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Research Article

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Impacts of Rice husk on rheological properties of water based drilling fluid

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Abstract When drilling fluids are exposed to a high temperature and high pressure situation in drilling, they lose their rheological properties such as viscosity, strength etc. The objectives of this research work are to investigate the effects of rice husk as additive on the rheological properties like viscosity on water based drilling fluid (WBDF). To achieve these objectives water based drilling fluids were produced using the standard laboratory barrel (350 ml) method from bentonite and water and the additive was introduced into the formulation in different proportion. The rheological properties of the samples were determined using Brookfield rotational viscometer (Ndj-5S) while the densities of the produced mud were determined using density cups. The structural analysis of the rice husk was also determined using Fourier Transformation Infra-red (FTIR) spectroscopy. From the results obtained it was observed that addition of rice husk to WBDF gave improvement to the viscosity of the fluid. The 5g of rice husk in the 350ml standard WBDF at 30^oC was able to increase the viscosity of the fluid from 296.5mPa.s to 1559.2mPa.s at 12rpm. From the FTIR analysis of the rice husk, the rice husk contained functional groups like OH, (indicated with bands of 3276.3 cm^{-1}, 2847.7 cm^{-1} and 1371.7 cm^{-1}) which enabled it to interact with the molecules of the bentonite and water in drilling fluid thereby enhance the viscosity of the WBDF. It could be recommended that the use of rice husk should be given favourable consideration in the bid to produce quality WBDF.

Keywords bentonite, rice husk, water based drilling fluid, rheological properties

1. Introduction

In the oil industry, drilling fluid has many uses some of which includes; drilling of deep wells to clean and transport the rock cuttings, maintain the whole integrity, lubricate and cool the drill bit, control the formation pressures to prevent blowouts [1-3]. The rheological properties of the drilling fluid describe the flow characteristics of a fluid under different flow conditions. To know the effects of flow, it is important that the flow behaviour of the drilling fluid at various points of interest in the fluid circulating system is known [4]. Furthermore, drilling fluids should be designed with several suitable characteristics to improve the efficiency of the drilling operation [5]. However, when drilling fluids are exposed to a high temperature high pressure situation in drilling, they tend to lose their rheological properties such as viscosity, gel strength, etc. Also, maintaining the desirable rheological properties of the drilling fluid is one of the challenges related to drilling deep wells [2, 6]. Environmental and economic considerations have led to the increasing use of the water-based drilling fluids in applications where oil based drilling fluid have previously been preferred, including high-pressure (HP), high-temperature (HT).

WBDF are among the most popular drilling fluids partly due to their reputation as easy to maintain, economically competitive drilling fluids [2]. Several researchers have investigated different viscosifiers like bentonite, xantha gum and nanoparticles impacts on the rheological properties of water based drilling fluid [7-9]. These products are imported and quite expensive, hence there is the need to consider local source for this task. Rice husk being an agricultural waste and a cheap product to obtain can easily fit into the task if found applicable. In underdeveloped countries and developing countries like Nigeria rice husk is seen as agro-waste due to the fact that the technological knowhow to utilize its potentials is lacked by the farmers in these countries [10]. Although in some countries it is used in the field of civil engineering as concrete fiber and in electrical engineering field as insulating materials [11-12] (Akoko *et al*., 2012; Kumar *et al*., 2012), in Nigeria the agro by-product is still largely agricultural wastes which is being generated in large quantity on daily basis. It was observed by previous researchers that rice husk contains approximately 20% opaline silica in combination with a large amount of the phenyl propanoid structural polymer called lignin [13-14]. Akinyemi and Alausa had earlier observed that silicate nanoparticles could improved the rheological properties of water based drilling fluid [7]. Hence, these compositions of rice husk are of great significance and can be utilized as potential rheological properties improver in the formulation of drilling fluid for drilling operations in the petroleum industry. From the foregoing, this study investigated the effects of rice husk on the rheological properties of water based drilling fluid.

2. Materials and Methods

2.1 Materials

The bentonite clay used was obtained from standard Nigerian chemicals organization. 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}).

2.2 Methods

2.2.1 Rice husk additive preparation and characterization

The rice was placed in the vacuum oven for about 4 – 5 hours to dry the moisture content at a temperature of about 45°C. 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.

2.2.2 Drilling fluid preparation

2.2.2.1*Sample one*

The first basic water based drilling fluid was prepared involving the use of water (350 ml) and bentonite clay (24.5g). 350ml of water was measured using a measuring cylinder and was put in a 600ml beaker.24.5g of bentonite clay was weighed using weigh balance and was poured into the beaker containing 350ml of water. A blender is used to mix the 24.5g of bentonite clay and 350ml of water for 10mins to obtained homogenous mixture.

2.2.2.2 *Sample two*

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.

2.2.2.3 *Sample three*

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.

2.2.2.4 *Sample four*

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.

2.2.2.5 Sample five

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.

2.3 Sample analysis

2.3.1 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. The resistance will be greater as the spindle size and/or rotational speed increase, for a material of a given viscosity. The viscometer used is a Ndj-5S Brookfield viscometer with measuring range 0f 20-200,000mPa.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.

2.3.1.1 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, samples 1, 2, 3, 4, and 5 used spindle 2 as a result of the less 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 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 respectively. These heated samples were taken to the viscometer, using spindle 2 and at different speeds of 6, 12, 30 and 60 rpm, each viscosity value was recorded for each sample.

2.3.2 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 additive was the grinded 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 cm^{-1}) was used to obtain the infrared radiation for the sample and the result is plotted on a graph of transmittance against wavelength.

3. Results

From the results obtained in the study, the viscosities of the drilling fluid 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 researchers [1, 7]. It was further observed that the viscosity of drilling fluid decreases with the increase shear rate, indicating that the water based drilling fluid is shear thinning and non-Newtonian. The same trend was also observed for other categories of samples produced (Figure 2). It was however found that the addition of rice husk to the water based drilling fluid increased the viscosity for every given temperature (Figure 3). This may be due to the interaction of the rice husk molecules with the molecules of the bentonite in the water thereby increasing the resistance of the fluid to flow. For addition of 5g of the additives rice husk increased the viscosity of the fluid from 296.5mPa.s to 1559.2mPa.s at 12rpm at temperature of 30^{o}C. At 30rpm and the same temperature of 30^{o}C, 5g of the rice husk was able to increase the viscosity of the water based drilling fluid from 232.9 mPa.s to 868.2 mPa.s. The substantial increase in viscosity of the WBDF by the rice husk may have been due to great interaction between the molecules of the rice husk and the bentonite in water. Thus, the rice husk may be used as viscosifier for water based drilling fluid. Furthermore, the results of the study showed that the higher the quantity of the rice husk added to the water based drilling fluid the higher the viscosity (Figure 4). However, the rate of increase reduces with increase in quantity of rice added. For instance, additional 5g of rice husk to WBDF already containing 5g rice husk only increased the viscosity by 567.2mPa.s at 30^{o}C and 30rpm shear rate (Figure 4) while further addition of 5g rice husk only increased by 541.3 mPa.s under the same condition of temperature.

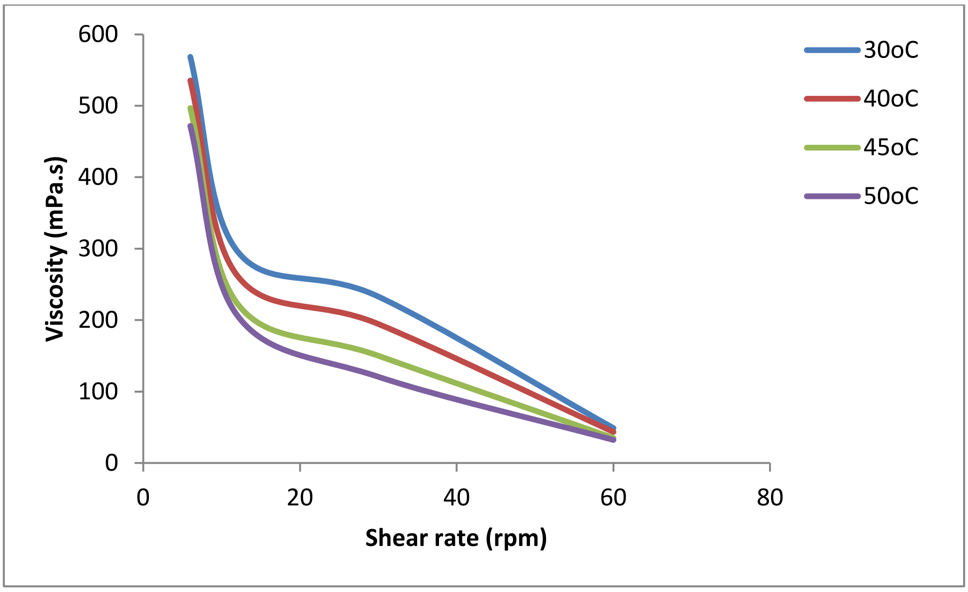

Figure 1: Graph of Viscosity against shear rate for sample with bentonite and water only

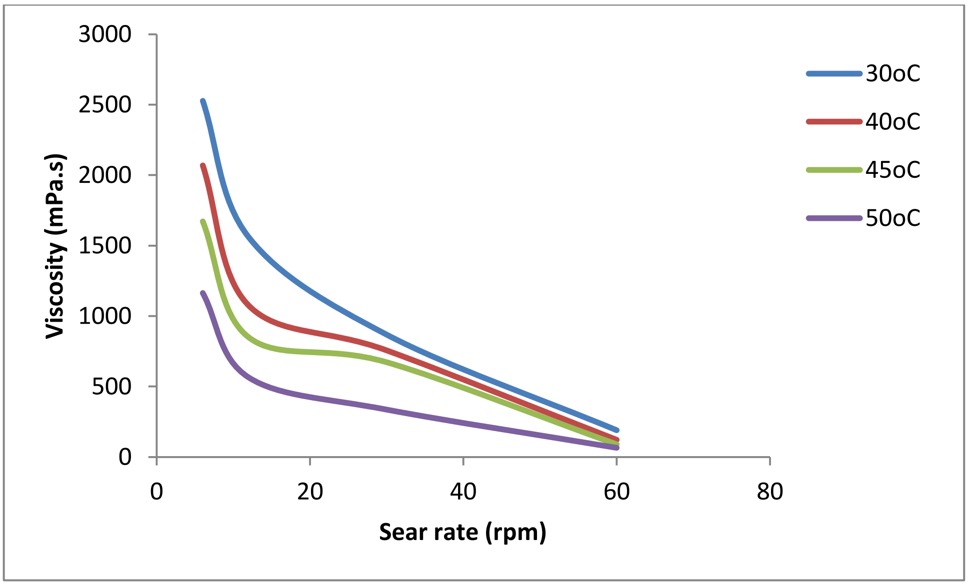

Figure 2: Graph of Viscosity against shear rate for sample with bentonite, water and rice husk only at various temperatures for 5g rice husk composition

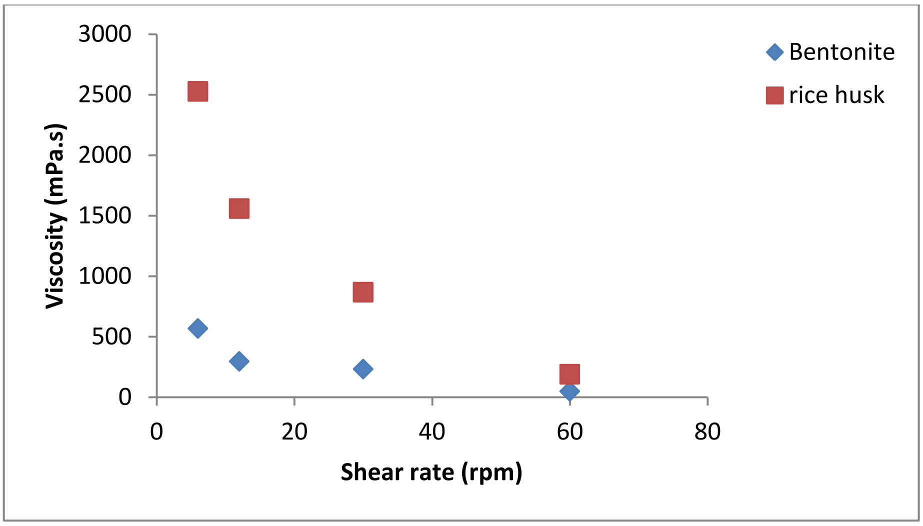

Figure 3: Graph of Viscosity against shear rate with 5g rice husk in the water based drilling fluid at 30^oC

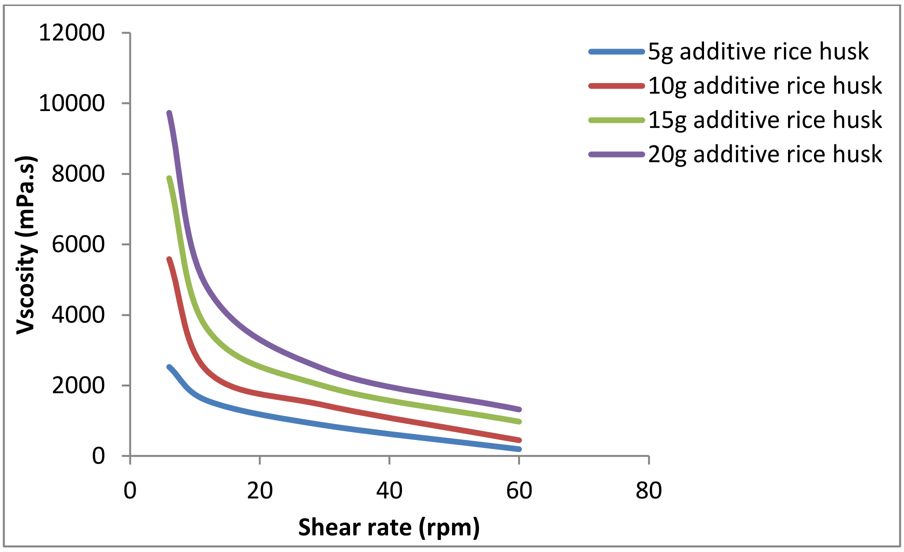

Figure 4: Graph of Viscosity against shear rate for sample with bentonite, water and rice husk only at 30^oC

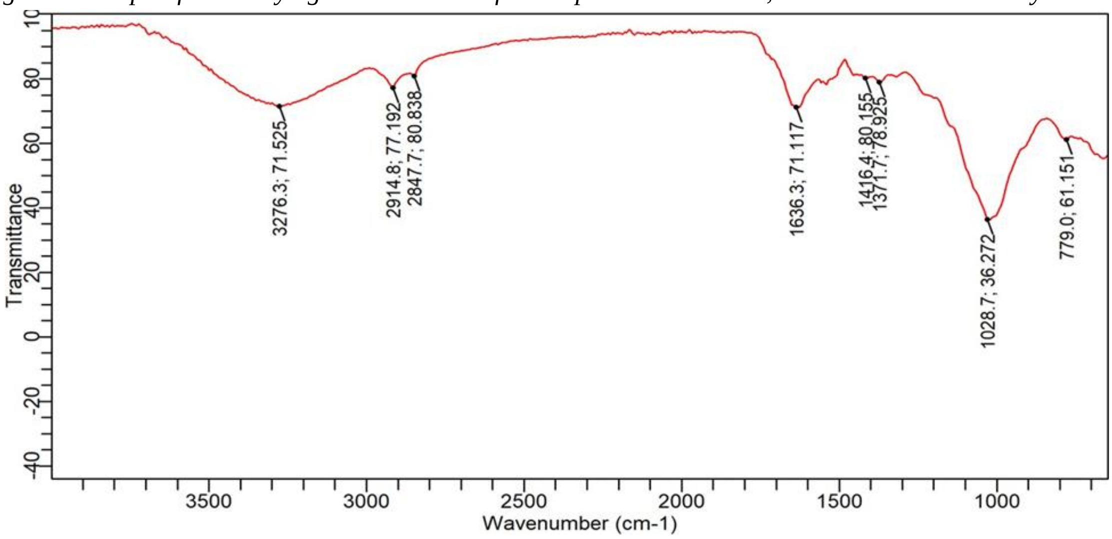

Figure 5: FTIR Spectrum of Rice husk

From Figure 5, FTIR spectrum of the rice husk revealed eight bands/peaks which are 3276.3 cm^{-1} (indicating O-H Stretching), 2914.8 cm^{-1} (indicating C-H Stretching), 2847.7 cm^{-1} (indicating O-H Stretching), 1636.3 cm^{-1}

(indicating H-O-H bending due to likely water content), 1416.4 cm^{-1} (indicating S=O stretching), 1371.7 cm^{-1} (indicating O-H bending), 1028.7 cm^{-1} (indicating C-O stretching), 779.0 cm^{-1} (indicating Si-H bond) [7, 15, 16]. The O-H functional group in the rice husk may have interacted with those in the bentonite and water thereby increasing the resistance of the fluid to flow [17]. This in agreement with observations previously obtained in rheological tests carried out on the water based drilling fluid containing different proportion of the rice husk discussed earlier.

4. Conclusion

The study investigated the effects of rice husk as additive on the rheological properties like viscosity on water based drilling fluid (WBDF). Water based drilling fluids were produced using the standard laboratory barrel (350 ml) method from bentonite and water while the additive was introduced into the formulation in different proportion. The 5g of rice husk in the 350ml standard WBDF at 30^{o}C was able to increase the viscosity of the fluid from 296.5mPa.s to 1559.2mPa.s at 12rpm. From the FTIR analysis of the rice husk, the rice husk contained functional groups like OH, (indicated with bands of 3276.3 cm^{-1}, 2847.7 cm^{-1} and 1371.7 cm^{-1}) which enabled it to interact with the molecules of the bentonite and water in drilling fluid thereby enhancing the viscosity of the WBDF. It could be recommended that the use of rice husk should be given favourable consideration in the bid to produce quality water based drilling fluid.

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