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Utilization of cellulose extracted from olive kernels (OK) and olive pomace (OP) to enhance drilling fluid properties in terms of filtration, viscosity and gel strength

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ABSTRACT

This study explores the effects of cellulose derived from olive kernels (OK) and olive pomace (OP) on the properties of drilling fluids. The analysis revealed that both OK and OP cellulose exhibit similar density values across identical concentrations, indicating consistent density properties under the tested conditions. In terms of plastic viscosity (P.V.), OP cellulose demonstrated a slightly higher value of 10.4 cp compared to 10 cp for OK cellulose at a concentration of 0.1%, suggesting that both may be nearing a plasticity threshold where cellulose particle aggregation reduces thickening efficiency. Apparent viscosity (A.V.) peaked at 16.5 for OK and 15 for OP at a 0.1% concentration, illustrating distinct shear-thinning behaviours where viscosity decreased with increased shear rates at higher concentrations. Further, yield strength was found to be concentration-dependent, with OK cellulose peaking at 0.05% and OP cellulose at 0.1%. Filtration efficiency was notably improved by the addition of natural cellulose, with the highest filtration results observed at concentrations of 0.4% and 0.25%, achieving a value of 11.5 for both OK and OP cellulose. This suggests that increasing cellulose concentration can positively impact filtration control. The consistent performance of OP cellulose across various concentrations highlights its stability in enhancing filtration properties. Overall, the differences in cellulose behaviour between OK and OP are likely due to their unique physical properties, influencing their performance in drilling fluids.

استخدام السليلوز المستخرج من نوى الزيتون (OK) وتفل الزيتون (OP) لتعزيز خصائص سوائل الحفر من حيث الترشيح، اللزوجة، وقوة الجل

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الكلمات المفتاحية:
سوائل الحفر
سليلوز نوى الزيتون
سليلوز تفل الزيتون
كربوكسي ميثيل السليلوز

ملخص:

تستكشف هذه الدراسة تأثيرات السليلوز المستخرج من نوى الزيتون (OK) وتفل الزيتون (OP) على خصائص سوائل الحفر. كشفت التحليلات أن كلاً من السليلوز المستخرج من نوى الزيتون (OK) ومن تفل الزيتون (OP) يظهران قيم كثافة متشابهة عبر التركيزات نفسها، مما يشير إلى خصائص كثافة متناسقة تحت الظروف المختبرة. من حيث اللزوجة البلاستيكية(P.V.) ، أظهر السليلوز المستخرج من تفل الزيتون (OP) قيمة أعلى قليلاً بلغت 10.4 سنتيبواز مقارنة بـ 10 سنتيبواز للسليلوز المستخرج من نوى الزيتون (OK) عند تركيز 0.1%، مما يشير إلى أن كليهما قد يقترب من عتبة البلاستيكية حيث يؤدي تجمّع جزيئات السليلوز إلى تقليل كفاءة التكثيف. بلغت اللزوجة الظاهرة (A.V.) ذروتها عند 16.5 للسليلوز المستخرج من نوى الزيتون و15 للسليلوز المستخرج من تفل الزيتون عند تركيز 0.1%، مما يوضح سلوكيات ترقق القص المختلفة حيث انخفضت اللزوجة مع زيادة معدلات القص عند التركيزات الأعلى.علاوة على ذلك، وُجد أن قوة الانسياب تعتمد على التركيز، حيث بلغت ذروتها عند 0.05% للسليلوز المستخرج من نوى الزيتون و0.1% للسليلوز المستخرج من تفل الزيتون. تم تحسين كفاءة الترشيح بشكل ملحوظ بإضافة السليلوز الطبيعي، حيث لوحظت أعلى نتائج للترشيح عند التركيزات 0.4%

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و0.25%، محققة قيمة بلغت 11.5 لكلا النوعين من السليلوز (OK و OP). يشير هذا إلى أن زيادة تركيز السليلوز يمكن أن تؤثر إيجابياً على التحكم في الترشيح. الأداء المتناسق للسليلوز المستخرج من تفل الزيتون عبر مختلف التركيزات يبرز استقراره في تحسين خصائص الترشيح. بشكل عام، تعود الاختلافات في سلوك السليلوز بين نوى الزيتون وتفل الزيتون على الأرجح إلى خصائصهما الفيزيائية الفريدة، مما يؤثر على أدائهما في سوائل الحفر.

Nomenclature

- CMC Carboxymethyl Cellulose
- OK Olive Kernel Cellulose
- OP Olive Pomace Cellulose
- API American Petroleum Institute
- WBDF Water Based Drilling Fluids
- OBDF Oil Based Drilling Fluids
- GDF Gaseous/Pneumatic Drilling Fluids
- cP Centi poise
- ECD Equivalent Circulating Density
- Mt Montmorillonite
- OCMA Oil Company Materials Association
- CCC Corn Cob Cellulose
- P.V Plastic Viscosity
- A.V Apparent Viscosity

1. Introduction

Drilling fluid can be broadly defined as the various compositions employed to aid in the creation and extraction of cuttings from a borehole. It is arguably the most critical element in any subsurface excavation process, particularly in the context of oil and gas drilling [1]. Drilling fluids play a crucial role in oil and gas drilling operations by performing several essential functions. They facilitate the transport of cuttings to the surface, maintain the integrity of the wellbore walls, and suspend cuttings until they can be removed. Additionally, drilling fluids help stabilize the temperature of drilling pipes and bits, prevent the collapse of the formation, and reduce friction between the drilling equipment and the formation[2] Drilling fluids are primarily classified into three categories based on their composition: water-based drilling fluids (WBDF), oil-based drilling fluids (OBDF), and gaseous/pneumatic drilling fluids (GDF). Water-based drilling fluids are often preferred due to their cost-effectiveness, ease of maintenance, treatment, and handling. They offer a wide range of available options, a continuous supply of treatment agents, and straightforward performance management. Additionally, WBDFs provide advantages such as rapid formation breakdown, effective cuttings removal, and efficient temperature control[3]

Carboxymethyl cellulose (CMC) is a water-soluble, anionic derivative of cellulose, which is a linear polysaccharide composed of repeating units of anhydro-glucose linked by β-1,4-glycosidic bonds. The primary distinction between CMC and cellulose lies in the presence of carboxymethyl groups (–CH2COOH) in CMC. These anionic groups replace some of the hydrogen atoms from the hydroxyl groups found in the original cellulose structure, as illustrated in Figure 1. Carboxymethyl cellulose (CMC) was first synthesized in 1918. Nonetheless, it was not until the early 1920s in Germany that commercial production of this crucial polymer began [4].

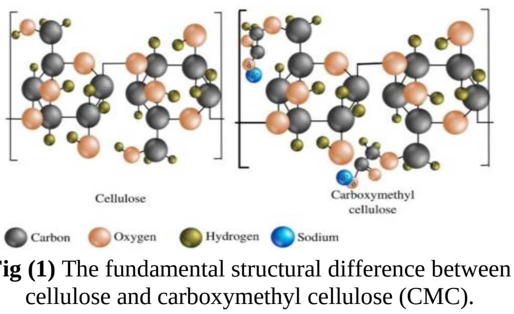

Fig (1) The fundamental structural difference between cellulose and carboxymethyl cellulose (CMC).

Despite the substantial cost and environmental benefits associated with Water-Based Drilling Fluids (WBDFs), their application faces notable challenges, particularly regarding the management of rheological properties. The rheology of drilling fluids encompassing attributes such as viscosity, yield point, and gel strengthis crucial for ensuring the efficiency and safety of drilling operations in the oil and gas sector. Drilling fluids often exhibit non-Newtonian, shear-thinning behavior, where viscosity decreases with increasing shear rate. This property aids in effective hole cleaning by allowing smooth fluid flow near the drill bit while maintaining enough viscosity to transport cuttings. The yield point and gel strength are critical for suspending cuttings at low flow rates and preventing their settlement when circulation stops. These rheological properties also influence pressure control by affecting equivalent circulating density (ECD), which helps balance hydrostatic pressure to prevent formation fluid influx and fracturing. Therefore, managing drilling fluid rheology is crucial for wellbore stability, operational efficiency, and overall drilling performance. The rheological properties of Water-Based Drilling Fluids (WBDFs) are primarily regulated by bentonite, a natural clay composed predominantly of montmorillonite (Mt)[5-11]. Montmorillonite (Mt) can form a network of interconnected particles, often described as a "house of cards" structure, when it swells and exfoliates in water. This characteristic imparts exceptional rheological properties to aqueous systems, making it an indispensable component in Water-Based Drilling Fluids (WBDFs)[11-20]. However, the performance of montmorillonite (Mt)-based drilling fluids is significantly impaired in saline and high-temperature environments due to the high surface charge density and limited stability of Mt [11,17-19,21-24].

In a study examining drilling fluid shear viscosity and elasticity, two fluid sets were analysed: one with constant shear viscosity but varying elasticity, and another with constant elasticity but varying shear viscosity. The study found that adjusting fluid elasticity more effectively controls static filtration rates and reduces fluid invasion compared to changing shear viscosity. Additionally, fluid elasticity has a more significant impact on pressure drop and formation damage. These insights suggest that optimizing fluid elasticity can enhance non-invasive fluid properties, reducing static filtration and formation damage [25].

A study assessed the effect of bentonite concentration on water-based drilling fluids using locally sourced bentonite from Umm Ali. Chemical analysis verified its quality. Carboxymethyl Cellulose (CMC) was added to boost viscosity and minimize filtration loss. The results demonstrated that 7% CMC and 7% local bentonite met API specifications for rheological properties, filtration loss, and yield point-to-plastic viscosity ratios [26].

Similarly, a study examined calcium bentonite activation using physical (ultrasonic) and chemical (carboxymethylcellulose and starch) methods. Physically activated bentonite met OCMA specifications with a density of 1.125 g/cm³, suitable for desert drilling fluids. Chemical activation with polymers effectively met OCMA, API, and high yield grade standards, making it ideal for versatile drilling fluid applications [27].

In another study, the use of corn cob cellulose (CCC) was evaluated as an eco-friendly alternative to imported mud additives for water-based drilling fluids. CCC was compared to sodium carboxymethyl cellulose (CMC) across concentrations ranging from 3 g to 15 g. The study found that CCC effectively increased viscosity, with plastic viscosities reaching 9 cP and 12 cP at 9 g and 15 g, respectively, compared to 4 cP with bentonite alone. Additionally, fluid loss decreased by 16% as CCC concentration increased from 3 g to 9 g. These findings suggest that CCC is a viable and sustainable additive for enhancing viscosity control in water-based drilling fluids[28]. Similarly, a study examined Sodium Carboxymethyl Cellulose (CMC) derived from palm fronds, produced at the Sudan University of Science and Technology and Central Petroleum Laboratories. X-Ray Diffraction (XRD) and laboratory tests demonstrated that this locally produced CMC performed comparably to commercial CMC in water-based drilling fluids. The local CMC was effectively utilized in the drilling fluid system at PetroEnergy Company's Block 6, Balela area[29].

The primary objective of this study is to develop innovative, renewable, biodegradable, and cost-effective functionalized cellulosic materials. These materials aim to enhance the performance of water-based drilling fluids while focusing on cost reduction and improved production efficiency. Cellulose was extracted from olive kernels (OK) and olive pomace (OP). The study evaluates the impact of these natural cellulose extracts on key properties of drilling fluids, including density, plastic viscosity, apparent viscosity, yield strength, filtration, salinity, and pH.

Olive pomace and Olive kernel ,The use of olive pomace and kernels to modify water-based mud represents a notable advancement in drilling fluid technology, merging environmental benefits with enhanced performance. This approach utilizes biodegradable by-products from olive oil production to boost the thermal stability, filtration control, and overall effectiveness of water-based mud. By integrating these olive-derived additives, we address environmental issues linked to traditional drilling fluids and provide a cost-effective solution that improves drilling operations. This paper highlights the benefits and practical uses of this eco-friendly modification and encourages further exploration by the scientific community and industry professionals.

Testing drilling fluids is crucial for ensuring safe and efficient drilling operations. Monitoring parameters like viscosity, density, and chemical composition allows engineers to assess fluid performance and make adjustments to optimize the drilling process, enhancing overall stability and effectiveness.

2. Experiment

2.1. Equipment

- FT-IR S 300 spectrophotometer for (IR – KBR)
- Mixer with container
- Mud balance

2.2. Methodology

- Viscosity was measured by Viscometer
- Density was measured by mud balance
- All sample has the same weigth of Bentonite is 22.5 grams
- preceptation time is 15 mins for all of the samples
- Gel strength was recorded before & after 10 mins by viscometer

2.3. Materials

- Olive pomace Collection date: November 28th 2022, Pressing Date was on December 27th 2023, sample was collected from Emsalatah Olive Press
- Olive kernel Collected from: Sabha's farms, Date of collecting: May 5/2023, Stored from last season of olive in 2022.
- Bentonite: API Test Calibration Bentonite PRC is a specialized type of bentonite utilized for calibration and reference in API (American Petroleum Institute) testing. It is formulated to comply with API standards for testing drilling fluids and was packaged on October 31, 2023.

2.4. Procedures

- . Olive pomace (OP) was used as raw material to extract cellulose by multi-step chemical method, and the extracted cellulose was characterized. The two steps of alkali treatment (alkali concentration, reaction time and reaction temperature) and bleaching (H_2O_2 concentration, NaOH concentration, bleaching time and bleaching temperature) were optimized. The results showed that the optimum conditions for alkali treatment were as follows: alkali concentration 6%, reaction time 2 hours, reaction temperature 95°C; the optimal bleaching conditions were as follows: 7.5% H_2O_2 solution, 5% NaOH, bleaching time 2 hours, bleaching temperature 75°C. After multi-step of chemical treatment.
- The cellulose fibres were air dried: Following thorough rinsing, the fibres were gently transferred from the filter paper or mesh to a clean, flat surface or drying racks. Arranged in a thin layer to enhance drying efficiency, the fibres were left in a well-ventilated area away from direct sunlight. The complete drying process may take several days.
- Store the dried cellulose: Once the cellulose fibres have thoroughly dried, store them in a clean, airtight container to safeguard against moisture and contamination. Place the container in a cool, dry environment, away from direct sunlight.

The Yield (%) of the resulting cellulose is calculated by Equation of number (1)

$$\boldsymbol{yield}\ \% = \frac{\boldsymbol{W\ dried\ cellulose}}{\boldsymbol{W\ dried\ sample}} \times 100 = \mathbf{83.3\%}$$

Table(1). Different concentrations with bentonie

Type	Concentrations %	sample weight (gm)	water (ml)	Resting time
OK	0.025	0.5625	350	none
OK	0.05	1.125	350	none
OK	0.1	2.25	350	none
OK	0.25	5.625	350	none
OK	0.4	9	350	none
OP	0.025	0.5625	350	24 hr
OP	0.05	1.125	350	24 hr
OP	0.1	2.25	350	24 hr
OP	0.2	4.5	350	24 hr
OP	0.3	6.75	350	24 hr
OP	0.4	9	350	24 hr

- **Slices from the olive kernel and pomace sample preparation:**
  I. Weigh the olive kernel and pomace samples accurately to achieve the correct proportion for blending with bentonite.
  II. Mix the specified weight percentages with bentonite using a blender.
  III. Allow the blended samples to rest undisturbed for 24 hours

- **After the 24-hour period, the following tests are initiated:**

➢ **Density test:**

- Prepare the measurement device
- Collect samples
- Place samples in the measurement device in order
- Record the measurements
- Account for temperature

➢ **Viscosity test:**

- Prepare the Measurement Device
- Collect the Sample
- Place the Sample in the Measurement Device
- Measure the Ø600 and Ø300

➢ Filtration test was conducted

➢ Gel Strength was tested

- Yield point strength and ration was recorded

3. Results & Discussion

FTIR result for Olive Kernel (OK)

The FT-IR spectra of cellulose revealed characteristic bands at 3351.36, 2910.16, 1043.64, 1602.95, and 1302.16 cm^{-1}, corresponding to the following functional groups: ʋ O-H stretching, ʋ CH_2 stretching, ʋ C-O-C stretching, ʋ OH bending due to absorbed water, and ʋ CH bending, respectively.

FTIR result for Olive Pomace (OP)

The FT-IR spectra of cellulose exhibited characteristic bands at 3511.36, 2907.53, 1041.52, 1607.16, and 1310.22 cm^{-1}. These bands correspond to the following functional groups: ʋ O-H stretching, ʋ CH_2 stretching, ʋ C-O-C stretching, ʋ OH bending from absorbed water, and ʋ CH bending, respectively.

3.1. Density results

At identical concentrations, both samples exhibit comparable density values, as shown in Table 2. This indicates that the cellulose extracted from OK and OP exhibit similar density properties at the specified concentrations, as illustrated in Figure 2.

Table (2) Density results

Concentration (%)	0.4	0.25	0.1	0.05	0.025	Pure
OK	8.7	8.65	8.65	8.65	8.65	8.33
OP	8.7	8.6	8.60	8.6	8.6	8.33

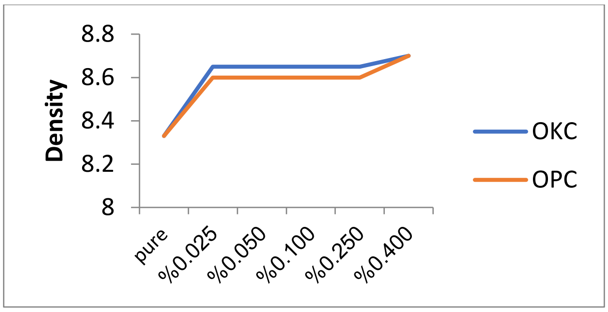

Fig. (2): Density resultes (OK & OP mixed with bentonite)

3.2. Plastic viscosity result (P.V)

The analysis of the provided data for OK Cellulose (Olive Kernel Cellulose) and OP Cellulose (Olive Pomace Cellulose) focuses on Plastic Viscosity (P.V) across different concentrations. The results reveal that both samples follow a pattern where Plastic Viscosity diminishes as the concentration decreases, suggesting that higher viscosities are associated with higher concentrations. A comparison between the two samples indicates generally comparable Plastic Viscosity values at the same concentrations, with some minor differences. At concentrations of 0.25% and 0.4%, both OK Cellulose (OK) and OP Cellulose (OP) samples exhibit identical Plastic Viscosity values of 9.5, suggesting similar flow characteristics at these levels. However, at a 0.1% concentration, the OK Cellulose sample shows a Plastic Viscosity of 10, while the OP Cellulose sample records a slightly higher value of 10.4. This implies that the OP Cellulose sample may exhibit marginally greater flow resistance compared to the OK Cellulose sample at this concentration (refer to Figure 3).

Table (3) Plastic viscosity for the OK & OP Cellulose mixed with bentonite.

Concentration (%)	0.4	0.25	0.1	0.05	0.025	Pure
OK	9.4	9.5	10	9	8	7
OP	9.5	9.5	10.4	9.2	8.5	7

Table (3) shows that at concentrations of 0.1%, at both samples OP and OK Cellulose sample consistently exhibits higher Plastic Viscosity values . Specifically, the OP Cellulose has Plastic Viscosity values of 10.4 cp, while the OK Cellulose has values of 10 cp, respectively. A notable change occurs at concentrations of 0.1% suggesting that the internal structure of the sample may have reached its peak plasticity. This observation implies a point where the system could be overloaded with cellulose particles, potentially causing entanglement or aggregation of the cellulose molecules. Such an overload could reduce the effectiveness of cellulose as a thickening agent, leading to a subsequent decline in the observed Plastic Viscosity values.

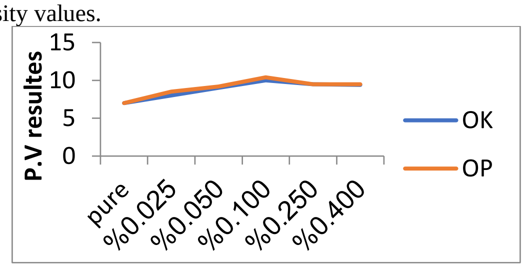

Fig.(3): P.V resultes for the the OK and OP mixed with bentonite.

3.3. Apparent viscosity (A.V) result

Table 4 shows that at a concentration of 0.4%, the OP Cellulose sample exhibits a slightly higher apparent viscosity (14.5) compared to the OK Cellulose sample (14). At a concentration of 0.25%, the OP Cellulose sample has an apparent viscosity of 15.5, which exceeds that of the OK Cellulose sample (12.5). In contrast, the OK Cellulose sample reaches its peak apparent viscosity of 16.5 at a concentration of 0.1%, while the OP Cellulose sample shows a viscosity of 15 at the same concentration. These variations can be explained by the different shear-thinning behaviours of the materials, where viscosity decreases as the shear rate increases. As the concentration of cellulose increases, the shear rate experienced by the fluid may also increase, leading to a decrease in apparent viscosity despite the higher cellulose concentration. This phenomenon warrants further investigation in future research. At a concentration of 0.025%, the apparent viscosity of the OP Cellulose sample (16.5) is higher than that of the OK Cellulose sample (12), as illustrated in Figure 4.

Table (4): A.V resultes for the OK& OP Cellulose mixed with bentonite.

Concentration (%)	0.4	0.25	0.1	0.05	0.025	Pure
OK	14	12.5	16.5	21	12	13
OP	14.5	15.5	15	12.5	16.5	13

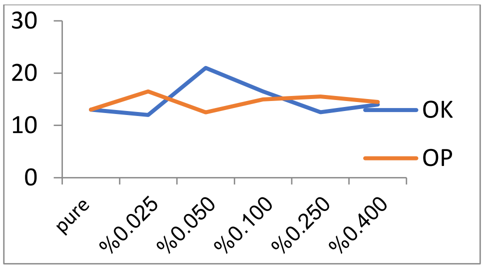

Figure (4): A.V resultes for the the OK and OP Cellulose mixed with bentonite.

3.4. Yield strength Results

Increased Yield Strength, The addition of natural cellulose derived from OK and OP likely led to an improvement in yield strength. The inherent strength and fibrous nature of cellulose may have enhanced the structural integrity of the drilling fluid, thereby raising its yield strength. The hydration and even distribution of cellulose particles within the fluid play essential roles in shaping its rheological properties.

At higher concentrations, cellulose particles may encounter challenges in hydrating or dispersing efficiently, potentially resulting in a decline in yield strength, as detailed in Table 5 which determining the optimal concentration was crucial for maximizing the beneficial effects of cellulose on drilling fluid properties

Table (5): Yield strength results for the OK and OP mixed with bentonite

Concentration (%)	0.4	0.25	0.1	0.05	0.025	Pure
OK	10	11	13	24	8	10
OP	7	13	20	9	13	10

Yield strength varied significantly with the concentration of the cellulose additive. Optimal concentration was 0.05 % for OK cellulose, and 0.1% for OP cellulose showed higher yield strengths compared to other concentrations, indicating that the enhancement in yield strength is influenced by the concentration level.

Variations in Cellulose Properties, The two types of cellulose additives, derived from OK cellulose and OP cellulose, may possess distinct properties that influence their performance in the drilling fluid. This difference in properties could account for the observed variation in yield strength between the two additives at various concentrations.

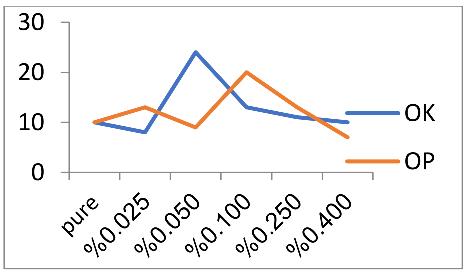

Figure (5): Yield strength resultes for the the OK and OP Cellulose mixed with bentonite.

3.5. Filtration Results

Effects of Cellulose Addition, The addition of natural cellulose extracted from OK Cellulose significantly influenced filtration results in both OK Cellulose and OP Cellulose samples. The filtration outcomes varied with the percentage of cellulose used.

Optimal Cellulose Percentage: For the OK Cellulose sample, the highest filtration result of 11.5 was achieved when cellulose constituted 0.4% and 0.25% of the drilling fluid's weight, as detailed in Table 6. This suggests that higher cellulose percentages may positively impact filtration efficiency.

Consistent Filtration Results: In contrast, the OP Cellulose sample consistently yielded filtration results of 11.5 across all tested cellulose percentages (0.4%, 0.25%, 0.1%, 0.05%, 0.025%), as illustrated in Figure 6. This indicates that the addition of OP -derived cellulose had minimal influence on the filtration performance of the drilling fluid.

Table (6): filtration resultes for the the OKand OP Cellulose mixed with bentonite.

Concentration (%)	0.4	0.25	0.1	0.05	0.025	Pure
OK	11.5	11.5	11	10.5	10	12.5
OP	12.5	11.5	11.5	11.5	11.5	12.5

Potential Applications, The findings indicate that incorporating cellulose extracted from OK may improve the filtration efficiency of drilling fluids. This enhancement is particularly valuable for drilling operations that require precise control over fluid loss and the consistent maintenance of drilling fluid properties.

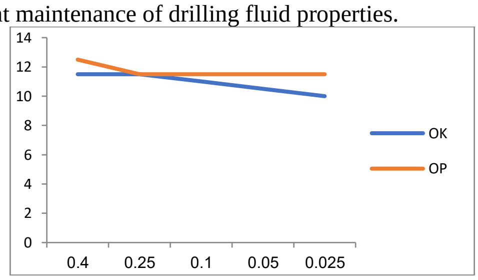

Figure (6): Filtration resultes for the OK cellulose and OP cellulose mixed with bentonite**.**

3.6. Salinity Results:

Table 7 presents the results of the salinity test for various concentrations of OK cellulose mixed with Bentonite. Meanwhile, Figure 7 displays the results of the same salinity test for different concentrations of the same material, also mixed with Bentonite.

Table (7): Salinity results for the OK cellulose and OP cellulose mixed with bentonite.

Concentration (%)	0.4	0.25	0.1	0.05	0.025
OK	185	192	203	217	234
OP	158	173	196	233	262

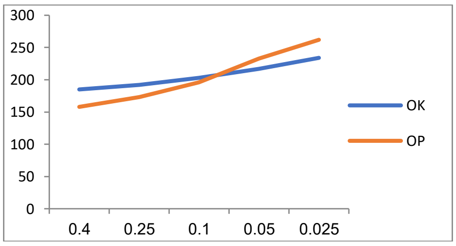

Figure (7): Salinity results for the OK cellulose and OP cellulose mixed with bentonite**.**

3.7. pH Test Results:

The experiment assessed the impact of incorporating natural cellulose extracted from OK into drilling fluid at various concentrations. The pH values of two samples, OK and OP, were measured to evaluate the effects of this addition. The results revealed minor fluctuations in pH values with varying cellulose concentrations. For the OK sample, pH values ranged from 8.5 to 8.7 as the cellulose concentration increased from 0.025% to 0.4%. Similarly, for the OP sample, pH values varied from 8.6 to 8.72 with increasing cellulose concentrations.

Table (8): PH results for the OK cellulose and OP cellulose

Concentration (%)	0.4	0.25	0.1	0.05	0.025	Pure
OK	8.7	8.65	8.6	8.52	8.5	9.2
OP	8.72	8.7	8.68	8.67	8.6	9.2

The observed differences in pH values between the cellulose concentrations were not significant, suggesting that the addition of cellulose from OK cellulose or OP cellulose had minimal impact on the overall pH level of the drilling fluid. It is worth noting that the pH values obtained were within a narrow range, indicating that the drilling fluid remained relatively stable despite the cellulose addition.

These findings imply that the addition of OK cellulose or OP cellulose to drilling fluid is unlikely to cause major pH disruptions.

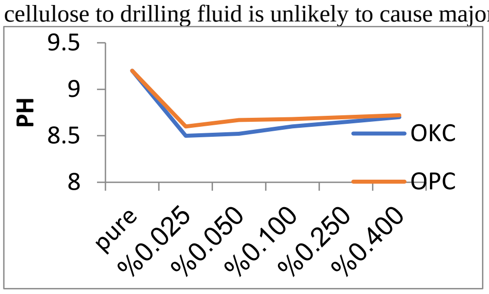

Figure (8): PH resultes for the OK cellulose and OP cellulose mixed with bentonite.

Conclusion

This study revealed that the density of drilling fluids remained relatively constant across different concentrations of cellulose extracted from olive kernels (OK cellulose) and olive pomace (OP cellulose). The plastic viscosity peaked at concentrations of 0.1% and 0.25%, suggesting a possible saturation threshold for cellulose particles. The apparent viscosity reached its highest values of 16.5 for OK and 15 for OP at a 0.1% concentration, indicating shear-thinning behaviour. Variations in yield strength were closely related to changes in viscosity. The most effective filtration efficiency was achieved at a concentration of 0.025% for OK cellulose. The effect of pH increases with higher concentrations of cellulose in both OK cellulose and OP cellulose samples. Increasing the concentration of cellulose extracted from OK and OP in Bentonite results in a higher salinity. Overall, cellulose derived from OK and OP notably improved the properties of drilling fluids and enhanced control over circulation loss.

Recommendation

It is recommended to account for the effect of temperature variations on viscosity during the preparation of drilling fluid concentrates. Future research should explore different concentrations and materials to compare their efficacy against the current results. An optimal concentration range may exist for maximizing yield strength enhancement. Remarkably, the most favourable outcomes were observed at lower concentrations, implying that achieving optimal performance could be both practical and cost-effective.

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