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Analysis of The Effect of Adding CMC Additive from Sunflower Seed Hull on The Rheology of Drilling Mud and Filtration Loss

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ABSTRACT

Drilling mud is a drilling fluid used to transport cuttings to the surface and assist in identifying subsurface formation layers; therefore, proper drilling mud design is essential for the success of drilling operations. One common problem in drilling activities is insufficient mud viscosity, which necessitates the addition of additives. Carboxymethyl cellulose (CMC) is commonly used to improve mud viscosity; however, its synthetic nature may pose environmental concerns. This research investigates the use of organic waste in the form of sunflower seed shells as an environmentally friendly alternative additive. Sunflower seed shells contain natural components, including cellulose, hemicellulose, and lignin, which may enhance mud viscosity. The objective of this study is to evaluate the effect of sunflower seed shell powder on the rheological properties of drilling mud and to compare its performance with that of CMC. The research was conducted through laboratory experiments at the STT Migas Balikpapan Laboratory. Rheological tests included viscosity over time, plastic viscosity, yield point, gel strength, mud cake thickness, and filtration loss. Mud samples were prepared with the addition of CMC and sunflower seed shell powder at concentrations of 1 g, 3 g, and 5 g. The results show that increasing the concentration of sunflower seed shell powder improves the rheological properties of drilling mud and reduces filtration loss. Although its performance is lower than that of CMC, sunflower seed shell powder demonstrates potential as an environmentally friendly alternative additive for drilling mud.

KEYWORDS

CMC;
Sunflower Seed Shells;
Rheology Drilling Mud;
Filtration Loss;
Mud Cake

INTRODUCTION

Drilling mud is a fluid that plays a vital role in drilling operations, including transporting cuttings to the surface, maintaining formation pressure, and cooling drilling tools (Rubiandini, 2010). Therefore, proper drilling mud program planning is essential to ensure that drilling operations can be conducted effectively (Ajimoko, 2025; Elrayah, 2024; Money et al., 2025; Zahran et al., 2025). The efficiency, safety, and cost of drilling operations are significantly influenced by the quality of the drilling mud (Al-Rubaii et al., 2023; J. Li et al., 2022; Q. Li & Wu, 2022; Money et al., 2025; Pereira et al., 2022; Taheri et al., 2024). The primary objective of using drilling mud is to prevent problems that may disrupt the smooth progress of the drilling process. One frequently encountered issue is low mud viscosity, which can lead to ineffective cuttings transport and fluid loss into the formation. To address this problem, drilling mud is commonly supplemented with additives such as Carboxymethyl Cellulose (CMC), which functions to bind water and increase mud viscosity (Akpan, 2024; Al-Rubaii et al., 2023; Asad et al., 2024; Safian et al., 2023).

Several previous studies have investigated the use of organic waste materials as alternative drilling mud additives (Bagum et al., 2022). Waropen et al. (2024) examined the effect of sunflower seed peel as a viscosifier in freshwater mud at temperatures of 80°F and 200°F, demonstrating that this organic material can improve rheological properties. Idress and

Hasan (2020) investigated various environmentally friendly waste materials as lost circulation additives in drilling fluids and concluded that organic waste materials show promising potential. Al-Hameedi et al. (2020) utilized eco-friendly drilling mud additives derived from waste materials to reduce the use of conventional chemical additives. Borah and Das (2022) conducted a comprehensive review of bio-product applications in drilling fluids to minimize environmental impact. Additionally, Akatan et al. (2022) and Battalova (2023) successfully demonstrated the highly efficient isolation of microcrystalline cellulose and nanocellulose from sunflower seed waste, confirming that sunflower seed shells contain significant amounts of cellulose, hemicellulose, and lignin—components that may potentially enhance drilling mud viscosity.

Despite these promising findings, most previous studies have focused on the general potential of organic waste as drilling mud additives without systematically comparing their performance with commercial CMC across multiple rheological parameters. Furthermore, research specifically examining sunflower seed shell powder as a direct alternative to CMC in drilling mud applications remains limited, particularly regarding comprehensive testing that includes viscosity over time, plastic viscosity, yield point, gel strength, mud cake thickness, and filtration loss. Addressing this research gap is important, given that CMC is relatively expensive and raises environmental concerns due to its synthetic nature.

According to data from the National Waste Management Information System, food waste constitutes the largest proportion of waste generated in Indonesia, ranging from 33.79 to 48 million tons annually. Organic waste is biodegradable and can naturally decompose within a certain period, making it environmentally friendly. Sunflower seed shells represent one such biodegradable material that remains underutilized. Therefore, this study aims to evaluate the effect of sunflower seed shell powder on the rheological properties and filtration loss of drilling mud and to compare its performance with commercial CMC at concentrations of 1 gram, 3 grams, and 5 grams through laboratory experimentation.

The novelty of this study lies in its systematic comparative analysis of sunflower seed shell powder and commercial CMC across six comprehensive rheological and filtration parameters, providing empirical evidence regarding the feasibility of this agricultural waste as an environmentally friendly alternative additive. This research is expected to contribute theoretically to the development of sustainable drilling fluid technology and practically to reducing drilling operation costs while addressing organic waste management challenges. The findings may serve as a foundation for further research aimed at optimizing organic waste-based additives and scaling up their application in the petroleum industry.

METHOD

The research was carried out in the laboratory with an experimental method, by testing the rheology of drilling mud and filtration loss between CMC and sunflower seed shells, which included viscosity, plastic viscosity, yield point, gel strength, mud cake and filtration loss.

Tools and Materials

These testing tools include:

Table 1. Testing Tools

No	Name	Uses
1	Timbangan Digital	Weighing the mass of the material to be used
2	Stopwatch	Measuring time during testing
3	Mud Mixer	Slurry media mixer
4	Sieve	Screening the materials to be used
5	Measuring Cups	Measuring volume levels
6	Gauge	Measuring *the thickness of mud cake*
7	Marsh Funnel	Measuring the flow rate of mud
8	LPLT Filter Press	Analyzes mud cake size and filtrate volume
9	Filter Paper	Media for mud cake
10	Fann VG Meter	Testing the rheology of the sludge, such as plastic viscosity, yield point, and gel strength

Source: Laboratory equipment inventory, STT Migas Balikpapan (2025)

The following are the test materials, including:

Table 2. Testing Materials

No	Name	Quantity
1	*Fresh Water*	350 ml
2	Bentonite	22.5 gr
3	CMC	1 gr, 3 gr, 5 gr
4	Sunflower Seed Skin	1 gr, 3 gr, 5 gr

Source: Research data processed by the author (2025)

Research Procedure

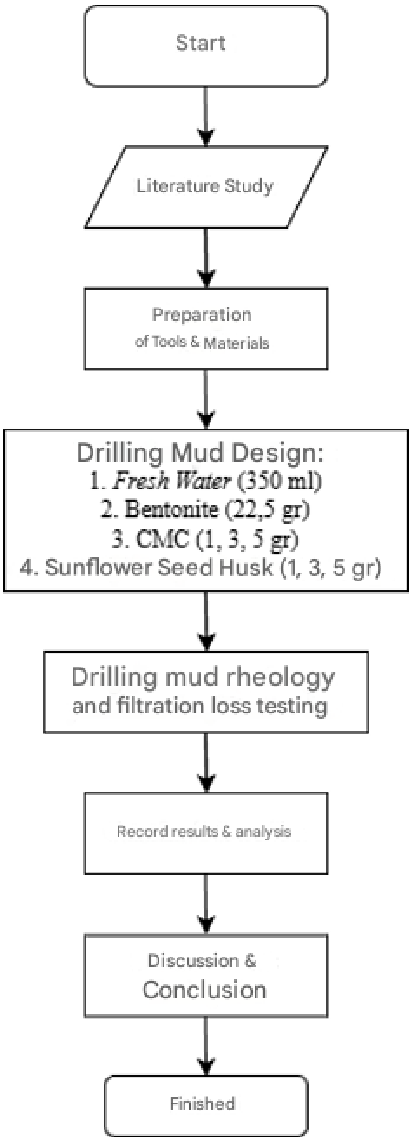

Figure 1. Flow Chart Testing The Effect Of CMC From Sunflower Seed Husk On Rheology Drilling Mud And Filtration Loss

Source: Research design by the author (2025)

The collection of literature studies as the basis for making the basis for research theory includes the function of drilling mud, the function of CMC additives, the function of the content contained in sunflower seed shells in rheology, and the uses and mechanisms of use of equipment to be used in research. The first is by planning equipment and materials, especially the materials used such as CMC and sunflower seed shells. Specifically, the preparation process for sunflower seed shells involves separating the skin from the seeds, then drying the skin in direct sunlight for approximately 10 hours, then mashing using a blender, and filtering to separate fine grains from coarse ones, until the required size and quantity are obtained. Next, drilling mud was made for research, namely using 350 ml of fresh water, and CMC and sunflower seed peel powder with concentrations of 1 gram, 3 grams, and 5 grams respectively made separately. Rheology testing of drilling mud that has been mixed with CMC and sunflower seed peel powder includes viscosity time, plastic viscosity, yield point, gel strength, mud cake, and filtration loss. Then record the results obtained during the test and analyze the data, and finally make a discussion on each data obtained and draw conclusions related to the results of the research carried out.

RESULT AND DISCUSSION

The following is data from the tests that have been carried out, namely regarding the rheology testing of drilling mud and filtration loss, namely by comparing CMC with Sunflower Seed Shells, including the results of viscosity, plastic viscosity, yield point, gel strength, mud cake and filtration loss.

Table 3. Viscosity Test Results

Weight (gr)	*Viscosity Time (seconds)*	
	CMC	**Sunflower Seed Skin**
1	15,8	15,7
3	17,3	16,3
5	18,5	17,2

Source: Primary data processed by the author (2025)

Based on the data above, the viscosity value of drilling mud samples with the addition of CMC additives and sunflower seed shells increased with each multiplication of the number of additives. For CMC, it is 15.8 seconds for 1 gram, 17.3 seconds for 3 grams, and 18.5 seconds for 5 grams. Meanwhile, the sunflower seed skin is 15.7 seconds for 1 gram, 16.3 seconds for 3 grams, and 17.2 seconds for 5 grams.

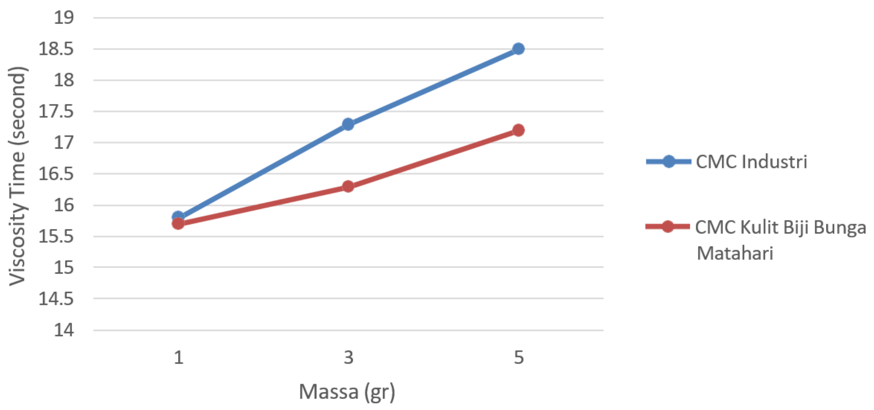

Figure 2. Viscosity Curve

Source: Primary data processed by the author (2025)

Based on the results of viscosity measurements carried out, in every addition of CMC additives and sunflower seed shells, it is able to increase the viscosity value of drilling mud. Especially for sunflower seed shells, this is due to the alkalinization process (cellulose) which undergoes structural fracturing so that the adsorbtion power of cellulose increases, this can be seen from the increase in viscosity values in the mud. Thus, in each addition of sunflower seed shell additives, it is able to increase the viscosity value in drilling mud from 15.7 seconds with a concentration of 1 gram, to 17.2 seconds with a concentration of 5 grams.

Table 4. Plastic Viscosity Test Results

Weight (gr)	***Plastic Viscosity* (cp)**	
	CMC	**Sunflower Seed Skin**
1	7	4
3	7	4
5	8	5

Source: Primary data processed by the author (2025)

Based on the data above, the more CMC additives and sunflower seed shells, the higher the plastic viscosity in the mud. In sludge with additives added with CMC, the value obtained at 1 gram is 7 cp, 3 grams are worth 7 cp, and 5 grams are worth 8 cp. Meanwhile, for the mud that was added with sunflower seed peel additives, 1 gram was worth 4 cp, 3 grams were worth 4 cp, and 5 grams were worth 5 cp.

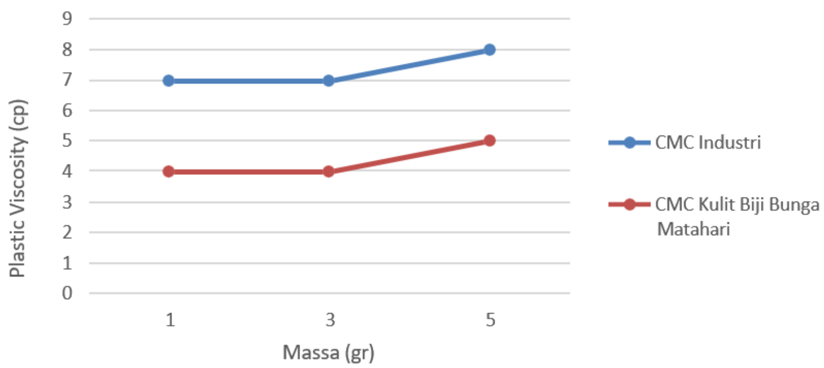

Figure 3. Kurva Plastic Viscosity

Source: Primary data processed by the author (2025)

The above data illustrates that the value of the drilled mud sample with sunflower seed shell is directly proportional to the value of the CMC, which means that the value of the plastic viscosity of the sunflower seed shell is able to approach the value of the CMC, although the difference in value is arguably quite far apart. This is because the alkalinization process in the skin of sunflower seeds is fibrous and has pores large enough to bind to water. The increase in the value of plastic viscosity is due to the properties of viscosifier. If the PV value is too high, it will require more energy to circulate the sludge and can cause lost circulation, but on the other hand, if the viscosity value of the sludge is too small, it will affect the removal of the cutting less than optimally so that the cutting will not be lifted and left in the borehole, which can result in the pipe series being pinched.

Table 5. Yield Point Test Results

Weight (gr)	*Yield Point* (lb/100 ft^2)	
	CMC	Sunflower Seed Skin
1	3	3
3	4	4
5	7	5

Source: Primary data processed by the author (2025)

In the data above, the yield point value of CMC and sunflower seed husks increases with each mass addition of each additive. For CMC found at 1 gram is worth 3 lb/ft2, 3 grams is worth 4 lb/ft2, and 5 grams is worth lb/ft2. As well as for sunflower seed shells, it is found at 1 gram worth 3 lb/ft2, 3 grams worth 4 lb/ft2, and 5 grams worth 5 lb/ft2.

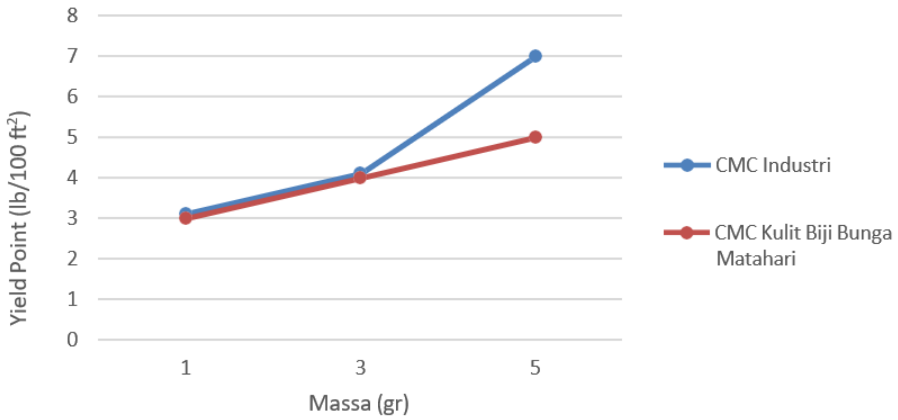

Figure 4. Kurva Yield Point

Source: Primary data processed by the author (2025)

The data above shows that the yield point value of the industrial CMC and the sunflower seed shell CMC is directly proportional, meaning that the sunflower seed shell CMC is able to increase the yield point value of the drilling mud with each increase in concentration, which is from 3 – 5 lb/100 ft2. According to API Spec 13A, the standard yield point is a maximum yield point of 3 lb/100 ft2. So in the following experiment, for CMC sunflower seed peel that meets the standard, namely at a mass of 1 gram. So, based on these results, CMC sunflower seed peel is able to increase the yield point value in the mud, but it is not able to match the yield point value in industrial CMC, because CMC sunflower seed peel is made of natural materials.

Table 6. Gel Strength Test Results

Weight (gr)	*Gel Strength* (lb/100 ft^2)	
	CMC	Sunflower Seed Skin
1	2	2
3	2	2
5	2	3

Source: Primary data processed by the author (2025)

Based on the data above, the value of Gel Strength in CMC is found at 1 gram worth 2 lb/ft2, 3 grams worth 2 lb/ft2, and 5 grams worth 2 lb/ft2, and the value in sunflower seed coolies is found at 1 gram worth 2 lb/ft2, 3 grams 2 lb/ft2, and 5 grams worth 3 lb/ft2.

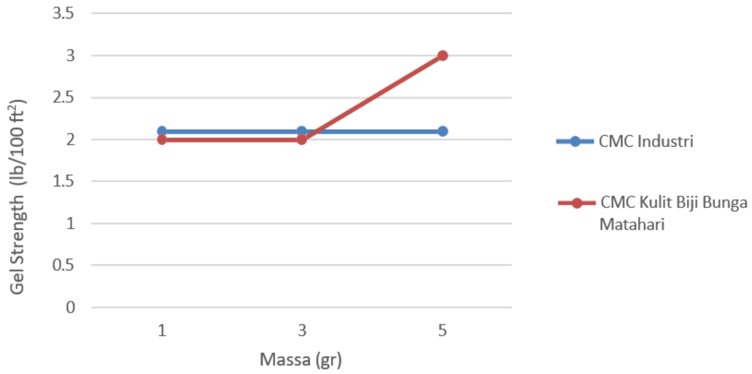

Figure 5. Gel Strength Curve

Source: Primary data processed by the author (2025)

The data above shows a comparison of gel strength from the two samples. Thus, the value of gel strength in CMC tends to be stable, and in the skin of sunflower seeds there is an increase in the addition of additives or dimasses of 5 grams. Gel Strength is influenced by the viscosity value, if the viscosity increases, the gel strength will also increase. When circulation is stopped, what has a vital role is gel strength, while when the sludge is circulated, the role is plastic viscosity. The data showed that the value of gel strength between CMC and sunflower seed shells tended to be stable, but there was a slight difference, especially in sunflower seed shells with a concentration of 5 grams, indicating that the value was the highest among others, which was 3 lb/100 ft2. This is because the skin of sunflower seeds is organic, and has pores to bind more water. The standard value for gel strength is 2-5 lb/100 ft2.

Table 7. Mud Cake Test Results

Weight (gr)	***Mud Cake* (mm)**	
	CMC Industrial	**Sunflower Seed Skin**
1	1	1,5
3	2	2,5
5	3	4

Source: Primary data processed by the author (2025)

Based on the data above, it shows that each mass addition to each additive will increase the value of the mud cake. As in CMC, 1 gram is worth 1 mm, 3 grams are worth 2 mm, and 5 grams are worth 3 mm. As well as for sunflower seed shells, 1 gram is worth 1.5 mm, 3 grams are worth 2.5 mm, and 5 grams are 4 mm.

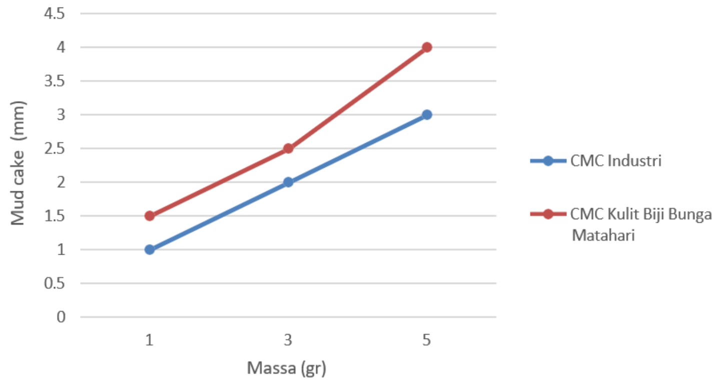

Figure 6. Mud Cake Curve

Source: Primary data processed by the author (2025)

The data above shows that the value of mud cake from CMC and sunflower seed peel is directly proportional to each increase in concentration from 1 – 5 grams. However, the value of mud cake from sunflower seed peel is slightly higher than CMC, which means that mud cake from sunflower seed peel is thicker, this is because sunflower seed peel is a natural material and in the form of fiber, so that every time sunflower seed peel powder is added, the thickness of the mud cake will increase which is filtered on filter paper. The ideal mud cake has the thinnest possible value, which is < 1.5 mm.

Table 8. Filtration Loss Test Results

Weight (gr)	*Filtration Loss* (ml)	
	CMC	Sunflower Seed Skin
1	9,2	11,5
3	7,5	9,4
5	6,3	7,8

Source: Primary data processed by the author (2025)

Based on the data above, the higher the value of additive additives, the lower the volume of filtrate produced. Such as CMC at 1 gram of 9.2 ml, 3 grams of 7.5 ml, and 5 grams of 6.3 ml. As well as sunflower seed peel at 1 gram of 11.5 ml, 3 grams of 9.4 ml, and 5 grams of 7.8 ml.

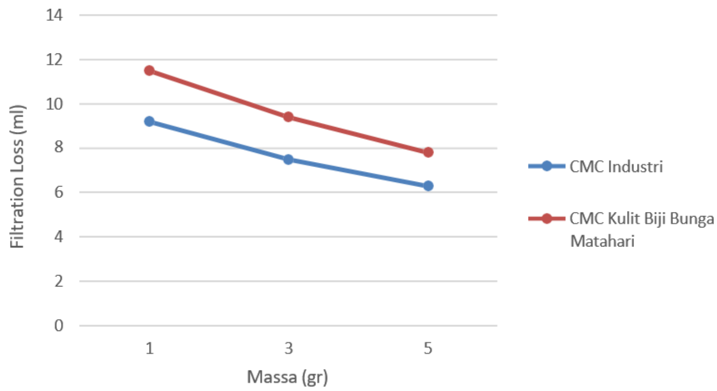

Figure 7. Filtration Loss Curve

Source: Primary data processed by the author (2025)

The above data shows that the volume value of the filtrate from CMC and sunflower seed husk is both decreased or directly proportional, the reduction in filtrate volume is due to the pores in the bentonite where the CMC content is covered in the drilling mud, as well as the sunflower seed husk powder. The closure of the pores in the bentonite layer is also due to the adsorbtion properties possessed by CMC that can bind water in the drilling mud. So with this, sunflower seed peel plays a good role in overcoming lost circulation, although not as effective as CMC, because sunflower seed peel is organic. Based on API Spec 13A, 2010 the maximum filtrate volume standard is 15ml.

CONCLUSION

Referring to the test results, it can be concluded that the rheological properties of drilling mud formulated with sunflower seed shell powder at concentrations of 1 gram, 3 grams, and 5 grams showed viscosity time values ranging from 15.7 to 17.2 seconds. The plastic viscosity values ranged from 4 to 5 cP, while the yield point ranged from 3 to 5 lb/100 ft². The gel strength values were within the range of 2 to 3 lb/100 ft². The mud cake thickness ranged from 1.5 to 4 mm, and the filtrate volume (filtration loss) ranged from 11.5 to 7.8 mL. These results indicate that sunflower seed shells influence and improve the rheological properties of drilling mud. However, based on the comparative tests conducted, sunflower seed shell powder does not perform as effectively as CMC in enhancing drilling mud rheology, likely due to its natural composition. Nevertheless, because sunflower seed shells are organic and biodegradable, their use is environmentally friendly and does not involve synthetic chemicals.

Based on these findings, several recommendations are proposed. For future research, it is suggested to optimize the processing method of sunflower seed shells, such as through chemical or enzymatic treatments to enhance cellulose content and improve their effectiveness as a viscosifier. Further studies should also investigate the thermal stability of sunflower seed shell-based additives under high-temperature and high-pressure conditions to better simulate actual drilling environments. Additionally, research on combination formulations with other organic or synthetic materials may produce synergistic effects and enhance overall performance. For the petroleum industry, sunflower seed shell powder may be considered as a partial substitute for commercial CMC, particularly in environmentally sensitive drilling operations, thereby contributing to cost reduction and improved waste management. Finally, scaling up laboratory findings to pilot-scale testing is necessary to assess the economic feasibility and practical applicability of this organic additive in field operations.

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