American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-11, Issue-07, pp-08-13
www.ajer.org
Research Paper Open Access

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

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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 property of the mud was determined at 25°C and 220°C using the filter loss method. The filtration behavior of 0.2g/mol of the pectin polymer mud (PP-mud) was compared to the filtration behavior of a chemically modified mud containing hydroxyl propyl starch (HPS). Results obtained show that the new pectin-based 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 mud has better diffusivity at 25°C and 220°C than HPS-based drilling mud.
Keywords: *Pectin, Biodegradable polymer, Drilling Mud, Diffusivity and Sorptivity.*

Date of Submission: 01-07-2022 Date of acceptance: 10-07-2022

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. show that the new pectin-based mud has better filtration behavior than the chemically[1]. Proto-pectin is insoluble but is converted to soluble pectin as fruits ripen or is heated in an acid medium[2]. Fruits such as pears, apples, guavas, quince, plums, gooseberries, and citruses such as oranges and tangerine, contain large quantities of pectin, while soft fruits like cherries, grapes, and strawberries, contain small quantities of pectin. 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%. In addition to fruits, pectin also accounts for 0.8% of the peel of tuber crops such as potatoes. It is also reported that sweet potato peel, contains about 15% pectin on a dry matter basis. Sweet potato, botanically called *ipomoea batatas*, a vegetative root crop, carbohydrate tuber, belonging to the perennial family of morning glories, is a pectin source[3]. The peels resulting from the sweet potato processing industry if not fed to ruminants or turned into organic manure, they may become a source of water pollution or environmental problem, if left unattended. Furthermore, pectin also has wide commercial applications in both the pharmaceutical[4]and food industries, where it acts as thickening and gelling agents, 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. The ease of pectin extraction is partly affected by the degree of esterification. However, drilling mud additives for use as viscosifiers, fluid loss and filtration control agents, are constantly being sort after in the oil and gas industry 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]. Filtration control is important in well drilling. In other to maintain the integrity of the oil well, fluid loss is controlled by addition of filtration control agents during cementation and casing. Inimical to oil well performance and productivity is high rate of fluid which creates glitches as differential sticking, instability in well bore, drilling mud losses to formation and formation damage[6], [7]. Furthermore, the need for environmentally friendly filtration control agents cannot be over-emphasized [8]. 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.

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;

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

Where;**V** is fluid loss (ml), **S** is sorptivity (ml/min) and $\mathbf{t^{1/2}}$ 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;

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

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, sodium hydroxide, 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 Methods

2.2.1 Sample Preparation

The sweet potato peels were shredded and dried in open air for 8 days. The dried peels of about 200g were put in glass jar and 650ml of 0.05M HCl solution was added to them. The prepared mixture is boiled at 90°C for 30min.The boiled mixture is stirred continuously for about 5mins. Filtrate and residue are separated with the help of cotton cloth, a light brown color was observed after boiling. 83g of NaOH was dissolved in 100ml of water and added to filtrate for neutralization; a dark brown liquid was observed. 260ml of 95% concentration ethanol was added to the filtrate. The final mixture is kept in freezer at about 4°C for 14hours. A sticky substance was observed at the bottom of the solution. It was separated from the mixture and the extracted pectin was modified.

2.2.2 Modification of Pectin

The extracted pectin was modified in order to cause pre-gelatinization. The modification was carried out by preparing calcium water first. 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 at interval of 10minutes for about 50 minutes. Then 200g by weight of the extracted pectin was added to the mixture. The whole solution was stirred at intervals in a mixer for about 24hrs, and gel was formed. The gel was then allowed to dry and solidify under atmospheric temperature. The solidified gel was grounded into powdered form.

2.2.3 Preparation of Drilling Mud

The new drilling 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 muds preparation was firstly done by mixing bentonite clay and water. The new pectin polymer was added slowly and stirred constantly for hours to prevent lump formation. Sodium hydroxide (NaOH) was added to adjust the pH level of the mud. This new pectin polymer drilling mud was tagged here as PP-mud while chemically modified drilling mud containing Hydroxyl Propyl Starch, used for comparison was tagged HPS-mud in this work.

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. 450ml of the mud, PP-mud (pectin polymer mud) was poured into the chamber of the standard filter press at a constant pressure of 100psi at room temperature, 25°C. The filtration test was run and the filter loss or filtrate volume was read at different time intervals in minutes. The same quantity of mud was heated in oven at higher temperature 220°C. Then, the heated mud was re-mixed and filtration experiment was run on it. The same experiment was carried out on the chemically-modified mud, HPS –mud and all the filtrate volume collected were measured with graduated cylinder. The readings were recorded and tabulated.

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 and the HPS chemically modified 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 $t^{1/2}$	PPM		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

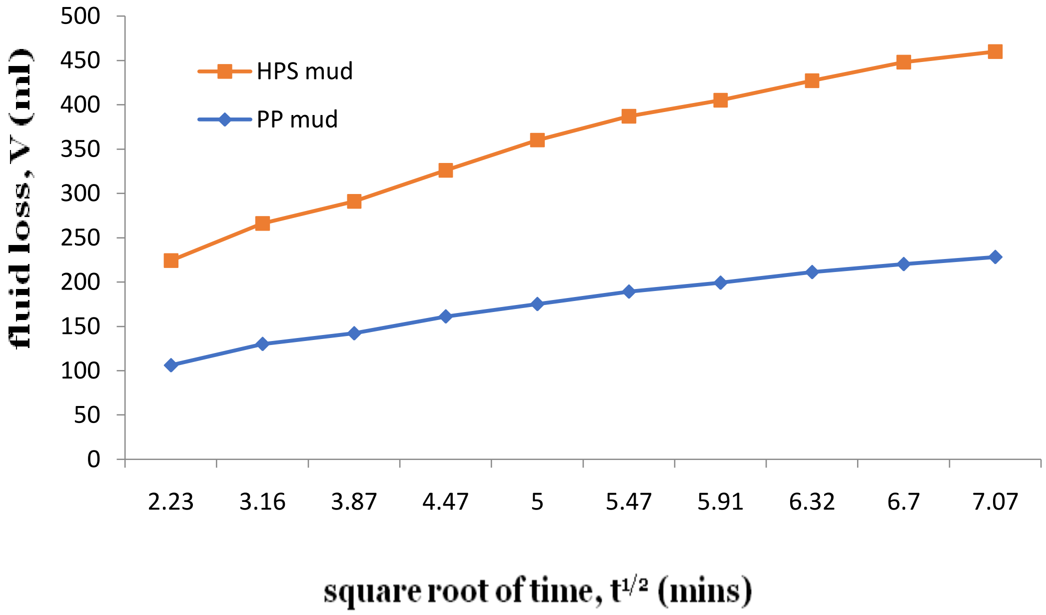

Figure 3.1: Plot of fluid loss against square root of time for muds at 25°C.

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 $\mathbf{V=St^{1/2}}$, where the slope of the graph is the fluid sorptivity presented in Table 3.3.

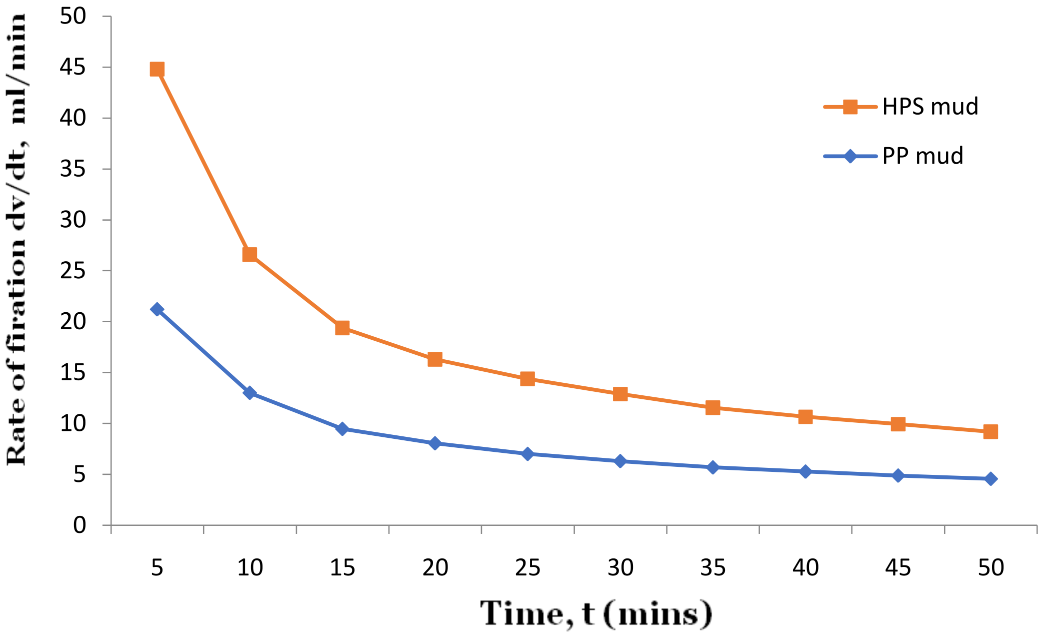

Figure 3.2: Plot of rate of filtration against time at 25°C

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 pectin polymer-based 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)	PPM		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

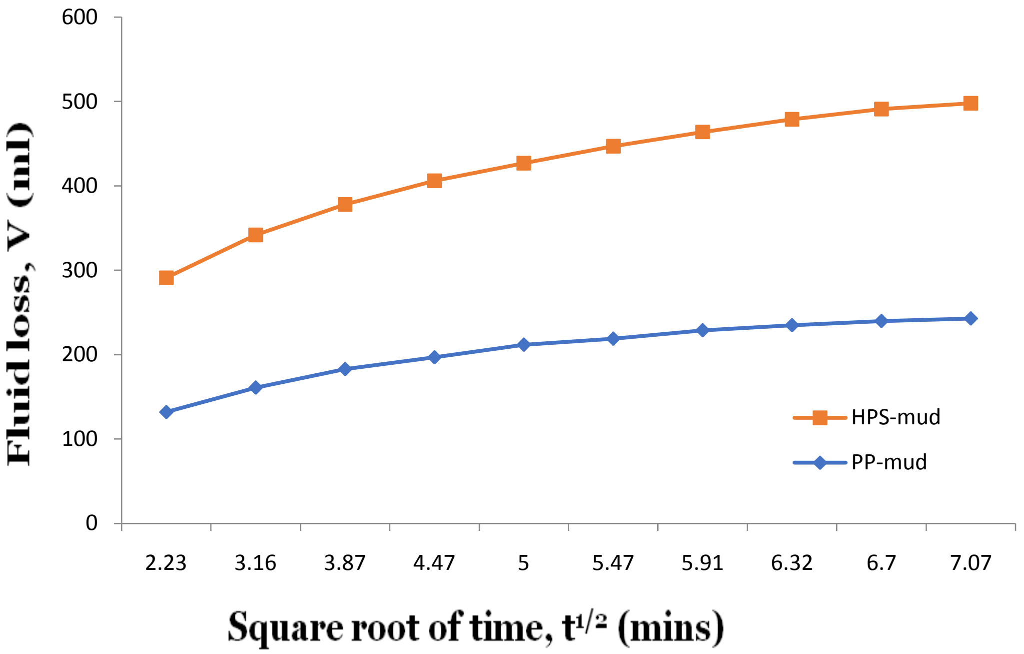

Figure 3.3: Plot of fluid loss against square root of time at 220°C

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.

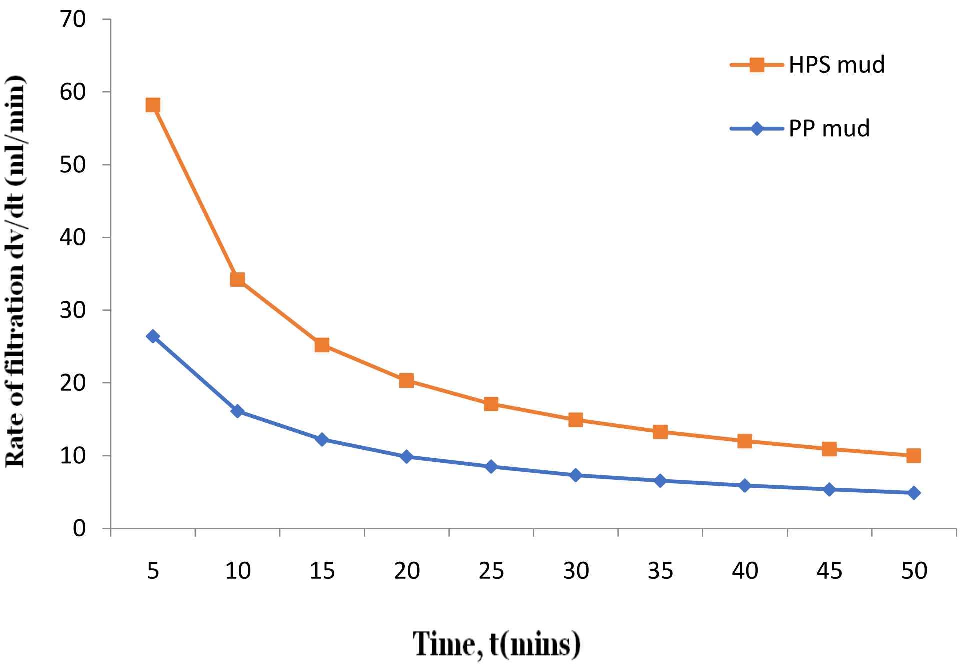

Figure 3.4: Plot of rate of filtration against time at 220°C

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.

Acknowledgement

The authors acknowledge the assistance received from the Laboratory Technologists in Polymer and Textile Engineering department, Federal University of Technology, Owerri, Imo State, Nigeria.

Declaration of conflict of interest

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

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