LABORATORY INVESTIGATION OF IMPROVING DRILLING FLUID PERFORMANCE OF WATER BASE MUD USING OILY GRAPHITE SILICATE AND NANO SILICA PARTICLES AS ADDITIVES

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Abstract - Drilling performance is enhanced by the use of a mud system that prevents or retards the dispersion of formation and cuttings and minimizes torque and drag on the drill string, water base drilling fluids for adaptability with environment and ease of operation. A water base drilling fluid can have a significant role in drilling operations with its desirable properties including rheology, fluid loss, coefficient of friction (CF), PH, and fluid weight. This work studies the effect of nanoparticles and oily graphite silicate on improving the properties of water-based drilling fluid in various laboratory experiments using rotary viscometer, standard filter press, lubricity meter, Ph- meter and mud balance.
In addition, fluid loss control additives were used as a control to compare the obtained results from application of nanoparticles and oily graphite and understanding the various effects of their presences in experiments. The results show a positive influence in drilling performance when compared against estimated drilling rate, which can lead to substantial savings in drilling costs, were observed. Torque values in the wells tested were generally low (between 250 and 450 Amps) drilling days were reduced by more than 20% of programmed. The compound also showed cost effectiveness in stabilizing the mud properties by eliminating the need for a defoamer. Results finding also showed that these compounds can increase yield point (YP) in mud (increased from 101b/100f1^2 to 121b/100ft^2), findings also indicate that oily graphite/nanoparticles can reduce drilling fluid loss in 100psi and T = 75^{o}f about 22% (from 4.5cc to 3.5cc during 30min).

***Key Words*:** *Drilling fluid, drilling performances, nano silica particles, oily graphite silicate, water base mud, fluid loss, cost effectiveness, fluid properties and drilling parameters*

1.INTRODUCTION

Drilling fluid play many important roles in accomplishing a successful drilling operation in a safe manner. It is used to facilitate the drilling process by serving different functions such as cutting transport (transferring cuttings from bottom hole to surface), suspending cuttings (during connecting drill pipe stands or other drilling fluid circulation halts), cooling off and lubricating drill bit and bottom hole assembly (BHA), providing hydrostatic pressure and support to avoid wellbore instability. In troublesome formation such as shale and fractured zones, it is important to choose and design the drilling fluid system properly to avoid costly wellbore instability and other fluid loss consequences.

Besides formation lithology, well bore geometry, in-situ stress and formation fluid properties, might dictate specific design for the drilling fluid system. Well bore instability and fluid loss are two major problems that occur due to poor drilling fluid system design in troublesome formations. Drilling fluid loss could occur as a partial or as complete loss. The ability of the 'oily' graphite/silicate containing compound as a lubricant and nano silica particle as additives, its contribution to borehole stability and drilling performances was investigated. This compound was compared against known asphaltic/gilosonite type products. Subsequently, its effect on drilling fluid properties was also investigated. The product was field tested in polymer drilling fluid on two deviated wells in Niger Delta to confirm its ability to improve hole stabilization and to determine its influence on drilling performance. Mud related operating time indicators was employed for monitoring performance during the evaluation procedure. Torque, rate of penetration and number of bits used, together with over pulls at trips were also used. The product was also used on wells where other asphaltic/gilsonite type products were not available. Although no comparative data were available, from offset wells, good drilling performance was observed from these wells.
This study scales to improves the performance of drilling mud using oily graphite silicate and nano silicate particles, a modern technology to improve drilling performance and mud overall performance in typical Niger Delta wells as case study as an enhancing additive at various concentrations.

NANOTECHNOLOGY

The term of nano-technology is the comprehensive word referring to all the developed technologies in working in nano-size. This means to say nano-scale usually is particles with 1-100nm. In this study, nano silica additive plays a key role in improving drilling performances by controlling fluid loss and stabilizing the well bore.

COMPOUNDS AND COMPOSITIONS FORMULATED.

a) OILY GRAPHITE SILICATE: The compound comprises of selected platy Aluminum silicate mineral, graphite and a small percentage of hydrocarbons, ground to a very fine constituent. It forms a tight suspension in water base drilling fluids, oil base mud and inverted emulsion fluids and is applicable in both low and high temperature wells up to 2600c.The hydrocarbons enhance the coating of potassium aluminum silicates and graphite on the well bore and the compound binds with polymers to produce thin, slickly and tough filter cake. This makes the filter cake hydrophobic, physically blocking entry of water into the formation.

b) GRAPHITE NANOPARTICLES: Graphite has 3D structure of carbon atoms with SP2 hybridization. Each carbon atom is bonded to 3 other atoms with 120 bond length and angle of 42.10. The interaction among layers in graphite is the weak Vander Waals forces. Therefore, this interaction is weak so graphene layers (one single layer of graphite) can slip all over the layer and gives the properties of a good lubricant to this material.

TABLE 1: CHEMICAL AND PHYSICAL PROPERTIES OF GRAPHITE NANOPARTICLES

Shape	Solid powder
Color	Black
PH	6.5–8.5
Nanoparticles(nm)	30-80
Solubility	Insoluble in water

METHODOLOGY

This study is based solely on laboratory experiment work. The rheological property tests are carried out in accordance with the advised procedure of APT RP for examining a drilling fluid. The experimental plan is as shown in the figure below.

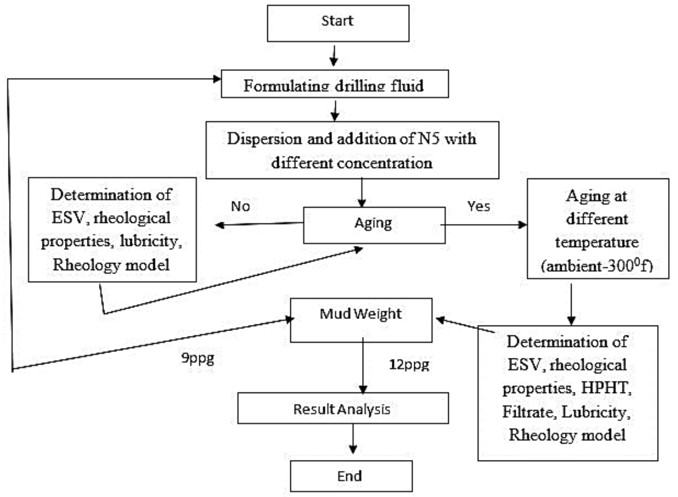

Figure 1: Experimental Methodology

LABORATORY PROCEDURES:

1. Formulate samples of oily graphite silicates.
2. Formulate water base mud (WBM)sample.
3. Formulate WBM with nano silica particles.
4. Evaluate the performance of WBM with nano silica and oily graphite silicate.
5. Formulate WBM with oily graphite silicate.
6. Evaluate the performance of WBM with oily graphite silicate on the rheological properties of drilling mud.

Table2: Formulation of the basic fluid

Starch	Pac 1v	Sodium Chloride	Potassium Chloride	Soda Ash	Xanthan gum	Clay Col	Lime Stone	Caustic Soda
101b/bbl.	21b/bbl	17/5 1b/bbl	17/51b/bbl	1 1b/bbl	0/7 1b/bbl	1%	116 1b/bbl	11b/bbl

Table3: Introduction of Samples

A	Basic fluid
P_1	Basic Fluid+1lb/bbl graphite nanoparticles
P_2	Basic fluid+21b/bbl graphite nano particles
P_3	Basic fluid+3lb/bbl graphite nano particles
P_4	Basic fluid+4lb/bbl graphite nano particles
P_5	Basic fluid+5lb/bbl graphite nano particles

LABORATORY INVESTIGATION

The graphite/silicate mixture was first tested in a laboratory to see how it would affect the current mud system. A pilot test using a 0.52 psi/ft Kcl PAC polymer mud revealed little impact from this component on the mud's plastic viscosity. For adequate hole cleaning, the yield point can be adjusted to a desired level by the level of concentration of the compound in the drilling fluid. The test results are a very low filtrate (4.0cc) with a thin, silky cake. There is no evidence of foaming. Its impact on shale cuttings is investigated further in the laboratory utilizing the Capillary Suction Time (CST) test method. The graphite/silicate additive outperformed other shale stabilizers in a comparison test using samples of shale cuttings from a known well.

Gypsum 5ppb was the base fluid utilized for the test. 6 ppb of each competing product were used to treat this. Shale's ability to disperse or not is determined by the Capillary Suction Time (CST) test, which is also used to determine the best drilling fluids for a certain type of formation. An inhibitive fluid or mud system can delay or stop the dispersion of clays in a shale deposit. The ability of that fluid or mud to inhibit is inversely correlated with CST value.

RESULT PRESENTATION AND DISCUSSION

Table 4: Comparative Test on effectiveness of shale stabilizers on shale cuttings sample from a known well using CST.

Shear Time	CSTTIME (secs) (BASE FLUID: 5PPB GYP)			
(sec)	**	Product 1	Product 2	Product 3
10	34.4	292.8	66.8	83.9
20	39.5	1114.1	59.9	90.4
30	44.6	936	50.8	95.0
80	51.4	1450.5	49.7	101.5
120	59.0	1642.7	61.0	147.6

According to *table 4's* results on the relative effects of competing products, the graphite/silicate nano silica compound has the lowest CST values, which suggests that it can prevent shale cuttings from dispersing. This lowers the amount of drill particles in the mud, which improves borehole stability.
Lubricating ability of the product could not be determined qualitatively in the field by observing the level of torque and drag on the drill string and the value of pulls at trips.
Measure of the Total Organic Content (TOC) of the cuttings from wells where only 3 ppm of hydrocarbon was discovered, the effects of the mud containing this graphite/silicate complex on the environment were examined. This demonstrates that the product can be used without risk during drilling operations in sensitive environmental locations.

Table 5: Effect of Graphite Nanoparticles on Fluid Weight and PH

Samples	A	P_1	P_2	P_3	P_4	P_5
MW(ph)	74	74	74	$74/_1$	$74/_1$	$74/_1$
PH	9/5	9/5	9/5	9/5	9/5	9/5

From table 5, there is no significant change in the PH and mud weight of the drilling fluid after adding the compound.

Table 6: PV and YP values for basic fluid and 5 other samples

Samples	A	P_1	P_2	P_3	P_4	P_5
P.V(cp)	13	13	13	14	15	16
Y.P(1bf/100ft^2)	10	10	11	11	12	12

From Table 6, there is significant increase in the plastic viscosity and t
Yield point when the compound was introduced into the drilling fluid. This increase will increase the potentials of the drilling fluid to clean the well bore, hence a cleaner hole.

Table 7: Values Fluid Loss for Basic Fluid and Five Samples Containing Graphite Nanoparticle

Samples	A	P_1	P_2	P_3	P_4	P_5
Fluid loss (cc)	4.5	4.2	4.2	4	3.8	3.5

Examining the related results to fluid loss by filter press device: The prepared mixture entered to the cell of filter press and imposed 100psi pressure.
Table 7 shows the fluid loss values for the basic fluid and five other fluid samples with the compound consisting of different concentrations. A significant reduction in fluid loss is observed in the sample with highest concentration of the compound from table 7.

CONCLUSION AND RECOMMENDATION

According to the conducted experiment tests on the basic fluid and 5 other sample fluids containing graphite silicate and nano silica particles, the following results were obtained.

1. Non-effectiveness of graphite nanoparticles on fluid weight and PH: The basic fluid weight is 74pcf, but the maximum weight of samples by adding nanoparticles was 74.1pcf, it means they had 0.1pcf that is not considered a significant increase. PH for the basic fluid and five other samples was 9.5, and no change was seen or noticed after adding graphite nanoparticles in samples PH.
2. Graphite nanoparticles increases yield point in mud. As the yield point for the basic fluid is 10lb/100ft^2 and sample P_5 has the maximum graphite nanoparticles, yield point became 12lb/100ft^2, and it means YP increased by 2lb/100ft^2. Since YP has more effect in cleaning the well, this increase makes the well cleaner. Thus, it is concluded that graphite nanoparticles such as nanocomposites and graphene nanoparticles improve rheological properties.
3. Based on the obtained results from filter press device, if the basic fluid is used under the same temperature and pressure containing graphite nanoparticles, fluid loss reduces to 3.5cc (about 22% reduction). It means a significant decrease was observed during 30mins in fluid loss. These results showed that graphite nanoparticles have the significant role in reduction of fluid loss. Therefore, based on the obtained results from the test using graphite nanoparticles as the additive material to the drilling fluid improves its loss. Consequently, good results are obtained in high depth where controlling loss is very sophisticated. Regarding to this subject, adding graphite nanoparticles to the drilling fluid blocks cracks and fracture of the formations for the small size of nanoparticles and loss will reach its minimum value.
4. It is observed by lubricity meter device and the obtained results through measuring FC that the FC of the basic fluid was 0.1673, while lubricity of filter cakes increased for the same fluid by adding graphite nanoparticles. Consequently, they slip in smaller than the specific angle which finally reduce FC to 0.0699(means 58% reduction). Thus it is concluded that graphite nanoparticles reduce FC but other nano particles such as clay nanoparticles and nano composites and nano-bentonite that were used previously didn't have such capacity. This FC reduction by graphite nanoparticles in the contacting points of drilling pipe with well walls greatly help and prevent abrasion increase between well wall and pipe.
5. According to the obtained results, it is concluded that graphite nanoparticles are effective on more properties of drilling fluid, but the other nano particles such as bentonite particles, nano composites, and clay nanoparticles influence only on one or two properties of drilling fluid.
6. The contribution of the 'oily' graphite silicate compound towards drilling performance has been positive on wells tested, torque reduction led to good penetration rates which resulted in shorter drilling days. Also over pulls were generally reduced to normal drag by treating the system with 1 or 2 extra ppb of the product. The benefits are that sufficient hydraulic power is available for the bit so that longer time is spent on drilling, resulting in fewer trips being made and fewer bits being used to drill the well.

7. The compound showed cost-effectiveness by eliminating the need for deformers in the mud. Stable mud weight was observed in all the well tested. This means that sufficient hydrostatic head was available for borehole stability. The thin filter cake which this compound produced by binding with polymers further help to improve hole stability by reducing the tendency towards differential pipe sticking.
8. The compound is safe for our sensitive environment. Only very little hydrocarbon residue is found in the drilling cuttings.

Finally, this 'oily' graphite/silicate compound and nano silica additive in water base drilling fluids can lead to improvements in our drilling performance. By reducing torque in the occurrence of tight hole, and by eliminating the use of deformers in the mud, when fully evaluated, this graphite/silicate mineral compound may prove to be a cost-effective additive for drilling highly deviated and deep wells.

LIMITATIONS

a) The PH of the mud decreases with increasing concentrations of the compound. This can be overcome by running a slow stream of caustic soda solution in the mud to maintain a steady level of alkalinity as drilling progresses.
b) The product will blind the screen when added at a fast rate and cause the mud to run over the shaker. This leads to escalation in mud cost. due to losses. This problem can be avoided by adding the in ferial slowly or by batch mixing and transfer into the main stream.

NOMENCLATURE

AMPS	=	Amperes
CP	=	Centipoise
Gyp=	=	Gypsum
KCL	=	Potassium Chloride
KIPS	=	Kilo Pascal
lb	=	Pound
Pac	=	Polyanionic Cellulose
Ppb	=	Pounds per barrel
Psi/ft per foot	=	Pounds per square inch
%	=	Percent
Ҿ	=	Density
n	=	exponent
k	=	flow consistency index
N_p	=	Plastic Viscosity
N_d	=	Dynamic Viscosity
T_y	=	Yield Stress
M_e	=	Initial sheer stress
Es	=	Electrical Stability values
ESV	=	Electrical stability
WBM	=	Water base mud
NS	=	Nano silica
API	=	American Petroleum Institute
LPLT	=	Low Pressure low temperature
HPHT	=	High pressure high temperature
PAC	=	Polyanionic Cellulose
PV	=	Plastic Viscosity
YP	=	Yield Point
ROP	=	rate of Penetration
T	=	Temperature
AHR	=	After hot rolling
BHR	=	Before hot rolling
COF	=	Coefficient of Friction
PCF	=	Pounds Per Cubic Foot

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ACKNOWLEDGEMENT
We wish to thank the management and staff of Federal University of Petroleum Resources Effurun, for the conducive environment for carrying out this project work in no distant time.