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Comparative Analysis of the Effects of Cashew and Mango Extracts on the Rheological Properties of Water Based Mud

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ABSTRACT
Comparative analysis of the effects of cashew and mango extracts on the rheological properties of water based mud is presented. To control corrosion of drilling materials, corrosion inhibitor is usually used as one of the drilling mud additives. Such inhibitive substance can only be applied when it improves the rheological properties of the drilling mud. In this work, the mud samples were formulated in the absence and presence of various concentrations of cashew and mango extracts. The production method of the mud and the determination of its rheological and allied properties were carried out based on the mud production standards of American Petroleum Institute. From the analysis of the experimental results, cashew and mango leaves extracts are suitable additives for the production of water based mud. Mango leaves extract shows higher improvement of the rheological properties of the drilling mud. Use of plant leaves extracts as drilling mud additives will encourage local content development.

Key words: Cashew extract, Mango extract, Mud, Rheological properties.

I. INTRODUCTION

Corrosion of the metallic parts of drilling installations may occur during drilling operations. To control corrosion of the drilling materials, corrosion inhibitor is usually used as one of additives in the formulation of the drilling fluid (mud). Such inhibitive substance can only be applied when it improves the rheological properties of the drilling mud. In general, drilling operation is enhanced by the application of drilling mud with suitable additives [1, 2]. The three major types of drilling mud, mostly used in drilling operations, are water based drilling mud, oil based drilling mud, and synthetic based drilling mud. Drilling mud selection is a function of the behavior of the formation to be drilled [3, 4]. Compared to other types of drilling mud, water based mud has the advantages of higher shear thinning, high true yield strength, good bit hydraulics and reduced circulating pressure losses. It improves borehole stability [5].

As the based fluid, water is the major constituent of the water based mud. All other constituents are regarded as additives. The additives are for proper viscosity, filtration and fluid loss control [3, 6, 7]. The drilling mud additives also serve as weighing agents and corrosion inhibitors. Most chemicals used as corrosion inhibitive substances are harmful to the environment. Studies revealed that plant extracts are potential eco-friendly corrosion inhibitors [8, 9]. Plant-derived substances are of great interest owing to their versatile applications. As bio-resources, plant extracts have been used for production of drugs and corrosion inhibitors.

Several studies have been carried out on the production of drilling mud and its additives [10, 11, 12, 13, 14]. From the review of the previous studies, there is need to carry out the comparative analysis of the effects of cashew and mango extracts on the rheological properties of water based mud. The nomenclatures of the plants are presented in Table 1 below.

Table 1, Plants family and nomenclature

Plant	Botanical Name	Family
Cashew	*Anacardiumoccidentale*	*Anacardiaceae*
Mango	*Mangiferaindica*	*Anacardiaceae*

II. MATERIALS AND METHODS

2.1 Equipment and raw materials

The equipment used in this work include; graduated measuring cylinder, beakers, electronic weighing balance, mixer, viscometer, drilling mud balance, water bath, pH meter, and stop watch. The raw materials used in the formulation of the water based drilling fluids (in the absence and presence of various concentrations of cashew and mango plant extracts) are presented in Table 2 below.

Table 2, Theraw materials used for the formulation of the drilling mud samples

S/N	Raw material	Function(s)	Quantity (mud + cashew extract)	Quantity (mud + mango extract)
1.	Water	Base fluid	245ml	245ml
2.	Bentonite	Viscosity and filtration control	5.0g	5.0g
3.	Xanthum Gum biopolymer (XCD)	Viscosity and fluid-loss control in low solid mud	0.4g	0.4g
4.	High viscosity Polyanionic Cellulose (PAC-R)	Fluid loss control and viscosifier	0.25g	0.25g
5.	Modified natural polyanionic cellulose (PAC-L)	Fluid loss control and viscosifier	0.25g	0.25g
6.	Potassium hydroxide (KOH)	Potassium source in inhibitive potassium mud	0.1g	0.1g
7.	Sodium carbonate(Na_2CO_3)	Calcium precipitant in lower pH mud	12.0g	12.0g
8.	Barite	Weighing agent	12.0g	12.0g
9.	Plant extract	Inhibitor	0%, 2%, 4% and 6% conc. by weight(cashew extract)	0%, 2%, 4% and 6% conc. by weight(mango extract)

2.2 Experimental procedure

The fresh leaves of cashew and mango were obtained from Akpugo, Enugu State, Nigeria. The cashew and mango leaves were separately washed with tap water and later rinsed with distilled water. The leaves extracts of cashew and mango plants were separately obtained using suitable extraction method [15].

The production methods of the drilling mud and the determination of the rheological and allied properties of the mud were carried out based on the API drilling mud production standards [4, 16, 17, 18]. The various quantities of the raw materials (shown in Table 2 above) were measured using the graduated cylinder and electronic weighing balance. The raw materials were then poured, one after the other, with an interval of 5 minutes into the steel cup of the single spindle mixer. The application of the raw materials was carried out in a descending order as arranged in Table 2 above. The mud samples were formulated in the absence and presence of various concentrations of the cashew and mango leaves extracts. As each material is being put into the mixer, the mixer is powered to cause the spindle to rotate and mix the contents inside the steel cup being held at a fixed position. As the materials have been completely applied into the mixer steel cup, it was allowed for 30 minutes, under stirring condition, for a total uniformity of the materials to give finely formulated water based drilling mud. Drilling mud balance was used to measure the density of the mud. Viscometer was used for the measurement of rheological properties of the formulated drilling mud. The rheological readings, API Testing,600 RPM (revolution per minutes), 300 RPM, 6 RPM and 3 RPM, were recorded.Also,10 seconds, 10 minutes and 30 minutes gel strength values were recorded. The plastic viscosity and yield point values were appropriately evaluated. The pH meter was used to measure the pH of the formulated drilling mud. This procedure is carried out in triplicate, and average value for each parameter was obtained.

III. EXPERIMENTAL RESULT AND ANALYSIS

The mud weight and pH of the formulated mud without the plant extracts are presented in Table 3 below.

Table 3, Mud weight and pH of the formulated mud without the plant extracts

Mud property	Value
Mud weight (1b/gal)	8.1
pH	9.1

The gel strength result of the mud in the absence and presence of different concentration of plant extracts is presented in Table 4 below.

Table 4, Gel strength result of the mud in the absence and presence of different concentrations of the plant extracts

Gel strength(1b/100ft^2)	Mud + 0% Plant extract	Mud + 2% Plant extract		Mud + 4% Plant extract		Mud + 6% Plant extract	
		Cashew	Mango	Cashew	Mango	Cashew	Mango
10 seconds Gel strength	1	2	2	3	3	7	7
10 minutes Gel strength	2	2	3	6	6	8	8
30 minutes Gel strength	2	4	5	7	8	9	10

The Dial-reading result of the mud in the absence and presence of different concentration of plant extracts is presented in Table 5 below.

Table 5, Dial readings of the formulated drilling mud at room temperature

RPM (Revolution per minute)	Mud + 0% Plant extract	Mud + 2% Plant extract		Mud + 4% Plant extract		Mud + 6% Plant extract	
		Cashew	Mango	Cashew	Mango	Cashew	Mango
600	21	28	30	32	33	34	36
300	13	18	19	21	22	22	23
6	2	3	4	5	6	10	10
3	1	2	3	4	4	7	6

The Plastic viscosity, yield point and apparent viscosity of the mud were calculated using Equations (1), (2) and (3) respectively.

$$\text{Plastic Viscosity (PV), cP} = 600\ \text{RPM reading} - 300\ \text{RPM reading} \quad [1]$$
$$\text{Yield Point (YP), lb/100 ft2} = 300\ \text{RPM reading} - \text{Plastic Viscosity} \quad [2]$$
$$\text{Apparent Viscosity (AV), cP} = 600\ \text{RPM reading} / 2 \quad [3]$$

The effect of concentration of the plant extracts on the rheological properties of the mud at room temperature (30 ^{0}C) is shown in Fig. 1 below.

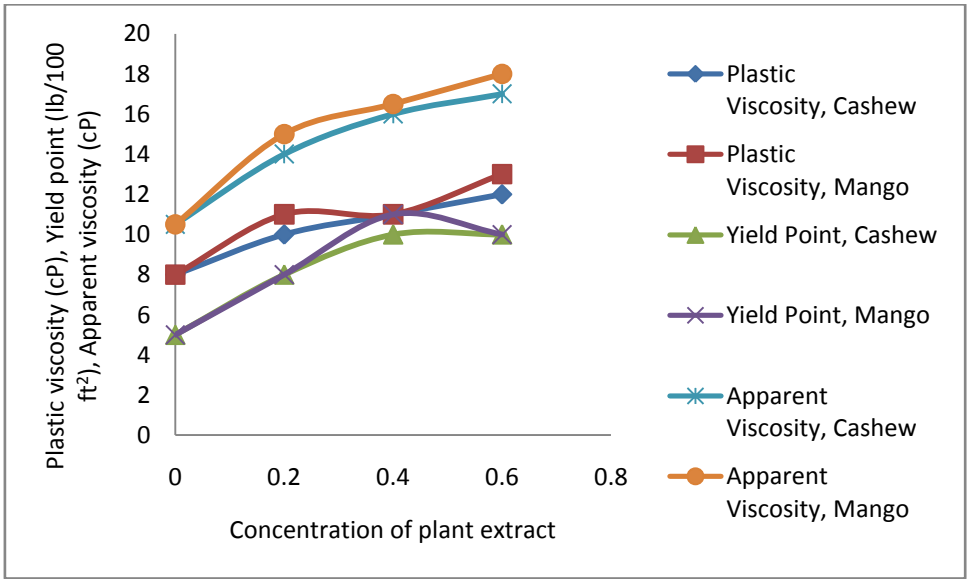

Figure 1, Effect of concentration on the rheological properties of the mud

The effect of temperature on the rheological properties of the drilling mud, with 4% plant extracts, is presented in Table 6 below.

Table 6, Effect of temperature on the rheological properties of the drilling mud

Parameter	30 ^{0}C		50 ^{0}C		70 ^{0}C		90 ^{0}C	
	Cashew	Mango	Cashew	Mango	Cashew	Mango	Cashew	Mango
600 RPM	32	33	31	31	28	28	25	26
300 RPM	21	22	20	21	18	19	16	17
PV (cP)	11	11	11	10	10	9	9	9
AV (cP)	10	11	9	10	8	10	7	8

RPM (Revolution per minute, PV (Plastic viscosity), AV (Apparent viscosity)

The effect of temperature on the yield point of the drilling mud, with 4% plant extracts, is presented in Fig. 2 below.

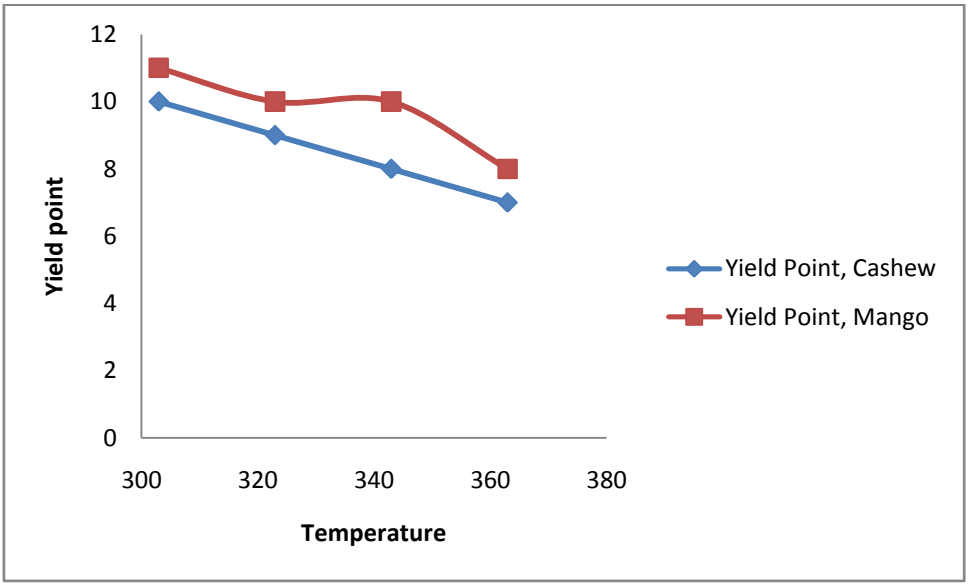

Figure 2, Effect of temperature (^{0}K) on yield point (lb/100ft^2)

3.2 Discussion of result

The mud weight and pH of the formulated mud in the absence of plant extracts are 8.1 (lb/gal) and 9.1 respectively (Table 3). From the pH value, the formulated mud is in alkaline state [16]. The effect of concentration of the locally sourced cashew and mango extracts on the gel strength of the mud is shown in Table 4. The gel strength measures the capability of the formulated drilling fluid to hold particles in suspension after flow ceases [2, 3]. In the absence of cashew and mango extracts, Table 4 shows value of 1 at 10 seconds gel strength and equality value of 2 at 10 minutes and 30 minutes gel strengths. For all the period of gel strength determination, increase in concentration of cashew and mango extracts increases the gel strength of the mud. At various concentrations of the plant extracts, there were slight variations of the gel strength values. On the average, mango extract gave the highest gel strength. Similar trend was noticed in the dial-reading results of the drilling mud (Table 5).Since mango and cashew are in the same family (*Anacardiaceae*), difference in their phytochemical and allied properties may have contributed to the variation on their effects on the rheological properties of the drilling mud.

The graphical representation of the plastic viscosity, yield point and apparent viscosity, as determined by substituting the dial-reading data into Equations (1), (2) and (3), is presented in Fig. 1. The graph shows that the cashew and mango extracts additive affects the rheological properties of the drilling mud. With the addition of the locally sourced cashew and mango extracts, there were improvements in the rheological properties of the drilling mud samples. Use of the plant extracts as drilling mud additives will encourage local content development. The effects of temperature on the rheological properties of the drilling mud samples are presented in Table 6.For all samples with cashew and mango extracts, increase in temperature decreases the plastic and apparent viscosities of the drilling mud. A similar trend was noticed on the effect of temperature on the yield point of the drilling mud (Fig. 2). The mango extract shows higher improvement of the rheological properties of the drilling mud.

IV. CONCLUSION

From the analysis of the experimental results, the following conclusions can be drawn:

- Cashew and mango leaves extracts are suitable additives for the production of water based mud.
- Mango and cashew, though in the same plant family of *Anacardiaceae*, have varied effects on the rheological properties of the drilling mud.
- Mango leaves extract shows higher improvement of the rheological properties of the drilling mud.
- Use of plant leaves extracts as drilling mud additives will encourage local content development.

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