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Filtration Behaviors of Polymer Drilling Mud Prepared with Pectin from Sweet Potatoes *(Ipomoea Batatas)* Peels

[1]K. O. Chike, [1]N. C. Iheaturu, [1]C. C. Okezie, [2]C.S. Uzoukwu

[1]Department of Polymer & Textile Engineering, Federal University of Technology, P.M.B 1526, Owerri, Imo State,Nigeria.
[2]Department of Civil Engineering, Federal University of Technology, P.M.B 1526, Owerri, Imo State,Nigeria.

Abstract
Pectin was extracted from ipomoea batatas otherwise known as sweet potatoes and pre-gelatinized using calcium water. The pre-gelatinized pectin was used to prepare biodegradable polymer drilling mud. The filtration behavior of 0.2g/mol of the pectinpolymer mud (PP-mud) was compared to the filtration behavior of a hydroxyl propyl starch chemically modified mud (HPS-mud) at 25°C and 220°C respectively using the filter loss method at 100 psi. Results obtained reveal that the pectin polymer mud has better filtration behavior than the chemically modified mud based on HPS. The study also showed that the new mud is thermally stable at a sorptivity value of 25.6 and 19.78 at 25°C and 220°C respectively. In addition, the PP-mudshowed better diffusivity at 25°C and 220°C than HPS-mud.

Keywords: *Pectin, Biodegradable polymer, Drilling Mud, Diffusivity and Sorptivity.*

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I. Introduction

Pectin is a high-molecular-weight carbohydrate polymer that is present in virtually all plants where it contributes to the cell structure. Pectin forms gels when dissolved in water under suitable conditions. It is derived from the proto-pectin found in the middle lamellae of plant cells and fruits[1]. Proto-pectin is insoluble but is converted to soluble pectin as fruits ripen or are heated in an acid medium[2]. Typical levels of pectin in some fruits and plants are as follows; apples 1-1.5%, apricots 1%, cherries 0.4%, oranges 0.5-3.5%, carrots 1.4%, and citrus peel 30%. Pectin also accounts for a good percentage of the peel of tuber crops such as potatoes. Sweet potato, a vegetative root crop, carbohydrate tuber,botanically called *ipomoea batatas*, belonging to the perennial family of morning glories, is a pectin source[3]. It has been reported that sweet potato peel, contains about 15% pectin on a dry matter basis. The peels resulting from the sweet potato processing industry if not fed to ruminants or turned into organic manure, usually becomes an environmental problem ora source of water pollution when it is left in the open to decay. On the other hand, pectin has wide commercial applications in both the pharmaceuticaland food industries[4], where it acts as thickening and gelling agent. It regulates the thickness and mouth-feel of fruit drink powder when the powder is dissolved in cold water, and prevents the formation of cheesy milk layer in gelled milk dessert. However, pectin's application may also extend to the oil and gas industry, where drilling mud additives for use as viscosifiers, fluid loss and filtration control agents, are constantly being sort after with the long term aim of a complete transition from non-degradable, eco-friendly drilling mud to a degradable and eco-friendly drilling mud[5],[8]. Filtration control is important in oil and gas well drilling. In other to maintain the integrity of the oil well, fluid loss is controlled with the addition of filtration control agents during cementation and casing. Inimical to oil well performance and productivity is high rate of fluidloss which creates glitches as differential sticking, instability of the well bore, drilling mud losses to formation and formation damage[6], [7]. This work therefore reports the filtration and fluid loss properties of polymer drilling mud formulated with environmentally friendly pectin extract from sweet potato peels.

1.1 Sorptivity and Diffusivity

Sorptivity and diffusivity may be defined with respect to water transport in compact yet porous media. Whereas, sorptivity is a measure of the capacity of any medium to absorb or desorb liquid in a capillary, diffusivity on the other hand, is a measure of the permeation of the drilling fluids in the well bore.

1.1.1 Sorptivity is the tendency of a material to absorb and transmit water and other liquids by capillarity[9]. It is also defined as the measure of the resistance against the fluid flowing through the filter cake[10]. Sorptivity is widely used in characterizing soil and porous construction materials such as brick, stone and concrete, the slope from the plots of fluid loss against square root of time will give the fluid sorptivity[11]. According to *America Petroleum Institute* (API) model sorptivity can be calculated with equation 1.1 given as;

$$V = St^{\frac{1}{2}} \quad \text{Equation 1.1}$$

Where;V is fluid loss (ml), S is sorptivity (ml/min) and $t^{1/2}$is time square root (min).

1.1.2 Diffusivity is a measure of the rate at which drilling fluids can spread. It is the ability of a substance to undergo diffusion. It is measured differently for different mediums. Computation of diffusivity in capillary channels or compact porous media may be computed using equation 1.2;

$$\emptyset(R) = \emptyset_o e^{-Dt} \quad \text{Equation 1.2}$$

Where;$\emptyset$and$\emptyset_o$are initial and final filtration rates respectively, while D is the fluid diffusivity and t, time.The slope of the plots of rate of filtration against time gives diffusivity indicates diffusivity.

II. Materials and Method

2.1 Materials

Sweet potatoes were locally sourced. Hydrochloric acid (HCl), sodium hydroxide (NaOH), ethanol and distilled water were of analytical grade and sourced locally as well.The Fann series 300 Filter Press apparatus was used for fluid loss / filtrationexperiment.

2.2 Method

2.2.1 Sample Preparation

The sweet potato peels were shredded and dried in open air, under sunlight for 8 days. The dried peels of about 200g were put in a glass jar and 650ml of 0.05M HCl solution was added to them. The prepared mixture was boiled at 90°C for 30min and then vigorously stirred for 5 minutes. The mixture was then filtered carefully. The filtrate and residue were separated with the help of a filter cloth, leaving a light brown colored residue which was also observed after boiling. 83g of NaOH was dissolved in 100ml of water and added to the filtrate in other to neutralize it, leaving a darker brown filtrate. 260ml of 95% concentration ethanol was added to the filtrate. The final mixture was kept in a freezer at about 4°C for 14hours. The resulting mass of filtrate was a highly viscous and sticky substance, pectin.

2.2.2 Modification of Pectin

The extracted pectin was modified in order to cause pre-gelatinization. The modification was carried out using calcium water. The calcium water was prepared by mixing calcium phosphate and water in the ratio of 1:4 which implied that 100g of calcium phosphate was added to 400ml of distilled water, and was well stirred. The stirring was done for about 50 minutes. Then 200g by weight of the extracted highly viscous and sticky substance, pectin, was added to the mixture. The whole solution was again stirred at in a high-speed mixer at 300 rpm for about 24hrsforminga gel. The gel was oven-dried at a temperature of 30°C. The solidified gel was then grounded into powder.

2.2.3 Preparation of Drilling Mud

The PP-mud was prepared by mixing 120g of the modified powdered pectin polymer in 600ml of water which gave 0.2g/ml concentration of the pectin in water. The pectin-in-water mixture was then added slowly to a bentonite clay-water mixture under constant stirring at 300 rpm for 3 hours to prevent lump formation. In other to adjust the pH, sodium hydroxide (NaOH) was added to the mud.

2.2.4 Determination of Filtration Loss

Filter loss method was used to determine the filtration properties of the two muds. The experiment was carried out at 25°C and 220°C high temperature respectively for both PP-mud and HPS-mud. 450ml of the PP-mud or HPS-mud, was poured into the chamber Fann Series 300Filter Press apparatus at a constant pressure of 100psi at different temperatures of 25°C and 220°C. The filter loss or filtrate volume was determined at different time intervals in minutes. The same measured volume of 450mlof either the PP-mud or HPS-mud was heated in the oven at 220°C, thenpoured into the main chamber of the Fann Series 300 Filter Press apparatus and filtrate volume collected were measured with graduated cylinder. The experiment generated filtration loss values forPP-mud and HPS –mud at 25°C and 220°C at 100 psi.

III. Results and Discussion

3.1 Results of Filtration Loss at 25°C

Table 3.1 presents the tabulated results obtained from the fluid loss experiment at 25°C of the pectin polymer-based mud (PP-mud) and the hydroxyl propyl starch modified mud (HPS-mud).While, Figures 3.1 and 3.2 are graphs of fluid loss in milliliter plotted against the square root of time in minutes at 25°C and filtration rate (dv/dt) plotted against time in minutes respectively.

Table 3.1: Results from the experiment run at 25°C

Time(mins)	Squareroot of time $t^{1/2}$	PP-mud		HPS-mud	
		Fluid loss volume V (ml)	Rate of filtration dv/dt (volume/time)	Fluid loss volume V (ml)	Rate of filtration dv/dt(volume/ time)
5	2.23	106.00	21.20	118.00	23.60
10	3.16	130.00	13.00	136.00	13.60
15	3.87	142.00	9.46	149.00	9.93
20	4.47	161.00	8.05	165.00	8.25
25	5.00	175.00	7.00	185.00	7.40
30	5.47	189.00	6.30	198.00	6.60
35	5.91	199.00	5.68	206.00	5.88
40	6.32	211.00	5.27	216.00	5.40
45	6.70	220.00	4.88	228.00	5.06
50	7.07	228.00	4.56	232.00	4.64

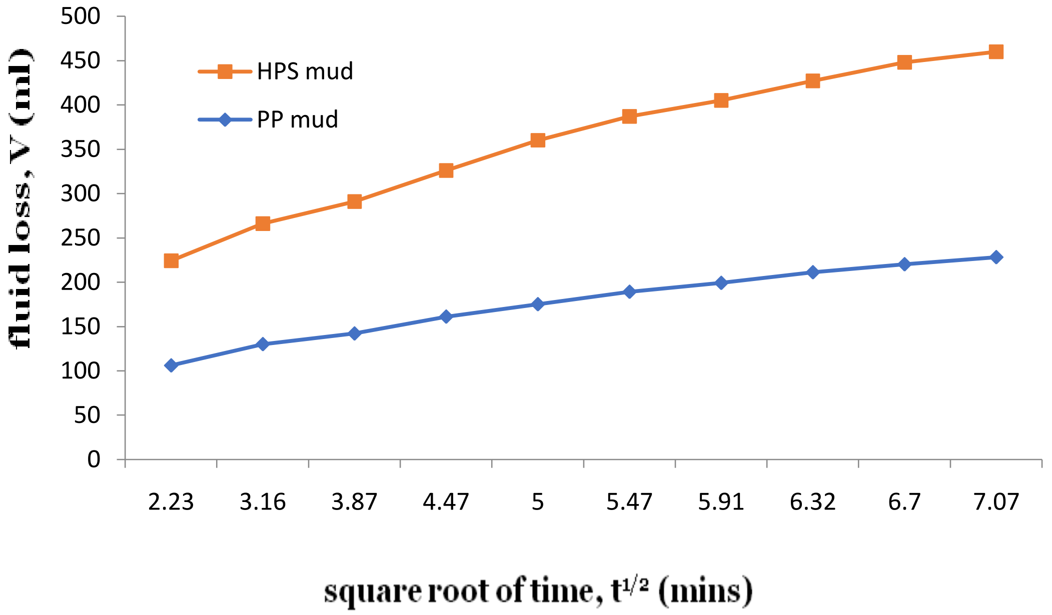

Figure 3.1: Plot of fluid loss against square root of time for muds at 25°C.

From Figure 3.1, at 25°C, fluid loss of HPS-mud and PP-mud rose arithmetically with respect to the square root of time. The higher fluid loss by HPS-mud shows HPS-mud is susceptible or liable to loss of enough fluid to be circulated round the wall of the wellbore during drilling process which leads to thermal degradation of the mud. PP mud has better sorptivity, showing the muds ability to form filter cake. Hence, PP mud is better. This follows the American Petroleum Institute (API) equation **$V=St^{½}$**, where the slope of the graph is the fluid sorptivity presented in Table 3.3.

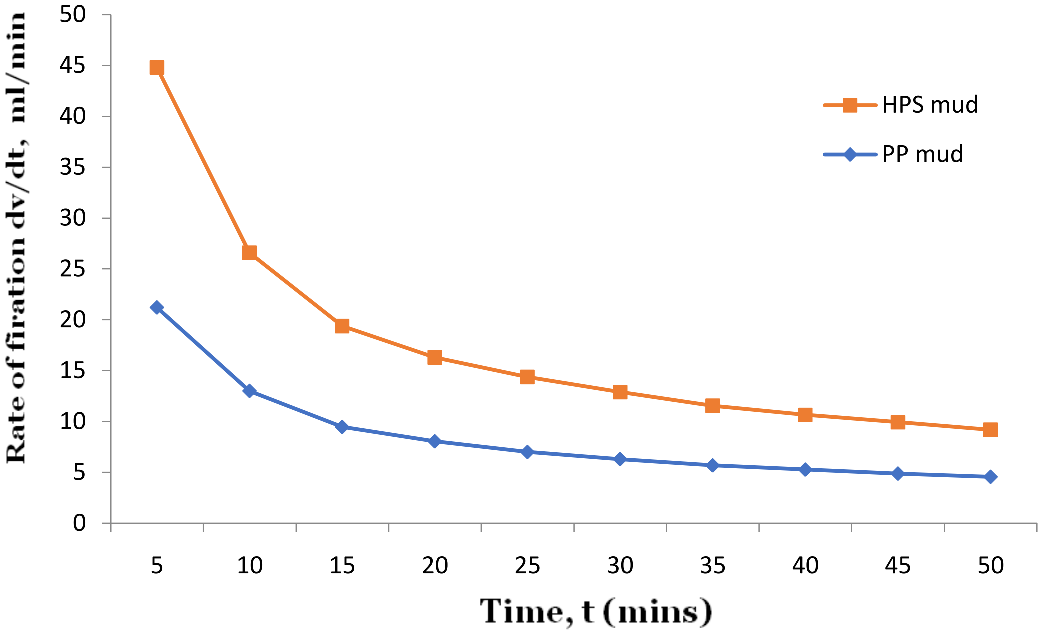

Figure 3.2: Plot of rate of filtration against time at 25°C

Figure 3.2 shows the rate of filtration of the two muds, PP & HPS mud. The rate of filtration of the muds decreases exponentially as time increases exhibiting a decay nature, this obeys the American Petroleum Institute (API) model which follows the equation;$\boldsymbol{Ø(R)= Ø_o exp^{-Dt}}$. This shows that the rate at which HPS-mud loses fluid is more than that of PPM, where the slope of graph refers to fluid diffusivity presented in Table 3.4.

3.2 Results of Filtration Loss at 220°C

Table 3.2 presents the tabulated results obtained from the fluid loss experiment at 220°C of the PP-mud and the HPS chemically modified mud.While, Figures 3.3 and 3.4 are graphs of fluid loss in milliliter plotted against the square root of time in minutes at 220°C and filtration rate (dv/dt) plotted against time in minutes respectively.

Table 3.2: Results from experimental run at 220°C

Time (mins)	Square root of time t1/2 (mins)	PP-mud		HPS-mud	
		Fluid loss volume V(ml)	Rate of filtration dv/dt(volume/time)	Fluid loss volume V(ml)	Rate of filtration dv/dt(volume/time)
5	2.23	132.00	26.40	159.00	31.80
10	3.16	161.00	16.10	181.00	18.10
15	3.87	183.00	12.20	195.00	13.00
20	4.47	197.00	9.85	209.00	10.45
25	5.00	212.00	8.48	215.00	8.60
30	5.47	219.00	7.30	228.00	7.60
35	5.91	229.00	6.54	235.00	6.71
40	6.32	235.00	5.87	244.00	6.10
45	6.70	240.00	5.33	251.00	5.57
50	7.07	243.00	4.866	255.00	5.10

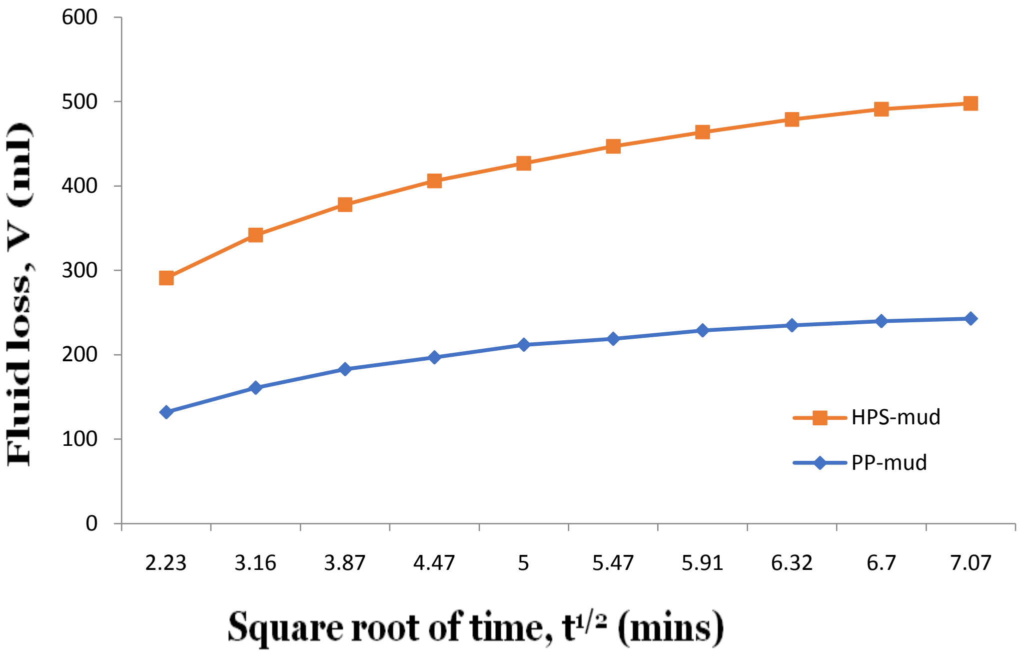

Figure 3.3: Plot of fluid loss against square root of time at 220°C

From Figure 3.3, at 220°C, fluid loss of **HPS**-mud and **PP**-mud increased arithmetically with respect to the square root of time. The higher fluid loss by HPS mud shows HPS mud is susceptible or liable to loss of enough fluid to be circulated round the wall of the wellbore during drilling process which leads to thermal degradation of the mud. PP mud has better sorptivity, showing the muds ability to form filter cake. Hence, PP mud is better. This follows equation 1.1,**$V=St^{½}$.** Where slope of graph refers to fluid sorptivity.

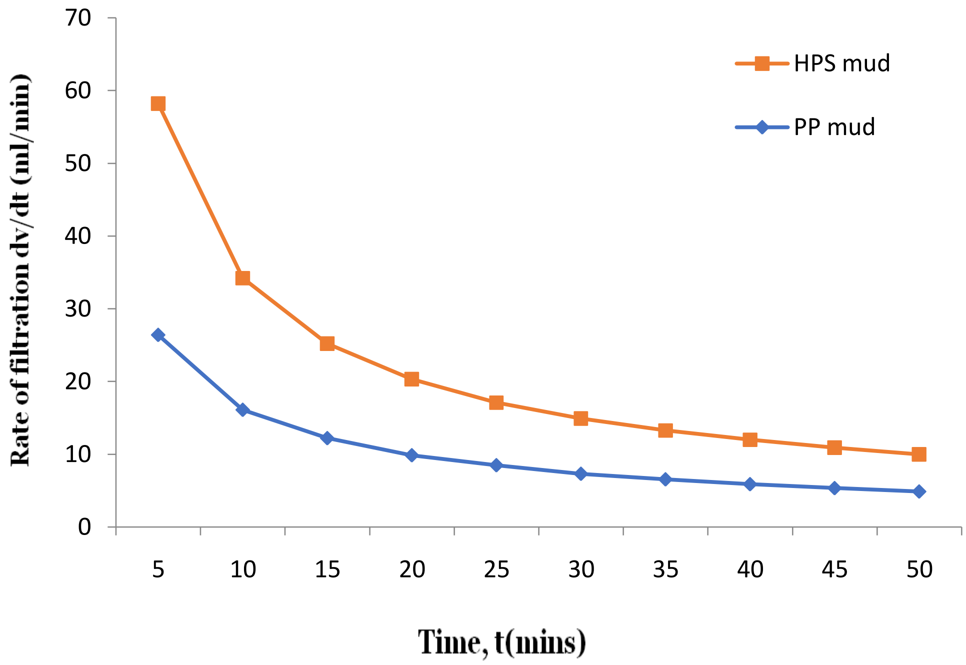

Figure 3.4: Plot of rate of filtration against time at 220°C

From Figure 3.4, at 220°C, the rate of filtration of the two muds, PP & HPS mud. The rate of filtration of the muds decreases exponentially as time increases exhibiting a decay nature. This obeys the American Petroleum Institute (API) model which follows the equation 1.2; **$Ø(R)= Ø_o exp^{-Dt}$**. This shows that the rate at which HPS mud loses fluid is more than that of PP-mud.

3.3 Results of sorptivity and diffusivity

The values of diffusivity and sorptivity obtained from the plots are given in Tables 3.3 and 3.4 respectively, where the slopes of the graphs in Figures 3.3 and 3.4 indicates fluid sorptivity and diffusivity respectively.

Table 3.3: Sorptivity values of the mud samples at different temperatures.

Mud samples	25°C	220°C
PP-mud	25.6	19.78
HPS-mud	24.45	19.21

Table 3.4: Diffusivity values of the mud samples at different temperatures.

Mud samples	25°C	220°C
PP-mud	-0.10	0.15
HPS-mud	-0.16	0.19

IV. Conclusion

The experiment showed how commercially valuable Pectin can be extracted from domestic wastes like potatoes peels and other foods. Potatoes are crops which are frequently produced in large quantities, it is readily available and accessible with its cost comparatively lower than cost required in acquiring chemicals for producing chemical drilling mud. These locally sourced materials are biodegradable and can be used as base material for enhancing water-based mud which will be of benefit to the oil and gas industries as it will reduce the cost of producing water-based drilling mud. The new pectin polymer mud made from potato has better fluid loss control behavior, filtration rates, high sorptivity and lower diffusivity than the widely used mud prepared chemically. From the experiment, the thermal stability of the mud at 220°C implies that the mud is suitable for drilling well bores having bottom hole temperatures as high as 220°C.

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Declaration of conflict of interest

The authors declare that there are no conflicts of interest in this project.

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