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Evaluation of Local Starch As a Filtration Control Additive in Water-Based Mud As Substitute For Imported Samples for Drilling Operations in Nigeria

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Abstract
Conventional application of polyanionic cellulose (Pac L and Pac R) as fluid loss agents in water-based mud has been proven to improve oilfield drilling over the years, however, these fluid loss agents are imported and therefore increase the capital cost of oil and gas drilling operations in Nigeria. Meanwhile, research has shown that the raw materials of most of these imported oilfield chemicals can be obtained locally. Therefore, it is imperative to identify local additives and determine their suitability as substitutes. The study evaluated the fluid loss control performance of selected local starch samples (TME 419, 1632, 0581, TME 416, PS, and CEMA) and compared their results with imported conventional polymer samples X, Pac L, Pac R. Fluid loss results from six local cassava starch samples (TME 419, 1632, 0581, TME 416, PS, CEMA) respectively, and four imported samples(X, Pac L, Pac R, Bentonite) respectively were evaluated. The calculated filtrate values were determined, and results of 4.2 ml, 4.0 ml, 6.3 ml, 3.6 ml, 5.3 ml, 5.3 ml, 3.6 ml, 3.2 ml, 3.8 ml, and 3.4 ml of the samples respectively were obtained. Tests were repeated with 0.5 % and the fluid loss was determined as applicable, the results of 3.9 ml, 3.8 ml, 3.5 ml, 3.0 ml, 5.0 ml, 4.9 ml, 3.4 ml, 2.6 ml, 3.3 ml, and 3.1 ml respectively were obtained. It was observed that there was a decrease in fluid loss volume with an increase in the concentration of the fluid loss agents (local starch and imported samples) respectively. This implies that all the samples are candidates for fluid loss control. However, among the six samples of the local cassava starches, TME 416 exhibited the best fluid loss control and compared favorably with the imported samples. Depending on the level of drilling operations, it is advocated that fluid loss value should be in the range of 10 ml filtrate volume (API Recommended Practice 29), all the local cassava starches meet this range of 10 filtrate volume and therefore are good candidates for filtration control and could be used as substitutes for imported samples.
Keywords: Fluid loss, filtration control, PAC R, PAC L, cassava starch, water-based mud, drilling fluids, local additives

I. Introduction

The success of any drilling operation is largely dependent upon adequate selection and monitoring of the drilling fluid system, (Ademiluyi et al., 2011). It then means good drilling fluid enhances the operation whereas a poorly designed fluid system will lead to drilling problems which may lead to operational downtime.

The primary functions of drilling fluid among others are as follows: It controls subsurface pressures, maintaining well control; removal of drill cuttings from beneath the bit and circulate them to the surface; it maintains wellbore stability, mechanically and chemically; transmission of hydraulic energy to the drill bit and downhole tools and lubricate the drill string and bit.

Effective fluid loss control in the course of drilling with water-based mud is a quality performance indicator of quality drilling mud. Therefore, drilling fluid cannot perform adequately if a significant volume of water as filtrate is lost from the drilling mud into the formation as this will result in an irreversible change in the drilling mud properties, and consequently affect the density and rheology of mud thereby resulting in wellbore drilling instability *(Petroleum Engineering Guide*, 2015).

Therefore, every drilling fluid is designed to avoid continuous fluid loss to the formation during drilling, as this is highly undesirable (*Azar and Samuel*, 2007)

Contemporary global environmental concern (that focuses on environmental safety and regulations' demands) on the oil and gas drilling operations pushes the petroleum and gas industries to encourage research on drilling fluids and its additives for non-toxic fluid loss control additives in drilling mud (*Dosunmu and Joshua*, 2010). Evolving environmental regulations, therefore, suggest that offshore and onshore exploration and exploitation of hydrocarbon must make use of environmentally friendly drilling muds as well as its additives to protect flora and fauna and their habitats. It has also been pointed out that environmental regulations encourage the use of water-based drilling fluid and its applications in areas where oil-based drilling fluids have been used previously due to the impacts of the oil-based mud challenges (*Tehrani et al*., 2009).

The cultivated cassava (Manihot esculenta) roots are mainly in tropical countries. The crop has large domestic and industrial economic value. It is a polymeric material consisting of two major components namely amylose and amylopectin. Chemically, it contains amylose, a linear polymer with a molecular weight in the range of 100,000 - 500,000, and amylopectin, a highly branched polymer with a molecular weight in the range of 1-2 million (Wing, 1988).

It is a reality that the Nigerian economy is highly dependent upon the oil and gas industry (Andrew, 2022). Chilingarian and Vorabutr (1983) stated that over the year, researchers have discovered that drilling and completion activities carried out by the oil companies require the import of additives required for the design of drilling fluids or the import of custom drilling fluids specifically designed to meet the need of the formation of the Niger Delta. Unfortunately, the costs associated with importing these additives can reach millions of dollars each year thereby affecting the nation's gross domestic product (GDP) and the economy, Elward-Berry et al (1997). Continuous importation of starch for drilling and completion of an oil well in Nigeria will impart negatively on the foreign exchange which in turn affects the socio-economic stability budget.

There is a need to have a paradigm shift in the area of importation of oilfield chemicals used in drilling and completion operations in-country by empowering indigenous participants to increase capacity in the production of oilfield chemicals used for drilling, completion, and production enhancement purposes; and this, in turn, will build local capacity, create linkages to other sectors of the national economy and boost industry contributions to the growth of our National Gross Domestic Product Nigerian content.

II. Materials and Method

The local starch was processed by an indigenous cassava starch processing company in Aba, Abia State, Nigeria. Other materials were imported polymers (*PAC R and PAC L)*

Equipment

Table 1. Shows Equipment and Functions

Item	**Equipment**	**Function**
1	API Filter Press Cell	To determine fluid loss
4	Electronic balance	To weigh materials
2	Fann VG 35A	To measure rheology
3	Hamilton mixer	To obtain homogeneity
6	Microwave oven	Removal of moisture
7.	Sieve mesh set	For particle size distribution
5	Vernier caliper	To determine filter cake

Methodology

50g of each sample was dried in the microwave oven at 105ºC for 30 minutes to remove moisture. It was then transferred to the desiccator and allowed to completely dry in 10 minutes. 22.5g of each sample was measured (from the dried 50g) with the aid of a weighing balance and to be mixed with 327.15 ml of distilled water to make up 350 ml of a barrel in the lab unit. 327.15ml of the distilled water was measured with the aid of a measuring cylinder into a Hamilton Beach mixer cup and allowed to stir for 1 minute. The 22.5g of sample was added to the stirred water in the mixer cup and the mixture was allowed to blend for 5 minutes while scraping the inner side of the cup to ensure proper mixing at a 1-minute interval. At the end of the 1 minute, the mixture was transferred into the API filter press cup.

API Fluid Loss Determination

The cover lid of the bottom of the cell of the filter press was detached. The O' ring was placed on filter paper and a groove was made of it, inverted to fill. The blended mixture was poured into the cell after the lid was placed and turned clockwise to hand-tight. A 10ml graduated cylinder was placed under the filtrate opening and pressure of 100 psi was engaged and maintained by a carbon dioxide cartridge. With the aid of a stopwatch, at 30 minutes the spurt loss was removed after 7 hours and 30 minutes, while the filtrate loss was taken at the end of the 30 minutes and the result was multiplied by 2 and recorded. Furthermore, the filter cake of each of the fluid loss agents was assessed and it was measured with the aid of Vernier clippers by subtracting the thickness of the filter paper from the total thickness in millimeters.
In addition, spurt loss was mathematically calculated with equation 1.1.

$$V_{30} = 2(V_{7.5} - V_{sp}) + V_{sp} \qquad 1.1$$

III. Results

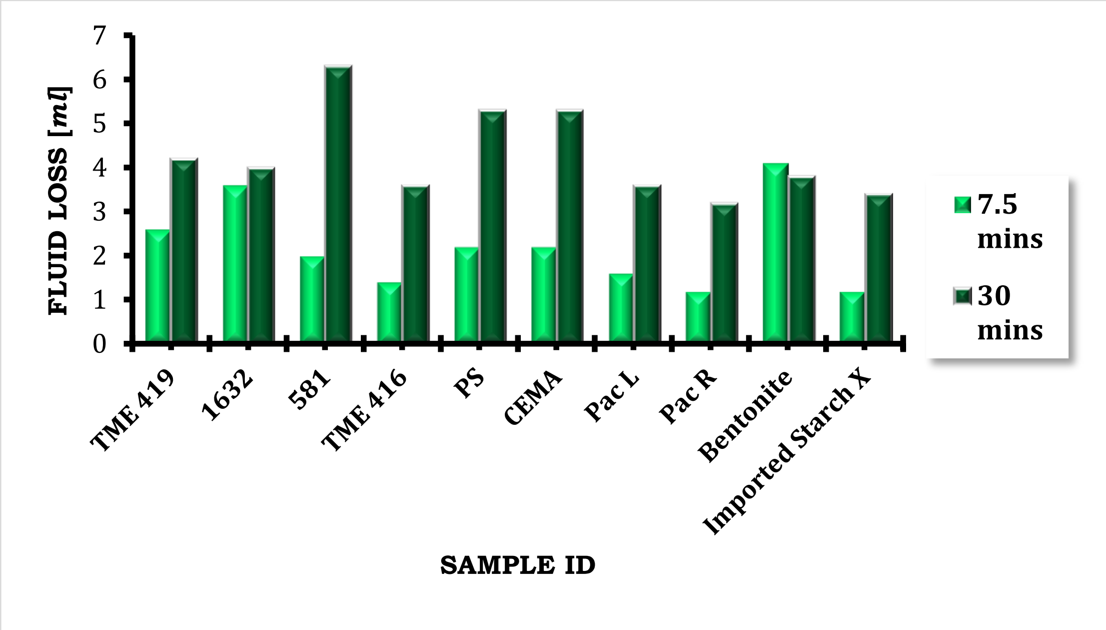

Figure 1: Plot of 0.1% of Polymer Samples vs. Fluid loss at 7.5 mins and 30 mins (*ml*)

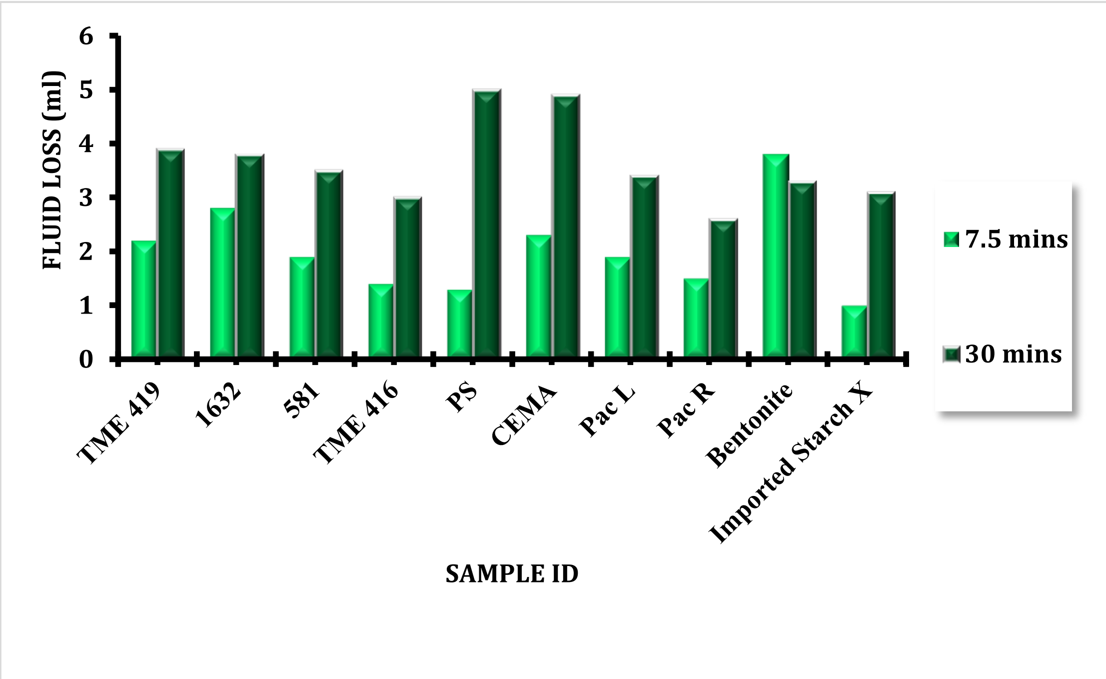

Figure 2: Plot of 0.5% of Polymer Samples vs. Fluid loss at 7.5 mins and 30 mins (*ml*)

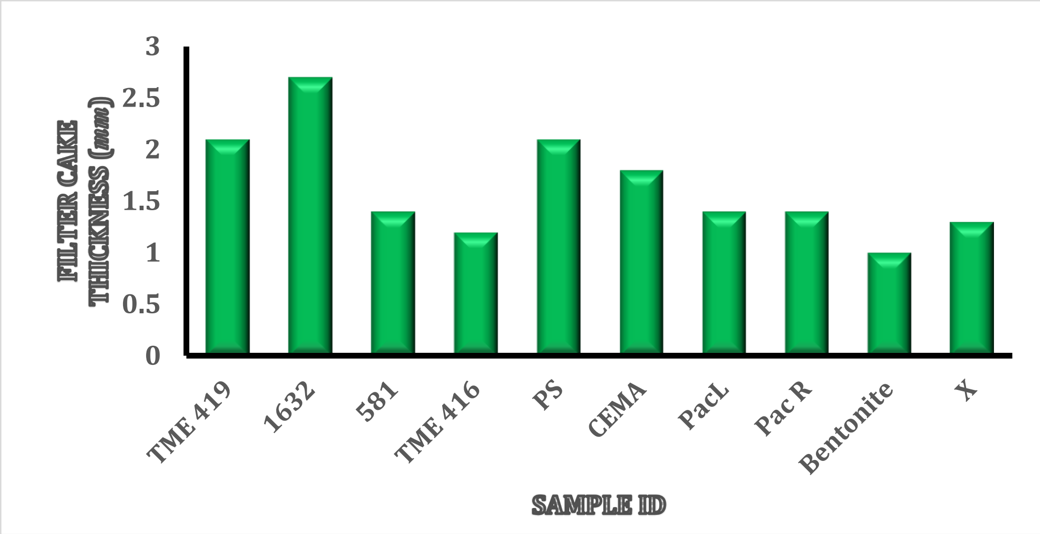

Figure 3: Plot of 0.1% of Polymer Samples vs. Filter cake thickness (*mm*)

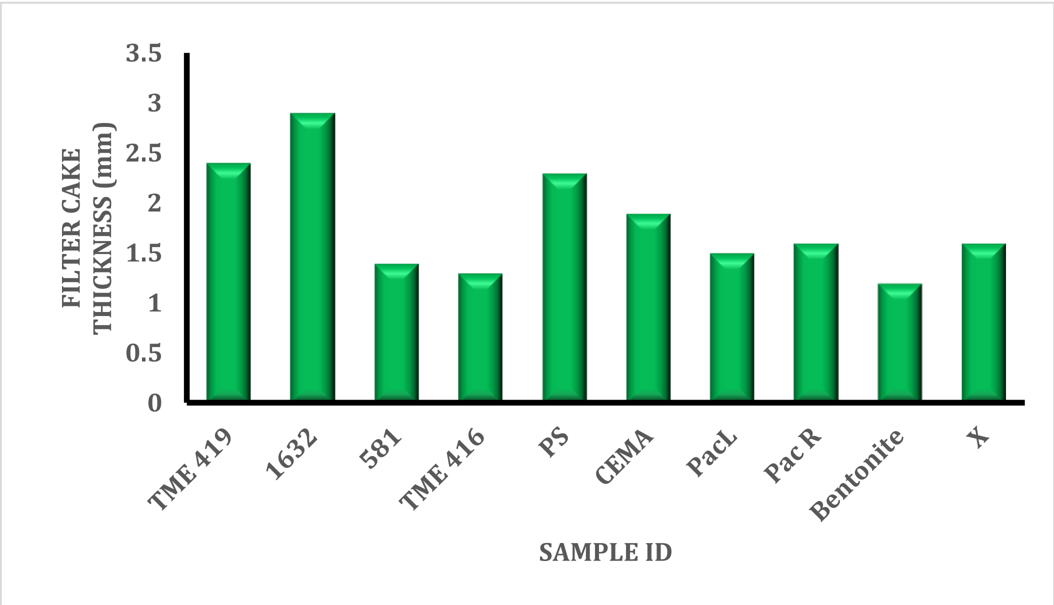

Figure 4: Plot of 0.5% of Polymer Samples vs Filter cake thickness (*mm*)

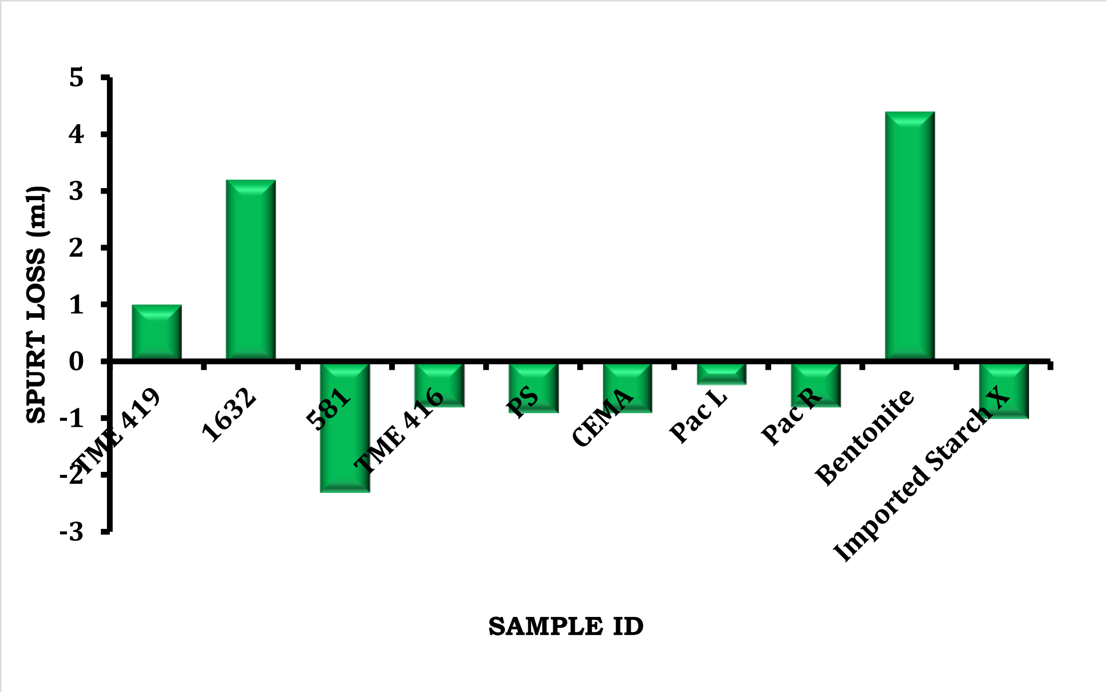

Figure 5: Plot of 0.1% of Polymer Samples of 0.1% of Sample vs Spurt loss (*ml*)

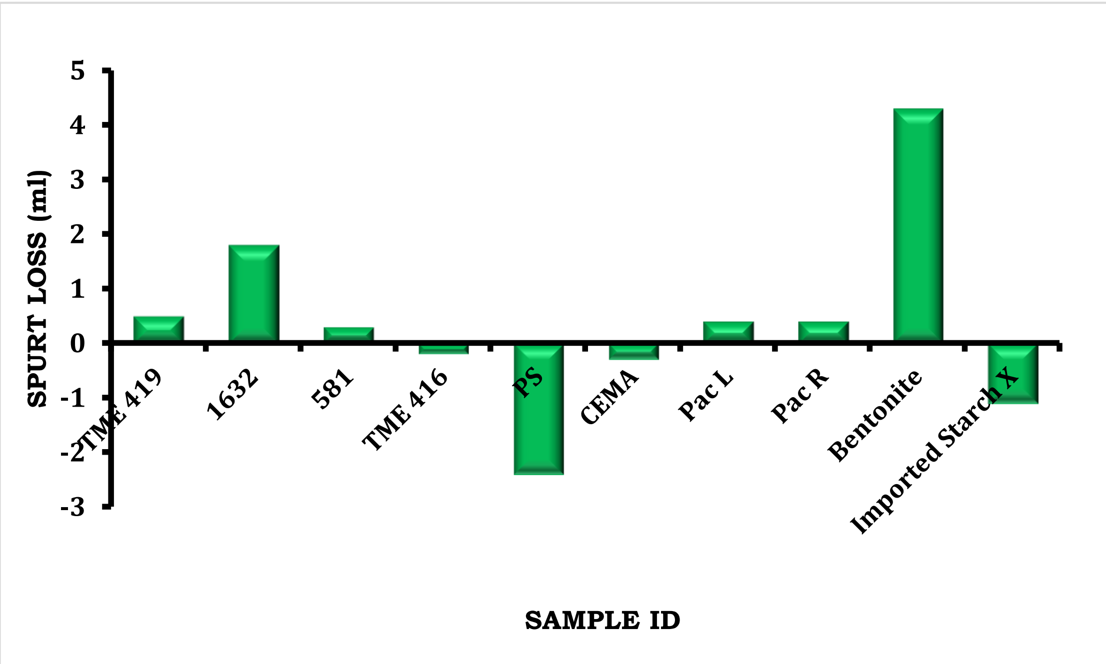

Figure 6: Plot of 0.1% of Polymer Samples vs. Spurt loss (*ml*)

IV. Discussion

Fluid loss

Fluid loss results from six local cassava starch samples (TME 419, 1632, 0581, TME 416, PS, CEMA), and four imported samples (Pac L, Pac R, Bentonite, X) respectively were evaluated. 0.1 % by weight of 350ml of the ten samples respectively was used to determine the fluid loss following the standard API procedure as indicated in section 2.3. The calculated filtrate values were determined and results of 4.2 ml, 4.0 ml, 6.3 ml, 3.6 ml, 5.3 ml, 5.3 ml, 3.6 ml, 3.2 ml, 3.8 ml, and 3.4 ml respectively were obtained (figure 1). The test was repeated with 0.5 % and the fluid loss was determined as applicable and the results of 3.9 ml, 3.8 ml, 3.5 ml, 3.0 ml, 5.0 ml, 4.9 ml, 3.4 ml, 2.6 ml, 3.3 ml, and 3.1 ml respectively obtained (figure 2). It was observed that there was a decrease in fluid loss volume with an increase in fluid loss agents (local starch and imported samples). This implies that all the samples are candidates for fluid loss control. However, among the six samples of local cassava starches, TME 416 exhibited better fluid control than others and compared favorably with the imported samples. Depending on the level of drilling operations, it is advocated that fluid loss value should be in the range of 10 ml filtrate volume (API Recommended Practice 29), all the local cassava starches met this range of 10ml filtrate volume and therefore are good candidates for filtration control and could be used as substitutes for imported samples

Filter Cake Evaluation

A further experiment was carried out to ascertain the degree of filter cake since it is essential during the drilling process. The filter cake is the residue deposited on a permeable medium when a slurry, such as a drilling fluid, is forced against the medium under pressure. Filtrate is the liquid that passes through the medium, leaving the cake on the medium. Filter cake plays an essential role in stabilizing porous permeable formations. The ideal (thin, tough, impermeable, and flexible) filter cake can isolate the wellbore fluids from the pore fluids at the wellbore wall. This is important in terms of wellbore stability and to prevent differential sticking. 0.1 % by weight of 350ml of ten samples respectively was used to determine the filter cake following the standard API procedure as indicated in section 2.3. The measured filter cake for the ten samples was, 2.1 ml, 2.7 ml, 1.4 ml, 1.2 ml, 2.1 ml, 1.8 ml, 1.4 ml, 1.4 ml, 1.0 ml, and 1.3 ml respectively (Figure 3). This test was repeated using 0.5% and corresponding results for the ten samples were 2.4 ml, 2.9 ml, 1.4 ml, 1.3 ml, 2.3 ml, 1.9 ml, 1.5 ml, 1.6 ml, 1.2 ml, and 1.6 ml respectively(Figure 4). Test results indicated that the filter cake deposit increased with an increase in fluid loss additives concentration for both the local and imported samples. However, results showed that local cassava starch (TME 416) had the lowest filter cake.

Spurt Loss

The instantaneous volume (spurt) of liquid that passes through a filter medium before deposition of a competent and controlling filter cake. In static filtration, the spurt volume can be a disproportionately large percentage of the total 30-minute filtrate in an API-type test. The spurt loss of the ten samples was mathematically calculated using equation 1.1 and results are indicated in Figures 5 and 6. It is advocated the spurt loss must be near zero to minimize base fluid invasion into the reservoir. Test results indicated that the six samples of the local cassava starch spurt loss volume tended to zero

V. Conclusion/Recommendation

1. Local starch can be used in water-based drilling mud as a fluid loss control additive and performed comparatively with the imported samples at the temperature ranges investigated (80 - 190 ^{o}F)
2. The Petroleum Industry and Nigerian Content Development and Monitory Board (NCDMB) should encourage using local starch as fluid loss reducers in the water-based drilling fluid formulation.
3. Establish a Triple Helix Model involving the (government and industry), that will help to commercialize the research findings for application as substitutes for imported samples

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