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Comparative Study of Impact of Aluminium and Titanium Oxides Nanoparticles on Viscosity of Water Based Drilling Fluid

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ABSTRACT: *Drilling fluid has a lot of importance and application in the oil drilling process which includes the removing of cuttings and prevention of fluid transfer to and from the rock strata. With the addition of nanoparticles it is possible to facilitate in-situ control of the drilling fluid rheology, increasing the hydraulic efficiency of drilling campaigns and reducing costs in a variety of reservoir environments. This study was aimed at investigating how water based drilling fluid (WBDF) rheological property can be improved using Aluminum oxide and Titanium oxide nanoparticles. To achieve this aim, ten laboratory samples of drilling fluids each in different proportion of additives and nanoparticles were prepared and analyzed. The WBDF samples were prepared using the standard laboratory barrel (350 ml) method. Different proportions of Xanthan gum, Aluminum oxide and Titanium oxide were used. Brookfield rotational viscometer was used to determine the rheological properties of the samples. Also, the structural analysis of the interaction between the nanoparticles and the xanthan gum were determined using Fourier Transformation Infra-red (FTIR) spectroscopy. From the results obtained, it can be concluded that aluminum and titanium oxide nanoparticle improved the rheological properties of the water based drilling fluid. In conclusion, the introduction of Aluminum oxide and Titanium oxide nanoparticles improved the rheological performance of water based drilling fluids with xanthan gum additive.*

Keywords: *WBDF, xanthan, Al_2O_3, TiO_2, Nanoparticles*

I. INTRODUCTION

Drilling fluid, often referred to as drilling mud, is more or less one of the most crucial parts of any earth excavation. It is an assortment of fluid, basically a mixture of clay, water, minerals and additives. Drilling fluid is pumped through the drill string and continuously introduced to the bottom as it squirts out from the drill nozzles. It provides several functions, some of which includes; removal of the drilled cuttings, lubrication and cooling of the drill bit, controls subsurface pressures, stabilize the exposed rock, provides buoyancy and prevents the contamination of the subsurface formation hydrocarbon fluids. Water-based drilling fluids are among the most popular drilling fluids; thanks in part to their reputation as easy to maintain, economically competitive drilling fluids (Majid and Younis, 2018). Recently, considerable attention has been paid to using nanoparticles to improve the performance of water based drilling fluids. Sadeghalvaad and Sabbaghi (2015) examined the effect of the TiO_2/polyacrylamide (PAM) nanocomposite on water-based drilling fluid properties. They found that the nano-enhanced water based drilling fluids increased the rheological properties such as plastic viscosity and yield point. Furthermore, the shear thinning behavior was increased by increasing the concentration of the additive. They performed also SEM analysis of the pure PAM and the TiO_2/PAM nanocomposite and the SEM images showed that the surface of the pure PAM sample was smooth. The comparison of these two images revealed that the TiO_2 grains appeared on the surface and inside of the PAM. Alizadeh et al. (2015) explored the rheological behavior of a drilling fluid containing alumina/polyacrylamide nanocomposite. The synthetic nanocomposite was synthesized through solution polymerization method. They noticed that addition of 4% of the nanocomposite increased the viscosity of the drilling fluid up to more than 300 cP for both fresh and salt water based mud. Furthermore, they showed that the nanocomposite tested was able to decrease the thixotropy of the produced drilling fluid. Amarfio and Abdulkadir (2016) explored the effect of Al_2O_3 NP on the rheological properties of water-based mud. They showed that Al_2O_3 NP provided thermal stabilization for the drilling fluid under high temperature conditions and that the Al_2O_3 NP were able to maintain the shear stresses of the fluid as temperature **increases. A** number of other researchers also investigated impact of nanoparticles on drilling fluid in various other capacities (Sayyadnejad et al., 2008; Amanullah, and Al-Tahini, 2009; Agarwal et al, 2011; Sabori et al., 2012; Kosynkin et al., 2012; Hoelscher, 2012; Ismail et al., 2016; Salih et al., 2016). Water based drilling fluid often contains viscosifying agents such as starches, polyacrylates, xanthan gums and a wide variety of synthetic and natural polymers to establish and control the rheological properties of drilling fluid. If there is a breakdown in the rheology of the drilling fluid will be unable to suspend solid dispersed within it such as the weighting or bridging agent or even the drill cuttings which can lead to severe problems such as settlement, loss in fluid density and possibly a blowout of the well. Since drilling fluid must have the correct heat transfer and fluid flow characteristics to work effectively, the use of aluminium oxide and Titanium oxide nanoparticles to improve the rheological properties such as viscosity etc. of water-based drilling fluids is essential in a drilling process. Application of nanoparticles to formulate high performance drilling fluids has the potential to overcome current as well as future technical challenges encountered by the drilling industry (Vryzas and Kelessidis, 2017). Hence, in this study, the impact of combination of xanthan gum and nano particles of aluminium oxide and titanium oxide in different ratio on viscosities of WBDFs were investigated. Also, Fourier transform infra-red (FTIR) analysis was used to investigate the interactions of the structures of the nanopartices with the xanthan gum in different proportions.

II. MATERIAL AND METHODS

2.1. Materials

The materials used were analytical grade and of high purity. The bentonite clay used was obtained from standard Nigerian chemicals organization. Xanthan gum, Aluminium oxide and Titanium oxide nanoparticles are products of Sigma-Aldrich. The major pieces of equipment used were Brook-field rotational viscometer (Ndj-8S) and Fourier Transform Infra-red (FTIR) spectrometer (Agilent; range: 4000-650 cm^{-1}).

1.2. Sample preparation

2.2.1 Sample one

The first water based drilling fluid sample was prepared with water and bentonite clay. 350 **ml** of water was measured using a measuring cylinder and was put in a 500 **ml** beaker. 15 grams of Bentonite clay was weighed using weigh balance and was poured into the beaker containing 350 **ml** of water. A magnetic stirrer was used to mix the 15 **g** of bentonite clay and 350 **ml** of water for 10 **mins**.

2.2.2 Sample two

The second water based drilling fluid prepared sample was made up of water, bentonite clay and xanthan gum. A measuring cylinder was used to measure 350 **ml** of water. 15 **g** of bentonite clay was weighed using weigh balance. Different proportions of xanthan gum were used for this experiment.

a) 350 **ml** of water and 15 **g** of bentonite clay was stirred for 10 minutes in a beaker using a magnetic stirrer. 1 **g** of xanthan gum was added and mixed thoroughly for 15 minutes using a magnetic stirrer.
b) A solution containing a thoroughly mixed 350 **ml** of water and 15 **g** of bentonite clay using a magnetic stirrer was prepared. 1.5 **g** of xanthan gum was mixed thoroughly with the solution for 15mins using a magnetic stirrer.
c) 2 **g** of xanthan gum was weighed using a weigh balance. A solution of 350 **ml** water and 15 **g** bentonite clay mixed thoroughly for 10 **mins** was prepared in a beaker. 2 **g** of xanthan gum was mixed with the solution for 15mins using a magnetic stirrer.

2.2.3 Sample three

The third water based drilling fluid sample was made up of water, bentonite clay, xanthan gum and aluminium oxide nanoparticle. 350 ml of water was measured using a measuring cylinder and was put into a beaker. 15 **g** of bentonite clay was measured using weigh balance. Different proportions of xanthan gum and aluminium oxide were used for this experiment.

a) 350 **ml** of tap water was mixed with 15 **g** of bentonite clay in water in a beaker. This solution was mixed for 20 minutes. 1 **g** of xanthan was weighed and added to the solution, it was mixed for 20 minutes. 1 **g** of aluminium oxide was weighed, added to the solution and mixed thoroughly for 20 minutes.

b) 350 **ml** of tap water was mixed with 15 **g** of bentonite clay in water in a beaker. This solution was mixed for 20 minutes. 1.5 **g** of xanthan was weighed and added to the solution, it was mixed for 20 minutes. 0.5 **g** of aluminium oxide was weighed, added to the solution and mixed thoroughly for 20 minutes.

c) 350 **ml** of tap water was mixed with 15 **g** of bentonite clay in water in a beaker. This solution was mixed for 20 minutes. 0.5 **g** of xanthan was weighed and added to the solution, it was mixed for 20 minutes. 1.5 **g** of aluminium oxide was weighed, added to the solution and mixed thoroughly for 20 minutes.

2.2.4 Sample four

The fourth water based drilling fluid sample was made up of water, bentonite clay, xanthan gum and titanium oxide nanoparticle. A measuring cylinder was used to measure 350 **ml** of water. 15 **g** of bentonite clay was weighed using weigh balance. Different proportions of xanthan gum and titanium Oxide were used for this experiment.

a) 350 **ml** of tap water was mixed with 15 **g** of bentonite clay in water in a beaker. This solution was mixed for 20 minutes. 1 **g** of xanthan was weighed and added to the solution, it was mixed for 20 minutes. 1 **g** of titanium Oxide was weighed, added to the solution and mixed thoroughly for 20 minutes.

b) 350 **ml** of tap water was mixed with 15 **g** of bentonite clay in water in a beaker. This solution was mixed for 20 minutes. 1.5 **g** of xanthan was weighed and added to the solution, it was mixed for 20 minutes. 0.5 **g** of titanium Oxide was weighed, added to the solution and mixed thoroughly for 20 minutes.

c) 350 **ml** of tap water was mixed with 15 **g** of bentonite clay in water in a beaker. This solution was mixed for 20 minutes. 0.5 **g** of xanthan was weighed and added to the solution, it was mixed for 20 minutes. 1.5 **g** of titanium Oxide was weighed, added to the solution and mixed thoroughly for 20 minutes.

2.3 Sample analysis

2.3.1 Test for viscosity

The viscosity of the prepared water based drilling fluid samples were determined using Brookfield viscometer. For a material of a given viscosity, the resistance will be greater as the spindle size and/or rotational speed increase.

$$Viscosity = \frac{shear\ stress}{shear\ rate} \qquad (1)$$

The viscometer used is a Ndj-8S digital Brookfield viscometer with measuring range of 20-2,000,000 mPa.s, rotational speeds (rpm) of 0.3, 0.6, 1.5, 3, 6, 12, 30, 60 (i.e. eight adjustable speeds), various spindles (code L1, L2, L3, L4) and a LCD screen display to display the viscosity, speed, torque, spindle and maximum viscosity can be measured in the current spindle speed value. The prepared solution of drilling fluid is poured into a beaker and placed under the viscometer. A spindle that suits the sample is used and knotted tight at the joint under the viscometer. The viscometer is then adjusted at the knob to the bottom to make the spindle enter the sample placed, the knob is stopped when the "stop-point mark" on the spindle is no longer visible as this indicates that the spindle is well inserted into the solution. The viscometer is powered on, the speed is picked by pressing a button that reads "speed" on it, it is pressed number of times till the speed used is picked, the thermometer from the viscometer is then inserted into the solution/sample to be examined, the spindle used is selected (i.e. spindle 1, 2, 3 or 4). After all these selections, the run viscometer shows the viscosity value button is pressed and the**,** the temperature of the sample, the speed and spindle used. Before another reading is taken, the spindle is removed, washed using distilled water and cleaned using a clean cloth.

In this study, samples 2A, 2B, 2C, 3A, 3B, 4A, 4B used spindle 3 as a result of the obvious thickness in the fluid. They were done individually and each of them was poured into a beaker. The thermometer was inserted into the solution which displayed the room temperature 31.5 **°C** and a speed of 30 rpm was inputted into the viscometer. The run button was pressed and the value displayed by the viscometer was recorded.

Another analysis was done with a speed of 60 rpm for these samples and the readings were recorded. Samples 2A, 2B, 2C, 3A, 3B, 4A, 4B were heated with the use of heating mantles to a temperature of 40 **°C**, these heated samples were taken to the viscometer, using spindle 3 and at a speed of 30 rpm, and the viscosity was recorded. Another reading using spindle 3 and at a speed of 60 rpm was recorded from the viscometer.

These samples were heated again using a heating mantle to a temperature of 45 **°C**. These heated samples were taken to the viscometer, using spindle 3 and at different speeds of 30 and 60 rpm, each viscosity value was recorded for each sample.

Sample 1, 3C and 4C used spindle 2 because of their less-thick nature. They were done differently and each of them was poured into a beaker. The thermometer was inserted into the solution and a speed of 30 and 60 rpm were used and two values of viscosity were recorded for each of these samples at 31.5 **°C** (room temperature). These samples were heated using a heating mantle and were heated to 40 **°C**. The same procedure was used to record the two values for viscosity of each sample. These samples were heated to 45 **°C** and the same procedure was used to record the two values of viscosity of each sample at this temperature.

2.3.2 Structure analysis

Fourier transform infra-red (FTIR) equipment was used to carry out the structure analysis of all the additives and their blends in different ratios in order to evaluate how the structures of the additives affected the properties of the drilling fluids samples. The additives were categorized into samples A to G as follows:

Sample A: 1 g aluminium

Sample B: 1 g xanthan gum

Sample C: 1 g titanium oxide

Sample D: 1 g xanthan gum + 1 g aluminium

Sample E: 1.5 g xanthan gum + 0.5 g aluminium

Sample F: 1 g xanthan gum + 1 g titanium oxide

Sample G: 1.5 g xanthan gum + 0.5 g titanium oxide

The Fourier transform infra-red analysis was done at the central laboratory of Yaba College of Technology, Lagos, Nigeria. FTIR uses an infrared (IR) light source to pass through the sample and onto a detector, which precisely measures the amount of light absorbed by the sample. This absorbance creates a unique spectral fingerprint that is used to identify the molecular structure of the sample and determine the exact quantity of a particular compound in a mixture. An Agilent Fourier transform infra-red spectroscope (range: 4000-650 $\mathbf{cm}^{-1}$) was used to obtain the infrared radiation for the sample and the result is plotted on a graph of transmittance against wavelength.

III. RESULT

The results obtained revealed that there is a decrease in the viscosity of the water based drilling fluid as shear rates increases for all the samples tested (Figures 1, 2 and 3). This implies that the drilling fluids produced are non-Newtonian. The drilling fluid is shear thinning as the viscosity decreases as the shear rates increases. At different temperatures, the viscosity of the drilling fluids decreases as shear rate increases. At every given temperature, the viscosity of the drilling fluid sample increases with increase composition of xanthan gum (Figures 1, 2, and 3). Thus, the xanthan gum acted as a viscosifier which is in agreement with findings of previous researcher (Al-Yasira *et al.*, 2019). It was observed that addition of 1 g xanthan gum to the water based drilling fluid increased its viscosity sharply and further addition of xanthan gum resulted in slight increase at all temperatures considered (Figures 1, 2, and 3). At 12 rpm, the apparent viscosity of the drilling fluid sample increased from 394.3 mPa.s to 2853.8 mPa.s on addition of 1 g xanthan gum at 40 **°C** (Figure 1). Further addition of 0.5 g xanthan gum increased the apparent viscosity to 3654.4 mPa.s and increasing the xanthan gum composition to 2 g only increased the apparent viscosity to 3928.2 mPa.s under the same condition (Figure 1). It was further observed that as the temperature increases above 40 **°C** the increment in apparent viscosity reduces for all the concentrations of xanthan gum at 12 rpm. This is trend subsist at 30 rpm and at 60 rpm (Figures 2 and 3). This is in agreement with the findings of other previous researchers (Vryzas and Kelessidis, 2017).

It was observed from Figure 4 that addition of aluminium oxide nanoparticles to the xanthan gum bentonte mixture formulated drilling fluid had impact on the viscosity of the fluid. Concentration of 1 g aluminium oxide nanoparticles and 1 g xanthan gum in the drilling fluid samples gave higher apparent viscosity than presence of only 1 g xanthan gum in the samples tested. However, samples with 0.5 g aluminium oxide and 1.5 g xanthan gave a better increase in viscosity than that of 1 g: 1 g concentration and sample containing only 2 g xanthan gum (Figure 4). Thus, the performance of the viscofier (xanthan gum) can be improved by addition of small quantity of aluminium oxide nanoparticles (ratio 3: 1 of xanthan gum to aluminium oxide). These observations are in agreement with the findings of other previous researchers (Alizadeh et al., 2015)**.** It was further observed that the 1.5 g aluminium oxide nanoparticles and 0.5 g xanthan gum mixture in the drilling fluid caused reduction in apparent viscosity. This implies that aluminium oxide nanoparticle alone may not be able to improve the viscosity of the water based drilling fluid without the xanthan gum or any other vioscosifier.

From Figure 5 that the little quantity of xanthan gum (0.5 **g**) and 15 g of titanium oxide had very little impact on the viscosity of the water based drilling fluid sample, which implied that addition of titanium oxide nanooparticles only may not increase the viscosity of the water based drilling fluid. The results, however showed that 1.5 g of xanthan gum and 0.5 g of titanium oxide nanopartices had appreciable impact on the viscosity of the drilling fluid and even better than 1 g xanthan gum to 1 g titanium oxide concentration. The impact of the 1.5 g xanthan gum to 0.5 g titanium oxide on the viscosity was even greater than that of sample containing only 2 g xanthan gum (Figure 5). Thus, the 3:1 ratio blending of the xanthan gum to nanoparticles for both aluminium oxide and titanium oxide can improve the rheological performance of the water based drilling fluid appreciably for a 350 ml volume. Comparison of the impacts of the xanthan gum, aluminium oxide and zinc oxide on the viscosity of the water based drilling fluid showed that as the concentration of the xanthan gum increased in the water based drilling fluid without nanoparticles, the viscosity of the fluid increases but the rate of increment reduces as the concentration increases (Figure 6). Blending of xanthan gum and nanoparticles in ratio 3:1 as additive increased the viscosity more than when 100% xanthan gum only of equal proportion is used on the water based drilling fluid (Figure 6). At certain temperature the improvement by aluminium oxide was better than that of titanium oxide while at some other temperatures the reverse is the case (Figure 6).

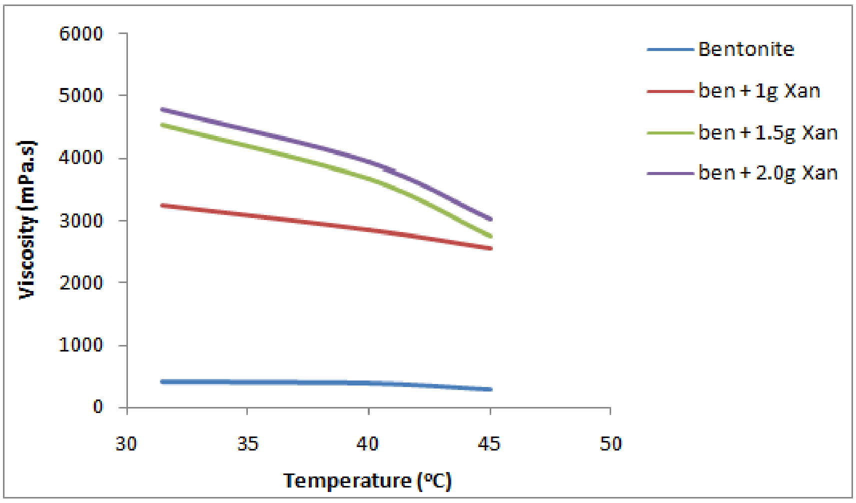

Figure 1:Viscosity against temperature of drilling fluid for different concentration of xanthan gum at 12 rpm

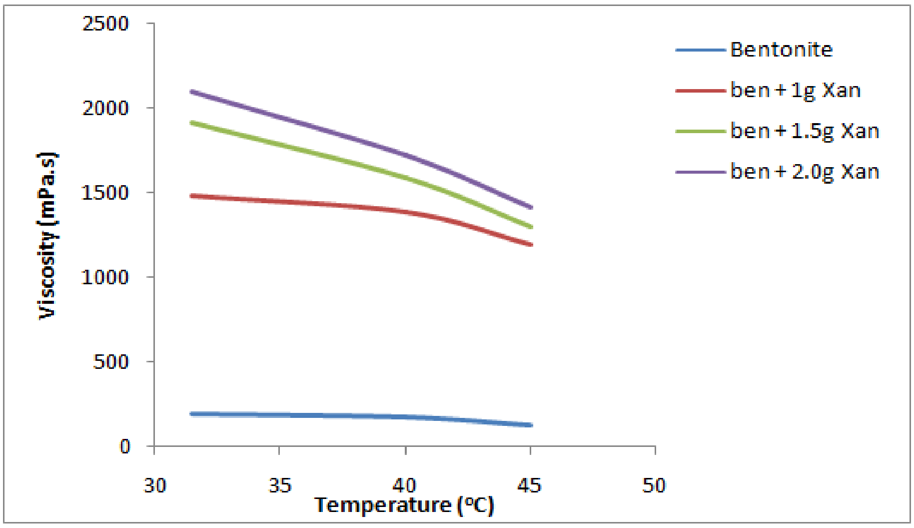

Figure 2:Viscosity against temperature of drilling fluid for different concentration of xanthan gum at 30 rpm

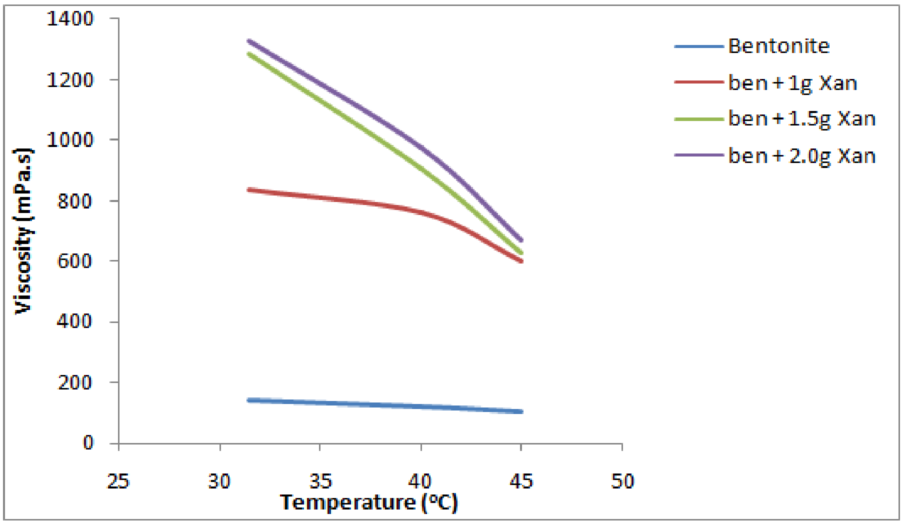

Figure 3:Viscosity against temperature of drilling fluid for different concentration of xanthan gum at 60 rpm

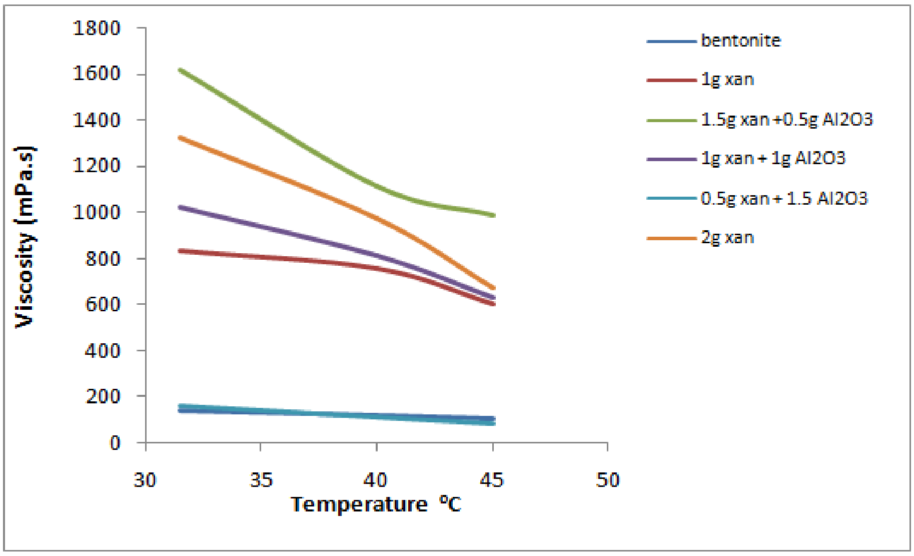

Figure 4:Viscosity against temperature at 60 rpm for drilling fluid containing bentonite, xanthan and aluminium oxide in different concentration

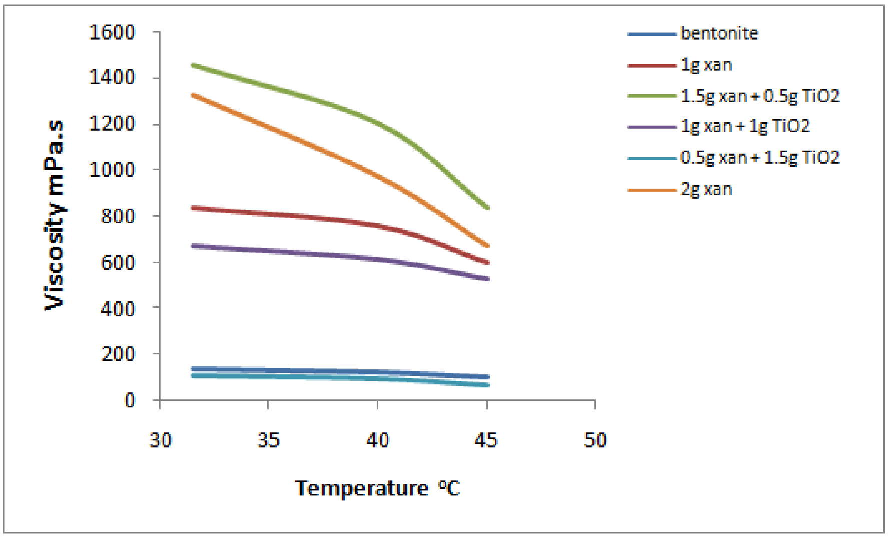

Figure 5:Viscosity against temperature at 60 rpm for drilling fluid containing bentonite, xanthan and titanium oxide in different concentration

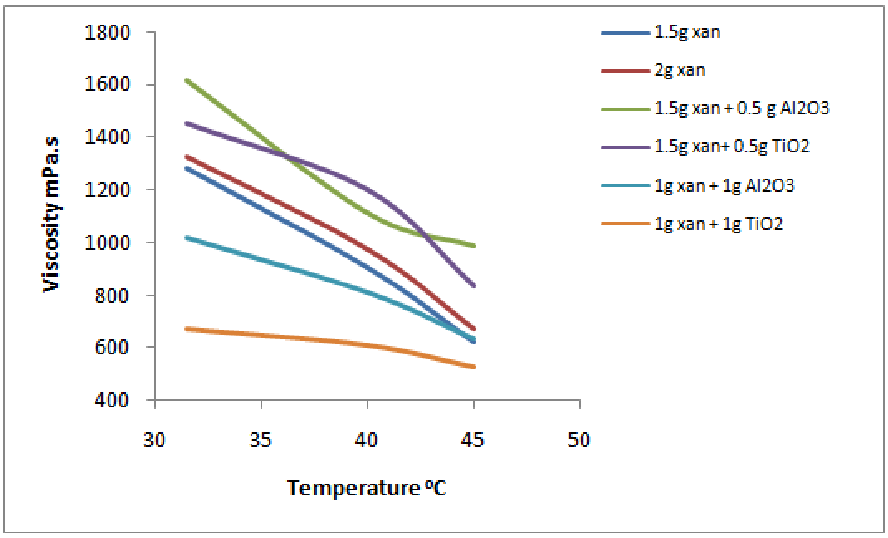

Figure 6:Viscosity against temperature at 60 rpm for drilling fluid containing bentonite, xanthan, aluminium oxide and titanium oxide in different concentration

From results of the structural analysis of the xanthan gum and its mixture with the nano particles using FTIR, it was observed that there were some interaction between the xanthan gum and the nanoparticles. The FTIR spectrum of the xanthan gum as shown in Figure 7 indicated various peaks/bands in additive: the presence of a stretching of strong hydroxyl groups was indicated by the band at 3418.0 **cm^{-1}**, O-H functional group was indicated by 3354.6 **cm^{-1}**, 3291.2 **cm^{-1}** and 2877.5 **cm^{-1}** bands, the band at 1714.6 **cm^{-1}** indicated carbonyl group C=O stretching, the band at 1599.0 **cm^{-1}** indicates C-C (ring) stretch and 1401.5 **cm^{-1}** indicates C-C (ring) stretch. Also, the band at 1367.9 **cm^{-1}** corresponds to –C-H bending while the band at 1244.9 **cm^{-1}** corresponds to C-O stretching. Furthermore, the band at 1155.5 **cm^{-1}** indicates C-O stretch, the band at 1017.6 **cm^{-1}** represents C-OR stretching, and the band at 786.5 **cm^{-1}** is assigned to aromatic group C-H. These observations are in agreement with the finding of previous researchers (Al-Yasiri et al., 2019).

The FTIR spectrum of the aluminium oxide nanoparticle showed in Figure 8 revealed some peaks/bands present in the nanoparticles: the band at 802.6 **cm^{-1}** indicates the Al-OH-Al bending while the 1021.3 **cm^{-1}** infrared band indicates Al-O-Al bond stretching.

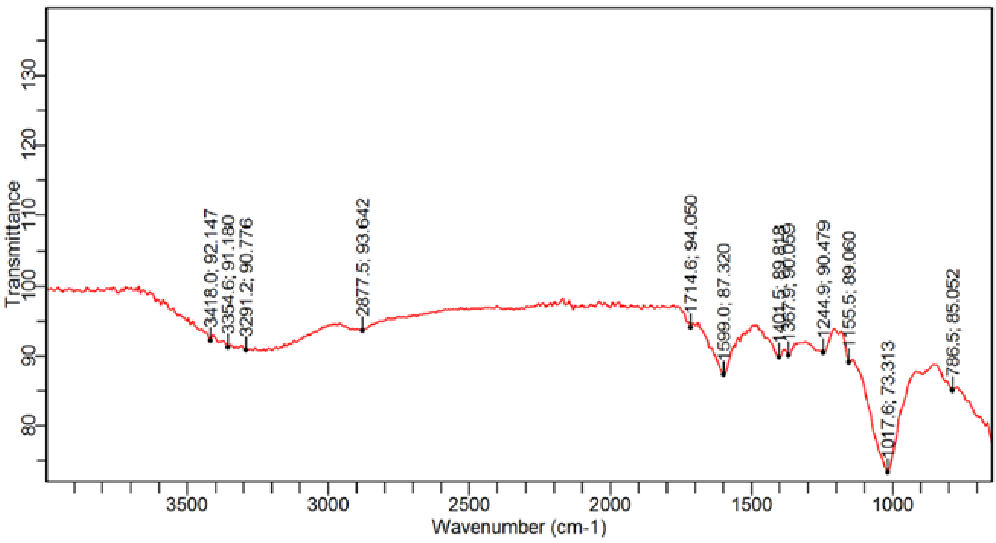

Figure 7: FTIR spectrum for xanthan gum

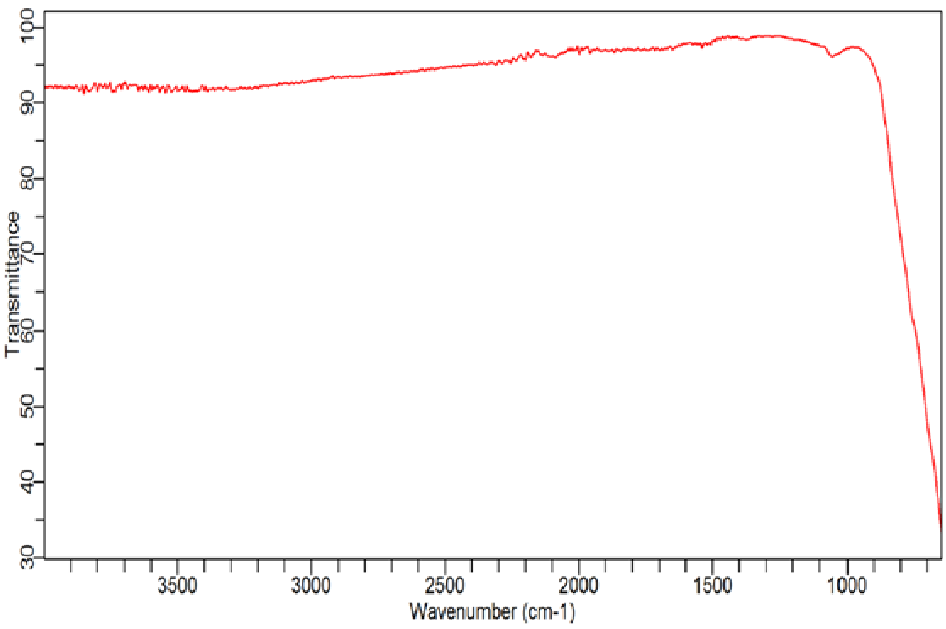

Figure 8: FTIR Spectrum of aluminium oxide nanoparticles

Six bands were shown by the FTIR spectrum for the blend of 1g xanthan with 1 g Aluminium oxide (Figure 9) while about 8 ba nds were shown by the FTIR spectrum of 1.5 g xanthan gum blend with 0.5 g of aluminium oxide nanoparticles (Figure 10): Comparing Figures 7, 8, 9 and 10, it was observed that some of the peaks present in the xanthan gum individual structure are not present in aluminium oxide and xanthan molecules structure while new peaks/bands were observed in the spectra (Figures 9 & 10). The presence of the new peak/bands in the infrared spectra in Figures 9 and 10 and disappearance of some peaks/bands formally in xanthan gum spectrum indicates there are interactions between the xanthan gum and aluminium oxide structures. However, the presence of less peaks and bands in Figure 9 compared to Figure 10 is an indication of lesser bond between the intermolecular structures of xanthan and aluminium oxide in the sample when mixed in equal proportion than when mixed in ratio 3:1. For instance the presence of new bands 3250.2 **cm**$^{-1}$, 2907.3 **cm**$^{-1}$, 1405.2 and 1371.7 **cm**$^{-1}$ in Figure 10 showed the formation of xanthan-aluminium oxide nanocomposite in the 3:1 ratio blend while the presence of 3384.4 **cm**$^{-1}$, 2933.4 **cm**$^{-1}$, 1602.8 **cm**$^{-1}$ and 1405.2 **cm**$^{-1}$ new bands in Figure 9 showed the formation of xanthan-aluminium oxide nanocomposite in the 1:1 ratio blend. Aslo, the presence of the new bands/peaks and the disappearance of some bands/peaks in both xanthan (e.g. 3418.0 cm^{-1} 3354.6 cm-1, 3291.2 cm^{-1}, 2877.5 cm^{-1}, 1401.5 cm^{-1}, 1367.9 cm^{-1}, 1155.4 cm^{-1} and 786.5 cm^{-1}) and aluminium oxide nanoparticles (e.g. 1021.3 cm^{-1} and 802.6 cm^{-1}) indicate the interaction of the two compounds to form the xanthan-aluminium oxide nanocomposite (Figures 7, 8 and 10) in the ratio 3:1 blend of xanthan gum and aluminium oxide nanoparticles. The interactions attributed to the improvement in the viscosity of the water based drilling fluid when the aluminium oxide nanoparticle was introduced into the bentonite/xanthan gum mixture in ratio 3:1 (Figures 4 and 6).

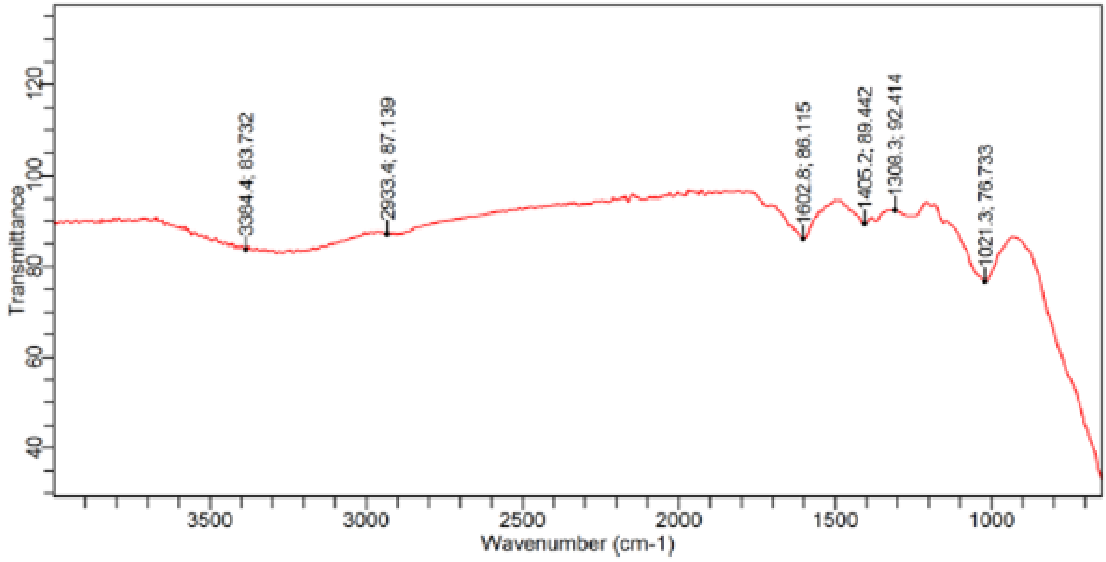

Figure 9: Spectrum of xanthan gum blend with equal proportion of aluminium oxide nanoparticles

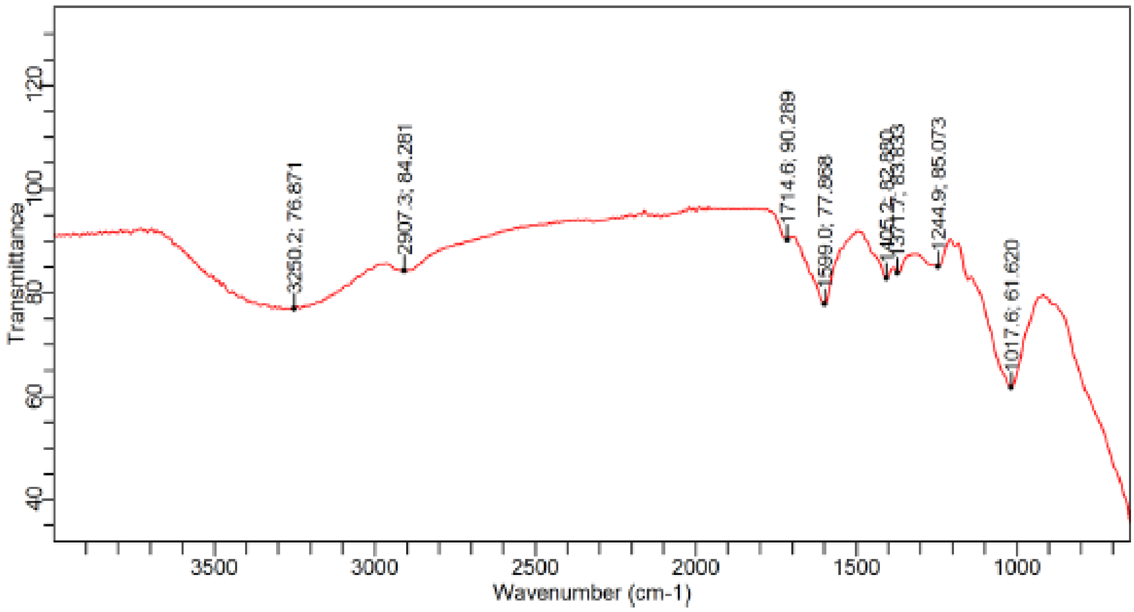

Figure 10: Spectrum of 1.5 g xanthan gum blend with 0.5 g of aluminium oxide nanoparticles

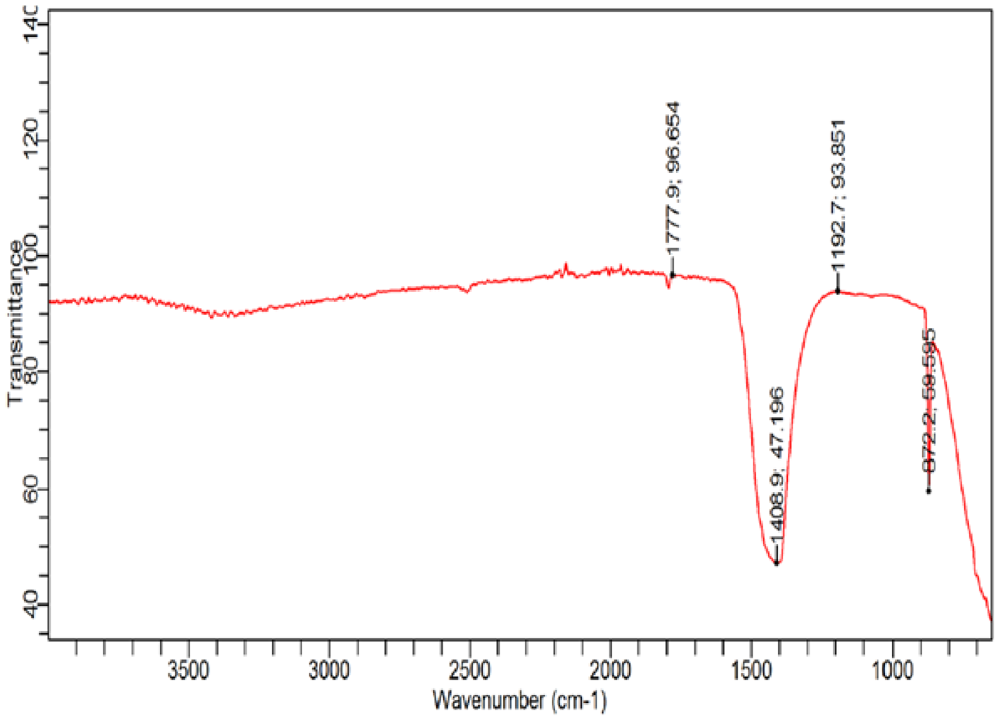

Figure 11: Spectrum of titanium oxide nanoparticles

The bands/peaks for titanium oxide are shown in Figure 11: Ti-H stretching is indicated by the band at 177.9 **cm**$^{-1}$, the band at 1408.9 **cm**$^{-1}$ is assigned to Ti-H bending, 1192.7 **cm**$^{-1}$ indicate Ti=O bending and the band at 872.2 **cm**$^{-1}$ Ti=O stretching. The spectra for blend of titanium oxide nanoparticles and xanthan gum the peaks/bands are shown in Figures 12 and 13: it was observed that the higher intensity represents the absorption of IR spectrum due to some additional bands which are in the titanium oxide nanoparticle used (Figures 12 and 13). These are indications that there are interactions between the molecules of the xanthan gum and the titanium oxide nanoparticles to form the xanthan-titanium oxide composite. Comparing Figures 12 and 13, there is much peak/bands in the spectrum representing sample with 3:1 ratio of xanthan to nanoparticles than the sample containing ratio 1:1 bending.

This implies the molecules of xanthan and titanium oxide nanoparticles at ratio 3:1 proportion bond well. For instance the presence of new bands 3254.0 **cm**$^{-1}$, 1595.3 **cm**$^{-1}$ and 1151.7 **cm**$^{-1}$ in Figure 13 showed the formation of xanthan-titanium oxide nanocomposite in the 3:1 ratio blend while the presence of 1596.3 **cm**$^{-1}$ and 1435.0 **cm**$^{-1}$ new bands in Figure 12 showed the formation of xanthan-titanium oxide nanocomposite in the 1:1 ratio blend. Furthermore, the presence of the new bands/peaks and the disappearance of some bands/peaks in both xanthan (e.g. 3418.0 **cm**$^{-1}$ 3354.6 **cm**$^{-1}$, 3291.2 **cm**$^{-1}$, 1599.0 **cm**$^{-1}$, 1401.5 **cm**$^{-1}$, 1155.4 **cm**$^{-1}$ and 786.5 **cm**$^{-1}$) and titanium oxide nanoparticles (e.g. 1777.9 **cm**$^{-1}$ and 1192.7 **cm**$^{-1}$) indicate the interaction of the two compounds to form the xanthan-titanium oxide nanocomposite (Figures 7, 11 and 13) in the ratio 3:1 blend of xanthan gum and titanium oxide nanoparticles. Hence, the strong interaction between the xanthan and the titanium oxide must have contributed immensely to the high improvement of the viscosity of the water based drilling fluid (Figure 6).

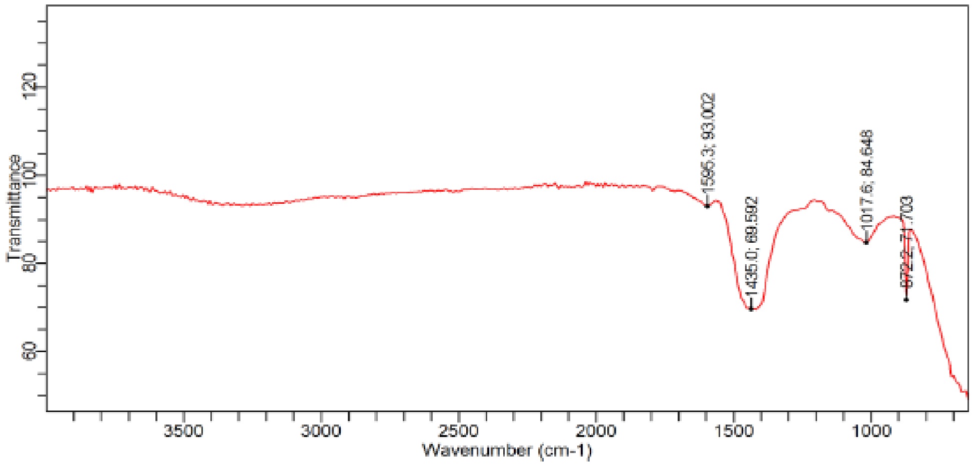

Figure 12: Spectrum of blend of titanium nanoparticles and xanthan gum in equal proportion

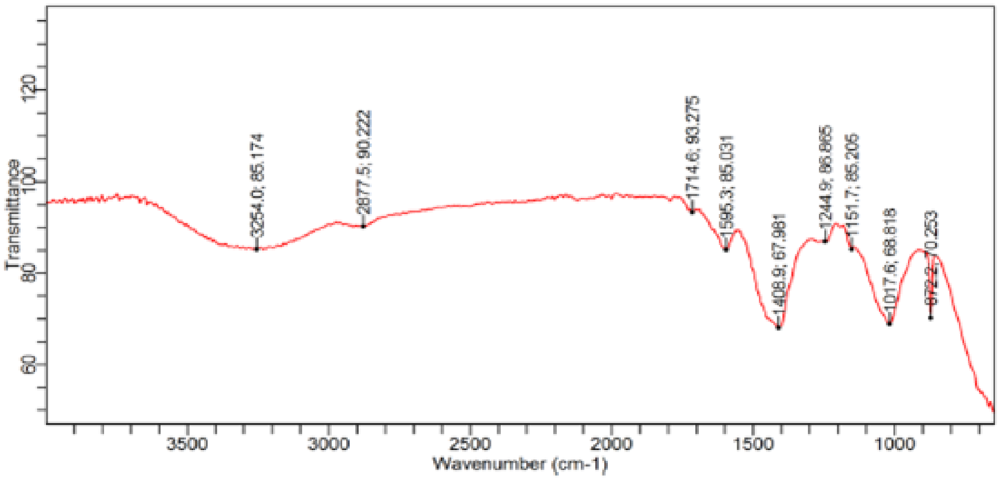

Figure 13: Spectrum of 1.5 g xanthan gum blend with 0.5 g of titanium oxide nanoparticles

The bands and peaks obtained from the spectra for the FTIR analysis of blending of xanthan gum with other proportions of the nanoparticles investigated also showed some interaction of the nanoparticles with the xanthan but not as much as the ones displayed by the spectra of the ratio 3:1 of xanthan to nanoparticles proportions.

IV. CONCLUSION

From the result obtained in this study, it is concluded that the rheological properties of water based drilling fluid improved with the addition of aluminium oxide and titanium nanoparticles. For 1.5 g xanthan blended with 0.5 g aluminum oxide (ratio 3: 1) and 1.5 g xanthan blended with 0.5 g titanium oxide nanoparticles the viscosity of the drilling fluid improved almost in the same pattern above when 2 g of xanthan only was used as additive to the water based drilling fluid. At certain temperature the improvement by aluminium oxide was better than that of titanium oxide while at some other temperatures the reverse was the case. The structures of the aluminium oxide nanoparticle interacted better with the additive than titanium oxide nanoparticle. The results of this study indicate that the bonds between nanoparticles and xanthan gum help rheological properties of the drilling fluids. Aluminium oxide nanoparticle improved the rheological performance of drillings fluids at almost rate as the titanium oxide nanoparticle when appropriately combined with xanthan gum. Therefore, for optimal improvement in rheological properties of water based drilling fluid, either aluminium oxide nanoparticles or titanium xide nanoparticles combined with xanghan gum is recommended for use in the oil and gas industry.

V. REFERENCES

1. Abdou M. I. and Ahmed E. H., (2011), Effect of particle size of bentonite on rheological behavior of the drilling mud. Petroleum Science Technology, vol. 29(21). pages 2220-2223. doi.org/10.1080/10916461003663065
2. Agarwal, S.; Tran, P.; Soong, Y.; Martello, D.; Gupta, R.K. (2011). Flow Behavior of nanoparticle stabilized drilling fluids and effect of high temperature aging. In Proceedings of the AADE National Technical Conference and Exhibition, Houston, TX, USA, 12–14 April 2011.
3. Alizadeh, S.; Sabbaghi, S.; Soleymani, M. (2015). Synthesis of alumina/polyacrylamide nanocomposite and its influence on viscosity of drilling fluid. Int. J. Nano Dimens, 6, 271–276.
4. Amanullah, M., & Al-Tahini A. M. (2009). Nano technology- its Significance in smart Fluid Development for Oil and Gas Field Applications. SPE Saudi Arabia Section Technical Symposium, AlKhobhar,Saudi Arabia, 9 – 11 May. http://dx.doi.org/10.2118/126102-MS
5. Amarfio, E.M.; Abdulkadir, M. (2016). Effect of Al_2O_3 nanoparticles on the rheological properties of water based mud. Int. J. Sci. Eng. Appl., 5, 7–11. Energies 2017, 10, 540 33 of 34
6. Al-Yasiri M., Awad A., Pervaiz S., Wen D. (2019). Influence of silica nanoparticles on the functionality of water-based drilling Fluids Journal of Petroleum Science and Engineering; 179 (2019) 504–512
7. Hoelscher, K. P., De Stefano, G., Riley, M., & Young, S. (2012). Application of Nanotechnology in drilling fluids. In Proceedings of the SPE International Nanotechnology Conference, Noordwjik, The Netherlands, 1214 June. http://dx.doi.org/10.2118/157031-MS
8. Ismail A. R., Seong T. C., Buang N. A. and Sulaimon W. R. W. (2014). Improve Performance of Water based Drilling Fluid Nanoparticles, Proceedings of the 5th Sriwijaya International Seminar on Energy and Environmental Science & Technology Palembang, Indonesia. September 10-11. Page 43-47.
9. Majid S A R, Younis A S. (2018). Nanoparticles as Drilling Fluids Rheological Properties Modifiers. Progress Petrochem Sci .1(5). PPS.000521.2018. DOI: 10.31031/PPS.2018.01.000521
10. Saboori, R.; Sabbaghi, S.; Mowla, D.; Soltani, A. (2012). Decreasing of water loss and mud cake thickness by CMC nanoparticles in mud drilling. Int. J. Nano Dimens. 3, 101–104.
11. Sadeghalvaad, M.; Sabbaghi, S. (2015). The effect of the TiO_2/polyacrylamide nanocomposite on water-based drilling fluid properties. Powder Technol., 272, 113–119.
12. Salih, A.H.; Elshehabi, T.A. (2016). Bilgesu, H.I. Impact of nanomaterials on the rheological and filtration properties of water-based drilling fluids. In Proceedings of the SPE Eastern Regional Meeting, Canton, OH, USA, 13–15 September 2016.
13. Sedaghatzadeh M., Khodadadi A. A., and Tahmasebi Birgani M. R. (2012). An Improvement in Thermal and Rheological Properties of Water-based Drilling Fluid using Multiwall carbon Nanotubes. Iran J. Oi Gas Sci. Technol. Pages 55-65.
14. Sharma, M.M.; Chenevert, M.E.; Guo, Q.; Ji, L.; Friedheim, J.; Zhang, R. (2012). A new family of nanoparticle based drilling fluids. In Proceedings of the SPE Annual Technical Conference and Exhibition, San Antonio, TX, USA, 8–10 October 2012.
15. Taraghikhah, S.; Kalhor Mohammadi, M.; Tahmasbi Nowtaraki, K. (2015). Multifunctional nanoadditive in water based drilling fluid for improving shale stability. SPE 18323. In Proceedings of the International Petroleum Technology Conference, Doha, Qatar, 6–9 December 2015.
16. Vryzas Z. and Kelessidis V. C. (2017). Nano-Based Drilling Fluids: A Review. Energies; 10, 540, pp 1-34; doi:10.3390/en10040540