Performance Study of Afzeila Africana-Marantha Arundinacea Nanoparticles Assisted for Fluid Loss Control in Water-Based Drilling Fluid

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Abstract

Drilling fluids (DF) play a vital role in oil and gas well drilling operations, particularly given the increasing economic, technical, and environmental challenges associated with different wells and fields. However, during drilling, DF often experiences filtrate (fluid) loss, which reduces the continuous phase volume and leads to an increase in mud cake thickness. To address this issue, various additives have been employed to enhance the properties of the mud filter cake and mitigate fluid loss. Conventional fluid loss additives, such as CarboxyMethyl Cellulose (CMC), have been widely used for this purpose; however, these chemicals are neither cost-effective nor environmentally sustainable, particularly in developing regions. Consequently, ongoing research seeks suitable local alternatives to replace these materials.

In this study, the efficacy of polymer-assisted nanoparticles for fluid loss control was evaluated. Biopolymers including Afzelia Africana (AA) and Maranta Arundinacea Root (MAR) were tested, along with Corncobs (CC) and Silica Oxide Nanoparticles (SiO_2) as nanoparticle additives. CMC served as the conventional material for comparison. Analytical methods including Fourier Transform Infrared Spectroscopy (FTIR), rheological analysis, and filtration tests were conducted. FTIR results revealed that CMC, AA, MAR, CC, and SiO_2 exhibited similar functional groups, such as alcohol, aromatic carboxylic acid, and isothiocyanate. Rheological testing demonstrated that the incorporation of SiO_2 and CC into AA-based and MAR-based water-based drilling fluids (WBDF) enhanced their rheological properties. Fluid loss tests further indicated that the inclusion of SiO_2 and CC improved the fluid loss control performance of the WBDFs, with CC having the most pronounced effect on both rheological and fluid loss performance.

The study provides promising insights into sustainable and cost-effective approaches to improving drilling fluid performance using locally available resources, which could enhance drilling efficiency and reduce environmental impact.

Introduction

The exploitation of crude oil and natural gas has experienced significant growth due to increasing global demand. As a result, rapid technological advancements, such as horizontal and directional drilling, have been implemented to enhance oil production efficiency (Tour et al. 2019). Drilling fluids (DFs) are crucial in the drilling of oil and gas wells, particularly given the complex economic, technical, and environmental challenges associated with various fields (Foxenberg et al. 2008). DFs are often referred to as the "lifeblood" of wellbore

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drilling activities in the petroleum industry (Udoh and Okon 2012). DFs consist of a dispersed phase and a continuous phase, which form the basis for their classification. They are typically categorized as water-based drilling fluids (WB-DF), oil-based drilling fluids (OB-DF), or pneumatic-based drilling fluids (PB-DF), with WB-DF being the most environmentally preferred option (Kerunwa 2020).

DFs perform several critical functions, including: 1) cooling and lubricating the drill string, 2) removing and transporting cuttings from the borehole, 3) managing subsurface formation pressures, 4) reducing friction between the drill string and the borehole, and 5) forming a thin, low-permeability filter cake to minimize fluid loss (Skalle 2012; Sayindla et al. 2017; Kerunwa and Gbaranbiri 2018). Among these, the prevention of continuous phase loss is a key function, which is achieved by forming a low-permeability filter cake along the borehole wall (Feng et al. 2009). Thus, DFs are formulated to minimize unwanted filtrate loss and promote borehole stability (Azar and Samuel 2007). The formulation process aims to enhance borehole stability, form a thin filter cake, and reduce fluid loss (Agwu and Akpabio 2018). This process, referred to as fluid-loss control, involves the addition of specific chemicals to improve the filter cake properties and lower the filtration rate (Bourgoyne et al. 1986).

Traditionally, fluid-loss control has been achieved using conventional additives such as polyanionic cellulose (PAC) and carboxymethyl cellulose (CMC) (Caenn and Chillinger 1996). However, these commercial polymers are neither cost-effective nor environmentally sustainable for developing countries, leading to increased interest in local alternatives for fluid-loss control. Previous studies have explored various biopolymers and local materials for their fluid loss control potential. For example, Olatunde et al. (2012) investigated the use of gum arabic in water-based mud (WBM), while Okon et al. (2014) evaluated rice husk for similar purposes. Other studies have examined corn cob cellulose (Nmegbu and Bari-Agara 2014), pleurotus tuber-regium (Chinwuba et al. 2016), and combinations of local materials, such as rice husk, detarium microcarpum, and brachystegia eurycoma (Okon et al. 2020). These studies demonstrated varying degrees of success, highlighting the potential of local materials in fluid loss control.

Furthermore, recent research has focused on the use of nanoparticles as promising fluid loss control additives (Uwaezuoke 2022). Studies by Ismail et al. (2016) and Dejtaradon et al. (2019) have shown that nanosilica and ZnO nanoparticles exhibit significant fluid loss control capabilities. Cheraghian (2019) and Gbadamosi et al. (2019) also reported improved fluid loss performance using silica nanoparticles. Despite these advancements, the rheological limitations of nanoparticles and locally sourced materials prevent them from fully replacing conventional additives like CMC and PAC-R.

In this study, silica oxide nanoparticles (SiO_2-NPs) were blended with two biopolymers, Afzelia Africana and Maranta Arundinacea, to enhance their fluid loss control properties in water-based drilling fluids (WBDF).

Materials and Methods

Materials. The materials utilized in this study for fluid loss control analysis included both locally sourced additives and conventional materials. The locally sourced biopolymers used were Afzelia Africana (AA) and Maranta Arundinacea Root (MAR), which served as fluid loss control additives. In addition, nanoparticles were incorporated, specifically Silica Oxide (SiO_2) and Corncobs (CC), to enhance fluid loss control performance. As a conventional fluid loss control additive, Carboxymethyl Cellulose (CMC) was used for comparison. Among them, the AA, MAR, and CC were sourced from a local market in the South-Eastern Part of Nigeria, West Africa. While CMC and SiO_2 were sourced from an industrial store and the locally sourced fluid loss control additives.

Other essential materials included Bentonite, used as a viscosifier to maintain fluid consistency, and Barite, employed as a weighting agent for density control. Sodium Hydroxide was used for pH control, and Calcium Carbonate was added to further stabilize the drilling fluid. The continuous phase of the drilling fluid consisted of water.

A variety of equipment was used to analyze the properties of the formulated drilling fluids. This included a Hamilton Beach Mixer for blending, a pH meter to monitor the pH levels, and a Buck 530 IR-spectrophotometer to identify functional groups. A Low Pressure-Low Temperature API Filter Press (LPLT) was utilized for filtration testing, while a Rotary Viscometer was used to measure the rheological properties. Additionally, a Mud Balance was employed for density measurements, along with a Stopwatch and Weighing Balance for accurate time and weight measurements throughout the experimentation process.

These materials and equipment collectively contributed to the comprehensive evaluation of the fluid loss control properties of the drilling fluids in this study.

Preparation of the Locally Sourced Bio-Polymer. To prepare the locally sourced biopolymers used in this study, the following procedures were followed for each material.

Afzelia Africana (AA) Preparation. Afzelia Africana pods were first subjected to a controlled heat treatment in an oven set to 60°C for 30 minutes. This process facilitated the extraction of the seeds from the pods. Once the seeds were released, they were pulverized using an industrial-grade blender to produce fine nanoparticles. The pulverized material was then passed through a 0.062 mm mesh sieve to ensure uniform particle size. The sieved particles were stored in a sealed container to preserve their integrity for use in the formulation.

Corncobs (CC) Preparation. Corncobs were dehydrated in an oven at 60°C for 48 hours to remove any residual moisture. After the dehydration process, the dried corncobs were ground into finer particles using an industrial blender. To ensure particle uniformity, the ground corncobs were sifted through a mesh sieve. The resulting fine particles were stored in an airtight container to maintain quality for later use in the drilling fluid formulation.

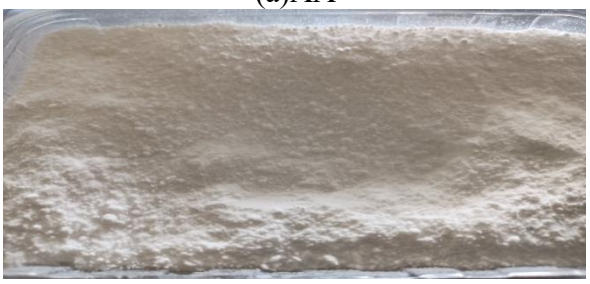
Maranta Arundinacea Root (MAR) Preparation. The Maranta Arundinacea (MAR) roots were first sliced into smaller pieces and blended with water to create a slurry. This slurry was allowed to stabilize for two hours before the water content was reduced. This process was repeated twice until a clear, transparent top layer of water was achieved. The transparent water was carefully removed by filtration, leaving behind a thick, dry substance. The remaining thick material was then dried in a laboratory oven for 48 hours at 45°C. Once fully dried, the MAR root was pulverized into fine powder using an industrial blender and sieved to achieve a consistent particle size. The powdered MAR was stored in an airtight container to ensure its quality was preserved.

These locally sourced biopolymers, along with conventional additives such as Carboxymethyl Cellulose (CMC) and Silica Oxide (SiO_2) nanoparticles, were used in this study to evaluate fluid loss control performance in water-based drilling fluids. **Figure 1** illustrates the powdered form of AA, MAR, SiO_2, CMC, and CC, respectively.

Methods. ***FTIR Analysis*.** The FTIR analysis was conducted using a Buck 530 IR-spectrophotometer to examine the molecular structure and functional groups of selected materials: AA, MAR, CC, SiO_2, and CMC. FTIR produces an absorbance spectrum plot, which highlights the unique molecular arrangements and chemical bonds within these materials. The spectrum contains peaks that correspond to specific functional groups (e.g., alkanes, carboxylic acids, chlorides, and ketones) present in the material. Each functional group absorbs infrared radiation at distinct wavelengths, allowing for their identification. These spectral data are then cross-referenced against a reference library to determine the precise range of values associated with the detected functional groups.

(a)AA

(b)MAR



(c)SiO_2

(d)CMC

(e)CC

Figure 1—Additives powder.

Mud Formulation. For the fluid loss experimental analysis, a total of seven mud samples were formulated. This included three independent mud samples: AA, CMC, and MAR, as well as four hybrid samples: AA-CC, AA-SiO_2, MAR-CC, and MAR-SiO_2. The detailed composition of these formulations is presented in **Table 1**.

Table 1—Mud formulation utilized for the study.

S/N	Mud Type	CMC	AA	MAR	CC	SiO_2
1	CMC	1g	Nil	Nil	Nil	Nil
2	AA	Nil	1g	Nil	Nil	Nil
3	MAR	Nil	Nil	1g	Nil	Nil
4	AA-CC	Nil	1g	Nil	0.2g, 0.4g, 0.6g, 0.8g and 1g	Nil
5	AA-SiO_2	Nil	1g	Nil	Nil	0.2g, 0.4g, 0.6g,0.8g and 1g
6	MAR-CC	Nil	Nil	1g	0.2g, 0.4g, 0.6g, 0.8g and 1g	Nil
7	MAR-SiO_2	Nil	Nil	1g	Nil	0.2g, 0.4g, 0.6g,0.8g and 1g

Mixing Procedure of Mud Sample Formulation. The following procedure was followed for the preparation of the mud samples:

1. The required amount of each additive was precisely weighed using a standard weighing balance.
2. 350 ml of distilled water was measured using a scientific cylinder and added to the mud preparation process.
3. The water was then subjected to agitation using a Hamilton Beach Mixer.
4. After initiating agitation, 15 g of Bentonite was added to the water and mixed thoroughly for five minutes.
5. 0.5 g of sodium hydroxide (NaOH) and 0.25 g of calcium carbonate (CaCO3) were subsequently introduced into the slurry and mixed for an additional two minutes.
6. 1 g of CMC was added to the solution and stirred for three minutes.
7. 10 g of Barite was added to the solution and stirred for 15 minutes to achieve an even mixture.

This procedure was repeated for the independent samples (AA, MAR) as well as for the hybrid samples (AA-CC, AA-SiO_2, MAR-CC, MAR-SiO_2). The Hamilton Beach Mixer was operated at medium speed, and the total mixing time required for each mud slurry was 30 minutes.

Table 2 provides the detailed composition of the water-based drilling fluid (WB-DF) for both independent and hybrid samples, using 1 g of each respective additive.

This process ensured a consistent and thorough mixing of the mud components to prepare the samples for subsequent fluid loss performance evaluations.

Table 2—Composition of WB-DF at 1g for both independent and hybrid sample.

Additives	Function	CMC-DF	AA-DF	MAR-DF	AA-CC-DF	AA-SiO_2-DF	MAR-CC-DF	MAR-SiO_2-DF
Water (ml)	Base Fluid	350	350	350	350	350	350	350
Barite (g)	Weighting	10	10	10	10	10	10	10
Bentonite (g)	Viscosifier	15	15	15	15	15	15	15
Calcium Carbonate (g)	Bridging Agent	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Sodium Hydroxide (g)	pH control	0.5	0.5	0.5	0.5	0.5	0.5	0.5
CMC (g)	Fluid loss Control	1	Nil	Nil	Nil	Nil	Nil	Nil
AA (g)		Nil	1	Nil	1	1	Nil	Nil
MAR (g)		Nil	Nil	1	Nil	Nil	1	1
CC		Nil	Nil	Nil	1	Nil	1	Nil
SiO_2		Nil	Nil	Nil	Nil	1	Nil	1

Mud Rheology. The rheological properties of the formulated mud samples were evaluated using a rotary viscometer. The prepared mud was poured into the viscometer cup, filling it up to the designated graduation mark, and the cup was securely mounted on the viscometer stand. The stand was then raised vertically to ensure that the rotating sleeve made proper contact with the mud. Measurements were taken at rotor speeds of 300 rpm and 600 rpm to obtain the dial readings for each mud sample. Based on these readings, key rheological parameters such as plastic viscosity (PV), yield point (YP), and apparent viscosity (AV) were calculated using the following empirical formulas:

$$\text{Plastic Viscosity}(cP) = \theta_{600} - \theta_{300}, \quad (1)$$

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

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

These calculations helped to assess the flow behavior and viscosity properties of the formulated muds, which are critical for effective drilling operations.

Mud Fluid Loss. The mud filtration study was conducted under low pressure-low temperature (LPLT) conditions using a standard API filter press. The filter press setup included six independent filter cells, each mounted on the system. Prior to testing, the cells were thoroughly cleaned and dried to eliminate any debris, and the rubber gaskets were inspected for proper sealing compliance.

Figure 2 shows the API filter press and the rotary viscometer. The assembly of the filter press cells was completed in the following sequence: the base cap, followed by a rubber gasket, a screen, filter paper, another rubber gasket, and finally the cell body. 130 ml of the formulated drilling mud (prepared as per the compositions in Tables 1 and 2) was introduced into each cell. The cell assembly was then tightened securely to ensure a proper seal. A 50 ml measuring cylinder was placed beneath the cell to collect the filtrate.

The cells were pressurized to 100 psi using inert gas to simulate typical reservoir conditions. After 30 minutes, the volume of filtrate was measured and recorded. Additionally, the thickness of the filter cake formed on the filter paper was measured using a vernier caliper and documented in x/32-inches units.

This procedure allowed for the evaluation of fluid loss characteristics and the effectiveness of the formulated muds in minimizing filtrate loss and creating a stable filter cake.

(a) API filter press

(b) Ofite rotary viscometer

Figure 2—Equipment used to measure mud filtration.

Result

FTIR Characterization. Figures 2 to **6** shows the FTIR spectra of AA, MAR, CMC, CC and SiO_2, respectively. AA showed the presence of functional group such as alkyl halides, aromatics, carboxylic, aliphatic amines, isothiocyanate, alkyne, alkane and alcohol (Figure 2). MAR showed the presence of functional group such as alkyl halides, aromatics, amine, isothiocyanate, alkyne, alkane, alkene and alcohol (Figure 3). CMC showed the presence of functional group such as alkenes, aliphatic amines, alkyl halideds, phenol, aromatics, isothiocyanate, carbon dioxide, carboxylic acid, aldehydes, alkanes, alcohol (Figure 4). CC showed the presence

of functional group such as alkyl halides, aromatic amine, amines, aromatic, isothiocyanate, carboxylic acid, aldehyde, amine salt and alcohol (Figure 5). SiO_2 showed the presence of functional group such as alkynes, aromatics, alkenes, amines, isothiocyanate, carboxylic acid, alkanes and alcohol (Figure 6).

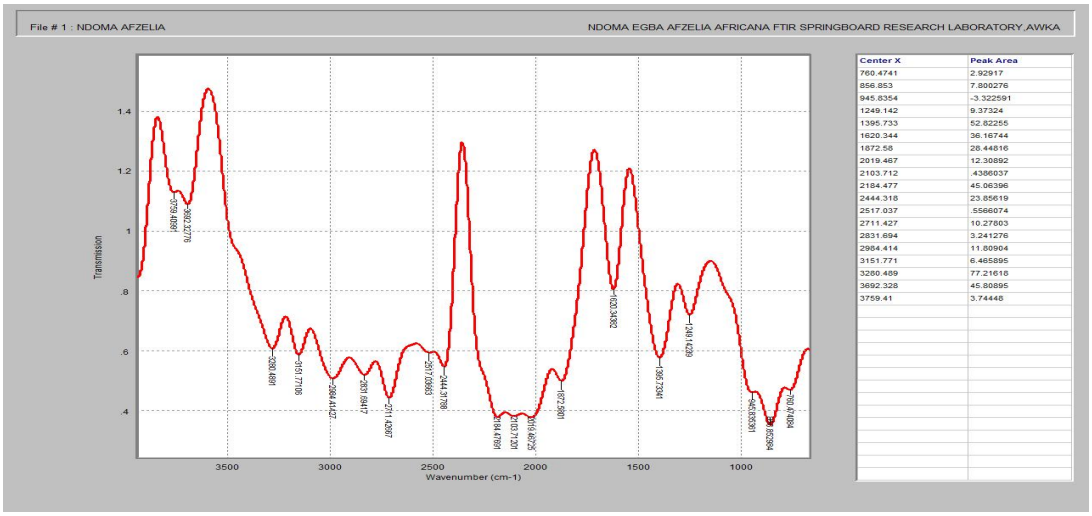


Figure 2—FTIR spectra of Afzelia Africana (AA).

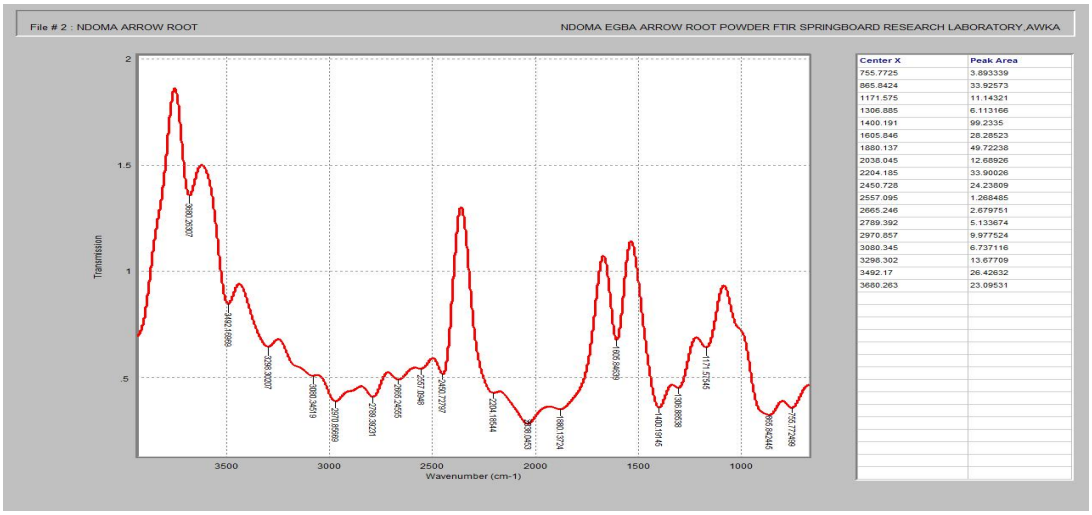


Figure 3—FTIR spectra of Marantha Arundinacea (MAR).

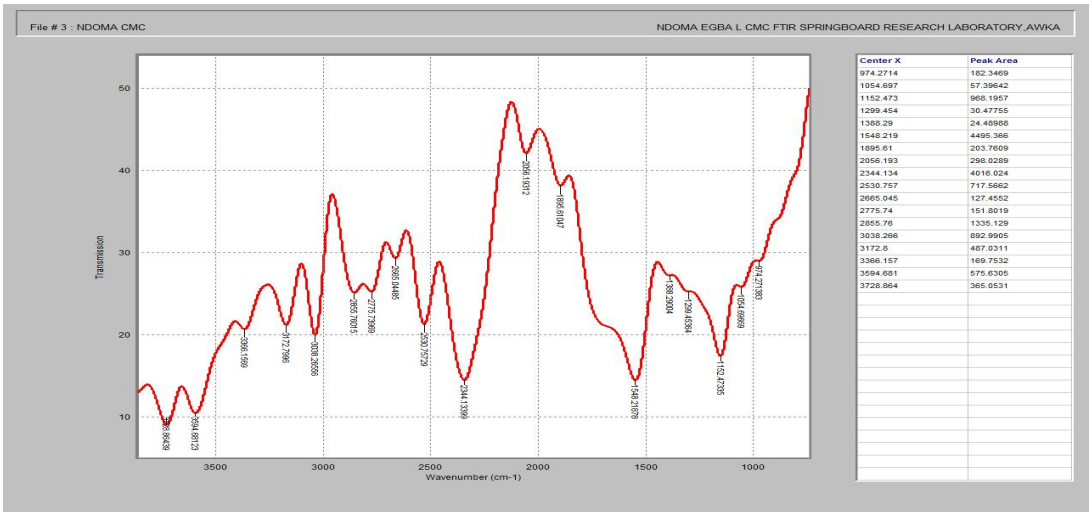


Figure 4—FTIR spectra of Carboxyl Methyl Cellulose (CMC).

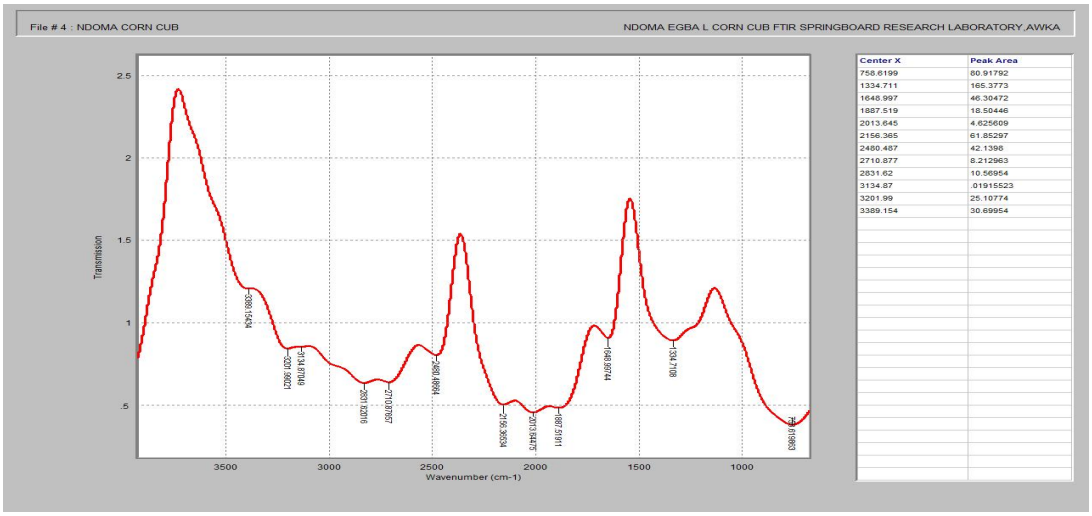


Figure 5—FTIR Spectra of Corn Cubs (CC).

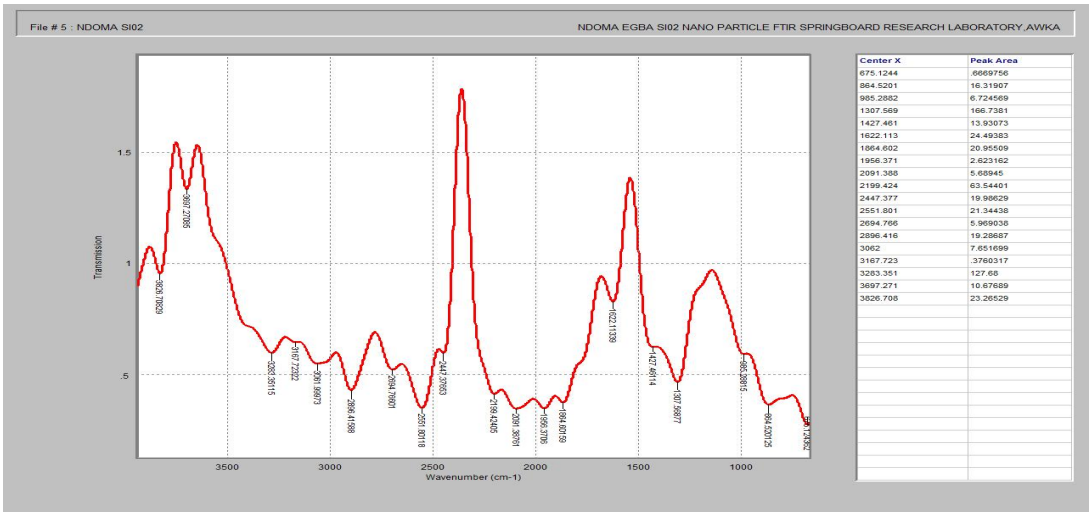


Figure 6—FTIR spectra of SiO_2-NPs.

A comparative analysis of the spectra (Figures 2 to 6) reveals several common functional groups among the materials. Alcohols, aromatics, carboxylic acids, and isothiocyanates detected in CMC were also present in the locally sourced materials AA, MAR, CC, and SiO_2. However, phenol, which was found in CMC, was absent in the spectra of AA, MAR, CC, and SiO_2. Additionally, alkenes were present in CMC, SiO_2, and MAR, but absent in AA and CC.

Overall, the FTIR analysis indicates that the locally sourced materials share a number of similar functional groups with the conventional material (CMC), suggesting their potential as alternative fluid loss control additives.

Rheology. Table 3 provides a detailed overview of the rheological properties of the formulated water-based drilling fluids (WBDFs). The analysis includes the assessment of plastic viscosity, yield point, apparent viscosity, and gel strength.

Plastic Viscosity. The base PV values for CMC, Afzelia Africana (AA), and Maranta Arundinacea (MAR) were 11 cp, 5 cp, and 4 cp, respectively. The introduction of Corncobs (CC) into AA-WBDF led to a 20% increase in PV at 0.2 g concentration, with further increases in CC concentration resulting in an 80% rise in PV. Similarly, adding SiO_2 to AA-WBDF caused a 20% increase in PV at 0.2 g concentration, with up to a 60% increase as concentration rose. For MAR-WBDF, the introduction of CC initially did not increase PV at 0.2 g concentration but resulted in up to a 75% increase at higher concentrations. The addition of SiO_2 to MAR-WBDF showed a 25% increase in PV at 0.2 g concentration, with further increases up to 50% at higher concentrations.

Yield Point. The YP for CMC, AA, and MAR was recorded at 10 lb/100ft², 4 lb/100ft², and 4 lb/100ft², respectively. Introducing CC into AA-WBDF caused a 100% increase in YP at 0.2 g concentration, though YP values decreased as the concentration increased, eventually dropping by 25%. Adding SiO_2 to AA-WBDF increased YP by 25% and 75% at 0.2 g and 0.4 g concentrations, respectively, but further increases in concentration resulted in YP drops of 25%, 50%, and finally 0%. For MAR-WBDF, the introduction of CC caused a 50% YP increase at 0.2 g concentration, with a peak increase of 100% at 0.8 g before dropping back to 50% at 1 g concentration. The addition of SiO_2 to MAR-WBDF resulted in 25% and 50% increases in YP at 0.2 g and 0.4 g concentrations, respectively, with further increases leading to up to 50% YP enhancement at 1 g concentration.

Apparent Viscosity. The AV values for CMC, AA, and MAR were 16 cp, 7 cp, and 6 cp, respectively. The introduction of CC into AA-WBDF improved AV by 42.9% at 0.2 g concentration and increased further to 64.3% at higher concentrations. Similarly, adding SiO_2 to AA-WBDF resulted in AV improvements of 42.9% to 64.3%, depending on the concentration. In MAR-WBDF, CC enhanced AV by 16.7% at 0.2 g concentration and up to 66.7% at 1 g concentration. SiO_2 also improved AV in MAR-WBDF by 25% at 0.2 g concentration and up to 50% at higher concentrations.

Gel Strength. Gel strength analysis showed that at 0.8 g concentration, CC enhanced the gel strength of AA-WBDF from an initial 10 and 15 lb/100 ft² to 22 and 24 lb/100 ft². SiO_2, at 1 g concentration, further increased gel strength to 24 and 26 lb/100 ft² for AA-WBDF. For MAR-WBDF, CC at 1 g concentration improved gel strength from 8 and 11 lb/100 ft² to 20 and 21 lb/100 ft². SiO_2, at the same concentration, enhanced gel strength from 8 and 11 lb/100 ft² to 19 and 21 lb/100 ft².

Overall, the results show that the addition of CC and SiO_2 to both AA and MAR-based WBDFs significantly improved their rheological properties. However, the AA blends exhibited rheological performance closer to that of the CMC-based WBDF, indicating its potential as an alternative to conventional fluid loss control additives.

Table 3—Rheological properties of the formulated water-based drilling fluids (WBDF).

S/N	Materials	Formulation	Θ_{600}	Θ_{300}	PV	YP	AV	10 secs	10 mins
1	CMC		32	21	11	10	16	20	30
2	AA		14	9	5	4	7	10	15
3	MAR		12	8	4	4	6	8	11
4	AA-CC	1g:0.2g	20	14	6	8	10	20	21
5		1g:0.4g	21	14	7	7	10.5	18	23
6		1g:0.6g	20	14	6	8	10	20	21
7		1g:0.8g	23	15	8	7	11.5	22	24
8		1g:1g	23	14	9	5	11.5	20	23
9	AA-SiO_2	1g:0.2g	20	14	6	8	10	21	23
10		1g:0.4g	20	14	6	8	10	21	25
11		1g:0.6g	21	14	7	7	10.5	21	23
12		1g:0.8g	20	13	7	6	10	22	24
13		1g:1g	23	15	8	7	11.5	24	26
14	MAR-CC	1g:0.2g	14	10	4	6	7	11	14
15		1g:0.4g	15	11	4	7	7.5	13	17
16		1g:0.6g	17	12	5	7	8.5	18	18
17		1g:0.8g	18	13	5	8	9	19	20
18		1g:1g	20	13	7	6	10	20	21
19	MAR-SiO_2	1g:0.2g	15	10	5	5	7.5	12	15
20		1g:0.4g	16	11	5	6	8	14	16
21		1g:0.6g	17	11	6	5	8.5	17	18
22		1g:0.8g	18	12	6	6	9	19	20
23		1g:1g	18	12	6	6	9	19	21

Fluid Loss. The fluid loss performance of the formulated water-based drilling fluids (WBDFs) was evaluated and is presented in **Figures 7** and **8**.

Figure 7 shows the fluid loss volume for CMC-WBDF, AA-WBDF, and MAR-WBDF after 30 minutes. The results indicate that CMC-WBDF recorded a fluid loss volume of 15 ml, demonstrating superior fluid loss control. In comparison, MAR-WBDF and AA-WBDF exhibited higher fluid loss volumes of 24 ml and 35 ml, respectively. CMC-WBDF's better fluid loss performance is attributed to its high cellulose content, which improves its ability to form an effective filter cake (Agwu et al. 2019).

Figure 8 compares the fluid loss performance of hybrid formulations, including MAR-SiO_2, MAR-CC, AA-SiO_2, and AA-CC blends. The introduction of SiO_2 to MAR-WBDF resulted in incremental reductions in fluid loss by 4.17%, 12.5%, 16.67%, 25%, and 29.17% at 0.2 g, 0.4 g, 0.6 g, 0.8 g, and 1 g concentrations, respectively. Similarly, the addition of CC to MAR-WBDF decreased fluid loss by 4.17%, 12.5%, 16.67%, 29.17%, and 33.33% at the same concentrations.

In contrast, the addition of SiO_2 to AA-WBDF caused an increase in fluid loss volume by 5.71%, 11.43%, 17.14%, 14.29%, and 14.29% at 0.2 g, 0.4 g, 0.6 g, 0.8 g, and 1 g concentrations, respectively. The addition of

CC to AA-WBDF similarly increased fluid loss, but to a lesser extent, with a consistent increase of 5.71% at concentrations up to 0.8 g, and 11.43% at 1 g concentration.

It is clear that MAR-WBDF blends (MAR-SiO_2 and MAR-CC) demonstrated superior fluid loss control compared to AA-WBDF blends (AA-SiO_2 and AA-CC) (Figure 8). At a 1g:1g formulation, MAR-CC achieved the best performance, recording the lowest fluid loss volume of 16 ml, followed by MAR-SiO_2 at 17 ml, while AA-CC and AA-SiO_2 recorded significantly higher fluid loss volumes of 39 and 40 ml, respectively.

The exceptional performance of MAR-CC is attributed to its increased cellulose content, which aids in effectively plugging pore spaces within the rock, reducing fluid loss. Comparing Figures 7 and 8, the introduction of CC and SiO_2 into MAR-WBDF significantly enhanced fluid loss control, making it comparable to CMC-WBDF.

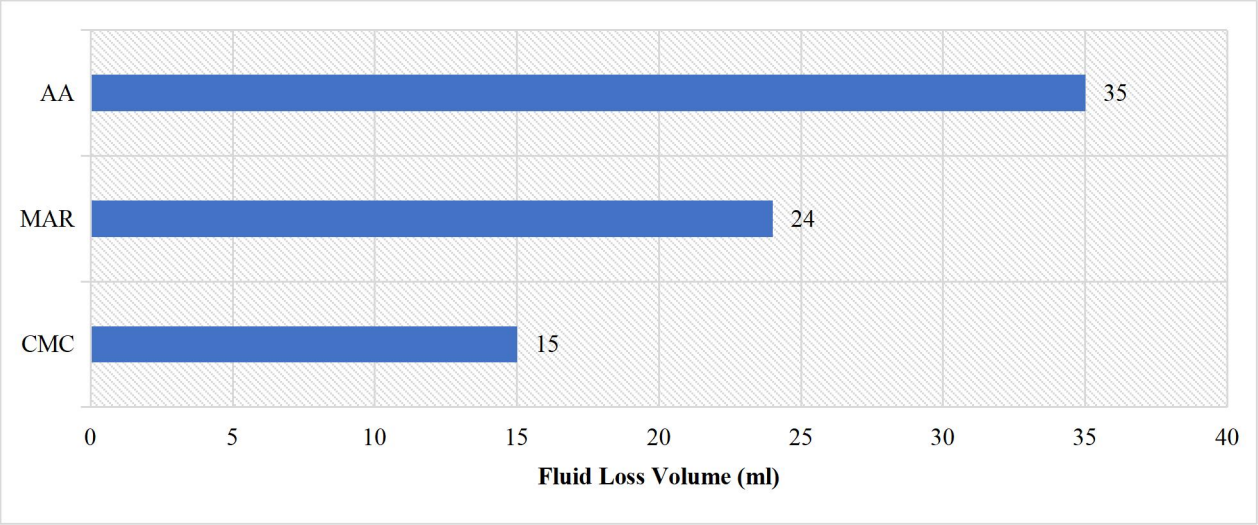


Figure 7—Fluid loss of AA-WBDF, MAR-WBDF and CMC-WBDF.

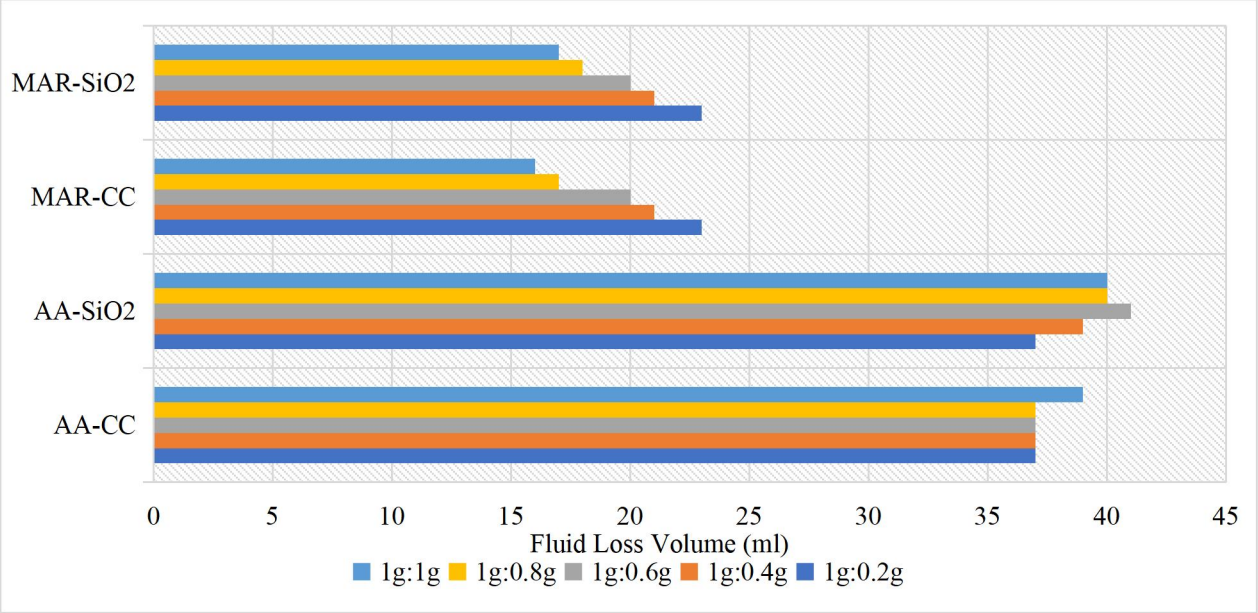


Figure 8—Fluid loss volume of MAR-SiO_2, MAR-CC, AA-SiO_2 and AA-CC WBDFs.

Table 4—Mud filter cake.

S/N	Materials	Formulation	Mud Cake
1	CMC	1g	2
2	MAR	1g	2.5
3	AA	1g	3
4	AA-CC	1g:0.2g	4
		1g:0.4g	3.5
		1g:0.6g	3
		1g:0.8g	3
		1g:1g	3
5	AA-SiO_2	1g:0.2g	4
		1g:0.4g	4
		1g:0.6g	3.5
		1g:0.8g	3.5
		1g:1g	3.5
6	MAR-CC	1g:0.2g	2.5
		1g:0.4g	2.5
		1g:0.6g	2.5
		1g:0.8g	2
		1g:1g	2
7	MAR-SiO_2	1g:0.2g	2.5
		1g:0.4g	2.5
		1g:0.6g	2.5
		1g:0.8g	2
		1g:1g	2

Mud Cake Thickness. **Table 4** provides the mud cake thickness for the various WBDF formulations. CMC recorded a mud thickness of 2/32 inches, MAR recorded 2.5/32 inches, and AA recorded 3/32 inches. The introduction of CC into AA-WBDF resulted in varying thicknesses, ranging from 4/32 inches at 0.2 g to 3/32 inches at higher concentrations. Adding SiO_2 to AA-WBDF similarly produced mud thicknesses between 4/32 inches and 3.5/32 inches.

For MAR-WBDF, the introduction of CC resulted in a consistent mud thickness of 2.5/32 inches at lower concentrations, which reduced to 2/32 inches at higher concentrations. Similarly, the addition of SiO_2 to MAR-WBDF maintained a mud thickness of 2.5/32 inches, which decreased to 2/32 inches at higher concentrations.

Overall, as shown in Table 4, the mud cake thickness of the AA and MAR formulations decreased with the introduction of CC and SiO_2. When compared with CMC-WBDF, the MAR blends demonstrated comparable mud thickness values.

The reduction in mud cake thickness observed in these formulations can be attributed to their ability to form effective filter cakes, which help reduce the volume of fluid lost to the reservoir rock. The standard API fluid loss value for WBDF is typically around 15 ml (Dankwa et al. 2018). The results indicate that the MAR-CC formulation meets this standard, making it a viable alternative for fluid loss control in drilling fluids.

Conclusions

From the experimental study conducted, the following conclusion can be drawn:

1. Afzelia Africana (AA), Maranta Arundinacea Root (MAR), and Corncobs (CC) exhibited similar functional groups, including alcohols, aromatics, carboxylic acids, and isothiocyanates, as those present in Silica Oxide (SiO_2) and Carboxymethyl Cellulose (CMC).
2. The addition of SiO_2 and CC to both AA-WBDF and MAR-WBDF resulted in notable improvements in their rheological properties.
3. Based on the rheological analysis, CC-AA WBDF and SiO_2-AA WBDF displayed rheological characteristics that were comparable to those of CMC-based WBDF. However, CC-AA WBDF demonstrated superior rheological performance.
4. The incorporation of SiO_2 and CC into AA-WBDF and MAR-WBDF significantly enhanced their fluid loss control capabilities.
5. From the fluid loss control study, CC-MAR WBDF and SiO_2-MAR WBDF exhibited fluid loss control properties similar to CMC-based WBDF, with CC-MAR WBDF displaying superior overall performance.
6. At a 1g:1g formulation, CC-MAR and SiO_2-MAR recorded fluid loss volumes of 16 and 17 ml, respectively.
7. CC had the most pronounced impact on both rheology and fluid loss control performance in WBDF formulations.

Overall, these findings suggest that CC and SiO_2 are promising additives for improving the performance of water-based drilling fluids, with CC showing particularly strong potential as a fluid loss control agent and rheology enhancer.

Conflicting Interests

The author(s) declare that they have no conflicting interests.

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