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Comparative study of Rice husk and Xanthan gum as viscosifer in water based drilling fluid

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ABSTRACT: The study investigated the possibilities of replacement of xanthan gum with rice husk as a viscosifier in formulation of water-based drilling fluid (WBDF). Water based drilling fluids were produced using the standard laboratory barrel (350 ml) method from bentonite and water; grinded rice husk and xanthan gum were added to the samples in different proportions. The viscosities of the samples were determined using Brookfield rotational viscometer (Ndj-5S) while the structural analysis of the rice husk and xanthan gum were determined using Fourier Transformation Infra-red (FTIR) spectroscopy. The results obtained revealed that addition of rice husk to water based drilling fluid gave a good improvement to the viscosity of the WBDF, although in higher quantity than required for xanthan gum. FTIR analysis revealed that rice husk contained functional groups which are present in the xanthan gum. Therefore, rice husk could be recommended for use as viscosifier in production of WBDF.

KEY WORDS: bentonite, rice husk, xanthan gum, water based drilling fluid

I. INTRODUCTION

The role of drilling fluid in drilling operations in the oil industry cannot be overemphasized. It performs many roles some of which are cleaning and transport of the rock cuttings, maintaining the whole integrity, lubricating and cooling the drill bit and control of the formation pressures to prevent blowouts (Akinyemi *et al*, 2020a; Ibrahim *et al*, 2017). However, when drilling fluids are exposed to a high temperature high pressure situation in drilling, their viscosities tend to reduce. Viscosity of drilling fluids is one of the major parameters that determines effective performance of fluid during drilling operations. Thus, the drilling fluid must possess adequate viscosity to retain its functionality during the drilling operations. Having this in mind, appropriate viscosifier is added into the formulations of drilling fluid to give it the required viscosity. One of the major viscosifier that is commonly used in the oil industry is xanthan gum. Water based drilling fluid has given has attracted more applications in the oil industry due to environmental and economic considerations.

Agricultural wastes like rice husk which have tendency of producing a viscous pulp may be considered for use to improve the viscosity of WBDF. It is a cheap product to obtain which is considered to be as agro-waste, in underdeveloped countries and developing countries like Nigeria rice husk largely because the technological knowhow to utilize its potentials is lacked by the farmers in these countries (Okon *et al.,* 2014). Although in some countries it is used in the field of civil engineering as concrete fiber and in electrical engineering field as insulating materials (Akoko *et al*., 2012; Kumar *et al*., 2012). Okon *et al.* (2014) investigated the use of rice husk as fluid loss control additive in water based drilling mud and found it to be favourable. Further study of activities of rice husk in water based drilling fluid formulation is quite necessary to enhance better understanding of producing environmentally friendly using agricultural waste. Hence, in this study, the possibilities of utilizing rice husk as viscosifier in water based drilling fluid formulation is being investigated.

II. LITERATURE REVIEW

Viscosity is one of the very important properties of drilling fluids. A drilling fluid with very small viscosity will cause solids to descend to the bottom of a well-bore. Hence, high viscosity is very important for efficient hole cleaning (Powell *et al*. 1991; Zamora *et al.* 1993; Akinyemi *et al.*, 2020a). Rate of solids settling in a drilling fluid can only be slowed down by a high viscosity (Akpan *et al.*, 2020). Viscosifying agents such as xanthan gums starches, polyacrylates, and a wide variety of synthetic and natural polymers are added to water based drilling fluid to establish and control the rheological properties of drilling fluid (Akinyemi and Alausa, 2020). In the process of drilling a subterranean well, water

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based drilling fluids are exposed to temperatures that can be in excess of 300°F and exposure to such temperatures can have a detrimental effect on the viscosifying agents, resulting to loss in velocity of the fluid at high temperatures (Akinyemi and Alausa, 2020). Among the commercial viscosifying agents, xanthan gum is commonly used in drilling fluids to provide viscosity (Akpan *et al.*, 2020; Galindo *et al.*, 2015). Xanthan gum which is a biopolymer has been found to be efficient in providing viscosity and fluid loss control in water-based mud systems and in completion fluids for a long time (Howard 1995; Powell *et al.* 1995). One of the major limitations of xanthan gum is its sensitivity to temperature (Akinyemi and Alausa, 2020; Gallino and Xiao, 1996). Consideration for utilization of rice husk in the formulation of water based drilling fluid was studied by Okon et al with the objective of using the rice husk to control fluid loss. The researchers found the rice husk to displayed favourable contribution to control of fluid loss in water based drilling fluid (Okon *et al*, 2014).

III. METHODOLOGY

The bentonite clay used was obtained from standard Nigerian chemicals organization. The xanthan gum used was product of Sigma-Aldrich. The rice husk was obtained from a local rice mill in Kebbi/Sokoto/Lagos State, Nigeria. The major pieces of equipment used were Brook-field rotational viscometer (Ndj-5S) and Fourier Transform Infra-Red (FTIR) spectrometer (Agilent; range: 4000-650 cm^{-1}).

Rice husk additive preparation and characterization

In preparation of the rice, it was placed in the vacuum oven for about 4 – 5 hours to dry the moisture content at a temperature of about 45°C. Thereafter, the dried rice husk was ground into small size with blender and sieved to 125 microns to obtain fine particles. The dried samples were characterized using FTIR.

Drilling fluid preparation

Sample one

The first basic water based drilling fluid was prepared from of water and bentonite clay only. 350ml of water was measured using a measuring cylinder and was put in a 600ml beaker.24.5g of bentonite clay was weighed using digital weighing equipment and was poured into the beaker containing 350ml of water. The (name of the mixer) blender was used to mix the 24.5g of bentonite clay and 350ml of water for 10mins to obtained homogenous mixture.

Sample two

The second based drilling fluid prepared involved water, bentonite clay and xanthan gum.
A measuring cylinder was used to measure 350ml of water. 24.5g of bentonite clay was weighed using weigh balance. Different proportions of xanthan gum were us00ed for this experiment.

a) 350ml of water and 24.5g of bentonite clay was prepared using a stirrer. 1g of xanthan gum was added and blended thoroughly for 10mins to obtained homogenous mixture.
b) A solution containing a thoroughly mixed 350ml of water and 24.5g of bentonite clay was stirred for 10mins in a beaker using a magnetic stirrer. 1.5g of xanthan gum was added and blended thoroughly for 10mins to obtained homogenous mixture.
c) 2g of xanthan gum was weighed using a weighing machine. A solution containing a thoroughly mixed 350ml of water and 24.5g of bentonite clay using a stirrer was prepared. 2g of xanthan gum was added and blended thoroughly for 10mins to obtained homogenous mixture.

Sample three

The third based drilling fluid prepared involved water, bentonite clay and rice husk.
A measuring cylinder was used to measure 350ml of water. 24.5g of bentonite clay was weighed using weighing balance. Different proportions of rice husk were used for this experiment.

a) 350ml of water and 24.5g of bentonite clay was prepared using a stirrer. 5g of rice husk was added and blended thoroughly for 10mins to obtained homogenous mixture.
b) A solution containing a thoroughly mixed 350ml of water and 24.5g of bentonite clay was stirred for 10mins in a beaker using a magnetic stirrer. 10g of rice husk was added and blended thoroughly for 10mins to obtained homogenous mixture.

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c) 15g of barite was weighed using a weigh balance. A solution containing a thoroughly mixed 350ml of water and 24.5g of bentonite clay using a stirrer was prepared. 15g of rice husk was added and blended thoroughly for 10mins to obtained homogenous mixture.
d) A solution containing a thoroughly mixed 350ml of water and 24.5g of bentonite clay using a stirrer was prepared. 20g of rice husk was added and blended thoroughly for 10mins to obtained homogenous mixture.

Sample analysis
Test for viscosity
A Brookfield viscometer of all is selected due to its availability. It measures the fluid viscosity at a given shear rates. Viscosity is a measure of fluid resistance to flow. For a material of a given viscosity, the resistance the will be greater as the spindle size and/or rotational speed increase.

The viscometer used is a Ndj-5S Brookfield viscometer with measuring range of 20-200,000 mPa.s, rotational speeds (rpm) of 6, 12, 30, 60 (i.e. four 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.

Procedure for using Brookfield viscometer
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, sample 1 used spindle 2 as a result of the less thickness in the fluid while samples 2A. 2B, 2C, used spindle 3. 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 30^{o}C and a speed of 6 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 12 rpm, 30 rpm and 60 rpm for these samples and the readings were recorded for 30^{o}C temperature. All these samples were heated with the use of water bath at the temperature of 40^{o}C, 45^{o}C and 50^{o}C and the analysis for determination of viscosity was repeated at each temperature.

Structure analysis
Fourier transform infra-red spectrometer (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 and B as follows:

Sample A – Xanthan gum
Sample B – Rice husk

The FTIR analysis was done at the central laboratory of Yaba College of Technology, Lagos, Nigeria. FTIR uses an Infra-Red (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 FTIR spectroscope (range: 4000-650) was used to obtain the infrared radiation for the sample and the result is plotted on a graph of transmittance against wavelength.

IV. EXPERIMENTAL RESULTS

From the results obtained in the study, the viscosities of the drilling mud produced using bentonite and water only decreased with increased in temperature as shown in Figure 1. This is in agreement with the findings of previous

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researchers (Akinyemi and Alausa, 2020; Akinyemi et al., 2020a). The same trend was also observed for other categories of samples produced (Figures 2 and 3). It was however found that the addition of xanthan gum to the WBDF increased the viscosity for every given temperature (Figure 4). This may be due to the interaction of the barite molecules to the molecules on the bentonite in the water thereby increasing the resistance of the fluid to flow. It was also observed that addition of rice husk to the drilling fluid increased its viscosity for every given temperature (Figure 4). The results obtained revealed that rice husk has appreciable effect on the viscosity of the water based drilling fluid but lower than that of xanthan gum when compared with the xanthan gum of similar quantity (Figure 4). However, the results obtained further revealed that addition of rice husk to water based drilling fluid gave a good improvement to the viscosity of the WBDF, when higher quantity was used. For instance, 10 g of rice husk in the 350ml standard WBDF at 40°C was able to increase the viscosity of the fluid from 184.5 mPa.s to 1063.4 mPa.s at 30 rpm while 1g xanthan gum increased the viscosity to 1390.8 mPa.s. With respect to cost, the 1g xanthan gum is more expensive than the 10 g rice husk. Furthermore, the WBDF containing 15g rice husk additive displayed similar trend to that doped with 10 g rice husk additive (Figure 5), however with greater increase in viscosity of the fluid at 40°C.

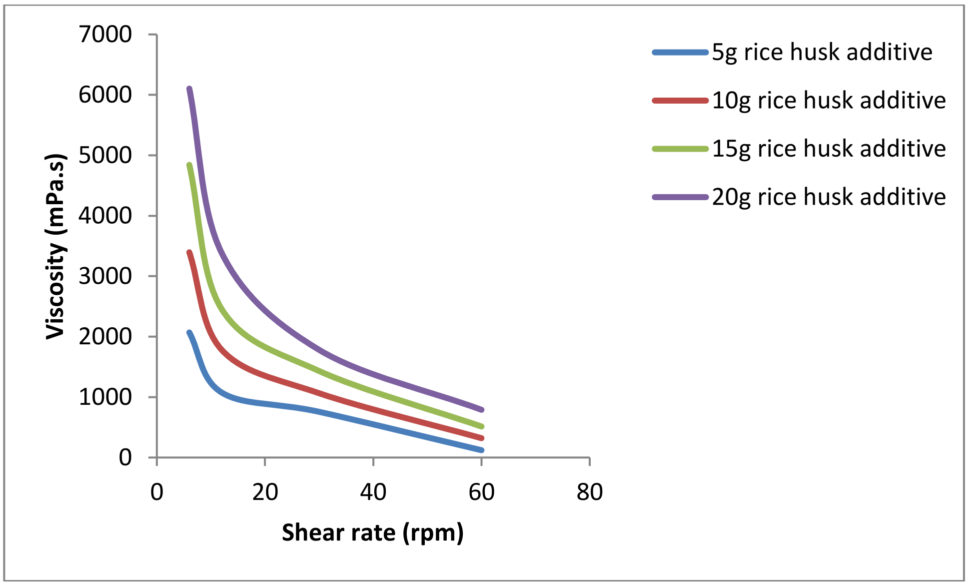

Figure 1. Viscosity versus shear rates of WBDF samples with different quantities of rice husk at 40°C

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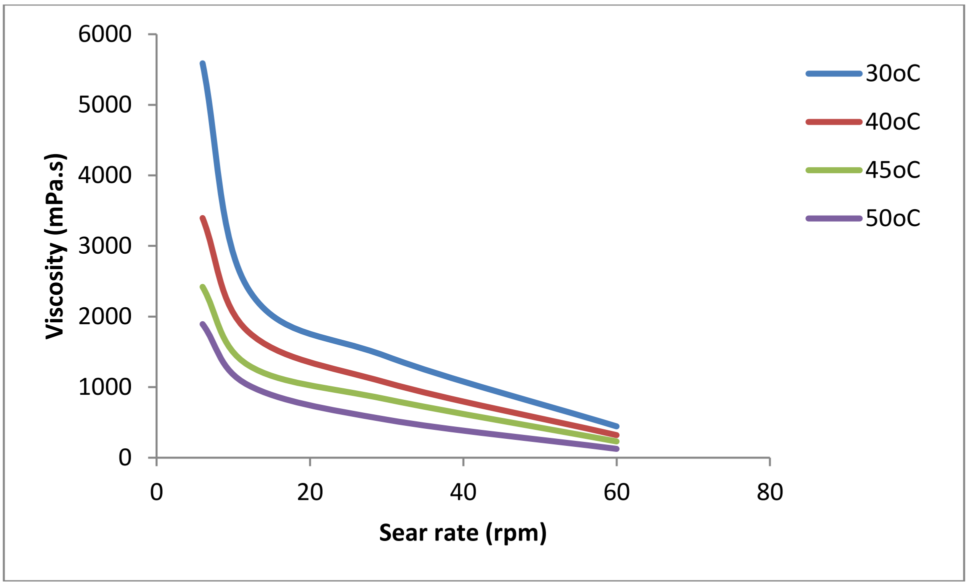

Figure 2. Graph of Viscosity versus shear rate for WBDF sample with bentonite, water and rice husk only at various temperatures for 10 g rice husk composition

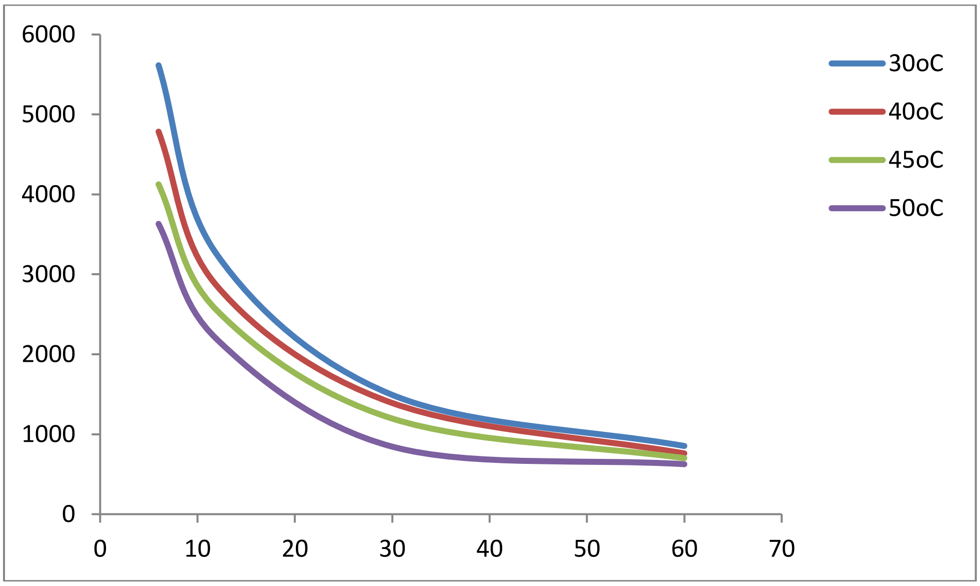

Figure 3. Graph of Viscosity versus shear rate for WBDF sample with bentonite, water and xanthan gum only at various temperatures for 1 g xanthan gum composition

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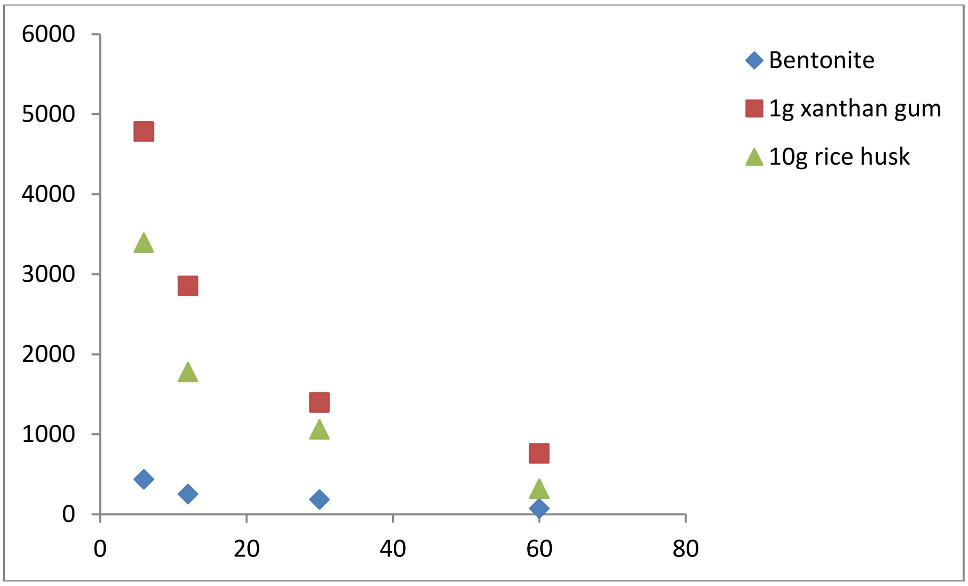

Figure 4. Comparison of graph of Viscosity against shear rate for WBDF with bentonite, 1 g xanthan gum, 10 g rice husk respectively at 40°C

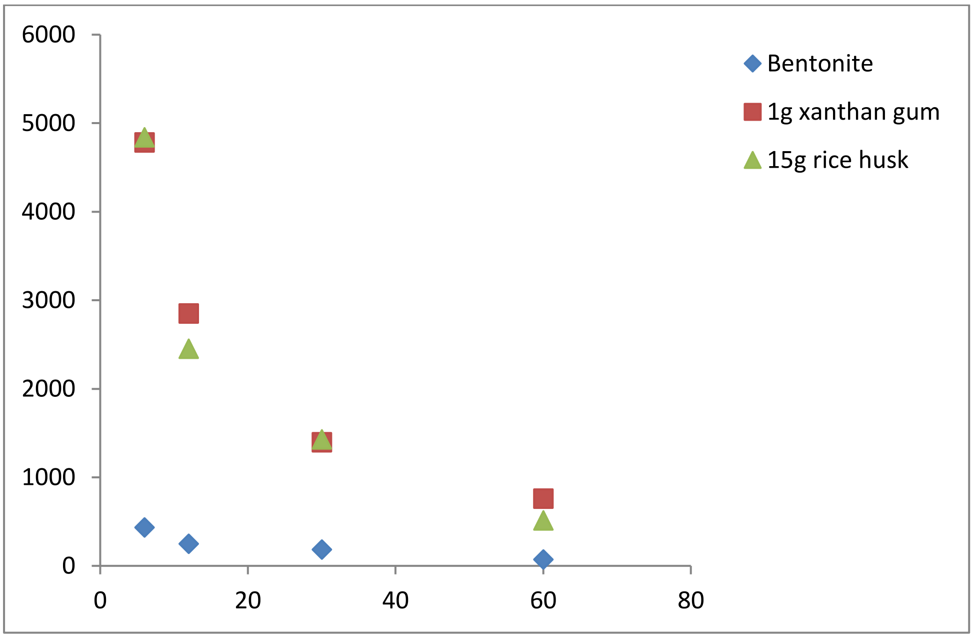

Figure 5. Comparison of graph of Viscosity against shear rate for WBDF with bentonite, 1 g xanthan gum, 15 g rice husk respectively at 40°C

From Table 1, FTIR spectrum of the rice husk revealed eight bands/peaks which are 3276.3 cm^{-1} (O-H Stretching), 2914.8 cm^{-1} (C-H Stretching), 2847.7 cm^{-1}(weak sharp O-H Stretching), 1636.3 cm^{-1} (H-O-H bending due to likely water content), 1416.4 cm^{-1} (S=O stretching), 1371.7 cm^{-1}(O-H bending), 1028.7 cm^{-1} (C-N stretching), 779.0 cm^{-1} (Si-H bond)

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[Akinyemi and Alausa 2020; Daffalla *et al.*, 2020; Akinyemi *et al.*, 2020b].

The FTIR spectrum of the xanthan gum showed twelve (12) peaks/bands (Table 1). The band at 3418.0 cm^{-1} indicate the presence of a stretching of strong hydroxyl groups, also, 3354.6 cm^{-1}, 3291.2 cm^{-1} and 2877.5 cm^{-1} indicates O-H functional group, the band at 1714.6 cm^{-1} is assigned to carbonyl group C=O stretching, 1599.0 cm^{-1} indicates C-C (ring) stretch 1401.5 cm^{-1} indicates C-C (ring) stretch. The band at 1367.9 cm^{-1} is assigned to –C-H bending. Furthermore, the band at 1244.9 cm^{-1} corresponds to C-N stretching, 1155.5 cm^{-1} indicates C-O stretch, the band at 1017.6 cm^{-1} represents C-OR stretching, and the band at 786.5cm^{-1} is assigned to aromatic group C-H. These observations are in agreement with the finding of previous researchers (Daffalla *et al.*, 2020; Akinyemi *et al.*, 2020b).

All the eight bands indicated by the rice husk were within the ranges of the peaks/bands indicated by xanthan gum which may be one of the reasons the rice husk could perform some roles xanthan gum performed in the water based drilling fluid. This could have resulted into the improvement in the viscosity of the WBDF on addition of the either the rice husk or the xanthan gum.

Table 1. FTIR analysis of rice husk and xanthan gum structures

Range	**Functional group**	**Rice husk**	**Xanthan gum**	**Type of bond**
3200 – 3500 Strong, broad	O-H stretching	3276.3	3418.0; 3354.6	Alcohol
2500 – 3300 Strong, broad	O-H stretching	2914.8	3291.2;	Carboxylic acid
2840-3000 Medium	C-H stretching	2847.7	2877.5	Alkane
1710-1706 Strong	C=O stretching		1714.6	Carboxylic acid
1566-1650	C=C stretching	1636.3	1599.0	Cyclic alkene
1330-1420 Medium	O-H bending	1416.4	1401.5	Alcohol
1310-1390	O-H Bending	1371.7	1367.9	Phenol
1124 -1205 [strong]	C-O Stretching		1155.5	Tertiary alcohol
1020-1250 [medium]	C-N Stretching	1028.7	1244.9	Amine
1000-1300 [strong]	C-O stretching		1017.6	Esther
750 – 800 [strong]	C-H bending	779.0	786.5	

V. CONCLUSION AND FUTURE WORK

Water based drilling fluid (WBDF) from bentonite, water and additives such as xanthan gum and rice husk in different proportions were produced in this study and the effects of the additives on the rheological of the WBDF at different temperatures were evaluated using standards methods. The structural analysis of the rice husk and barite were also determined using Fourier Transformation Infra-red (FTIR) spectroscopy. The results obtained revealed that addition of rice husk to water based drilling fluid gave a good improvement to the viscosity of the WBDF, although in higher quantity than required for xanthan gum. The 10 g of rice husk in the 350ml standard WBDF at 40^oC was able to increase the viscosity of the fluid from 184.5 mPa.s to 1063.4 mPa.s at 30 rpm while 1g xanthan gum increased the viscosity to 1390.8 mPa.s. With respect to cost, the 1g xanthan gum is more expensive than the 10 g rice husk. From the FTIR analysis of the rice husk and xanthan gum, the rice husk contained functional groups (indicated with bands for O-H stretching, C-H stretching, C-N stretching, O-H bending and C-H bending, of 3276.3 cm^{-1}, 2914.8 cm^{-1}, 2847.7 cm^{-1}, 1636.3 cm^{-1}, 1028.7

cm^{-1}, 1371.7 $cm^{-1}$and 2914.8 cm^{-1} respectively) which are present in the xanthan gum. This could have been the reason for its comparative performance with xanthan gum as viscosifier in WBDF. Therefore, rice husk could be recommended for use as viscosifier in production of WBDF.

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