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Journal of Earth Energy Engineering

Publisher: Universitas Islam Riau (UIR) Press

Investigation Into Local Additives As Substitute To Standard Viscosifier; Advances in Drilling Technology

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Article History:

Received: August 17, 2023
Receive in Revised Form: September 10, 2023
Accepted: September 11, 2023

Keywords:

Local Content Alternatives, Drilling Technology, Environmental Sustainability, Cost Effectiveness, Rheological Properties.

Abstract

In Nigeria, drilling companies import a bulk of drilling fluid materials that they use to carry out their respective operations. This has been a major concern to oil and gas industries since these drilling fluid materials cannot be recycled, are highly expensive in terms of foreign exchange, are not environmentally friendly, not very effective, and non-biodegradable. This work presents an experimental investigation into the reliability of the use of local materials as a substitute to conventional viscosifiers. Local materials used in the analysis are mucuna solannie (Ukpo), brachystegia eurycoma (Achi), and detarium microcarpium (Ofo). The results obtained from the experimental analysis show that they compared closely to the standard viscosifer formulated with Pac-R. The results showed that the density, specific gravity, pH, yield stress, gel strength, plastic viscosity, and yield point of mud formulated from local materials compared favourably with that of the imported viscosifiers. An increase in concentration of the local sample also favoured its potential to replace the Pac-R. In terms of cost, cutting carrying ability, and positive environmental impacts, the local materials could serve the Nigerian drilling company better.

INTRODUCTION

In the oil and gas industry, drilling mud or fluid is needed to enhance drilling operations. Drilling muds are simply a heterogeneous mixture of chemicals, water, oil, clay, and/or certain local materials that aid drilling operation. The fluid controls subsurface pressure, removes drilled cuttings, enhances well-bore stability, cleans the hole, controls fluid loss, among other functions. It also helps for maximum penetration of the bit into the geological formation. The absence of the mud may result in major drilling problems such as stuck pipe, lost circulation, formation damage, pressure losses, kicks, or blowout (Amoco Production Company, 2000). The mud properties must as well be altered with additives during the drilling process to escape these drilling problems. The drilling Engineers monitor and formulate mud suitable for a given geological formation. Thus, the properties of drilling mud are dependent on the prevailing formation parameters.

Viscosity as we know is the resistance to fluid flow. The higher the viscosity of a fluid, the lesser its tendency to flow and vice-versa. Less viscous fluids flow faster than more viscous fluids. Viscosity is the major property of a drilling fluid. Viscosifiers are usually used to modify fluid flow tendency. We cannot either select polymer with premature gelation time as it causes pumping problems and plugging on tubing (Hakiki et al, 2023).

Viscosifiers are Polymer additives used to increase drilling fluid resistance to flow. It helps to moderate the viscosity of drilling fluid. The viscosifying agents tend to control the thickness of the drilling fluid to suit the prevailing well-bore condition. Mud viscosity is increased to enhance cuttings suspension, mud cake formation, and reduce water loss to the formation while drilling.

Some foreign-made Viscosifiers(additives) have been commonly used for the viscosifying purpose. Regular Poly Anionic Cellulose (PAC-R), Carbonyl Methyl Cellulose (CMC), and Hydroxyl Ethyl Cellulose(HEC) are

DOI: 10.25299/jeee.2023.14166
eISSN: 2540-9352 pISSN: 2301-8097

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common examples of imported standard viscosifiers. Since imported, the conventional materials are expensive owing to high foreign exchange rate. The standard viscosifiers are not environment friendly as it causes major pollution challenges, especially to aquatic lives. Hence, the need for a mud that is biodegradable, less toxic, and less costly from organic sources so it could serve as fertilizer after drilling activities.

The Nigerian Local Content Initiative was established to find a local substitute for imported foreign materials. In this practical research, plant seeds such as Brachystegia eurycoma (Achi), Mucuna solannie (Ukpo), and Detarium microcarpium (Ofor) were evaluated. The seeds are well-known thickeners and could be effective viscosifiers. The materials are cheaply available across Nigeria.

So far, researchers have intensified efforts to discover a local substitute to imported foreign Viscosifiers. A lot of materials have been subjected to experimental evaluations/investigations. Good enough, their findings are promising and could be improved.

Igwe I. K. (2016) on his work "Enhancing the Performance of Ukpakala Clay for Use as Drilling Mud" proved that clay viscosity in their natural state does not meet American Petroleum Institute (API) standard specifications. Therefore, not suitable for drilling mud formulation unless improved by beneficiation with some percentage concentration of sodium carbonate. Hakiki et al (2015) noted that viscosity increases with increasing polymer concentrations due to increasing intermolecular entanglement. In related research, Mortatha Al-Yasiri (2023) used broad bean peels to improve the rheological characteristics of drilling fluid, decrease fluid loss, and provide significant insight into the chemical make-up of the peels that can be used to maximize their effectiveness as drilling fluid additives. According to these findings, broad bean peels might be a practical and long-term replacement for conventional drilling fluid additives, resulting in drilling operations that are more cost- and environmentally-conscious (Mortatha Al-Yasiri, 2023).

Figure 1. Samples of Ukpo, Achi, and Ufor for test analysis.

MATERIALS AND METHODS

Reagents/Chemicals

Materials used for the research experiment included Distilled Water, Sodium Chloride (NaCl), Bentonite (local clay), Barite, Regular Poly Anionic Cellulose (PAC-R), *Mucuna solannie* (Ukpo), *Brachystegia eurycoma* (Achi), and *Detarium microcarpium* (Ofor). All the reagents were obtained from local sources except imported Pac-R bought from chemical shop.

Equipment

The experimental apparatus used in the study consists of a 200 Mesh Tyler Sieve, Ostward Viscometer, Weighing balance, Thermometer, Pipette, and Stopwatch. These equipment are available at the department of Petroleum Engineering laboratory, Federal University of Technology, Owerri, Nigeria.

Theory and Calculation

The seeds of Ukpo, Achi, and Ofor were treated, processed, and stored according to the research of (Nwosu, J. N, 2012). In the study, samples of Ukpo, Achi, and Ofor processed by soaking methods and stored in a fireplace or plastic container have higher viscosity. Soaking method was used because it was proved to possess higher viscosity compared to blanching, cooking, and roasting method.

The Raw seeds of Ukpo, Achi, and Ofor were sorted, soaked for 6hrs, dehulled, briefly dried under sun, grinded into flour, dried, and then stored in a labelled plastic container for a practical experiment.

Measurements of Freshwater(350ml), Bentonite(22.5g), Barite(5g), and NaCl(5g) as used in the experiment were adapted from the work of (Markinde, Adejumo, et al, 2011). The measured quantities comply with API specifications for standard.

350ml freshwater, 22.5g Bentonite, 5g Barite, and 5g NaCl are added to a given quantity of Pac-R, Ukpo, Ofor, and Achi as shown in Table 1 below. The same procedure was repeated for each sample of Pac-R, Achi, Ukpo, and Ofor.

Mud sample properties especially viscosity is tested, evaluated, and a conclusion drawn.

Table 1. Sample of Compositions and Mixtures.

Mud Mixtures	Samples	Mud Mixtures	Samples
5g Pac-R + *M	A1	5g Achi + *M	C1
6g Pac-R + *M	A2	10g Achi + *M	C2
7g Pac-R + *M	A3	15g Achi + *M	C3
8g Pac-R + *M	A4	20g Achi + *M	C4
5g Ukpo + *M	B1	5g Ofor + *M	D1
10g Ukpo + *M	B2	10g Ofor + *M	D2
15g Ukpo + *M	B3	15g Ofor + *M	D3
20g Ukpo + *M	B4	20g Ofor + *M	D4

Mathematical Expressions and Symbols

API - American Petroleum Institute

Pm - Mud Density

RPM - Revolution Per Minute

AV - Apparent Viscosity

PV - Plastic Viscosity

Yp - Yield Point

A = Mud Sample Mixture of Pac-R

B = Mud Sample Mixture of Ukpo

C = Mud Sample Mixture of Achi

D = Mud Sample Mixture of Ofor

$$*M = 350\text{ml Water} + \text{Bentonite}22.5\text{g} + 5\text{g Barite} + 5\text{g NaCl} \quad (1)$$

RESULTS AND DISCUSSION

Table 2. Readings and evaluation of some rheological properties

Samples	Weight (g)	Pm(ppg)	Φ600 (cp)	Φ300 (cp)	AV (cp)	PV (cp)	Yp (cp)
A1	5	7.60	270	205	135	65	140
A2	6	7.80	286	218	143	68	150
A3	7	8.70	292	223	146	69	154
A4	8	9.30	310	237	155	73	164
B1	5	7.40	65	43	32.5	22	21
B2	10	7.45	215	170	107.5	45	125
B3	15	7.55	290	218	145	72	146
B4	20	8.80	330	270	165	60	210
C1	5	7.20	26	16	13	10	6
C2	10	7.40	68	60	34	18	42
C3	15	7.60	174	147	87	27	120
C4	20	7.65	248	202	124	46	156

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D1	5	7.40	25	16	12.5	9	7
D2	10	7.60	53	42	26.5	11	31
D3	15	7.60	93	69	46.5	24	45
D4	20	7.70	176	137	88	39	98

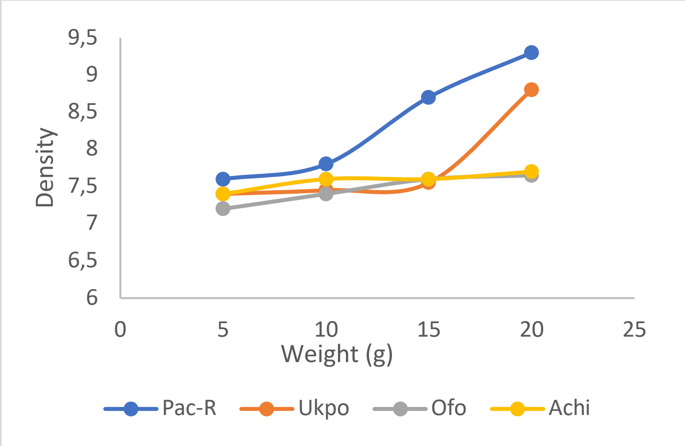

Figure 2. Effect of mud concentration(w/w) on density.

In Figure 2; An increase in weight of drilling mud resulted to increased mud density and hydrostatic pressure required to subdue formation pressure. Pac-R, Ukpo, Achi, and Ofor showed a similar effect of increased mud concentration on density. An increase in mud density increased carrying capacity.

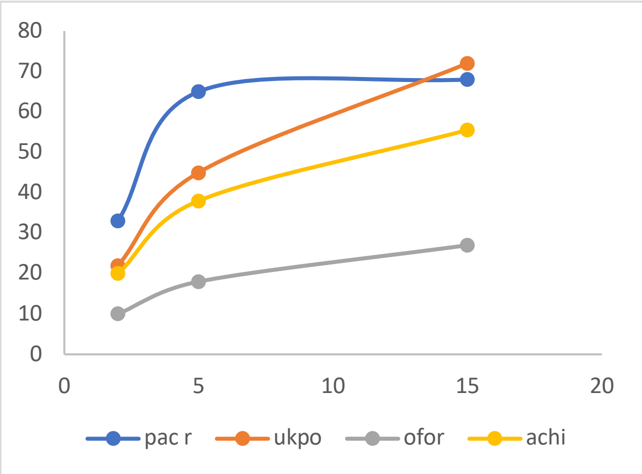

Figure 3. Effect of mud concentration(w/w) on the Plastic Viscosity.

In Figure 3, Ukpo showed a higher value of plastic viscosity due to increased weight. (Hakiki et al, 2015) noted that viscosity increases with increasing polymer concentrations due to increasing intermolecular entanglement. The surfactant-polymer reduces mobility ratio, and increases oil recovery. Hence, an increase in the concentration of the mud increases its resistance to flow.

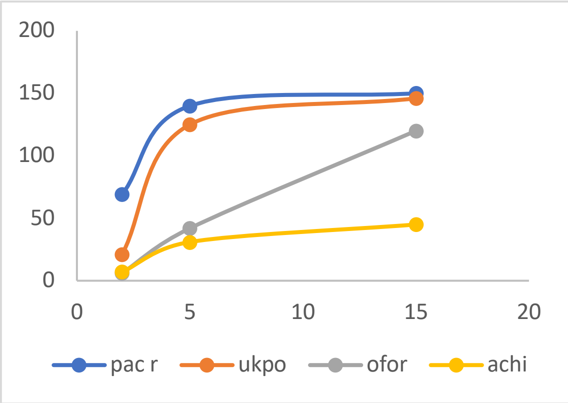

Figure 4. Effect of mud concentration(w/w) on Yield Strength

From figure 4; The yield strength of the local materials compares closely to that of Pac-R. An increase in the weight of the local additives increases its effectiveness in resisting flow due to increased viscosity.

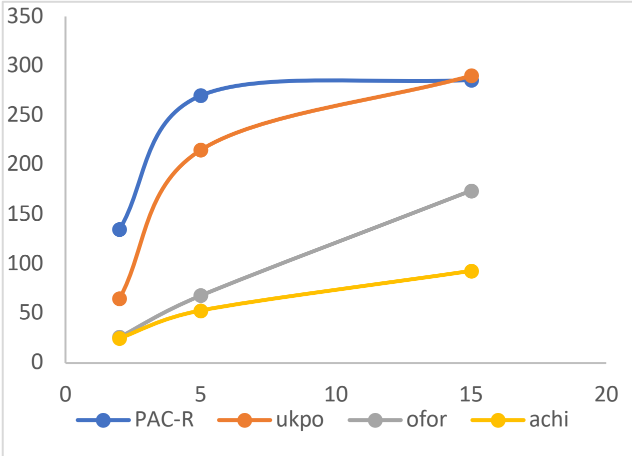

Figure 5 - Effect of mud concentration(w/w) on Viscosity at Φ 600 rpm.

From Figure 5, at 600RPM, although Pac-R still is a better viscosifiers, the local materials (Ukpo, Ofo, and achi) are not far behind. An increase in the quantity of the local based materials increases its viscosity and could be used as a substitute for Pac-R.

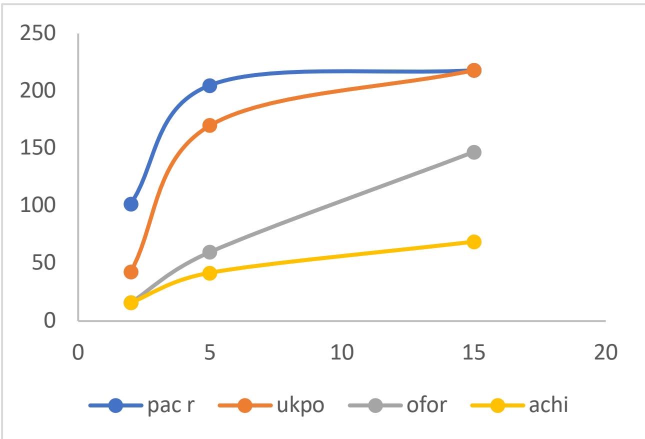

Figure 6 - Effect of mud concentration(w/w) on Viscosity at Φ 300 rpm.

From Figure 6; At 300RPM the Pac-R is a better viscosifiers. When the revolutions being made during the drilling process are low Pac-R is a still better additive to achieve a better ROP (rate of penetration). Meanwhile, Ukpo, Ofo, and Achi followed closely.

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CONCLUSION

Results from the study of the local additives (Mucuna solannie, Brachystegia eurycoma, and Deterium microcarpium) showed they have the potential to substitute standard viscosifier (Pac-R). The following conclusions were drawn;

(i) Mud density of the local additives is good enough to provide hydrostatic pressure necessary to balance formation pressure.

(ii) The viscosity of the local materials is high enough for efficient hole cleaning, cutting transport and removal.

(iii) The Local Additives are biodegradable, non-toxic, less expensive, environmentally friendly, and can protect the environment from the detrimental effect of conventional mud additives.

(iv) At 300rpm and 600rpm, Pac-R is still a better viscosifiers to achieve a good Rate of Penetration during a drilling operation. But, Ukpo, Achi, and Ofor followed closely. There was no significant difference between the rate of penetration of Pac-R and that of local additives, especially that of Ukpo.

The Nigerian drilling companies can adopt these local materials as alternative to imported Pac-R to save drilling costs and eschew environmental disasters. Mud filtrates from Pac-R are toxic to the environment, and pollutes the aquifer. But, these local additives would save our environment from detrimental impacts of the conventional viscosifiers. One good thing is that drilling mud from the local materials can even be used as fertilizers after the drilling activities. These local materials (Achi, Ukpo and Ofo) are cheaply available across Nigeria especially in the South Eastern region. Local contents are worthwhile amidst the rising foreign exchange rate to save Nigerian economy from eminent collapse. Conclusively, the experimental work has proved brachystegia eurycoma (Achi), mucuna solanine (Ukpo), and detarium microcapium (Ofor) as near perfect substitute to standard viscosifier (Pac-R).

ACKNOWLEDGEMENTS

We appreciate the efforts of Engr. U. I. Duru, the Project Supervisor and the Lab Technologists in Department of Petroleum Engineering, Federal University of Technology, Owerri. The work would not have come through without their assistance.

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