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Drilling Mud Formulation Using Potato Starch(Ipomoea Batatas)

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ABSTRACT

In the search for suitable local alternatives as additives in the manufacture of drilling muds which is an essential entity in the exploration of oil and gas, some vital considerations must be put in place such as cost and environmental effect. This study focuses on the suitability of locally processed potato starch as a viscosifier and fluid loss agent in drilling mud. Comparative analysis of properties obtained from the prepared potato starch mud and that formulated from Polyanionic cellulose (PAC) were carried out. Results from this investigation showed that rheological properties (plastic viscosity and yield point) of the potato starch mud increased when the content of both viscosifiers were equal at 1.0g/ 316.4ml of water. Plastic viscosity also increased by 13.6% when potato starch concentration increased by 50%. Also, a combination of PAC and potato starch at a ratio of 1:1 to 0.5:1.5 gave a fluid loss of 7.1 - 7.7 ml which were very close to that of the standard mud at 6.8ml. the pH, mud weight and specific gravity of the formulated mud samples ranged from 7.0 - 9.0, 7.0 - 9.1 and 0.83 - 1.09 respectively, which were all in line with the standard mud specifications.

***Keywords*–**Drilling Fluid, Fluid Loss Control, Potato starch and Viscosifiers.

I. INTRODUCTION

Drilling fluids have passed through major technological evolution since the first operations performed in the US, using a simple mixture of water and clays, to complex mixtures of various specific organic and inorganic products for specific operations. These products improve fluid rheological properties and filtration capability, allowing bits to penetrate heterogeneous geological formations under the best conditions [1]. The effectiveness of the drilling fluid to perform its primary functions is based on certain properties, which are formulated continuously to meet formation conditions during drilling operations. Failure of the drilling fluid to meet its designed functions can prove extremely costly in terms of loss of materials and time, [2]. In other words, since drilling fluid is an integral part of the drilling process, many of the problems encountered during the drilling of a well can be directly or indirectly attributed to the drilling fluids. Therefore, these fluids must be carefully selected and/or formulated to fulfill their roles in the drilling process.

A successful drilling activity depends on the correct mixture and monitoring of the drilling mud. The functionality of the drilling fluid system will result to an efficient drilling practice based on technological, economic and ecological factors. During the drilling process, mud viscosity and fluid loss control are very important factors to investigate. If proper care is not given to these factors, some drilling problems such as improper hole cleaning and formation damage may occur, which in turn may lead to reduction in well productivity hence increases cost [3]. Various materials, chemicals and polymers are used in mud formulation to convene different practical mud requirements such as density, rheology and fluid loss control etc. One of such material, starch (polymers)used for fluid loss control and as a Viscosifier, forms the basis of this study.

Hydroxypropyl and Carboxymethyl starches are used in drill-in fluids, completion fluids and various brine systems as well as in drilling-mud systems. The use of starch typically causes temperature stability, a minimal increase in viscosity while effectively controlling fluid loss [4]. Several corn-based starches using local resources to study their suitability to use as drilling fluid additive have been developed [5]. Experimental results indicate that some of the newly developed starch products have similar or better filtration control properties than the filtration control properties of the widely used imported starch. The novel products have higher purity and thus expected to be better candidates for exploration and exploitation of oil and gas in environment sensitive areas. Also, the study carried out in [6] on the comparative performance of cassava starch with PAC observed that rapid biodegrading and thermal degradation of the local starch was not put into consideration. Starch based drilling fluid additives are generally considered to be useful at temperatures up to 225^0F [7], [8]. At this point, rapid hydrolysis and degradation takes place as well as rapid biodegradation of starch.

However, the use of drilling fluid in Nigeria over the years has been faced with the challenges of either importing materials for mud production or importing already prepared drilling mud which is extremely cost [9]. The present consumption of bentonite in the drilling operations in Nigeria is put at over 50 thousand tons a year and all of it is imported from USA [10], [6]. This trend is expected to continue as drilling activity increases in the shores of Niger Delta. To this end, the establishment of Nigerian Local Content Initiative in the Oil and Gas Sector by the Federal Government of Nigeria has necessitated the need for local substitutes to foreign drilling fluid materials [11], [12]. Thus, it is imperative to source for locally available drilling fluid materials and evaluate their various characteristics, then formulate fluids that can be used in drilling process. This study tends to investigate the formulation of drilling fluid using locally sourced material and in turn reduce the overdependence of some very expensive viscosifiers.

II. METHODOLOGY

Materials used for this study: water (H_2O), caustic soda (NaOH), soda ash (Na_2CO_3), Polyanionic cellulose (PAC), potassium chloride (KCl), barite, xanthan gum, dilute acetic acid and freshly harvested potato. Equipment used include Oven (type 48 BE Apex Tray Drier), weighing balance, measuring cylinder, beakers, Hamilton beach mixer and cup, pH indicator strip, thermometer, knife, sieving mesh, bucket, bowl and stop watch, Fann viscometer, API filter press, mud balance and a 150 micron sieve and spatula.

2.1 Preparation of starch

The starch preparation followed a series of processes. Preparation included washing of the tubers, Pretreatment operation which included peeling off the tuber skin, grinding, sieving, decanting Drying and finally Starch extraction

The potato tubers were retrieved from Ikom Local Government Area in Cross River State, Nigeria and the experiment was conducted at the Rivers State University of Science and Technology drilling mud laboratory. The potato samples were washed manually peeled using a steel knife and washed again thoroughly with potable water to remove dirt and adhering sand particles. The peeled tubers were grinded. The grinded potato was sieved and small quantity of water was added simultaneously. The filtrate was allowed to settle for about 3-4hours in a beaker. This was decanted and a white, odorless and tasteless starch obtained from the bottom of the beaker. The resultant wet starch was thinly spread over an aluminum tray in the open air for drying under ambient conditions (28-30°C, 50-65% Relative humidity) for 5 hours, to minimize damage of native starch granule. It was further dried in an air oven at about 60°C for about 6 hours. The dried cake was milled using a blender to fine particles.

2.2 Experimental Proceedure

i. Barite Preparation:

76.8grams of barite was dissolved in 316.4ml of water and properly mixed using an electronic mixer for 5 minutes. The resultant solution was left for about 12hrs for proper yielding.

ii. Mud Formulation Procedure:

316.4ml of barite solution was measured out into the electronic mixer and agitated with the correct measurement of each material additive added at 5 minutes interval according to the order in which they appear on Table 1 below.

TABLE 1: Standard Mud Preparation Composition (sample A)

ADDITIVES	CONCENTRATION	FUNCTION
Water	316.4mls	Base fluid
Caustic soda	0.2g	Alkalinity control
Soda ash	0.2g	Calcium ion removal
Polyanionic cellulose (PAC)	2.0g	Filtration control
Xanthan gum	2.8g	Viscosifier
Potassium chloride	18g	Inhibition control
Barite	76.8g	Weighting agent
Borax	2.5g	Preservative

TABLE 2: Preparation of Experimental Samples

Additives	Sample B	Sample C	Sample D	Sample E	Function
Barite	76.8g	76.8g	76.8g	76.8g	Weighting material
Water	316.4g	316.4g	316.4g	316.4g	Base fluid
Caustic soda	0.2g	0.2g	0.2g	0.2g	Alkalinity control
Soda ash	0.2g	0.2g	0.2g	0.2g	Calcium ion removal
PAC	1.0g	0.5g	0.25g	0.0g	Filtration control
Potato starch	1.0g	1.5g	1.75g	2.0g	Viscosifier/filtration control
Borax	2.5g	2.5g	2.5g	2.5g	Preservative
Potassium chloride	18g	18g	18g	18g	Inhibition control
Xanthan gum	2.8g	2.8g	2.8g	2.8g	Viscosifier

iii. Mud Density, Specific Gravity, Fluid Viscosity, And Fluid Loss Determination:

The standard procedure for determination of mud density and specific gravity were adopted for this research, a calibrated mud balance was used for this operation. A Fann viscometer was used to test for prepared mud viscosity and a pH indicator was adopted to ascertain the pH of the mud samples. Fluid loss determination was done using a filter press and records of filtrates obtained were taking of 20minutes interval.

III. RESULTS AND DISCUSSION

The following samples (A-E) were prepared using 316.4ml of water as below.
Sample A (Standard mud: 2.0g of PAC, 0.0g of Potato starch).
Sample B (Mud with 1.0g of PAC, 1.0g of Potato starch).
Sample C (Mud with 0.5g of PAC, 1.5g of Potato starch).
Sample D (Mud with 0.25g of PAC, 1.75g of Potato starch).
Sample E (Mud with 0.0g of PAC, 2.0g of Potato starch).

The resultant mud properties were tested and recorded as seen in Tables 3-9.

TABLE 3: Mud Properties.

Samples	M.W (ppg)	PV (cp)	YP (lb/100ft^2)	pH	S.G
A	9.1	23	56	7.0	1.09
B	9.0	11	43	8.0	1.08
C	7.9	12.5	21	9.0	0.95
D	8.4	10	24	7.0	0.96
E	7.0	5	25	8.0	0.83

TABLE 4: Rheology of Sample A

Rheometer speed (rpm)	Shear rate, γ (sec^{-1})	Shear stress, τ (dyne/cm^2)	Viscosity, μ (cp)
600	1021.8	521.1	0.51
300	510.9	403.6	0.79
200	340.6	337.1	0.99
100	170.3	235	1.38
60	102.18	178.8	1.75
30	51.09	117.5	2.3
6	10.218	38.3	3.75
3	5.109	28.00	5.5

TABLE 5: Rheology of Sample B

Rheometer speed (rpm)	**Shear rate, γ (sec^{-1})**	**Shear stress, τ ($dyne/cm^2$)**	**Viscosity, μ (cp)**
600	1021.8	332.0	0.33
300	510.9	275.8	0.54
200	340.6	235	0.69
100	170.3	168.5	0.99
60	102.18	132.8	1.3
30	51.09	102.18	2
6	10.218	28	2.75
3	5.109	17.88	3.5

TABLE 6: Rheology of Sample C

Rheometer speed (rpm)	**Shear rate, γ (sec^{-1})**	**Shear stress, τ ($dyne/cm^2$)**	**Viscosity, μ (cp)**
600	1021.8	235.01	0.23
300	510.9	171.15	0.34
200	340.6	135.38	0.39
100	170.3	102.18	0.60
60	102.18	69.4	0.65
30	51.09	49	0.8
6	10.218	25.55	2.5
3	5.109	15.32	3

TABLE 7: Rheology of sample D

Rheometer speed (rpm)	**Shear rate, γ (sec^{-1})**	**Shear stress, τ ($dyne/cm^2$)**	**Viscosity, μ (cp)**
600	1021.8	224.7	0.22
300	510.9	173.7	0.34
200	340.6	137.9	0.41
100	170.3	102.18	0.60
60	102.18	66.4	0.65
30	51.09	40.8	0.80
6	10.218	25.5	2.5
3	5.109	15.327	3

TABLE 8: Rheology of Sample E

Rheometer speed (rpm)	**Shear rate, γ (sec^{-1})**	**Shear stress, τ ($dyne/cm^2$)**	**Viscosity, μ (cp)**
600	1021.8	178.8	0.175
300	510.9	153.2	0.3
200	340.6	127.7	0.37
100	170.3	97	0.57
60	102.18	56.2	0.55
30	51.09	35.7	0.7
6	10.218	15.327	1.5
3	5.109	10.218	2

TABLE 9: Volume of Fluid Loss (ml) in time (mins) For Mud Samples.

Samples	**Time (min)**					
	t = 5 min	**t = 10 min**	**t = 15 min**	**t = 20 min**	**t = 25 min**	**t = 30 min**
A	2.9	4.1	5.2	5.9	6.6	6.8
B	3.24	5.3	6.1	6.6	6.9	7.10
C	3.52	5.8	6.59	7.3	7.5	7.7
D	5.3	7.2	8.9	9.6	10.2	11.5
E	5.9	7.0	9.4	10.8	11.9	13.5

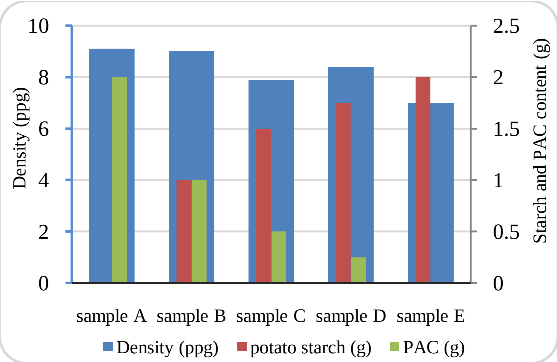

Fig 1: Comparison ofmud density at various potato starch and PAC contents

In fig 1, Sample B which contained equal amounts of Potato starch and PAC gave to a mud weight of 9.0ppg, a reduction in PAC content and increase in potato starch, in sample C gave a slight reduction in the mud density. The density of mud sample D increased by 6.33% with a further increase in the potato starch content from 1.5-1.75g. Sample E showed the lowest density as a result of the absence of PAC in the mud.

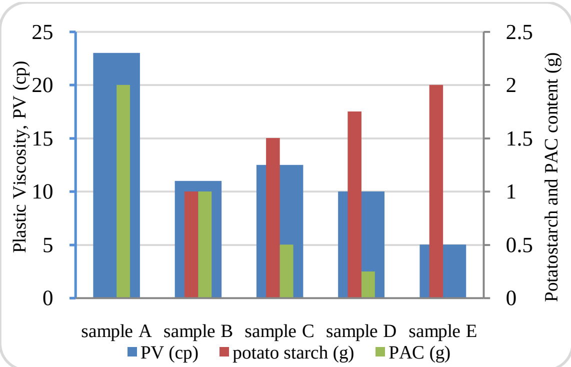

Fig 2: Comparison of Plastic viscosity of mud samples at various potato starch and PAC contents

Fig 2 above shows that plastic viscosity(PV) increased in formulated mud samples B, C and D on addition of PAC but decreased in sample E where PAC was absent. The slight increase in PV in sample C could be as a result of the presence of PAC when potato starch content is increased. PV in Sample D reduced when PAC was reduced. Sample E recorded the lowest plastic viscosity at zero PAC content.

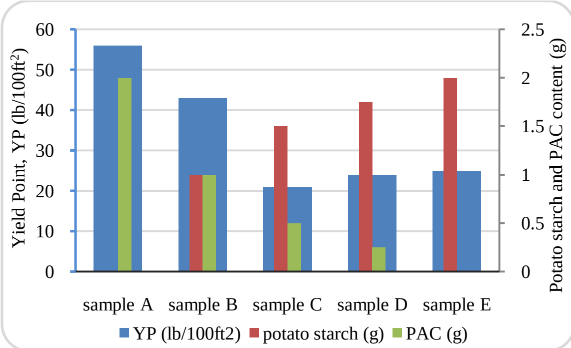

Fig 3: Comparison of Yield Point of mud samples at various potato starch and PAC contents

From figure 3, yield points in all the formulated mud samples varied from high in sample B with equal content of both potato starch and PAC to moderate in samples C where potato starch content was slightly increased and PAC also reduced; In D there was further increase in potato starch content to about 16.67% and reduction of PAC to about 50% and also in E with a further increase in potato starch content to 14.3% without PAC.

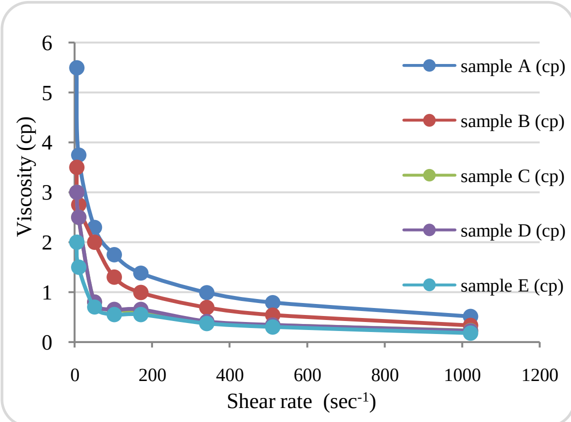

Fig 4: Viscosity - Shear rates relationship for mud samples A, B, C, D and E.

It is observed in Fig 4 that an increase in shear rate results in a decrease in mud viscosity, all of which took same pattern as sample A. This shows the suitability of the formulated samples as drilling mud and their good hole cleaning ability.

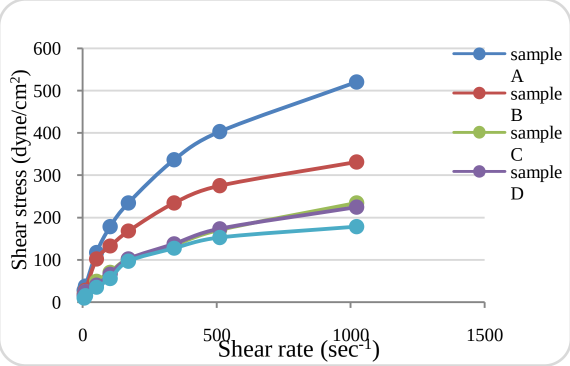

Fig 5: Shear stress - Shear rate relationship of mud samples.

In Fig 5, besides sample E slightly deviating from others, all the formulated drilling mud samples showed a non-linear relationship that does not pass through the origin. The phenomenon causing the intercept to occur at some point on the shear stress axis is because of the minimum force required to initiate mud flow. As this force increases, flow also increases and there is a transition from plug to viscous flow, up to the Bingham yield point [13], [14]. After the Bingham yield point is exceeded, equal increments in shear stress will produce equal increments in shear rate and the system assumes the flow pattern of a Newtonian fluid [15], [16], [17].

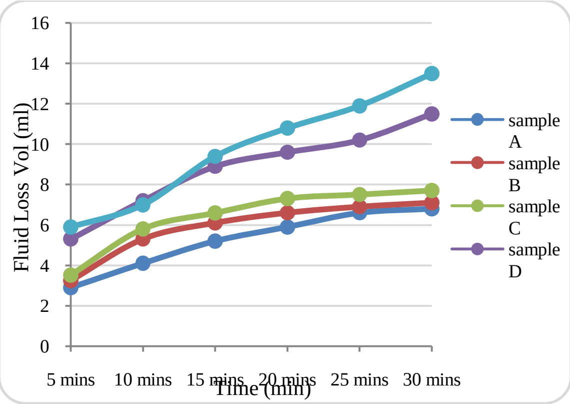

Fig 6: Volume of fluid loss with time for samples A, B, C, D and E

From the plot shown above (Fig 6) and also taking sample A as standard, it is shown that sample B and C showed the closest curve match to that of the standard mud. Derived from table 9, at 25 min, 20 min and 15 min the volume of fluid loss in samples A, B and C are relatively close. It is also shown that after 15-30mins, sufficient mud cake has been formed to reduce fluid loss in samples B and C. At these times, the volumes of fluid loss in each of the samples become very close. Sample D and E do not form mud cake fast enough to prevent fluid loss into the formation. This accounts for the deviation in their curve.

IV. CONCLUSION AND RECOMMENDATIONS

Results from this study have shown the efficiency of Potato starch as a viscosifier and as a fluid loss reducing agent. It recorded a pH ranging from 7.0 to 9.0, Specific gravity between 0.83-1.09 and mud density ranging between 7.0 and 9.1ppg which are all in line with a standard mud specification [17], [18]. The rheological properties of the mud formulated increased when potato starch was added to it. However, using potato starch alone cannot improve these rheological properties as shown in for sample E in fig 1 – fig 6.

This work has shown conclusively that a combination of potato starch and PAC in a near-equal proportion is suitable for the improvement of rheology and fluid loss control properties of drilling mud for economical reason. From the foregoing, subsequent scholars investigating the suitability of potato starch as a viscosifier must consider the various reservoir conditions as well as formation properties so as to estimate tolerable pressure and temperature levels.

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