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Reducing the Bentonite Consumption in the Surface Hole Using Food Waste Products

Abo Taleb T. Al-Hameedi, Husam H. Alkinani, and Shari Dunn-Norman, Missouri University of Science and Technology

Abstract

Conventional chemical materials that are commonly utilized in modifying the fluid characteristics are considered as non-biodegradable and some as toxic additives. Hence, they constitute an origin of environmental contamination issues from the oil and gas drilling wastes. The release of impurities to the surroundings and freshwater aquifers has attracted maximizing consciousness and investigation. Thus, eco-friendly biodegradable drilling mud materials are needed nowadays.

This work introduces an experimental examination of the efficiency of biodegradable food waste products, which are mandarin peel powder (MPP) and orange peel powder (OPP) as appropriate additives to control fluid rheology specifications such as yield point (YP), plastic viscosity (PV), and filtration characteristics when reducing the bentonite percentage in the reference fluid (RF). The impacts of various concentrations of MPP and OPP were conducted using API testing methods (the standard API filter press at 100 psi and the standard API rotary Model 800 Viscometer), then the findings were juxtaposed with the characteristics of spud water-based fluid.

The findings revealed that MPP and OPP efficiently enhanced both of the filtration characteristics and the rheological properties. In addition, the results demonstrated the natural potential to reduce bentonite consumption by up to 40% without any side effects on the main reference fluid specifications, signifying their ability to be invested as viscosifiers and seepage loss control agents. To sum it, these investigational outcomes elucidate that MPP and OPP additives have the possibility to be used as biodegradable drilling fluid materials in substituting and supporting the bentonite material, particularly in the surface hole. Hence, minimizing the size of non-biodegradable waste disposed to the environment, attaining the personnel safety, and reducing the drilling cost.

Introduction

Biodegradable materials used as alternative drilling fluid additives have grown tremendously throughout the years due to their low cost, being environmentally friendly, and easily accessible. Certain food products can enhance drilling fluid properties in order to achieve good results throughout the drilling process. The need to find environmentally friendly drilling additives has been at an all-time high.

In recent years, the oil and gas industry has shifted its focus from oil-based drilling mud to water-based drilling mud. Water-based mud is considered much safer and more environmentally friendly compared to oil-based fluid. The most common additives used by the industry in previous years have paid little attention to health, safety, and environment (HSE). A few common chemical additives used in drilling muds are: polyamine, potassium sulfate, chromium-containing thinners, fluid loss additives, etc. (Amanullah, 2007).

Within the last few years, the United States Environmental Protection Agency (EPA) have changed the restrictions on the disposal of drilling fluid and cuttings to make it more difficult for the drilling company. These stricter rules and regulations have inspired companies and universities to look into cheaper and safer biodegradable additives to substitute the toxic and non-biodegradable additives. The inexpensive and biodegradable factor of food waste made this a desired and tangible option to be analyzed as an alternative to replace or at least support the conventional non-biodegradable materials.

Previous studies have shown that food waste improves drilling fluid properties (Amadi et al., 2018). Food waste is produced in large quantities every day giving the industry a reliable source. Recycling these food wastes into biodegradable drilling fluid additives will help reuse the waste and improve drilling fluid efficiency (Al-Hameedi et al., 2019a).

Grass powder (GP), an environmentally friendly additive, was found to improve drilling fluid properties (Al-Hameedi et al., 2019b). The GP additive has been found to improve the quality of filter cake and reduce seepage which can substitute for conventional starch materials. Another environmentally friendly additive investigated by Al-Hameedi et al. (2019c) is potato peel powder (PPP). The results showed the PPP decreased rheological properties and fluid loss by decreasing the yield point and gel strength. Al-Hameedi et al. (2019d) also researched mandarin peels powder (MPP) as an environmentally friendly additive. The MPP was able to enhance the filtration properties and rheological characteristics. Further investigations discovered seepage loss was minimized with little to no effect on density. After investigating MPP, the new additive was compared to a conventional drilling additive, polyanionic cellulose – low viscosity (PAC-LV). The results showed MPP worked just as efficiently as PAC-LV. Other fibrous food waste materials (FFWM) were investigated as an environmentally friendly drilling additive (Al-Hameedi et al., 2019e). The findings showed FFWM can be used as a seepage loss control agent and rheology elevator. Another unique food waste product is rice husk, which was investigated by Okon et al. (2014). The husk showed its ability to control fluid loss. Adding 20 lb/bbl of husk allowed the seepage loss to be reduced by 65% juxtaposed to the 10 lb/bbl of carboxymethyl cellulose (CMC). Unfortunately, the experimental additive showed undesirable plastic viscosity change.

It can be concluded that food waste is a biodegradable and environmentally friendly drilling additive that can be utilized to substitute or at least minimize the use of harmful chemical additives. Running more tests will popularize food waste products in the near future.

In this work, the feasibility of using MPP and OPP generated from food wastes as eco-friendly drilling mud additives in order to ameliorate the rheological and the filtration properties as well as reducing the bentonite consumption is investigated.

Materials and Methods

This section will highlight the executed steps in preparing the two eco-friendly waste materials, which are mandarin and orange Peels. Furthermore, the laboratory procedures used to evaluate the efficiency of these two additives will be illustrated. Lastly, the reference fluid sample characteristics, as well as the implemented set of tests utilizing various blends at multiple concentrations, will be introduced.

Preparation of the Orange and Mandarin Peels' Powders

The focal point of this sub-section is to clarify the outlined steps of making the MPP and OPP. At the outset, the raw waste materials have been collected at homes as shown in **Figure A.1a** and **A.1b** (**Appendix A**). Then, they were cut into small pieces to increase the drying speed and get rid of moisture as exhibited in **Figure A.1c and A.1d**. Sequentially, **Figure A.1e and A.1f** present the dry small pieces of making the mandarin peels (MP) and the orange peels (OP). The tiny pieces of MP and OP have been placed in an oven at 95ºC (204ºF) for 4 hours. Next, they were left in a dry area for 7 days. Ultimately, to ensure the completion of the drying operation, MP and OP were placed in an oven repeatedly at the same previous temperature until the materials were thoroughly oxidized. Once dried, MP and OP additives were ground into a very fine powder using a food processor. **Figure A.1g, A.1h, and A.1i** illuminate the fine powder of the mandarin and orange peels as well as the food processor, respectively; while the diagram given in **Figure A.2** exhibits the outline of preparing the mandarin and orange peels as powders.

Preparation of the Reference Spud Fluid Sample

The reference fluid (RF) sample referred to as the spud mud was made utilizing only bentonite (6%) and caustic soda (NaOH). The blend of the mud involves; 39 grams of bentonite mixed with 650 cc of freshwater and 1 gram of NaOH in order to provide a good environment for the bentonite hydration. The reference fluid specifications are introduced in **Table A.1** (**Appendix A**).

Three separate test samples of drilling mud were developed by blending various concentrations of MPP and OPP to the reference mud sample along with reducing the bentonite percent to have the following samples:

- Sample 1: RF – 10% (4 gm) bentonite + 1% (7 gm) of MPP + 1% (7 gm) of OPP.
- Sample 2: RF – 20% (8 gm) bentonite + 2% (13 gm) of MPP + 2% (13 gm) of OPP.
- Sample 3: RF – 40% (15 gm) bentonite + 3% (20 gm) of MPP + 3% (20 gm) of OPP.

Experimental Measurements

To assess the validation of MPP and OPP additives on the RF sample, the seepage loss characteristics involving the filtrate in cc/30 and the mud cake properties were conducted utilizing the standard API filter press at 100 psi. The rheology including; plastic viscosity (PV) and yield point (YP) as well as the initial and final gel strengths were also obtained utilizing the standard API rotary Model 800 Viscometer.

Results and Discussion

The summary of the laboratory findings acquired for the reference fluid and three sample additives of MPP and OPP are introduced in **Table A.2**. The outcomes are the rheological properties including YP, PV, initial gel strength, and final gel strength; in addition to the filtration characteristics involving the filtrate at 7.5 and 30 min as well as the mud cake thickness in mm.

The Impacts of MPP and OPP on the Rheological Properties

Starting with 1% of MPP and OPP (Sample 1), and in spite of reducing the bentonite by 10% (4 gm), the effect of the addition of 1% concentration (7 gm) of MPP and OPP on the rheological properties of the reference fluid was evaluated by comparing the measured values with the initial reference fluid readings. MPP and OPP were quite efficient to substitute the bentonite reduction as shown in **Figure A.3**. Where PV and YP were increased by 260% and 20%, respectively. However, the initial and final gel strengths were not affected by 1% of MPP and OPP additives. For 2% of MPP and OPP additives (Sample 2), MPP and OPP were more effective than 1% of MPP and OPP in regards to replacing the 20% (8 gm) reduction of bentonite as shown in **Figure A.3**. Where PV and YP were maximized by 420% and 80%, respectively. On the other hand, the initial gel strength was insignificantly increased when comparing to the reference fluid. Finally, 3% of MPP and OPP concentration (Sample 3) was the most functional sample since it highly contributed to reinforcing the rheological properties by 1040%

for PV and by 710% for YP as shown in **Figure A.3**. In the same context, the initial and final gel strengths were tremendously maximized as compared to the RF. Nonetheless, the difference between the initial and final gel strength is still an acceptable number. Therefore, 3% of MPP and OPP concentration can be used for stopping partial loss without the concern of breaking the gel strength during the pump off conditions.

The Impacts of MPP and OPP on the Filtration Characteristics

Starting with 1% of MPP and OPP (Sample 1), and despite reducing the bentonite by 10% (4 gm), the effect of the addition of 1% concentration (7 gm) of MPP and OPP on the filtration characteristics of the reference mud was assessed by comparing the conducted measurements with the initial reference mud results. MPP and OPP were very efficacious to substitute the bentonite reduction as shown in **Figure A.4**. Where filtrate (cc/30 min) and filter cake were decreased by 52% and 33%, respectively. For 2% of MPP and OPP additives (Sample 2), MPP and OPP were more effective than 1% of MPP and OPP in regards to substituting the 20% (8 gm) reduction of bentonite as shown in **Figure A.4**. Where filtrate (cc/30 min) was reduced by 64%; while filter cake was the same as the effect of adding 1% of MPP and OPP concentration. Lastly, 3% of MPP and OPP concentration (Sample 3) was the best one because it substantially mitigated fluid loss by 76%. However, the mud cake was negligibly maximized when comparing to 1% and 2% of MPP and OPP additives as shown in **Figure A.4**.

Conventional Viscifiers and Filtration Control Agents Utilized to drill the Surface Hole

Due to the large size of the surface hole and the unconsolidated shallow formations, bentonite is highly consumed in this hole in order to provide the wellbore stability, to avoid formation collapse, and to furnish an efficient hole cleaning. Cuttings will be tremendously generated during drilling the surface hole, and sometimes they are uncontrollable due to the weak and soft drilled zones. In reality, some polymers, including but not limited to attapulgite clay, viscifiers polymers, polyanionic cellulose high viscosity (PAC-HV), and carboxymethyl cellulose (CMC-HV) are utilized to reduce the bentonite consumption, to achieve the required viscosity, and to regulate the seepage loss specification. Usually, 70-80 kg/m^3 of bentonite is utilized to accomplish the desired properties along with other viscosifiers. The ultimate objective of using high amount of bentonite material in the first hole is to support the weak borehole wall from caving by creating a good mud cake; in addition to providing a sufficient viscosity that will be responsible to provide an acceptable transportation ratio and lift the excessive cuttings to the surface during the pump on conditions; while bentonite will be in charge of providing a good cutting suspension and avoid any settling in the pump off conditions (Basra Oil Company, 2007).

In short, the main aim of this section is to elucidate that the mandarin peel powder (MPP) and orange peel powder (OPP) waste products can be invested as an alternative or supportive eco-friendly additives for some of the conventional non-biodegradable products such as PAC-HV, CMC-HV, and attapulgite clay as they generated excellent results under the laboratory conditions by substituting the bentonite percentage reduction. The experimental outcomes revealed the potential of MPP and OPP to be used as viscosity elevator and filtration control agents. In other words, MPP and OPP additives have the strength to achieve the results that conventional viscosifiers can obtain in the oilfield. Therefore, more research needs to be done about using these materials in the field to assure their success in the drilling operations.

Conclusions

Four independent laboratory investigations to conduct and examine the outcomes of the influence of the MPP and OPP and their effectiveness in substituting the bentonite material and in optimizing the performance of water-based fluid were implemented. According to this experimental investigation, the following insights were made:

- MPP and OPP are multipurpose eco-friendly additives, with considerable amelioration of the rheological and filtration characteristics of the spud mud.
- 1% of MPP and OPP additives have the potential to substitute the 10% reduction of bentonite in terms of adjusting the viscosity and regulating the filtration properties.
- 2% of MPP and OPP additives are more effective than 1% of MPP and OPP; where they revealed the capability to replace 20% reduction of bentonite without any negative side effects on the performance of the water-based mud.
- 3% of MPP and OPP additives are the most effective concentration in regards to changing the drilling fluid properties and substituting 30% reduction of bentonite. However, this concentration can be suggested to be used to stop the partial loss rather than the normal drilling operations.
- Minimizing the bentonite consumption in the field is a big deal, especially in drilling the surface hole. However, to have further insights, it is important to examine MPP and OPP materials in various conditions (fresh and aged) to understand if they are also applicable in the sub-surface field conditions or not. Therefore, more investigations are required to be executed under hostile downhole circumstances

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Appendix A

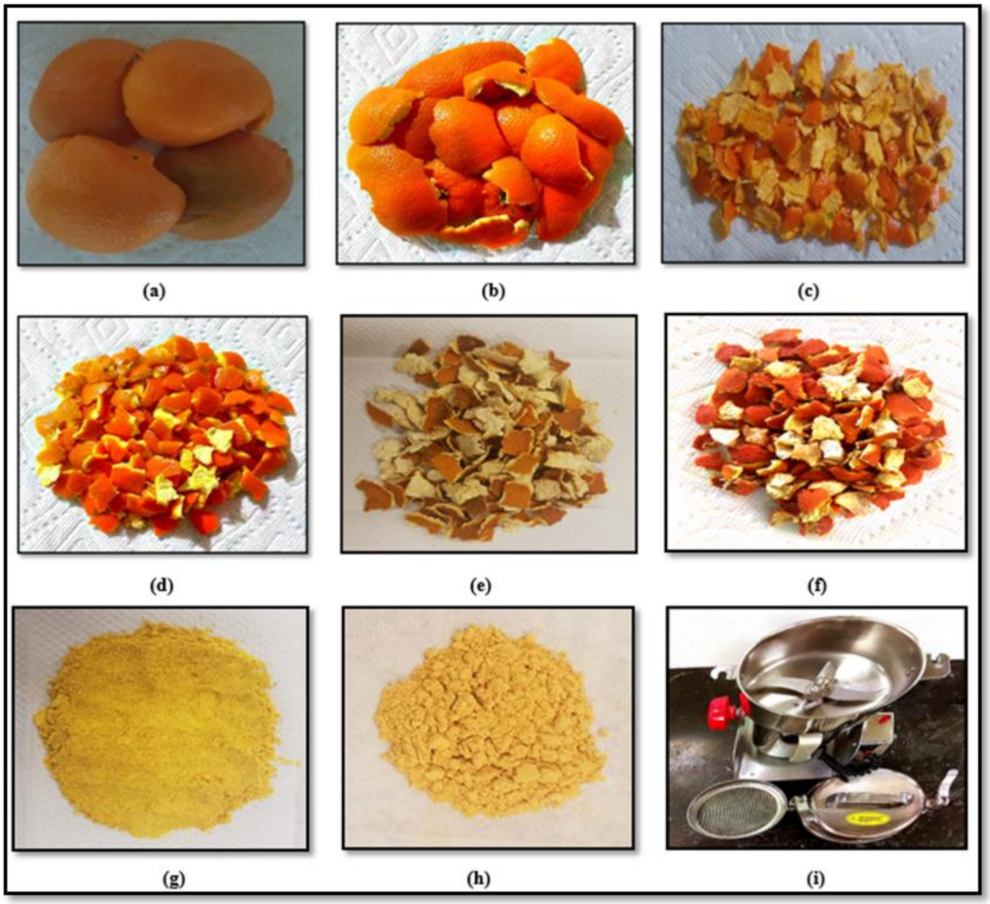

Figure A.1. (a) Raw Waste Material of MP, (b) Raw Waste Material of OP, (c) Small Chopped Pieces of MP, (d) Small Chopped Pieces of OP, (e) Dried Small Chopped Pieces of MP, (f) Dried Small Chopped Pieces of OP, (g) MPP, (h) OPP, (i) The Food Processor

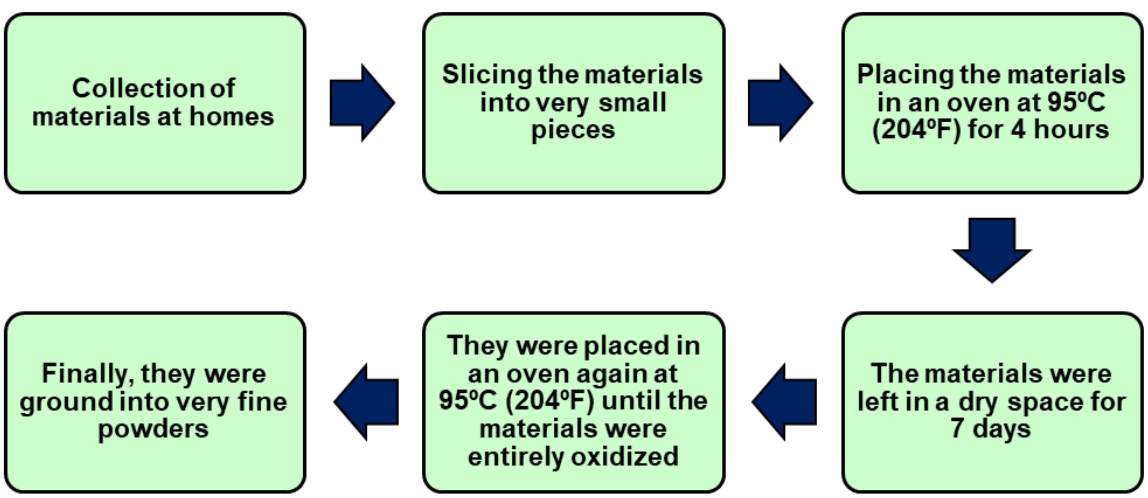

Figure A.2. Diagram Elucidating the Outline of Preparing MPP and OPP

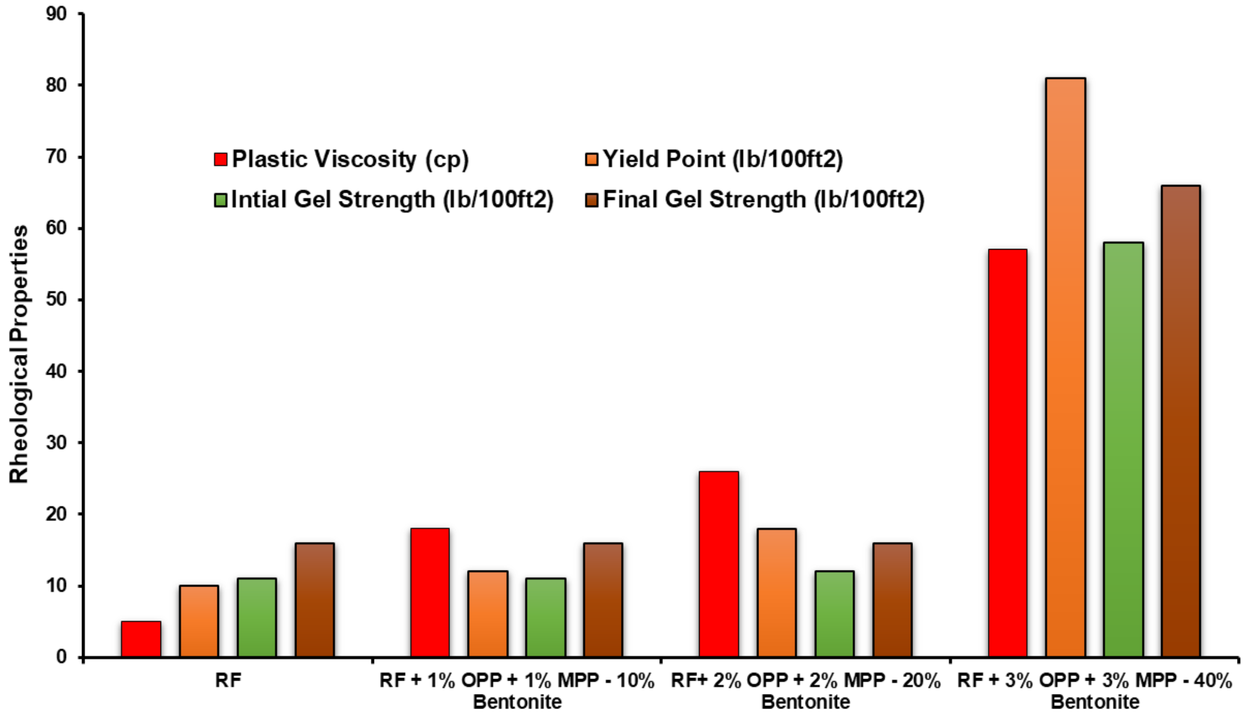

Figure A.3. Effect of Different Concentrations of MPP and OPP on the Rheological Properties

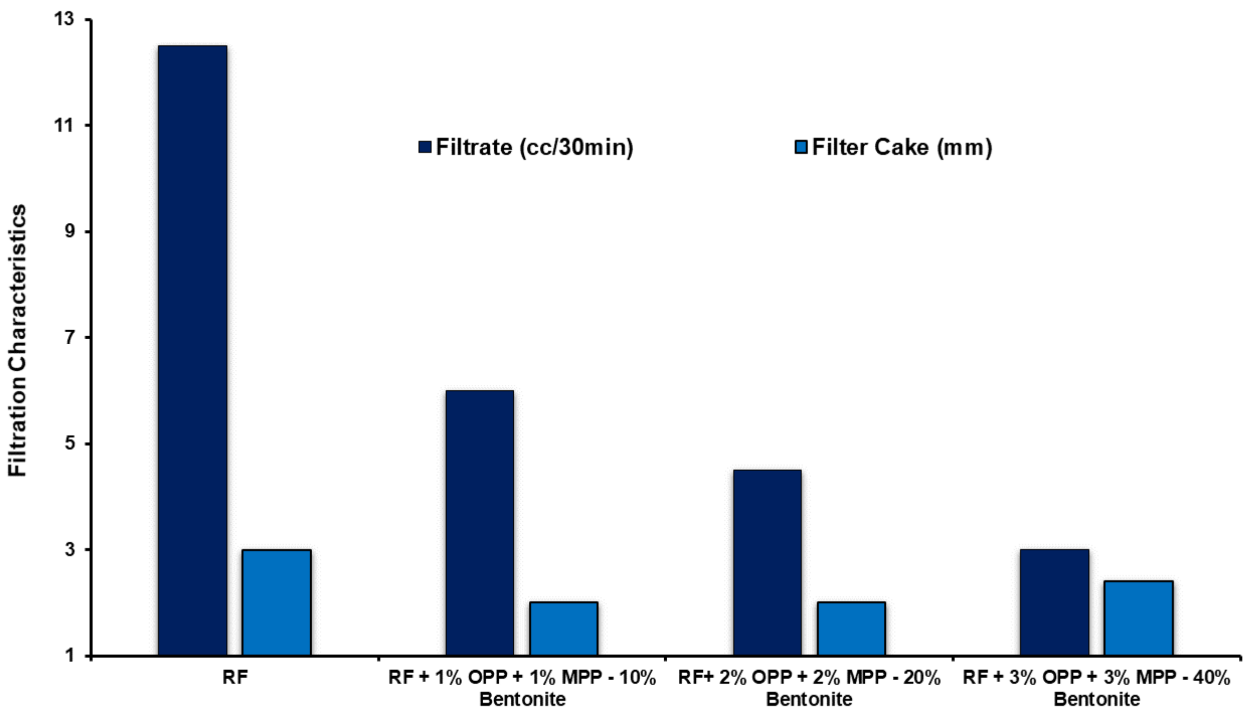

Figure A. 4. Effect of Different Concentrations of MPP and OPP on the Filtration Characteristics

Table A.1. RF Properties

Property	RF
Plastic Viscosity (PV), (cp)	5
Yield Point (YP), (lb/100ft²)	10
Initial Gel Strength, (lb/100ft²)	11
Final Gel Strength, (lb/100ft²)	16
7.5 min Filtrate, (cc)	6
30 min Filtrate, (cc)	12.5
Filter Cake Thickness, (mm)	2.8

Table A.2. Summary of Laboratory Measurements for all Samples

Property	RF	RF + 1% OPP + 1% MPP - 10% of 39 gm of Bentonite	RF + 2% OPP + 2% MPP - 20% of 39 gm of Bentonite	RF + 3% OPP + 3% MPP - 40% of 39 gm of Bentonite
PV, (cp)	5	18	26	57
YP, (lb/100ft²)	10	12	18	81
Initial Gel Strength, (lb/100ft²)	11	11	12	58
Final Gel Strength, (lb/100ft²)	16	16	16	66
7.5 min Filtrate, (cc)	6	3	2	1
30 min Filtrate, (cc)	12.5	6	4.5	3
Filter Cake Thickness, (mm)	3	2	2	2.4