mud was determined using mud balance as described by Akinyemi and Abdulhadi (2023). The base of the mud balance was set down on a level, flat surface while the sample to be tested was placed within the balancing cup to the top, and the lid was then secured by slowly turning it until it was properly seated. In order to rid the sample of any entrained air or gas, such in the test sample is forced out through the vent hole in the lid (Caenn *et al.*, 2011). By moving the rider along the balancing arm after the knife edge of the arm had been inserted into the fulcrum, the assembly was balanced. Anytime the level bubbles move an equal distance to either side of the center, the mud balance is horizontal (Bourgoyne *et al.*, 1991). The rider's side closest to the balancing cup was used to read the sample's weight; the measurement reading corresponds to the sample's specific gravity. The same procedure was repeated for all the four samples with and without the chemical additives.

### 2.2.4 Determination of pH value

The drilling mud's pH value indicates whether it is acidic or alkaline (Afolabi *et al.*, 2017). The pH of the drilling mud samples were measured using the pH meter, which is immersed in deionized water to standardize the meter before being filled with the mud sample in a beaker. Afterwards, the meter's probe was put into the mud sample, and the meter's stable pH reading was recorded (Zhang, 2016). The same procedure was repeated for all the four samples with and without the chemical additives and results recorded.

III. RESULTS

3.1 The pH and other basic Properties of the four pure samples

The pH and other basic properties of the four drilling fluid samples A, B, C and D at 30°C are shown in Table 2. Sample A has the highest pH of 9.1 while sample D has the least pH value of 8.7. Since samples B and C have the pH of 8.8 each, all the samples can be said to be alkaline. The Gel strength of sample A was the highest among the four samples for both 10 seconds and 10 minutes range; it was 34.2 lbf/100 ft<sup>2</sup> for 10 seconds and 36.8 lbf/100 ft<sup>2</sup> for 10 minutes. Sample B had the lowest Gel strength for both 10 seconds and 10 minutes range, having 2.3 lbf/100 ft<sup>2</sup> for 10 seconds and 2.8 lbf/100 ft<sup>2</sup> for 10 minutes. The 51.3 cP apparent viscosity and 16.0 cP plastic viscosity of sample A were the highest in each case for all the samples considered. From the results, the Gel strengths and viscosities of the pure samples increased in the order of sample B > sample D > sample C > sample A. The yield point of Sample A (70.5 lbf/100 ft<sup>2</sup>) was the highest followed by that of sample D (26.5 lbf/100 ft<sup>2</sup>). The plastic viscosity expresses the fluid resistance to flow due to mechanical friction (Kassim, 2016).

Table 2 The Basic characteristic properties of Samples A to D at 30°C

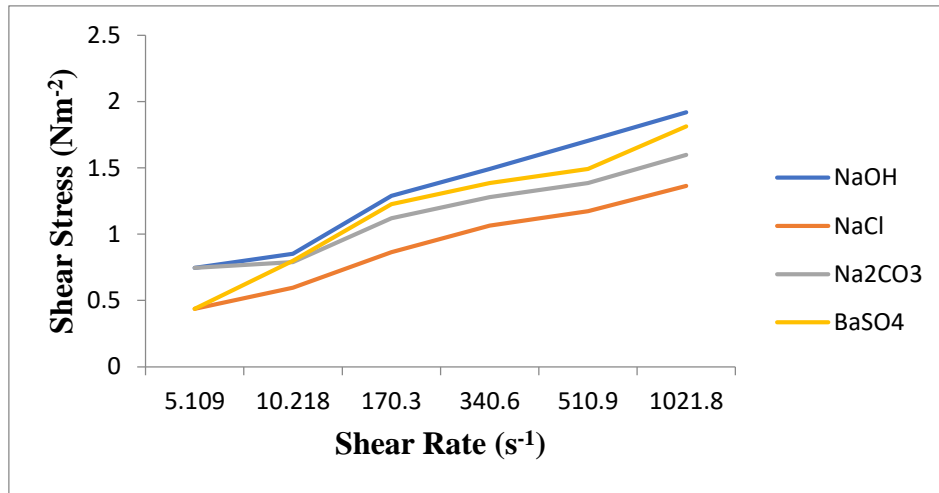
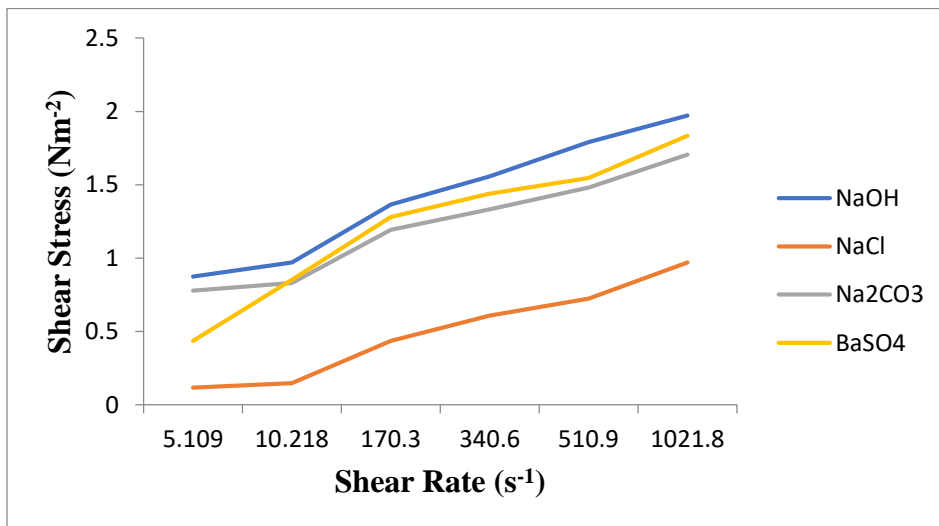
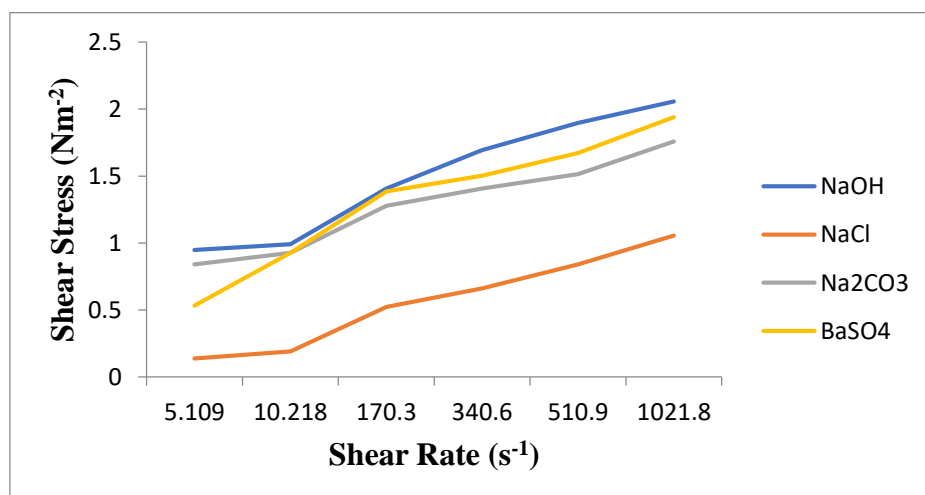
| Property                               | Sample 8 (A) | Sample 12 (B) | Sample 14 (C) | Sample 15 (D) |
|--|--------------|---------------|---------------|---------------|
| Ph                                     | 9.1          | 8.8           | 8.8           | 8.7           |
| GS 10 (sec) (lbf/100 ft <sup>2</sup> ) | 34.2         | 2.3           | 10.6          | 10.2          |
| GS 10 (min) (lbf/100 ft <sup>2</sup> ) | 36.8         | 2.8           | 12.1          | 11.3          |
| AV (cP) @ 30° C                        | 51.3         | 13.0          | 24.6          | 24.1          |
| PV (cP) @ 30°C                         | 16.0         | 5.0           | 12.1          | 10.8          |
| YP (lbf/100 ft <sup>2</sup> ) @ 30°C   | 70.5         | 16.0          | 25.0          | 26.5          |
| YP/PV                                  | 4.41         | 3.20          | 2.07          | 2.45          |
| MW                                     | 9.1          | 10.0          | 9.8           | 9.8           |

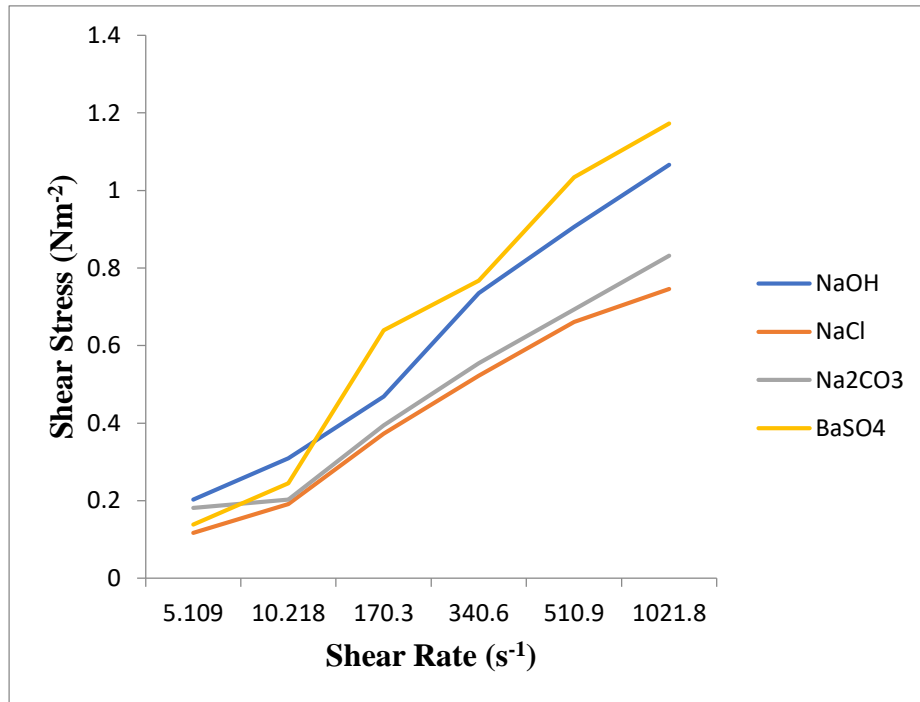
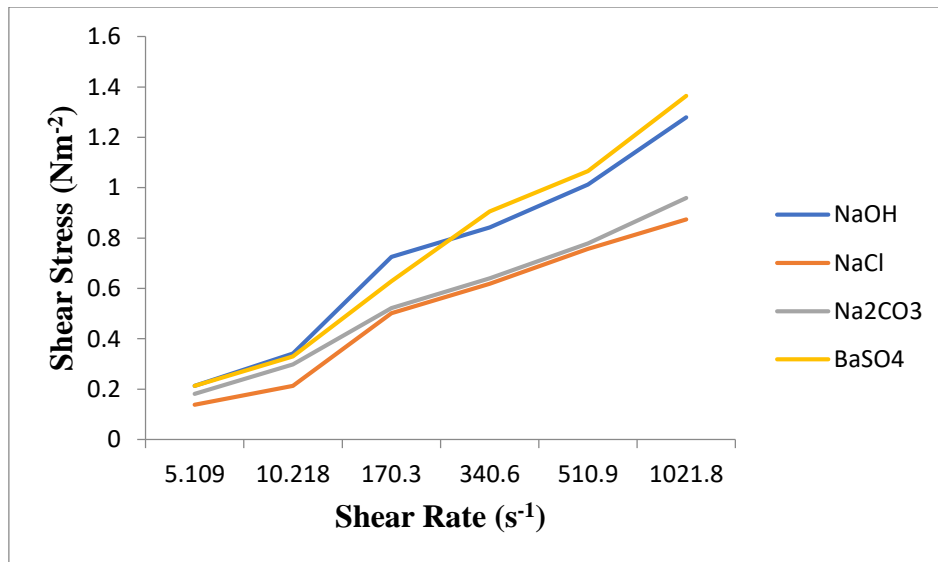
3.2 Rheological properties of samples with additives in different proportions

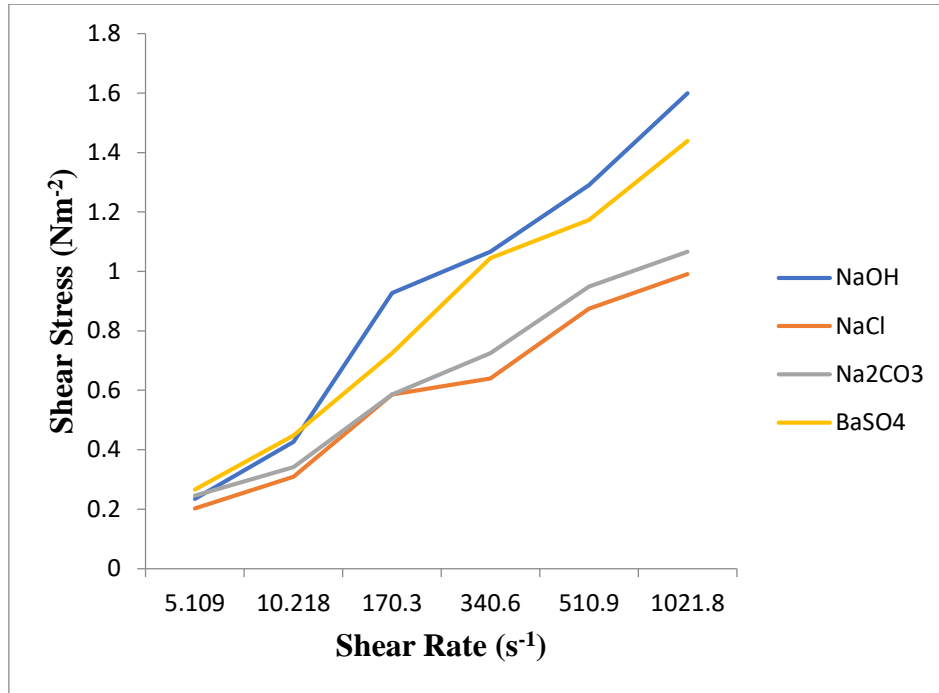
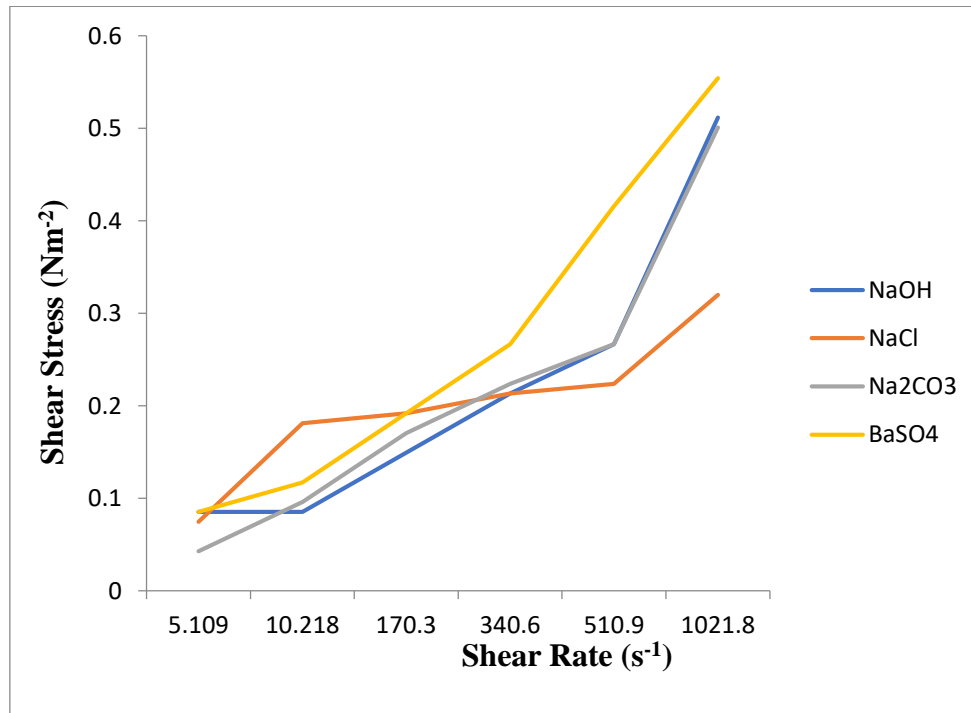
The shear stress values of the samples A, B, C and D after introducing the additives showed increasing trends with increase in shear rate (Chilling Arian & Vorabutr, 1981). In all the four cases considered for sample A, NaOH additive exhibited the highest shear stress-shear rate relationship thus displayed highest viscosity (Figures 1 to 3). BaSO<sub>4</sub> additive exhibited second best viscosity at 17.5g composition through to 52.5g composition in sample A (Figures 1 to 3) while NaCl displayed the least impact in shear stress-shear rate relationship of sample A throughout the increment in additives considered (Figures 1 -3).

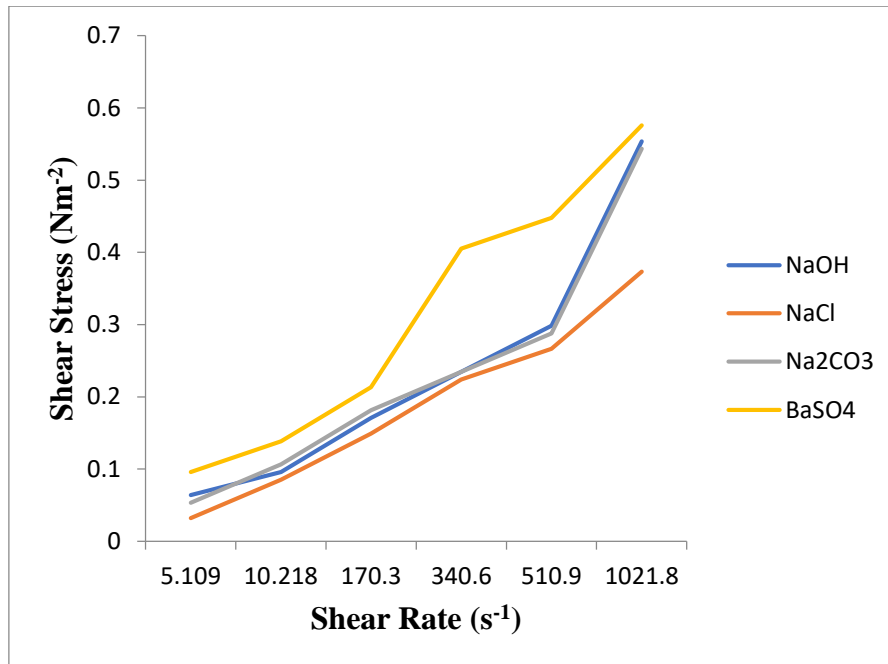
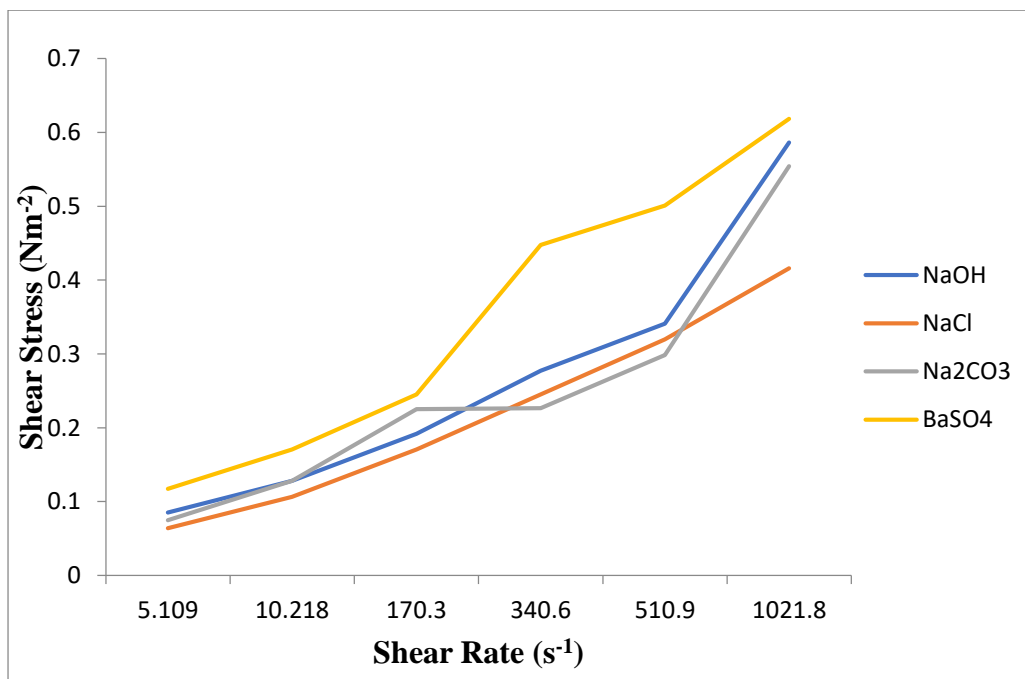
For sample B, BaSO<sub>4</sub> exhibited the highest shear stress-shear rate relationship thus having highest viscosity on addition of 17.5 g and 35 g but became second best on impact of the viscosity of the sample B with addition of 52.5g (Figures 4 to 6). NaCl remained the least effect on the viscosity of sample B (Figures 4 to 6). NaOH, though was the second best with addition of 3.5 g and 7g to sample B but displayed highest impact on the viscosity of sample B with addition of 10.5 g (Figures 4 to 6). BaSO<sub>4</sub> still exhibited the best impact on the viscosity of sample C throughout the compositions of 17.5 g to 52.5 g considered while NaCl displayed the least impact (Figures 7 to 9). However, Na<sub>2</sub>CO<sub>3</sub> displayed a second best impact on sample C at addition of 3.5 g but was taken over by NaOH at 7 g and 10.5 g addition to sample C (Figures 7 to 9).

For sample D, BaSO<sub>4</sub> exhibited the best impact on the shear stress-shear rate relationship (viscosity) of sample D throughout the compositions of 17.5 g to 52.5 g considered while NaCl displayed the least impact throughout the 3.5 g to 10.5 g compositions considered (Figures 10 to 12). However, NaOH and Na<sub>2</sub>CO<sub>3</sub> displayed approximately similar impact on sample D at addition of 3.5 g to 10.5 g addition to sample D (Figures 10 to 12). This trend is in agreement with the findings of other previous researchers (Amer and Abu, 2007; Udoh and Okon, 2012).

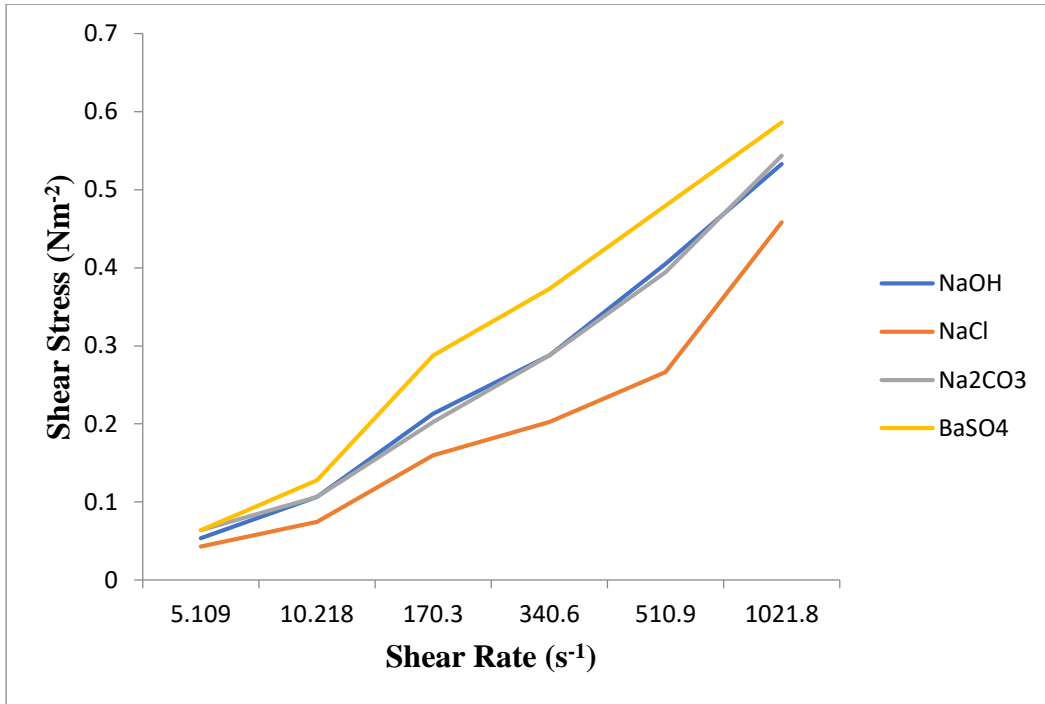
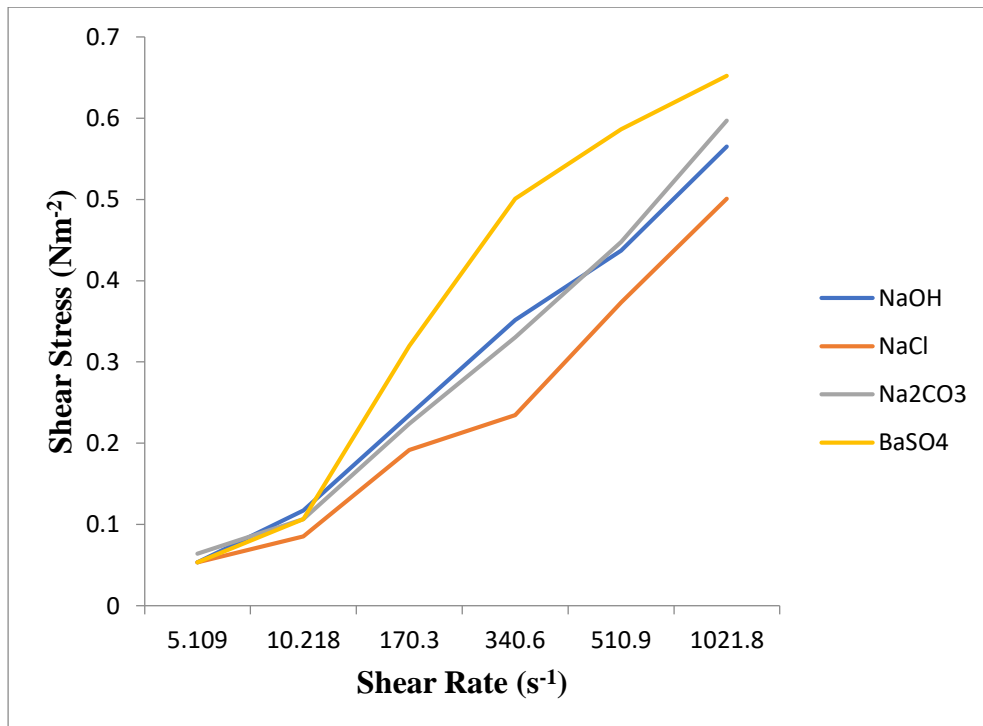
Figure 1: Sample A with 3.5g each of (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 17.5g of BaSO<sub>4</sub> at 30°CFigure 2: Sample A with 7g each of (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 35g of BaSO<sub>4</sub> at 30°CFigure 3: Sample A with 10.5g each of (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 52.5g of BaSO<sub>4</sub> at 30°C

Figure 4: Sample B with 3.5g each of (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 17.5g of BaSO<sub>4</sub> at 30°CFigure 5: Sample B with 7g each of (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 35g of BaSO<sub>4</sub> at 30°C

Figure 6: Sample B with 10.5g each of (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 52.5g of BaSO<sub>4</sub> at 30°CFigure 7: Sample C with 3.5g each of (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 17.5g of BaSO<sub>4</sub> at 30°C

Figure 8: Sample C with 7g each of (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 35g of BaSO<sub>4</sub> at 30°CFigure 9: Sample C with 10.5g each of (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 52.5g of BaSO<sub>4</sub> at 30°C



Figure 10: Sample D with 3.5g each of (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 17.5g of BaSO<sub>4</sub> at 30°CFigure 11: Sample D with 7g each of (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 35g of BaSO<sub>4</sub> at 30°C

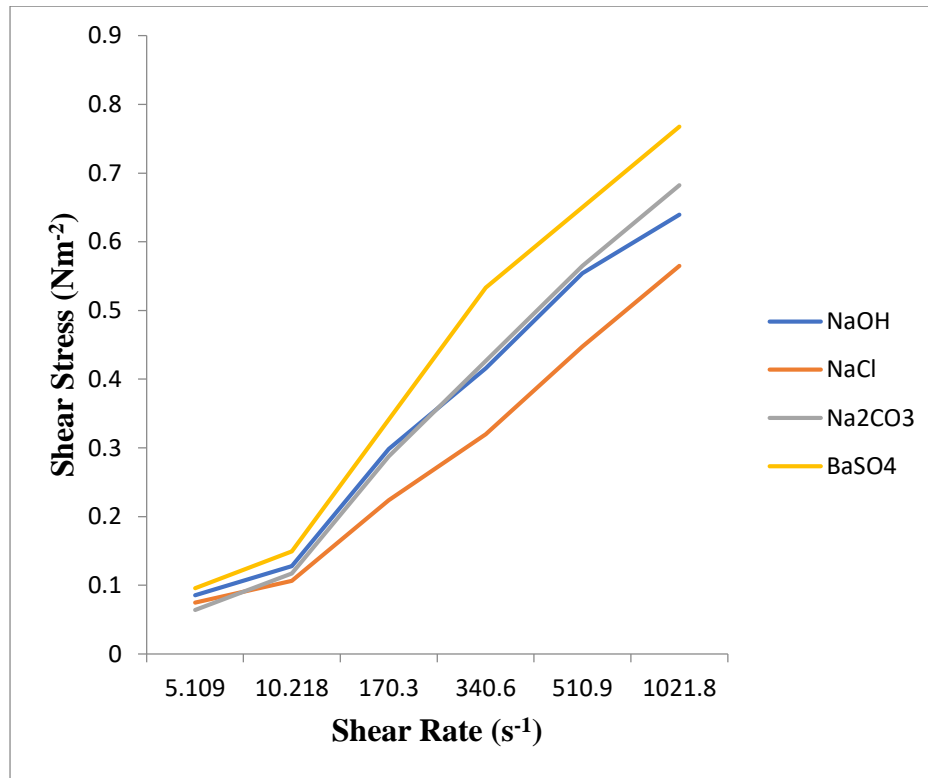


Figure 12: Sample D with 10.5g each of (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) and 52.5g of BaSO<sub>4</sub> at 30°C

### 3.3 Impacts of Additives on Gel strength of samples

The Gel strength of the samples were affected by the addition of the chemical additives both after 10 seconds and 10 minutes. However,, it was observed the differences in the impact at 10 seconds were not difference in most cases when the gel strength were taken after 10 minutes. From Figure 13, sample A displayed the highest gel strength after 10 seconds compared to other samples for all the chemical additives added when NaOH, NaCl, and Na<sub>2</sub>CO<sub>3</sub> were 3.5g addition each while BaSO<sub>4</sub> was 17.5g of at 30°C. The value of the sample A for instance increased from 34.2 (lbf/100 ft<sup>2</sup>) to 140 (lbf/100 ft<sup>2</sup>) for NaOH, to 120 (lbf/100 ft<sup>2</sup>) and 130 (lbf/100 ft<sup>2</sup>) for addition of 3.5g chemical additive while BaSO<sub>4</sub> increased to 153 (lbf/100 ft<sup>2</sup>) at addition of 17.5 g chemical additive. Sample C displayed the least increment in gel strength on addition of the four chemical additives at 30°C (Figure 13). It was observed sample B displayed second highest increment in gel strength following the same trend with that of sample A for the four chemical additive used. Addition of 3.5g of NaOH to sample B increased it gel strength from 2.3 (lbf/100 ft<sup>2</sup>) to 96 (lbf/100 ft<sup>2</sup>) for NaOH, to 68 (lbf/100 ft<sup>2</sup>) and 74 (lbf/100 ft<sup>2</sup>) for addition of 3.5g chemical additive while BaSO<sub>4</sub> increased to 110 (lbf/100 ft<sup>2</sup>) at addition of 17.5 g chemical additive.

Thus, it could be noted that the NaCl had lowest impact on the gel strength of the drilling fluid samples A to D while BaSO<sub>4</sub> had highest impact on the gel strength of all the samples tested. From Figure 14, it was observed that sample A still displayed the highest gel strength after 10 seconds compared to other samples for all the chemical additives added when NaOH, NaCl, and Na<sub>2</sub>CO<sub>3</sub> were 7 g addition each while BaSO<sub>4</sub> was 35 g of at 30°C. The trend of increment in gel strength followed the one displayed in Figure 13 for all the drilling fluid samples with the addition of the chemical additives considered. It was however, observed that the 7 g NaOH increased the gel strength more than the 3.5g NaOH while addition of 7g NaCl did not increase the gel strength as when 3.5g of the chemical was added to the drilling fluid samples. The increment of the gel strength of sample A by addition of 35 g BaSO<sub>4</sub> (154 (lbf/100 ft<sup>2</sup>)) was almost the same as that of addition of 17.5 g BaSO<sub>4</sub> (153 lbf/100 ft<sup>2</sup>), while the increment of the gel strength for the samples at 7g Na<sub>2</sub>CO<sub>3</sub> addition was higher than that at 3.5g for each of the sample tested. This trend was also displayed by the other three samples. Furthermore, Figure 15 revealed that further addition of the chemical additive at 30°C, to all the samples increased their gel strength the more, following the same trend as in Figures 13 and 14.

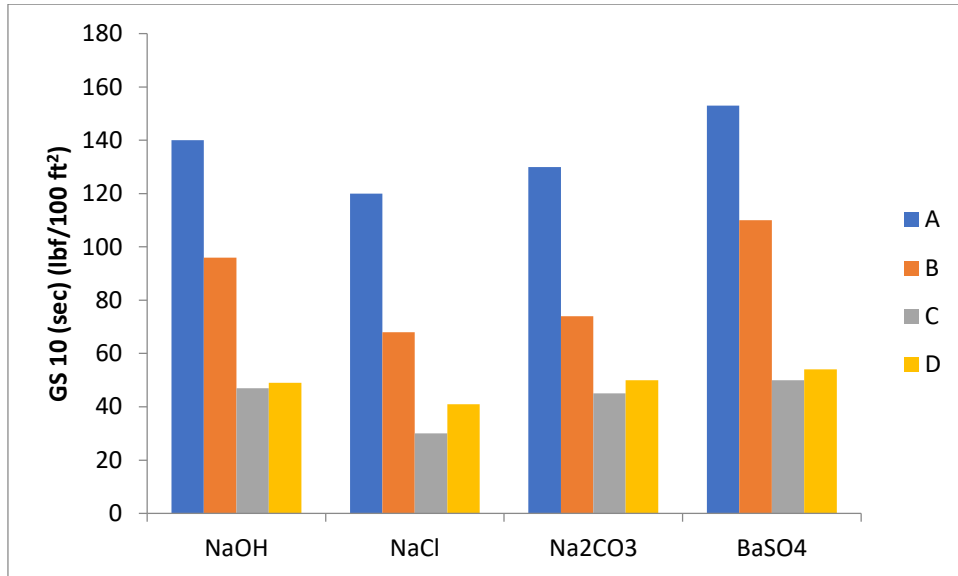


Figure 13. Gel strength of samples A to D at 10seconds for samples with 3.5g each of NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub> and 17.5g of BaSO<sub>4</sub> at 30°C

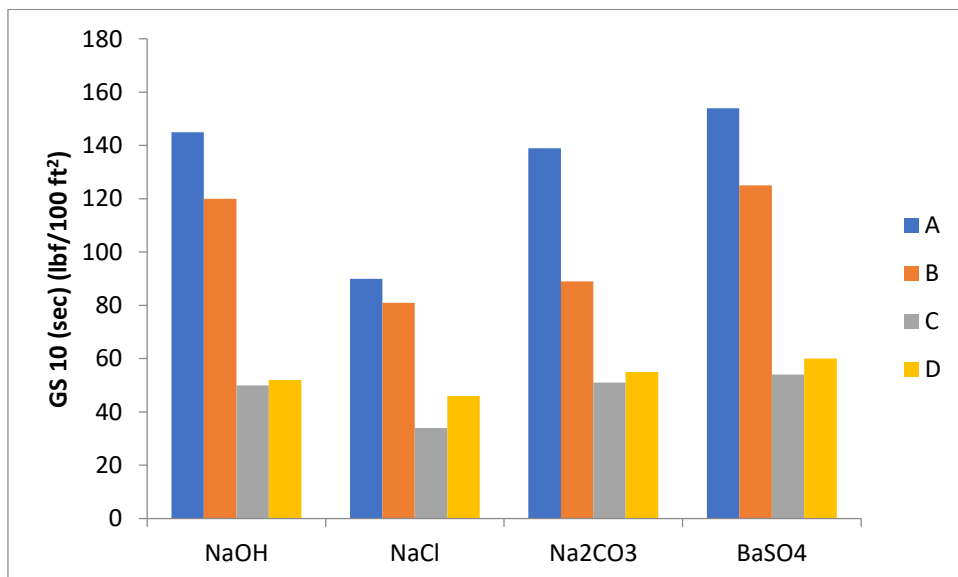


Figure 14. Gel strength of samples A to D at 10seconds for samples with 7g each of NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub> and 35g of BaSO<sub>4</sub> at 30°C

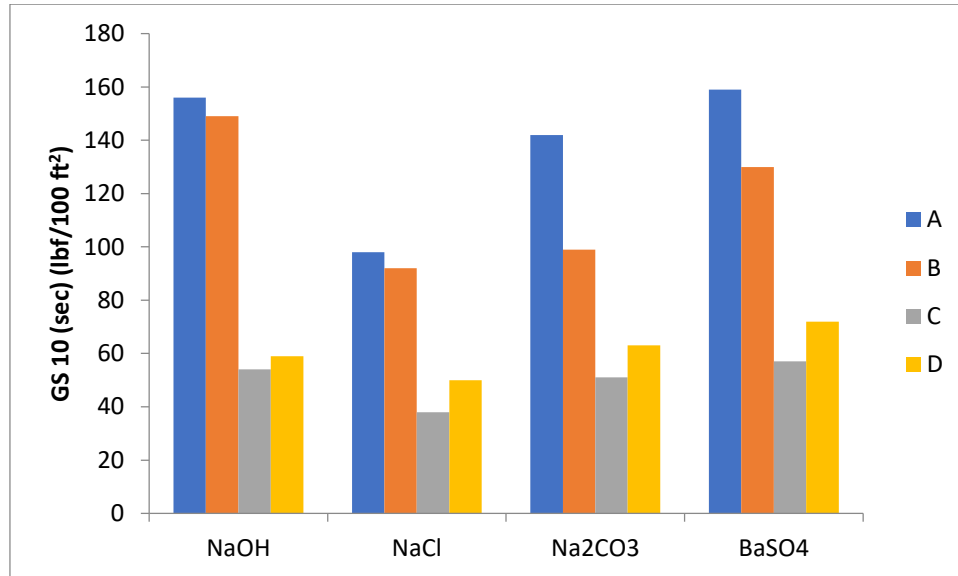


Figure 15. Gel strength of samples A to D at 10seconds for samples with 10.5g each of NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub> and 52.5g of BaSO<sub>4</sub> at 30°C

### 3.4 Impacts on Yield point and plastic viscosity of samples

The yield point and plastic viscosity ratio (YP/PV) of all the samples were affected by all the chemical additives. For sample A, as shown in Figure 16, 3.5 g of NaOH increased its YP/PV ratio than all other drilling fluid samples. Also, 3.5g Na<sub>2</sub>CO<sub>3</sub> increased YP/PV ratio of sample A more than the other samples. From Figure 16, it was further observed sample B displayed the highest YP/PV ratio when 3.5g of NaCl and 17.5g BaSO<sub>4</sub> were added to it separately when compared with the other three samples. The increment in the YP/PV ratio may be indication that addition of the chemical additives to samples A, B and D will improve the carrying capacity of the samples (Allawi et al., 20219).

It was observed addition of any of the chemical additive reduced the YP/PV ratio of sample C, which is an indication that the composition of the sample C with the additives in the proportions considered may not have good carrying capacity at this temperature of 30°C and therefore not having best hole cleaning ability (Allawi et al., 20219). From Figure 17, sample A displayed the highest YP/PV ratio for all the chemical additives added except for NaCl where sample B displayed the highest YP/PV ratio for addition of 7 g (NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub>) additives and 35 g BaSO<sub>4</sub> additive.

At this concentration samples C and D displayed decrement in YP/PV ratio, sample A displayed increment in YP.PV ratios for NaOH and Na<sub>2</sub>CO<sub>3</sub> only while sample B displayed increment in YP/PV ratio in NaCl and NaCO<sub>3</sub> additives only (Figure 17 and Table 2). It was revealed by Figure 18 that sample A displayed highest YP/PV ratios for NaOH and Ba SO<sub>4</sub> while sample B displayed the highest YP/PV ratio for NaCl and NaCO<sub>3</sub>. Sample A showed increment in YP/PV ratio for all the chemical additives except for NaCl while sample showed increment of YP/PV ratio for only NaCl and NaCO<sub>3</sub> additives. Sample C showed increment in YP/PV for NaCl and BaSO<sub>4</sub> while sample D showed increment in YP/PV ratio for all the chemical additives which implies that sample D may have good carrying capacity in this concentration of chemical additives at 30°C.

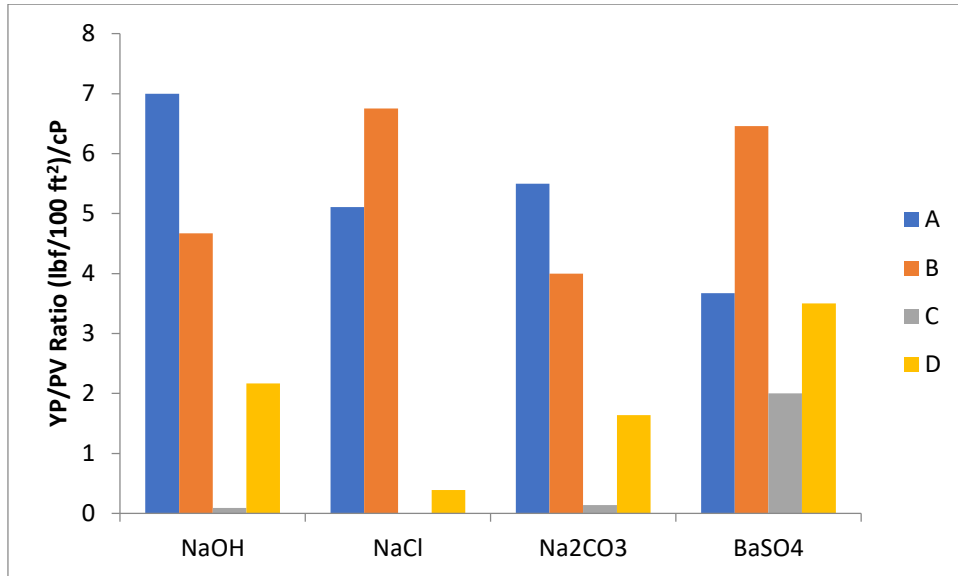


Figure 16. Yield point and Plastic viscosity ratio of samples A to D for samples with 3.5g each of NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub> and 17.5g of BaSO<sub>4</sub> at 30°C

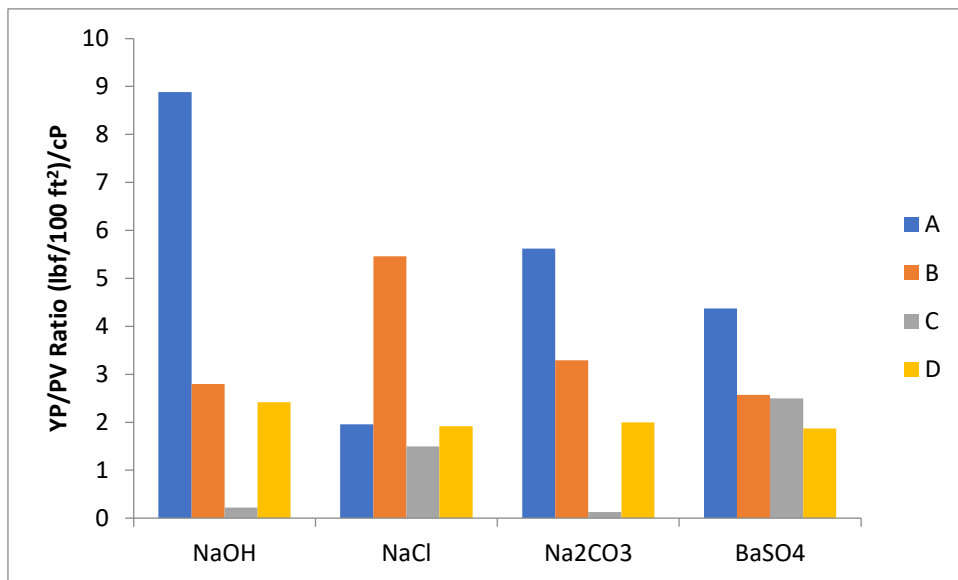


Figure 17. Yield point and Plastic viscosity ratio of samples A to D for samples with 7 g each of NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub> and 35g of BaSO<sub>4</sub> at 30°C

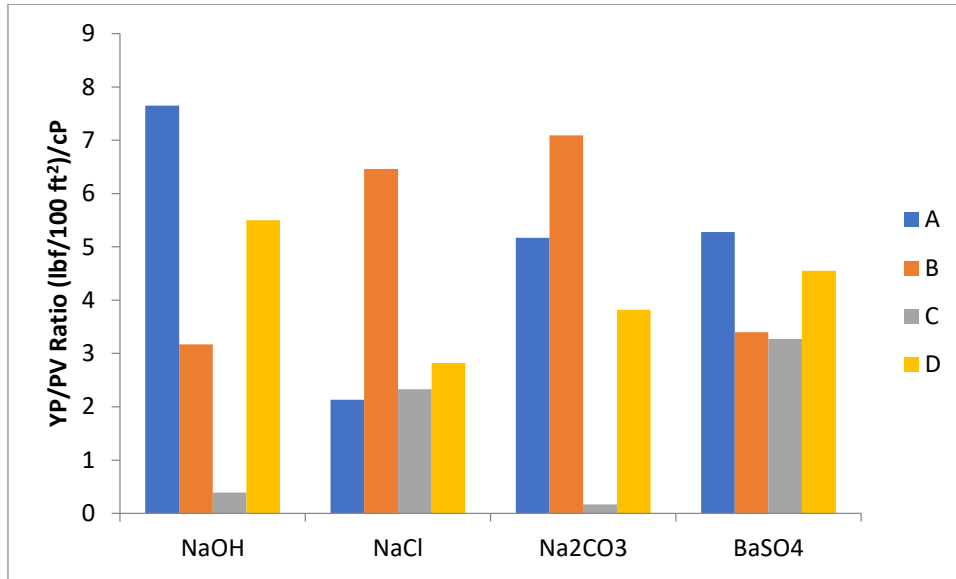


Figure 18. Yield point and Plastic viscosity ratio of samples A to D for samples with 10.5 g each of NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub> and 52.5g of BaSO<sub>4</sub> at 30°C

### 3.5 Impacts on pH of Samples

The comparison of the impact of the chemical additives on the pH of the samples revealed that pH of all the samples remained in the alkaline region when 3.5 g of NaOH, 3.5g NaCl, 3.5g Na<sub>2</sub>CO<sub>3</sub> and 17.5 g BaSO<sub>4</sub> were added to them separately at 30°C with sample the having pH that is closest to neutral during the addition of 3.5 g NaCl (Figure 19). Sample A exhibited the highest pH value of 9.5 with 3.5g NaOH additive at 30°C (Figure 19). It was observed from the Figure 20 that the samples the same trend of pH values when 7g of NaOH, 7g of NaCl, 7g of Na<sub>2</sub>CO<sub>3</sub> and 35g of BaSO<sub>4</sub> were added separately at 30°C. It was observed further addition of NaOH tend to make all the samples more alkaline with sample A still maintaining the lead with pH of 11.5 for 10.5 g NaOH addition (Figure 21). Further addition of NaCl tends to make the samples more neutral in pH. Therefore it couldbe inferred that addition of the chemical additives will not make any of the samples acidic in any serious way. This is good for injection facilities to be used to introduce the drilling fluid into the drilling system.

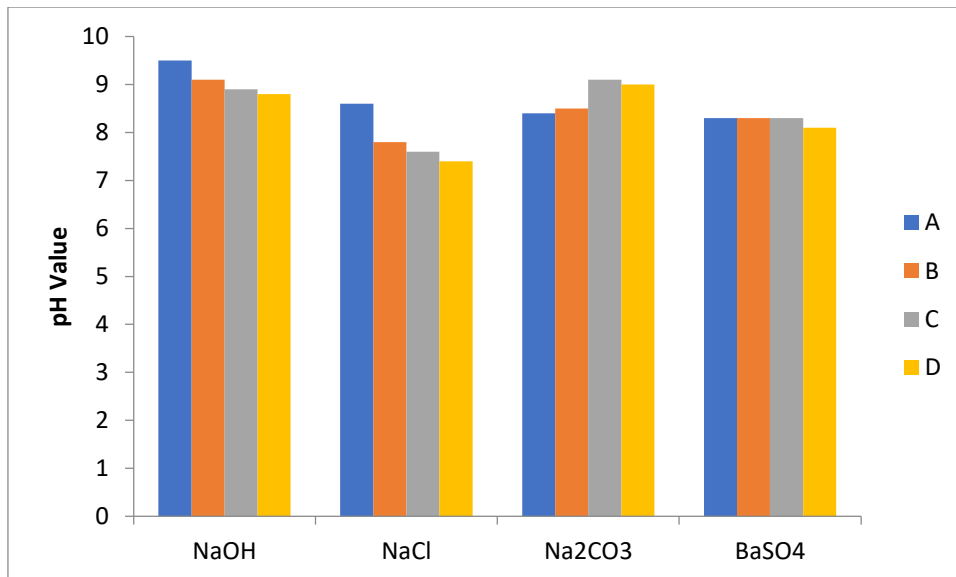


Figure 19. pH of samples A to D for samples with 3.5 g each of NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub> and 17.5g of BaSO<sub>4</sub> at 30°C

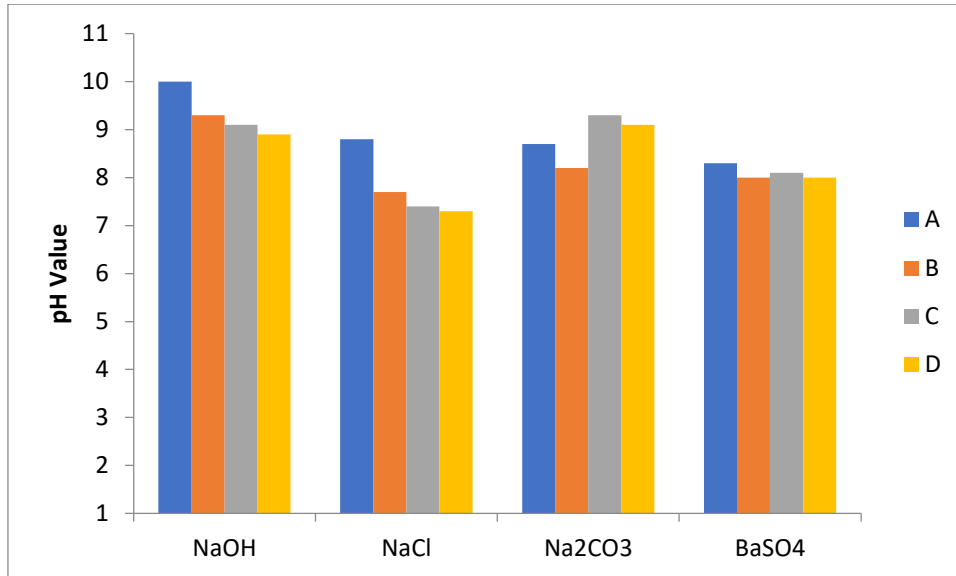


Figure 20. pH of samples A to D for samples with 7 g each of NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub> and 35g of BaSO<sub>4</sub> at 30°C

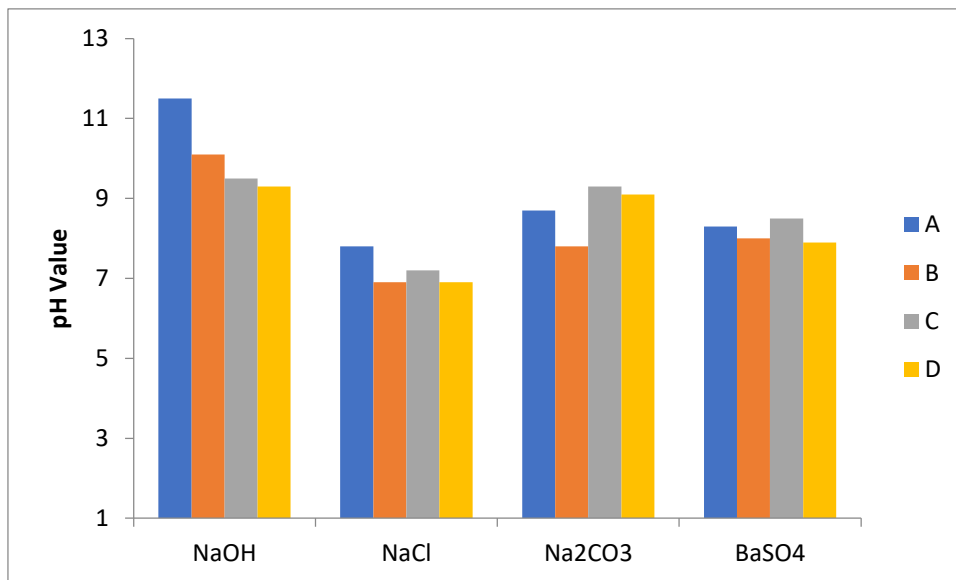


Figure 21. pH of samples A to D for samples with 10.5 g each of NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub> and 52.5 g of BaSO<sub>4</sub> at 30°C

#### IV. CONCLUSION

Four samples of drilling fluid containing bentonite, rice husk and xanthan gum in different proportion were investigated to know the impact of the additives like NaOH, NaCl, Na<sub>2</sub>CO<sub>3</sub> and BaSO<sub>4</sub> on the rheological properties and pH at 30°C. It could be concluded from the results obtained that the chemical additives had positive impacts on the rheological properties of the drilling fluid samples. Sample A with xanthan gum and bentonite only had most improved viscosity when the chemical additives were added followed by sample B with bentonite (24.5g), rice husk (20g) and xanthan gum (1g). Also, the Gel strength of the samples could be increased by the addition of any of the chemical additives, samples A and B still had more improvement than the other two samples. The carrying capacity of the drilling fluid samples could be increased by the addition of NaOH, NaCl and BaSO<sub>4</sub> based on the results obtained in this study on yield point and plastic viscosity (YP/PV ratio values).

The pH of all the samples were alkaline close to neutral when moderate quantity of NaOH and any quantity of other chemicals are added to them. Thus, it could be concluded that drilling fluid with 20g rice husk and 1 g xanthan gum and standard 24.5g bentonite proportion could be improved upon with the addition of any of the chemical additives in appropriate quantity for effective performance in drilling operations.

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