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Utilizing Orange Peel Pectin as a Green Additive to Improve Bentonite Mud Performance in Oil Well Drilling

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Abstract

Orange peel pectin (OPP) is widely used in chemicals and food technology as a viscous agent. This material is eco-friendly and available. This work aims to examine the utilization of OPP as an additive in drilling mud formulas. Several experiments were conducted by adding OPP to bentonite mud in various weight percentages (%wt): 0%, 0.1%, 0.2%, 0.3%, and 0.4%. Tests followed the American Petroleum Institute standard to investigate the influence of OPP addition on rheological behavior and filtration properties of bentonite mud. The results showed a positive correlation between rising OPP content and rheological parameters, improving hole cleaning. The fluid's apparent viscosity tripled at 0.4%wt of OPP. Adding 0.4 %wt OPP increased the yield point (YP) by 86% and slightly increased plastic viscosity (PV) from 5 to 13 cP. A trend of increased gel strength with higher percentages of OPP. Additionally, the 35% reduction in fluid loss volume as concentration increases to 0.4%wt. Additionally, the reduction in fluid loss volume associated with an increase in OPP concentration aids in preventing drilling fluid leakage.

Keywords: *Drilling fluid; Green additive; Orange peel; Rheology.*

1. Introduction

Drilling is a necessary step in each oil and gas project, and because of the complexity and dangers involved, the cost of this activity can account for as much as 50–80% of the total cost during the exploratory phase and 30–80% of the total cost during field development [1]. Specifically, drilling fluid—which is referred regarded as the "lifeblood" of drilling—is a crucial determinant of a drilling project's success or failure and is responsible for the majority of drilling-related expenses [2]. Drilling fluid serves several vital purposes, including clearing the well, cooling the drilling assembly, suspending cuttings when circulation is stopped, and preserving hydrostatic pressure within the well [3-4]. It must therefore always be researched and improved in order to lower costs, reduce formation contamination due to solution loss, and be stable in harsh conditions. This is because drilling is a difficult process that involves many challenges and difficulties, including formation contamination, great depth, high temperature, and high pressure.

Along with the current development, the world's demand for energy is increasing, so the demand for directional and horizontal drilling is gradually becoming a global trend [5].Continuous improvements of equipment made horizontal drilling save time and cost during the drilling process, especially improving the oil recovery rate in the reservoir [2]. However, horizontal drilling also posed challenges, the most prominent being hole cleaning [5-6]. A well's ability to be cleaned effectively depends on a number of variables, including the drill bit, RPM, rate of penetration ROP, formation structure, trajectory, angle, density and rheological characteristics of the drilling fluid [7]. High efficiency drilling can be achieved by optimizing these elements, which will also result in successful hole cleaning. Therefore, research on additives to increase drilling fluid characteristics has been conducted to improve drilling difficulties since drilling fluid properties can be fully modified [8]. Beck provided evidence of the impact of drilling fluid's rheological characteristics. They discovered that the well cleaning efficiency was more enhanced when the plastic viscosity value (PV) was lower [9]. Drilling fluids of various rheological qualities (low to high) were used in studies by Mitchell and colleagues. They discovered that the greater the YP, the greater the mud transport rate.

The search is on for environmentally friendly and efficient additives for the oil and gas drilling industry. The chemicals employed in the oil and gas industry's drilling process must have a minimal ecological imprint because of the stringent environmental rules in place [10-11]. The chemical addition ought to be non-toxic, non-accumulative, and biodegradable [12]. Consequently, in order to address issues during drilling, the oil and gas drilling sector is searching for environmentally safe additives. The Table 1 provides a summary of research on the impact of environmentally friendly additives on the characteristics of drilling fluid. The additives that have been studied all share the trait of having high pectin contents.

The use OPP, which are categorized as agricultural waste products, as a green addition for bentonite mud was investigated in this study. To assess the effectiveness of orange peel pectin as a hole cleaning improvement additive at different concentrations, a number of studies were carried out.

Table 1. A summary of research on the impact of environmentally friendly additives on the characteristics of drilling fluid.

Materials	Concentrations %	Dosage	Rheology		References
			Plastic viscosity (PV)	Yield point (YP)	
Grapefruit peel	1	600mL H_2O 18.6g Bentonite	↑	↓	[11]
Banana peels	0.285, 0.57, 1.425	325.5mL H_2O 24.5g Bentonite	Significant increase to 0.285%, then decrease		[12]
Orange peels	0.1, 0.15, 0.2, 0.25	325.5mL H_2O 24.5g Bentonite	No significant increase	↓	[9]
Potato peels	1, 2, 3 ,4	600mL H_2O 0.6g NaOH 36g Bentonite	↑	↓	[13]
Tangerine peels			↑	↑	
Okra	10, 20	340mL H_2O 21g Bentonite	↑	↑	[14]

2. Material and methods

2.1. Material

This study utilized drilling fluid additives, bentonite powder, tap water, and orange peel pectin. OPP was purchased from the local supermarket. The food, pharmaceutical, and cosmetic sectors are interested in pectin since it is a naturally occurring, adaptable, and nontoxic heteropolysaccharide. Because of its many health benefits, thickening, gelling, and emulsification qualities, this biomolecule has been a useful component in the food and pharmaceutical sectors for many years. According to Mishra [13], there were two stages to the pure pectin thermal deterioration. The sample's thermal salvation was linked to the first thermal event, which was a weight loss of up to 10% in the 50–100°C range. The second event, which was associated with the depolymerization of pectin chains, began at 200°C and reached its maximum at 234°C. This matches the temperature within the well during drilling to prevent material degradation and the loss of the additive function. The bentonite was supplied by DMC, Vietnam. The tap water was collected directly from a purified water system in the Ho Chi Minh City University campus.

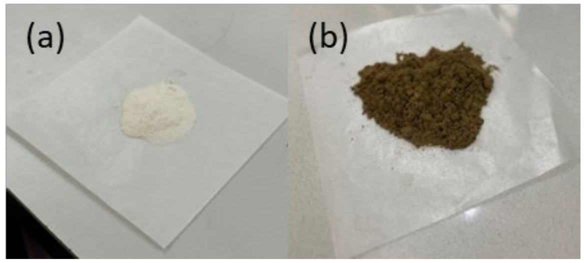

Fig. 1. (a) Bentonite (b) Orange peel pectin powder.

2.2. Bentonite mud preparation

Five samples of bentonite mud were formulated to conduct experiments. Tap water, bentonite, and OPP were added to the mixture. The mixture was stirred by Hamilton beach mixer in Fig.2(a) for 30 minutes to ensure perfect homogeneity [11]. One bentonite mud sample without OPP was used as the control. As indicated in Table 2, the concentrations of OPP rise progressively in steps of 0.1 weight percent, from 0 to 0.4 weight %wt. To ascertain the impact of OPP on bentonite mud, filtration loss tests and rheological analyses were performed by 8-speed viscometer and OFITE Filtration.

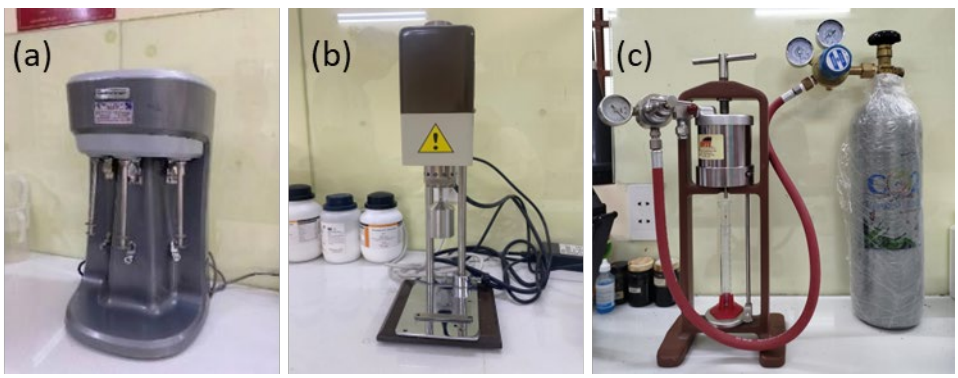

Fig 2. (a) Hamilton Beach mixer; (b) 8-speed viscometer; (c) OFITE Filtration.

Table 2. Formulation of drilling mud samples.

Additives	Sample				
	Control	0.1 %	0.2%	0.3%	0.4%
Tap water, (mL)	350	350	350	350	350
Bentonite, (%wt.)	5	5	5	5	5
Orange peel pectin, (%wt.)	0	0.1	0.2	0.3	0.4

2.3. Rheological measurements

Rheological tests, including the measurement of plastic viscosity (PV), apparent viscosity (AV), yield point (YP), and gel strength at 10 seconds (Gel 10s), and 10 minutes (Gel 10m), were conducted using an 8-speed viscometer in Fig.2(b). Following the right placement of the dry and clean rotor, the device cup was filled with a specific amount of water-based drilling fluid and mounted on the apparatus. The viscometer was run at eight different spinning speeds (R600, R300, R200, R100, R60, R30, R6, and R3 rpm), and reading values were noted. The plastic viscosity (PV) was computed as the difference between observations at 600 rpm and 300 rpm measured in the cP unit. The viscometer was switched on at STIR for 10 seconds to measure the gel strength, then turned off for ten seconds. In the next steps restart the viscometer at 3 rpm, and the maximum value that the viscometer index reached was recorded.

The same steps were repeated when the viscometer was stopped 10 minutes, respectively to measure the final gel strength value by using lb/100ft^2 units [2].

Plastic viscosity: PV = R600-R300 [cP] (1)
Yield point: YP = 2R300-R600 [lb/100ft^2] (2)
Apparent viscosity: AV= R600/2 [cP] (3)

2.4. Filtration characteristics determination

Using an OFITE Filtration in accordance with API regulations, the filtration qualities of drilling fluid samples were assessed. During the filtration test, which simulated fluid loss in the wellbore, the filtrate volume—a measurement of water loss from fluid to the formation—was ascertained. A 100 psi pressure was applied to the sample, and after 30 minutes, the volume of fluid lost was recorded [14].

3. Results and discussions

3.1. Effect of pectin on apparent viscosity

Data are obtained from experiments performed at room temperature and atmospheric pressure are shown in Table 3. The findings of apparent viscosity of bentonite mud with increasing OPP concentrations are displayed in Fig.3. It illustrates how the addition of OPP to the bentonite mud increases the drilling fluid's apparent viscosity. In comparison to the control, the fluid's apparent viscosity tripled when 0.4%wt of OPP, the apparent viscosity of all samples with OPP was higher. It enhances the drilling fluid's capacity to suspend cuttings and efficiently clean the well [2].

Table 3. Viscometer dial reading data.

Dial reading at (RPM)	Sample				
	0% orange peel pectin	0.1% orange peel pectin	0.2% orange peel pectin	0.3% orange peel pectin	0.4% orange peel pectin
600	43	58	79	88	106
300	38	49	68	75	93
200	37	45	63	71	87
100	36	41	60	68	80
60	36	40	58	66	77
30	36	39	56	64	74
6	35	37	52	59	69
3	35	37	52	58	69

3.2. Effect of pectin on rheological behavior

In comparison to the standard bentonite mud, the results indicated a slight rise in plastic viscosity. The plastic viscosity increased from 5 to 13 cP when 0.4 %wt of OPP was added. This may be because there is more solid material in the bentonite mud, increasing the friction pressure loss that occurs when the drilling fluid circulates during the operation. Particularly in the early phases of drilling, the rise in plastic viscosity causes a number of issues. The increase in equivalent circulating density (ECD) brought about by the rise in the plastic viscosity of the bentonite mud may cause undesired formation damage. The pressure of the mud pumps rises as a result of the increase in plastic viscosity, raising the overall cost of drilling [2]. PV can show that OPP hasn't a bad impact on this value with a small increase [9].

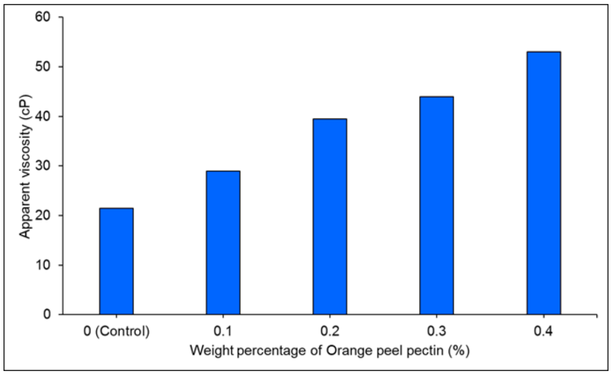

Fig. 3. Apparent viscosity of drilling mud with different dosages of orange peel pectin.

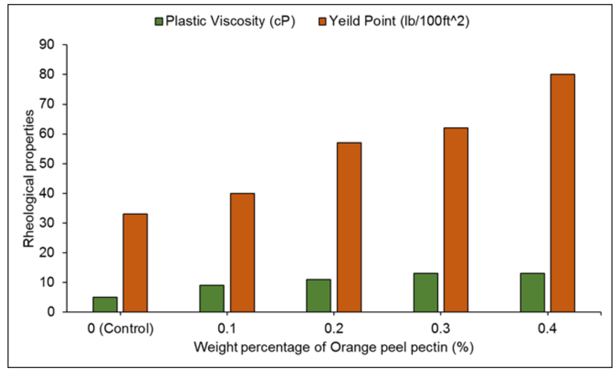

Fig. 4. Rheological behavior of drilling mud with different dosages of orange peel pectin.

The yield point data indicated that as the concentration of OPP grew, so did the yield point, which was consistent with the apparent and plastic viscosity values. Adding 0.4 %wt OPP increased the yield point by 86%. This indicates a rise in the carrying capacity of bentonite mud, which benefits the effectiveness of hole cleaning during drilling operations [15].

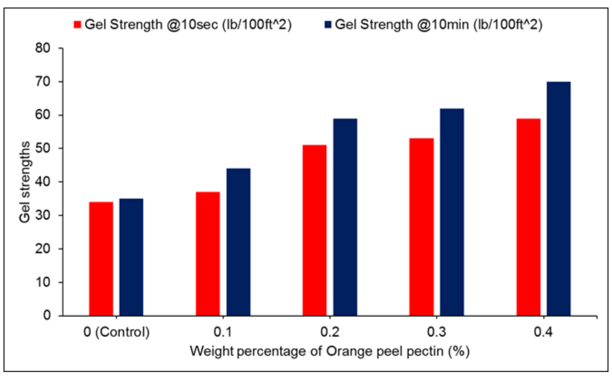

Fig. 5. Gel strengths of drilling mud with different dosages of orange peel pectin.

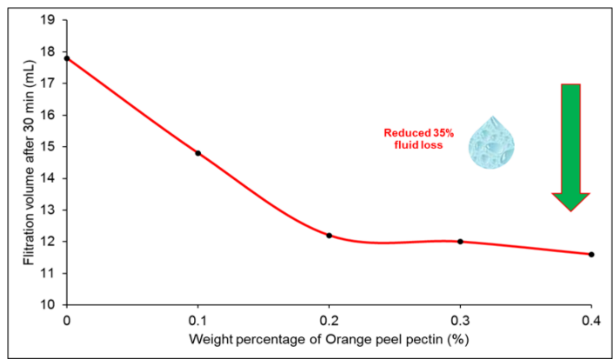

Fig. 6. Filtration volume after 30min of drilling mud with different dosages of orange peel pectin.

For both the 10-second (Gel 10s) and 10-minute (Gel 10 min) intervals, Fig.5 clearly demonstrates a trend of increased gel strength with higher percentages of orange peel pectin. Notably, orange peel pectin significantly improves the gel strength of drilling mud; the increase in gel strength 10s and 10min from the control to the highest pectin concentration (0.4%wt) is approximately double.

Pectin is a viable additive to enhance the rheological characteristics of drilling fluids for better hole cleaning, as seen by the gradual increase in PV and the notable increase in YP and AV, Gel 10s, Gel 10 min.

3.3. Effect of pectin on filtration properties

In this part, bentonite mud samples generated with and without OPP were compared to reference mud in terms of fluid loss volume. The fluid loss test results are displayed in Fig.6. It shows that adding OPP up to 0.4%wt has a beneficial impact on a reduction in the amount of fluid lost by 35%. There are two components to OPP's effect in Fig.4. A notable 33% reduction in water loss is seen when the OPP concentration rises to 0.2%wt. Nevertheless, there is only a minor drop in water discharge—less than 4% of the reduced volume of water loss—between concentrations of 0.2%wt and 0.4%wt. Therefore, the inclusion of OPP aids in preventing a number of drilling issues brought on by fluid loss such as kick, etc. According to API, a recommended maximum volume of fluid loss is 15 mL [2], stated that the fluid loss values for all samples in the presence of OPP revealed acceptable fluid loss values with a small concentration.

4. Conclusions

The OPP proved to be a beneficial addition to the bentonite mud. The rheological parameters—such as the plastic viscosity, yield point, and apparent viscosity—increased with the addition of OPP at increasing concentrations. All of this will contribute to increasing viscosity to enable the hole-cleaning procedure to be successful while minimizing pressure loss during pumping. It also dramatically minimizes fluid loss with a low concentration of OPP, reducing the risk of drilling problems.

Symbols

OPP	*Orange peel pectin*
PV	*Plastic viscosity, cP*
YP	*yield point, lb/100ft^2*
AV	*Apparent viscosity, cP*
Gel 10s	*gel strength at 10 seconds, lb/100ft^2*
Gel 10min	*gel strength at 10 minute, lb/100ft^2*
R600	*viscometer reading at t 600 rpm*
R300	*viscometer reading at 300 rpm*
R200	*viscometer reading at 200 rpm*
R100	*viscometer reading at 100 rpm*
R60	*viscometer reading at 60 rpm*
R30	*viscometer reading at 30 rpm*
R6	*viscometer reading at 6 rpm*
R3	*viscometer reading at 3 rpm*

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