EVALUATION OF FLUID LOSS CONTROL PERFORMANCE OF LOCAL BIOPOLYMER

ABSTRACT

Drilling mud is recognized as the life-wire of drilling operations in the oil and gas industry, and is needed in the exploration and production of subsurface hydrocarbon resources. Drilling mud is majorly plagued by fluid loss, which reduces the volume of the continuous phase while increasing the mud cake thickness. This problem has led to the introduction of additives which enhances the mud filter cake features and reduces filtration rate. Several conventional fluid loss control additives such as PolyAnionic cellulose (PAC) and CarboxyMethyl Cellulose (CMC) have been utilized for fluid loss control, but these additives are expensive and harmful to the environment. These have led to the continued research for more suitable local alternatives, which if successful, could substitute for these conventional materials. In this study, the performance of locally sourced materials; Afzelia Africana (AA) and Maranta Arundinacea Root (MAR), was compared to the conventional material CarboxyMethyl Cellulose (CMC). Fourier Transform Infrared Spectroscopy (FTIR), rheology and filtration test were carried out in this study. From the FTIR results, AA and MA had similar functional groups such as amines, aromatic, carboxylic acid and alcohol with CMC. From the rheology result, AA recorded similar viscosity increasing attribute observed in CMC while MAR was showed to be a poor viscosifier. From the filtration loss result, MA recorded 21ml fluid volume at 9g, AA recorded 66ml fluid volume at 9g while CMC recorded 10ml at 9g. MAR demonstrated potential to substitute for CMC as a fluid loss control additive when modified.

Keywords: Drilling fluids, Fluid loss, Afzelia Africana, Maranta Arundinacea, Water-Based Mud

INTRODUCTION

In drilling engineering study, liquid-based drilling fluid also called drilling mud (DM) is revered to as the blood of all drilling activities in the oil and gas industry [1]. They are widely utilized to aid drilling activities for the exploration and exploitation of subsurface hydrocarbon resources [2]. The DM can be water-based DM, oil-based DM or synthetic-based DM, but water-based DM is the most utilized due to cost and environmental consideration [3]. The drilling mud consists of several additives, and must be properly engineered to effectively match a well requirement [4]. Thus, some of the functions expected from a DM includes subsurface pressure control [5], maintenance of borehole stability [6], bottom-hole cleaning and transportation of cutting to the surface [7]. Among the highlighted functions, DM are designed to close wellbore walls been drilled to avert fluid loss. This is achieved by the development of a filter cake of low permeability on the borehole [8]. As a result, DM are engineered to prevent undesired continuous loss of fluid to the formation [9]. These engineering are done to prepare DM that promote borehole stability, forms thin filter cake and reduces fluid loss [10]. The engineering of DM to achieve set objectives is what is referred to as fluid-loss or filtrate-loss control. The fluid-loss control entail introducing chemicals to the drilling mud to enhance its cake features and reduce its filtration rate [11]. The static and dynamic filtration mechanism are the mechanism that influences the buildup of filter cake, with the static filtration corresponding to non-circulation time while the dynamic filtration corresponding to circulation period. To handle this drilling mud function commercial chemicals such as polyanionic cellulose (PAC), carboxymethyl cellulose (CMC) and other polymers have been utilized as fluid loss control additives [12]. These commercial polymers are however expensive and in some cases not eco-friendly, and this have led to the shift in the utilization of locally-sourced materials as filtrate loss control agent in water-based mud (WBM) [13].

Olatunde et al [14] conducted a fluid loss control test on WBM with 32gram of gum arabic. From their experimental study, gum arabic recorded 17ml fluid loss. Adebayo and Chinonyere [15] carried out fluid loss control study of sawdust (0.5-1mm sized) in WBM. From the result of their study, sawdust recorded 12-59ml fluid loss at 5-30gram respectively. Egun and Abah [16] experimented on the fluid loss control performance of cassava starch on WBM. From the result of their study cassava starch record 4-8ml fluid loss volume at 2-4gram respectively. Azizi et al [17] conducted a fluid loss control test on WBM using Agarwood waste (45 and 90µm). From the result of the experiment

6gram of Agarwood waste yielded fluid loss volume of 13-16ml. Dagde and Nmegbu [18] carried out fluid loss control evaluation on groundnut husk. From their experimental study 2-4gram of groundnut husk yielded 7.6ml and 6.5ml respectively. Okon et al [19] experimented on the fluid loss performance of Rice Husk (125μm) on WBM. From their experimental study 5-20gram of rice husk yielded 16-42.5ml fluid loss. Nmegbu and Bari-Agara [20] experimented on the fluid loss performance of corn cob cellulose. From their experimental evaluation 2-3gram of corn cob cellulose yielded 5.8 and 5.8ml fluid loss volume respectively. Chinwuba et al [21] experimented on the performance of pleurotus tuber-regium. From their experimental study, pleaurotus tuber yielded 8-10.8ml at 5-6gram. Okon et al [22] conducted a fluid loss control study using local material to wit: rice husk (RH), detarium microcarpum (DM) and brachystegia eurycoma (BE), and conventional materials to wit; carboxymethyl cellulose (CMC). From their experimental study, at RH yielded the best fluid loss control performance as it recorded 2.8ml while DM, BE and CMC recorded 4.5ml, 7.3ml and 4.2ml respectively. Chinwuba et al [23] evaluated the fluid loss potential of local bentonite with combination of periwinkle shell and mucuna solannie. From their experimental study, 5g-5g of periwinkle shell:mucuna solannie improved its fluid loss control performance as it recorded 12 filtrate volume. Ikram et al [24] conducted a fluid loss control performance investigation on okra and starch. From their study, okro yielded 20.8ml, 17.6ml and 17ml at 0.25%wt, 0.5%wt and 1%wt concentration respectively, while starch recorded 18.8ml fluid loss at 0.25%wt concentration. Kerunwa et al [25] evaluated the performance of coconut fiber (CF) and corn cobs (CC) as fluid loss control additive alternative to carboxymethyl cellulose (CMC). From the result of their experimental study, CF-CC blend yielded the best fluid loss control performance as it yielded fluid volume of 8ml while CMC, CF and CC yielded 8.6ml, 14ml and 10.2ml fluid volumes respectively. As shown from the review studies have recorded positive signs in substituting materials such as carboxymethyl cellulose (CMC) for fluid loss control.

In this work, the fluid loss control performance of Afzelia Africana (AA) and Maranta Arundinacea Root (MAR) was compared with carboxymethyl cellulose (CMC), in water-based drilling mud. Afzelia Africana is largely grown in the savannah region, drier parts of the rain forest zones and fringing forest within the African continent. Their seeds are utilized as soup thickners just as irvingia gabonensis and citrullus lanatus. Maranta Arundinacea Root is a white, flavorless starch recovered from tropical tubers, and is utilized as a gluten-free thickener for soups and sauces. FTIR characterization was utilized to confirm the functional group present in AA, MAR and CMC, before the utilization of rheology and fluid loss study was used to compare their performances in water-based mud (WBM) system.

EXPERIMENT

MATERIALS

The following are materials used for this study: locally sourced fluid loss control additive such as Afzelia Africana (AA) and Maranta Arundinacea Root (MAR), conventional fluid loss control additive (Carboxymethyl Cellulose (CMC)), Barite (weighting agent/density control agent), Bentonite (Viscosifier/lubricant agent), Calcium carbonate, Water(Base fluid), Sodium hydroxide (pH control agent), Hamilton Beach mixer, Buck 530 IR-spectrophotometer, pH meter, Low Pressure-Low Temperature API Filter Press (LPLT) in Figure 2, Baroid Mud Balance, Rotary Viscometer (Ofite Model 800s) in Figure 1, Weighing Balance (Ohaus) and Stopwatch

Figure 1: Ofite Rotary Viscometer

Figure 2: API Filter Press

SOURCING OF MATERIAL

Afzelia Africana (AA) was sourced from Enugu State, South-Eastern Nigeria. Maranta Arundinacea Root (MAR) was sourced from Imo State, South-Eastern Nigeria. Bentonite, Barite, Distilled Water, Calcium Carbonate, Sodium Hydroxide and CarboxyMethyl Cellulose (CMC) was sourced from ChemScience Store.

PREPARATION OF THE LOCALLY SOURCED BIO-POLYMER

The local bio-polymers to wit; Afzelia Africana (AA) and Maranta Arundinacea (MA) were sourced from a local market in the South-Eastern Part of Nigeria. The pods of AA was placed in an oven for 30 minutes at 60°C to reduce moisture content. The pods were then broken to recover the seeds. The recovered seeds were further oven dried for 2hrs at 75°C, and thereafter crushed into fine particles using an industrial blender. The crushed particles were sieved using 0.062mm sieve to obtain powdered particles which were stored in an airtight container. The MA root were sliced into smaller pieces and grinded in a water mixture. The MA-water solution was allowed to stabilize for 2hrs before the water content was reduced. The process was repeated twice until a transparent top water was achieved. The transparent water was extracted from the solution by filtration leaving the dry thick substance. The dry thick substance was dried in laboratory oven for 48hrs at 45°C before being pulverized. The pulverized MA root was sieved to powdered particles before being stored in an airtight container. Figures 3(a) and 3(b) show AA and MAR respectively, while Figures 4(a) and 4(b) shows powdered AA and MAR respectively utilized for the study respectively.

Figure 3(a): Afzelia Africana (AA)

Figure 3(b): Maranta Arundinacea root (MAR)

Figure 4(a): Ground AA

Figure 4(b): Ground MAR

FTIR EVALUATION

Fourier Transform Infrared (FTIR) evaluation was done using the Buck 530 IR-spectrophotometer. The local materials are Afzelia Africana (AA) and Maranta Arundinacea Root (MAR), while Carboxymethyl cellulose (CMC) was used as conventional material. The FTIR test produces a graph in the form of absorbance spectra, which shows the unique molecular structure and chemical bonds of the sample materials. The absorption spectrum has peaks which represent components present in the materials. The absorbance peaks show functional groups (e.g alkanes, acid chloride and ketones). The various bond types and corresponding active groups absorb infrared radiation of varying wavelength.

The analytical spectrum is then checked in a reference library catalogue to determine to find the range of values used in identifying functional groups present.

MUD FORMULATION

In the fluid loss experimental study, three (3) different mud samples namely CMC Mud sample, AA Mud sample and MAR Mud sample were formulated with concentration of fluid loss control additives varied at 1g, 3g, 5g, 7g and 9g respectively. CMC-Mud Sample is the mud sample with CMC as filtrate loss control additive, AA-Mud Sample is the mud sample with AA as fluid loss control additive, while MAR-Mud Sample is the mud sample with MAR as fluid loss control additive.

MIXING PROCEDURE OF MUD SAMPLE FORMULATION

The defined quantity of the additives utilized were weighed using a weighing balance. 350ml of Distilled water was measured using cylinder with defined graduations. The distilled water was introduced into mud cup and agitation commenced using the Hamilton Beach Mixer. Thereafter 15g of Bentonite was introduced to the agitated water and stabilized for five minutes. 0.5g of NaOH and 0.25g of $CaCO_3$ were introduced to the slurry and agitated for two minutes. 1g of CMC was introduce to the resultant solution and mixed for three minutes. 10g of Barite was introduced to the resultant solution and mixed for 15minutes. The approach was conducted for 3g, 5g, 7g and 9g of CMC. The Hamilton beach mixer was utilized to mix the mud slurry at medium speed and the total mixing time requirement was thirty minutes. The same formulation approach for CMC mud was utilized for AA mud sample and MAR mud sample respectively. Table 1 depicts composition of water-based mud (WBM) with 1g of Fluid Loss Control Additive. This composition were repeated for 3g, 5g, 7g and 9g of fluid loss control additives

Table 1: Composition of Water-Based Mud (WBM) with 1g of Fluid Loss Control Additive

Additives	**CMC Mud Sample**	**AA Mud Sample**	**MAR Mud Sample**
Water (ml)	350	350	350
Barite (g)	10	10	10
Bentonite (g)	15	15	15
Calcium Carbonate (g)	0.25	0.25	0.25
Sodium Hydroxide (g)	0.5	0.5	0.5
CMC (g)	1	Nil	Nil
Ground AA (g)	Nil	1	Nil
Ground MAR (g)	Nil	Nil	1

MUD RHEOLOGY

The formulated mud was introduced into the cup of the viscometer (Figure 1) up to the graduated point, fix on the viscometer stand, and elevated to graduated point to ensure sufficient immersion by the rotating sleeve. Rotor speeds of 3rpm, 6rpm, 30rpm, 60rpm, 100rm, 200rpm, 300rpm and 600rpm were used to obtain dial readings for the mud sample. Using the dial readings, the plastic viscosity (PV), apparent viscosity (AV) and yield point (YP) were derived using the following equations.

$$Plastic\ \ Viscosity(cP) = \theta_{600} - \theta_{300} \tag{1}$$

$$\text{Yield Point}\ (\text{lb}/100\text{ft}^2) = \ \theta_{300} - \text{PV} \tag{2}$$

$$\text{Apparent Viscosmeter (cp)} = \frac{\theta_{600}}{2} \tag{3}$$

WBM especially with local bio-polymer fits Herschel-Buckley equation perfectly than Power Law or Bingham Plastic Model [26] and is expressed as

$$\tau = \tau_0 + \text{k}\gamma^{\text{n}} \tag{4}$$

where: τ, n, y, k and τ_0 represents shear stress, flow behavior index, shear rate, yield stress and consistency index of the fluid. Fluid is Newtonian when flow behavior index is zero, Dilant when flow behavior index is less than one and Pseudo-plastic when flow behavior index is greater than one [27]. The yield stress of the fluid can be derived as recommended by API for the rheological parameters of Herschel Buckley model using R6/R3 [28]

$$\tau_0 = 2\tau_3 - \tau_6 \tag{5}$$

where τ_3 and τ_6 are shear stress at 3rpm and 6rpm respectively.

The 10 minutes and 10 seconds gel strength were also derived from the mud sample during the determination of the thixotropic properties. The rotary sleeve speed of the viscometer was set at above 600rpm, and the mud was stirred for 60 seconds, before a sudden stop in the process. The stirred mud was undisturbed for 10 seconds, after which the flip toggle was shifted to the gel speed and the maximum dial reading recorded. The same procedures were repeated for 10 minutes and its corresponding result recorded.

MUD FILTRATION

The mud filtration study was conducted under LPLT condition using API Filter Press. The filter press is used for filtration tests. The API filter press is utilized for filtration evaluation, and consists of 6 independent filter cells with one inert gas sources as shown Figure 2. The test procedure for filtration study was conducted at ambient temperature and100psi to assume overbalance pressure, using the following sets of procedure.

(1) The cells were cleaned, dried and rubber gaskets inspected
(2) The cells were coupled-up in the following sequence- base-cap, rubber-gasket after base-cap, screen, filter paper, rubber gasket after filter paper and cell body.
(3) 130ml of the formulated drilling mud using additives from Table 1 was introduced to the cell before being fixed into the base and tighten to ensure enclosure.
(4) 50ml graduated cylinder was placed at the base of the cell to recover filtrate
(5) The cell was pressurized with 100psi of inert gas
(6) The filtrate volume was recorded at different intervals of 30mins
(7) The additional thickness of the formulated mud on the filter paper was derived using a caliper and documented in x/32-in unit

RESULTS AND DISCUSSIONS

FTIR EVALUATION

FTIR Evaluation was conducted in these study for the various fluid loss control additives. Figures 5-7 depict the FTIR Spectra of Afzeila Africana (AA), Maranta Arundinacea Root (MAR) and CarboxyMethyl Cellulose CMC respectively. As shown in Figure 5, the absorption spectra of 974.27cm^{-3}, 1054.7cm^{-3}, 1152.47cm^{-3},1299.45cm^{-3},1388.29cm^{-3},1895.61cm^{-3},2056.19cm^{-3},2344.13cm^{-3},2530.76cm^{-3},2665.05cm^{-3},2775.74cm^{-3},2855.76cm^{-3}, 3038.27cm^{-3},3172.8cm^{-3},3366.16cm^{-3}, shows the presence of functional groups such as alkenes, aliphatic amines, alkyl halides, phenol, aromatic, isothiocyanate, carbon dioxide, carboxylic acid, aldehyde, alkanes, aromatics, alcohol, 1,2 amines, amides. From Figure 6, the absorption spectra of 755.77cm^{-3},865.84cm^{-3},1171.58cm^{-3},1306.89cm^{-3},1400.19cm^{-3},1605.85cm^{-3},1880.14cm^{-3},2038.05cm^{-3},2204.19cm^{-3},2450.73cm^{-3},2557.1cm^{-3},2665.25cm^{-3}, 2789.39cm^{-3},2970.86cm^{-3},3080.35cm^{-3},3298.3cm^{-3},3492.17cm^{-3}, shows the presence of functional groups such as alkyl halides, aromatics, aromatics amines, 1 amines, aromatic compound, isothiocyanate, alkyne, carboxylic acid, thiol, aldehyde, alkane, alkenes, 1,2 amines, amides, alcohol. As shown in Figure 7, the adsorption spectra of 675.12cm^{-3},864.52cm^{-3},985.29cm^{-3},1307.57cm^{-3},1427.46cm^{-3},1622.11cm^{-3},1864.6cm^{-3},1956.37cm^{-3},2091.39cm^{-3},2199.42cm^{-3},2447.38cm^{-3}, 2551.8cm^{-3},2694.77cm^{-3},2896.42cm^{-3}, 3062cm^{-3}, 3167.72cm^{-3}, 3282.35cm^{-3}, 3697.27cm^{-3}, 3826.71cm^{-3}, shows the presence of functional groups such as alkynes, aromatics, alkenes, alcohols, carboxylic acid, ethers, 1 amines, aromatic compound, isothiocyanate, isocyanate, alkane, alkynes(terminal). As observed from Figures 5-7, Alcohol, Aromatics, Carboxylic Acid and Isothiocyate compounds present in CMC was also present in AA and MAR. Phenol compound present in CMC was absent in the AA and MAR. Alkene present in CMC and MAR was absent in AA. The results shows that the local materials are polysaccharides.

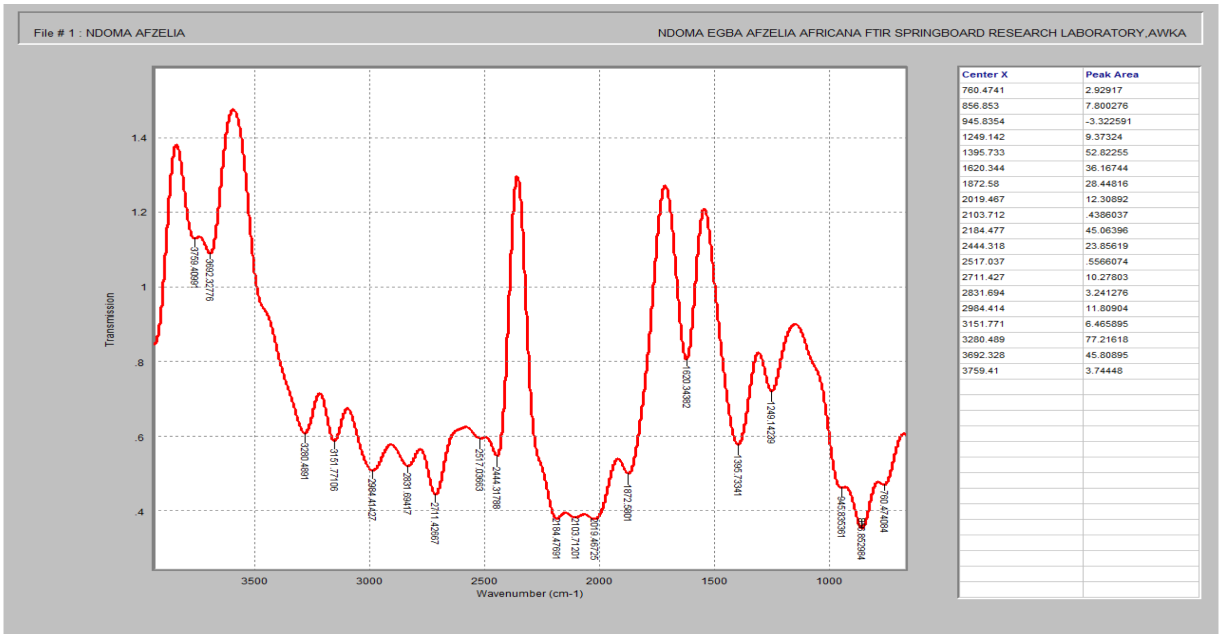

Figure 5: FTIR Spectra of Afzelia Africana (AA)

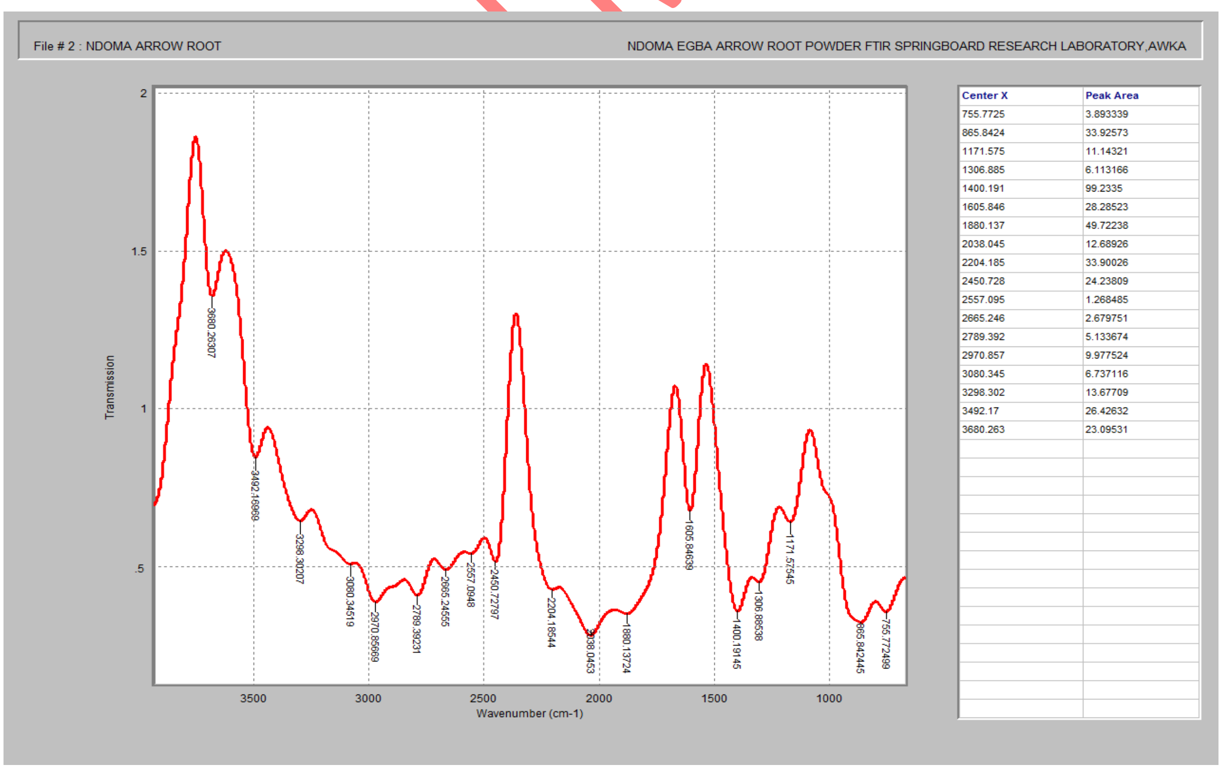

Figure 6: FTIR Spectra of Maranta Arundinacea Root (MAR)

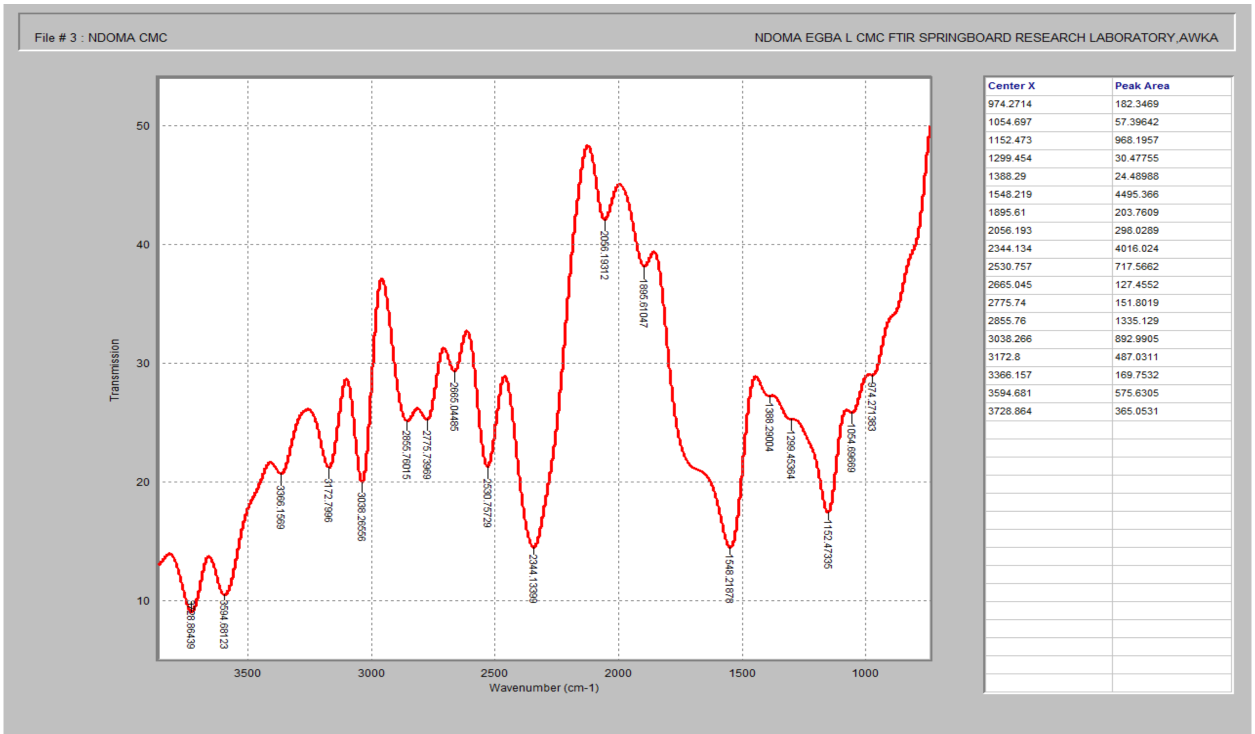

Figure 7: FTIR Spectra of Carboxyl Methyl Cellulose (CMC)

RHEOLOGY

Table 2 depicts the rheological features of the AA-WBM, CMC-WBM and MAR-WBM. As shown from the result of PV, CMC's initial PV of 11cp at 1gram, increased to 13cp, 16cp and 18cp when concentration increased to 3g, 5g and 7g respectively, while further concentration to 9g did not improve PV. For MAR, the initial of PV of 4cp at 1g, dropped to 2cp when concentration was increased to 3g, returned back to 4cp at 5g, before continuous decline with increase in concentration. For AA, its initial of PV of 5cp at 1g concentration, increased to 9cp, 11cp and 14cp at 3g, 5g and 7g concentration respectively, while further concentration had not impact on the PV. As observed from the result, AA and CMC recorded their highest PV at 7g while MAR recorded its highest best at 1g. As shown from YP result, CMC recorded 10, 17, 23, 29 and 38lb/100ft^2 at 1g, 3g, 5g, 7g and 9g respectively, MAR recorded 4, 3, 4, 3 and 2lb/100ft^2 at 1g, 3g, 5g, 7g and 9g respectively, while AA recorded YP of 4, 11, 21, 21 and 39lb/100ft^2 at 1g, 3g, 5g, 7g and 9g respectively. As observed from the YP result, AA recorded higher YP than CMC at 9g, while at other concentration CMC recorded a higher YP than AA. As shown from AV result, CMC recorded 16cp, 21.5cp, 27.5cp, 325cp and 37cp at 1g, 3g, 5g, 7g and 9g respectively, MAR recorded 6cp, 3.5cp, 6cp, 3.5cp and 4cp at 1g, 3g, 5g, 7g and 9g respectively, while AA recorded 7cp, 14.5cp, 21.5cp, 24.5cp and 29.5cp at 1g, 3g, 5g, 7g and 9g respectively. As observed from AV result, CMC recorded a higher viscosity value than AA, while MAR did poorly. As shown from YS result, CMC recorded 32.6, 44.6, 57.3, 68.4 and 80.0 at 1g, 3g, 5g, 7g and 9g respectively, MAR recorded 12.3, 7.3, 12.3, 7.3 and 8.1 at 1g, 3g, 5g, 7g and 9g respectively, while AA recorded 14.2, 29.9, 46.0, 51.2 and 70.4 at 1g, 3g, 5g, 7g and 9g respectively. As observed from the result, the YS of AA and CMC increased with increase in concentration. Combining PV, YP, AV and YS results, AA recorded similar rheological pattern to CMC, and this can be attributed to the number of substitute chains in its chemical make-up which enables it to increase its viscosity with concentration [29,30]. MAR-based WBM recorded poor rheological value showing that they are not effective in improving mud rheology. From the gel strength result AA competed favorably with CMC. AA and CMC recorded constant gel strength value at 9g concentration respectively. Gamal et al [31] reported that flat rheology is needed for mud where the gel strength values is constant overtime. Mud formulation with this concentration will require flat rheology.

Table 2: Rheological properties of the formulated water-based drilling muds

S/N	MATERIALS	CONC.	Plastic Viscosity (PV) (cp)	Yield Point (YP) ($lb/100ft^2$)	Apparent Viscosity (AV) (cp)	Yield Stress (YS) ($lb/100ft^2$)	Gel Strength	
							10 Secs.	10 Mins.
1	Carboxyl methyl cellulose	1 gram	11	10	16	32.6	20	30
		3 grams	13	17	21.5	44.6	32	38
		5 grams	16	23	27.5	57.3	45	47
		7 grams	18	29	32.5	68.4	52	53
		9 grams	18	38	37	80.0	56	56
2	Maranta Arundinacea Root	1 gram	4	4	6	12.3	8	17
		3 grams	2	3	3.5	7.3	4	8
		5 grams	4	4	6	12.3	5	11
		7 grams	2	3	3.5	7.3	4	7
		9 grams	3	2	4	8.1	5	10
3	Afzelia Africana	1 gram	5	4	7	14.2	10	15
		3 grams	9	11	14.5	29.9	25	34
		5 grams	11	21	21.5	46.0	38	46
		7 grams	14	21	24.5	51.2	40	48
		9 grams	10	39	29.5	70.4	50	50

FLUID LOSS

Figure 8 shows the fluid loss volumes of MAR, AA and CMC WBMs. From Figure 8, 1g of AA recorded fluid loss of 35mls, while further increase in concentration to 3g, 5g, 7g and 9g resulted in corresponding increase in fluid loss of 46mls, 54mls, 60mls and 66mls respectively. 1g of MA recorded fluid loss of 24ml, while further increase in concentration to 3g, 5g, 7g and 9g gradually reduced fluid loss volume of 23ml, 23ml, 22ml and 21ml respectively. 1g of CMC record fluid loss of 15ml, while further increase in concentration to 3g, 5g, 7g and 9g gradually reduced fluid loss volume to 13ml, 12ml, 10ml and 10ml respectively. As observed MAR performed better than AA as it recorded the least fluid loss volume at 9g with filtrate volume of 21ml, while AA recorded the least fluid loss volume at 1g with filtrate volume of 35ml. The fluid loss control performance of MAR over AA can be attributed to the finer particle sizes of MAR as a nanoparticle and AA in particle size of 250 mesh size. Although MAR performed better than AA, CMC recorded the least fluid loss of the materials utilized as it recorded filtrate loss of 10ml at 7g and 9g respectively. The performance of CMC over MAR and AA could be attributed to its ability to yield more increased cellulose content in the DF as result of increased additive concentration [32]. Comparing Figure 6 with Table 2, AA can be considered as a viscosity increasing additive while MAR can be considered a fluid loss control additive.

Tables 3 depicts the mud cake thickness formed by the formulated mud samples. As can be observed from Table 3, CMC recorded 2/32 of an inch mud cake thickness from 1g-5g concentration respectively, while from 7g-9g concentration mud cake thickness increased to 3/32 of an inch respectively. MAR recorded 2.5/32 of an inch mud cake thickness from 1g-3g concentration respectively, while from 5g-9g concentration, mud cake thickness reduced to 2/32 of an inch respectively. AA recorded 3/32 of an inch mud cake thickness at 1g, and this increased to 7/32, 8/32, 11/32 and 17/32 of an inch respectively. When compared to other, MAR recorded closer mud cake thickness to CMC while the mud cake thickness of AA continued to increase with increase in concentration. Comparing the Tables 3 with Figure 6, the thickness of mud cake for CMC slightly increased with reduction in fluid loss volume, the thickness of mud cake for MAR reduced with reduction in fluid loss volume, while the thickness of the mud cake for AA increased with increase in fluid loss volume. The slight increase in mud cake thickness for CMC could be attributed to the deposition or sedimentation effect of the material. The increase in mud cake thickness for AA is attributed to the loss of fluid volume, and if untreated gives rise to differential sticking of the drill-pipe and possible non-productive time (loss time) which negatively impacts the drilling operations (extra cost) and formation damage (skin) . MAR recorded a drop in filter cake thickness and filtrate volume with increasing concentration. This is due to the ability of MAR to form thin filter cake of low permeability to reduce volume of fluid lost to the formation. Comparing the fluid loss result of MAR, with the works of [14], [17] and [24] which recorded 5%, 4%-5% and 6%-5% fluid losses respectively, MAR can be considered as a possible substitute for CMC.

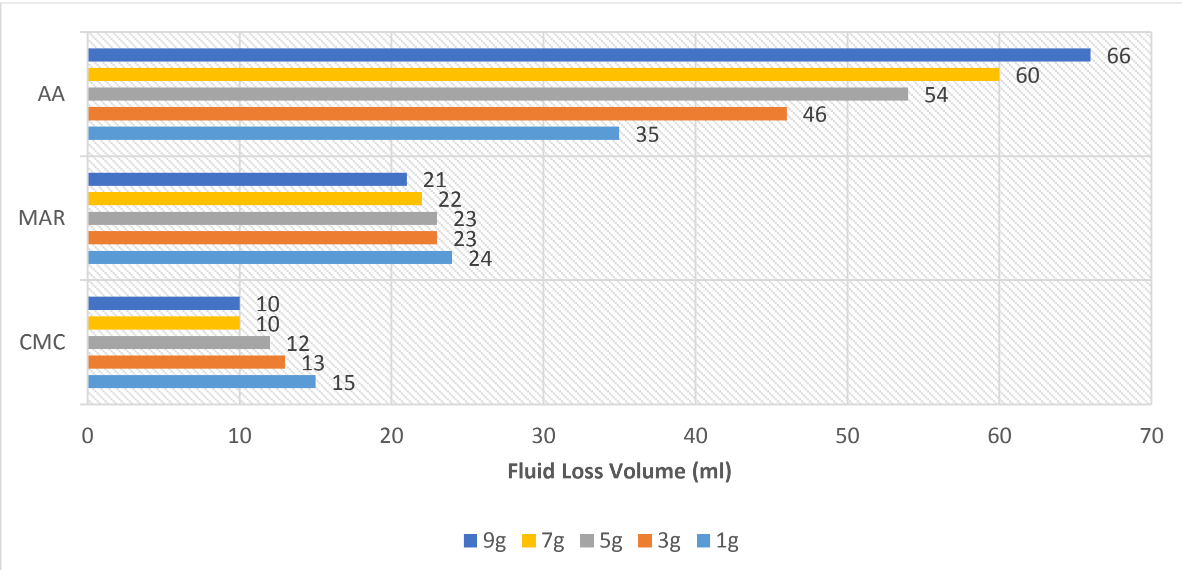

Figure 8: Fluid loss volumes of the formulated mud samples

Table 3: Mud cake thickness formed by the formulated mud samples

S/N	MATERIALS	FORMULATION	Mud cake thickness (x/32)inch
1	Carboxyl methyl cellulose (CMC-WBM)	1grams	2
		3grams	2
		5grams	2
		7grams	3
		9grams	3
2	Maranta Arundinacea Root (MAR-WBM)	1gram	2.5
		3grams	2.5
		5 grams	2
		7 grams	2
		9 grams	2
3	Afzelia Africana (AA-WBM)	1 gram	3
		3 grams	7
		5 grams	8
		7 grams	11
		9 grams	17

CONCLUSION

From the experimental study carried out and the result obtained, the following conclusions can be drawn.

(1) From the FTIR characterization study conducted, the locally sourced bio-materials recorded similar functional groups such as carboxylic acid, amines, aromatic and alcohol which were present in carboxymethyl cellulose (CMC).
(2) From the rheology study carried out, AA competed with CMC can be utilized as a viscosifier based on its rheological behavior
(3) From the fluid loss control study carried out, MAR recorded better fluid loss control performance than AA as 9g of MAR yielded filtrate loss volume of 21ml at 30mins respectively while 9g of AA yielded filtrate loss volume of 66ml at 30mins,
(4) MAR competed favorably with CMC in fluid loss control and can be utilized as alternative fluid loss control additive
(5) Increase in fluid loss of water-based mud (WBM) results in the Increase of the thickness its filter cake.

FURTHER RESEARH AREA

(1) Performance Study of MAR and AA as partial replacement additive for CMC in WBM.
(2) The impact of temperature, salinity and oil contamination on the performance of MAR and AA in WBM.
(3) Improvement on the rheological Performance of MAR using heat reformulation approach, and improvement on the fluid loss control performance of AA using locally sourced nanoparticles.

ACKNOWLEDGEMENT

Profound Appreciation and Gratitude to the Staff at the Drilling Fluids Laboratory, Petroleum Engineering Department, Federal University of Technology Owerri.

REFERENCE

[1] Udoh F.D., Itah J.J., Okon A.N. Formulation of synthetic-based drilling fluid using palm oil derived ester. Asian J. Microbiol. Biotechnol. Environ. Sci. 14(2), 2012, 175-180.
[2] Kerunwa A. Evaluation of the Impact of pH on the Rheological Property of Drilling Fluid Formulated with Mucuna Flagellipe and Brachystegia Eurycoma. Petroleum and Coal. Vol 62(4), 2020, 1586-1594
[3] Anderson R.L., I Ratcliffe H.C. Greenwell et al. Clay swelling—a challenge in the oilfield. Earth Science Reviews 98(3), 2010, 201-216.
[4] Odunukwe R.C. Suitability of Detarium Microcarpum as an Additive in Drilling Fluid. 2015 www.uniprojectsearch.com/suitability-detarium-microcarpum-additive-drilli ng-fluid/. (Accessed 13 March 2018).
[5] Gonzalez J.M, Quintero F., Arellano J.E., Marquez R.L., Sanchez C., Pernia D. Effects of interactions between solids and surfactants on the tribological properties of water-based drilling fluids. Colloids and Surfaces A: Physicochem. Engr. Aspects 391(1), 2011, 216-223
[6] Bourgoyne Jr A.T., Millheim K.K., Chenevert M.E., and Young Jr F.S. Drilling Fluids. In: Applied Drilling Engineering. SPE Vol. 2, 1986, p. 41-84.
[7] Khodja M., Khodja-Saber M., Canselier J.P., Cohaut N., Bergaya F. Drilling Fluid Technology: Performances and Environmental Considerations. Products and Services. From R&D to Final Solutions. Intech Open Access Publishers, 2010, pp. 228-256.
[8] Feng Z., Hongming T., Yingfeng M., Gao L. and Xijin X. Damage Evaluation for water-based underbalance drilling in low permeability and tight sandstone gas reservoir. J. Petreo. Exp. Develop. 36(1), 2009, 113-119.
[9] Azar J.J. and Samuel G.R. Drilling Engineering. PennWell Books-Technology and Engineering, 2007, p 486.
[10] Agwu O.E. and Akpabio J.U. Using agro-waste materials as possible filter loss control agents in drilling muds. J. Petrol. Sci. Eng. 163, 2018, 185-198.
[11] Bourgoyne A.T., Millheim K.K., Chenevert M.E., Young F.S. Applied Drilling Engineering, 2. Textbook Series, Society of Petroleum Engineers, Richardson Texas, 2003.

[12] Caenn R. and Chillinger G.V. Drilling Fluids: State of the Art. J. Petrol. Sci. Eng. Vol 14, 1996, 221-230.

[13] Tugwell, K.W. Evaluation of Locally Sourced Filter Loss Control Materials for Water Based Drilling Fluid. BEng. Project, University of Uyo, Nigeria, 2018.

[14] Olatunde A.O. Usman M.A. Olafadehan O.A. Adeosun T.A. Ufot O.E. Improvement of rheological properties of drilling fluid using locally based materials. J. Petroleum Coal 54 (1), 2012, 65–75.

[15] Adebayo T.A. and Chinonyere P. Sawdust as a filtration control and density additives in water-based drilling mud. Int. J. Sci. Eng. Res. 3(7), 2012, 176-204.

[16] Egun, I.L. Abah, A.M. Comparative performance of cassava starch to PAC as fluid loss control agent in water based drilling mud. Discovery J. 3(9), 2013, 36–39. www .discovery.org.in.

[17] Azizi A., Ibrahim M.S.N., Hamid K.H.K, Sauki A., Ghazali N.A. and Mohd T.A.T. Agarwood Waste as a New Fluid Loss Control Agent in Water-Based Drilling Fluid. Int. J. Sci. 5(2), 2013), 101-105.

[18] Dagde K.K. and Nmegbu C.G.J. Drilling fluid formulation using cellulose generated from groundnut husk. Int. J. Adv. Res. Tech. 3(6), 2014, 65-71.

[19] Okon A.N. Udoh F.D. Bassey P.G. Evaluation of rice husk as fluid loss control additive in water based drilling mud. SPE NAICE Paper, 2014.

[20] Nmegbu C.G.J. Bari-Agara B. Evaluation of corn cob cellulose and its suitability for drilling mud formulation. Int. J. Eng. Res. Afr. 5 (9), 2014, 48–54.

[21] Chinwuba I.K. Princewill O.N. and Vivian O.C. Evaluation of the fluid loss properties of pleurotus and its commercial availability. Int. J. App. Inno. Eng. Manag. 5(5), 2016, 259-264.

[22] Okon A.N. Akpabio J.U. and Tugwell K.W. Evaluating the locally sourced materials as fluid loss control additives in water-based drilling fluid. Heliyon 6, 2020, https://doi.org/10.1016/j.heliyon.2020.e04091

[23] Chinwuba I.K. Uwaezuoke N. Ukaka C.M. Anaefule C.V. and Zakka S.B. Evaluation of rheological and fluid loss properties of Nigerian bentonite using periwinkle and mucuna solanie, Cogent Engineering, 8, 2021, 1885324. http://dx.doi.org/10.1080/23311916.2021.1885324

[24] Ikram R. Jan B.M, Sidek A. and Kenanakis G. Utilization of Eco-Friendly Waste Generated Nanomaterials in Water-Based Drilling Fluids; State of the Art Review. Materials, 14, 2021, 4171

[25] Kerunwa A, Akoma G.J., Okoronkwo R.O., Okereke N.U. and Udeagbara S.G. Performance Evaluation of CNF and ZMCs as Fluid Loss Control Additive in Water Based Mud. Petroleum and Coal, 65(2), 2023, 565-580.

[26] Kerunwa A, and Gbaranbiri B. Evaluation of Local Viscosifiers as an Alternative to Conventional Pac-R. Advances in Petroleum Exploration and Development, 15(1), 2018, 1-8

[27] Hassiba KJ, and Am-Qwani M. The Effect of Salinity on the Rheological Properties of Water Based Mud under High Pressures and High Temperatures for Drilling Offshore and Deep Wells. Earth Science Research, 2(1), 2013, 175-186.

[28] Muherei MA. Common Versus Herschel-Bulkley Drilling Fluid Models: Effect of their Rheological Parameters on Dynamic Particle Settling Velocity. American Scientific Research Journal for Engineering, Technology, and Sciences. Vol. 16(1), 2016, 155-177.

[29] Eiroboyi I, Ikiensikimama SS, Oriji BA, Okoye IP. The Effect of Monovalent and Divalent Ions on Biodegradable Polymers in Enhanced Oil Recovery. InSPE Nigeria Annual International Conference and Exhibition 2019 Aug 5 (p. D033S027R002). SPE

[30] Dike CF, Izuwa NC, Kerunwa A, Nwanwe O, Enyioko ND, Obah B. An Investigation on the Enhanced Oil Recovery Performance of Local Biopolymers. Journal of Chemical and Petroleum Engineering (JChPE), 2024 58(2): 311-324.

[31] Gamal H, Elkatatny S, Basfar S, and Al-Majed A. Effect of pH on Rheological and Filtration Properties of Water-Based Drilling Fluid Based on Bentonite. Sustainability. (11), 2019, 1-13.

[32] Agwu OE, Akpabio JU, and Archibong GW. Rice husk and saw dust as filter loss control agent for water based mud. Heliyon Journal, 5(7), 2019, 1-8.