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Evaluating Filtration and Thermal Stability of Water-Based Mud Using Green Synthesized Zinc Oxide Nanoparticles

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Abstract

Nanoparticles (NPs) have unique capabilities that make them an eye-opener opportunity for the upstream oil industry. Their nano-size allows them to flow within reservoir rocks without the fear of retention between micro-sized pores. Incorporating NPs with drilling and completion fluids has proved to be an effective additive that improves various properties such as mud rheology, filtration, thermal conductivity, and wellbore stability. However, the biodegradability of drilling fluid chemicals is becoming a global issue as the discharged wetted cuttings raise toxicity concerns and environmental hazards. Therefore, it is urged to utilize chemicals that tend to break down and susceptible to biodegradation. This research presents the practical application of bio-based Zinc Oxide nanoparticles (ZnO NPs) prepared chemically from celery leaf plant extract as green additive in water-based mud drilling fluid (WBM). The study aimed to evaluate the filtration and thermal stability of WBM using green-synthesized ZnO NPs. The results showed that the ZnO NPs have minimal effect of mud density, but significant improvement in mud thermal stability and filtration properties were attained with concentrations lower than 1g. The fluid loss rate was reduced by 33% with 0.45g of ZnO nanoparticles, and the thinnest mud cake was obtained as well. In terms of thermal stability, the bio-based ZnO NPs greatly enhanced the rheological properties of WBM at elevated temperatures. The rate of increment in plastic viscosity (PV) or decrement in yield point (YP) and gel strength occurred in a controllable manner compared to the rheological properties of base mud at high temperatures reaching 90°C. This study provides insight into the effect of green-synthesized ZnO nanoparticles on the performance of water-based mud and highlights their potential as an effective and environmentally friendly additive for the oil and gas industry.

Keywords: ZnO nanoparticles, fluid loss, thermal stability, WBM, HT Rheology.

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1- Introduction

It has become a necessity for researchers to deeply focus on improving the rheological behavior of WBM to solve current technical challenges using novel materials such as nanoparticles and biodegradable additives [1]. Nanoparticles are the building blocks of nano-materials and defined as any ultra-small particles with size ranges (1-100) nm [2]. In recent technology and advances in the petroleum industry, it is required to have drilling fluid with satisfactory performance in complicated and harsh drilling operations i.e., shale formations in ultra-deep-water drilling, high temperature high pressure (HPHT) wells, etc. Hence major development has been conducted on various emulsifiers, surfactants, and other drilling fluid additives to enhanced drilling fluid properties. Most additives are generally produced from polymers, but nanotechnology has proved its effectiveness in enhancing drilling fluid properties especially in water-based muds. The reactivity of nanomaterials is attributed to the incredibly high surface area to volume ratio because this ratio tends to increase as shapes get smaller. More chemical reactions are obtained due to the more reactive atom surfaces exposed to each other [3-5]. The most recent approach in nanotechnology is to make it green industry and produce more environmentally friendly nanoparticles that are applicable to real world practices. It has been reported that biological systems such as yeast, algae, bacteria and plants can potentially transform inorganic metal ions into metal nanoparticles through reductive capability of proteins exist within their structure [6]. It is remarkable to mention the fundamental control over the morphology and size of produced nanoparticles from plants is connected to the interaction of biomolecules with metal ions since plant contain different concentrations and composition of components that are biologically active. The morphological diversity of produced nanoparticles synthesized from plants can be described as triangles, spheres, cubes, nanorods, or nanowires. Generally, plants contain various metabolites and effective phytochemicals including terpenoids, polyphenols, sugars, alkaloids, amides, flavones and phenolic which are the main bio-reduction components of

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metal ions from metal salts yielding nanoparticles [7]. In 2018, Assi, used potato starch as drilling fluid additive and results showed improved filtration loss and mud cake consistency also, it increased basic rheological parameters in high pH media [8]. In 2019, Al-Hameedi et al. worked on introducing grass powder (GP) as drilling fluid additive and results showed viscosity improvement from 8 to 9 cP, gel strength improvement from 22 to 26 lb/100ft^2 and 28% reduction in fluid loss [9]. In 2021, Novriansyah reported that 2 wt% of cassava starch is able to improve drilling fluid filtration properties through reducing fluid loss from 5.2 to 1.6 ml as well as improving the gel strength from 0.4 to 0.6 lb/100ft^2 [10]. In 2022, Jagar *et al.*, developed nano-biodegradable drilling mud using pomegranate peel (PP), Prosopis Farcta Plant (PFP) and SiO_2 and TiO_2. Results showed better filtration properties and rheological properties with TiO_2 and PP [11]. ZnO nanoparticles are widely recognized as safe, biocompatible and technological material that has caught profound attention due to its distinguished performance as photoluminescence agents in biosensors, antibacterial agents in many products, and UV-absorbers in coating materials [7-12]. ZnO nanoparticles are known to have stable physical and chemical properties during applications as they show the least sensitivity to temperature and pressure variation, indicating a stable elemental compound and favored to be used for industrial applications [13]. ZnO NPs are registered as an eco-friendly material providing the lowest toxicity even at high concentrations [14]. The term “nanofluid” is referred to drilling fluid system that incorporates nanoparticles. It is a colloidal dispersion of any nano-sized material such as (nanofibers, nanotubes, nanorods or nanowires) into base medium of (water, oil, polymer solution or ethylene glycol). These incorporated fluid systems show distinctive thermos-physical properties compared to base fluid. The very small size of the dispersed nanoparticles with its high surface to volume ratio enhances the electrical and thermal properties of the nanofluid. Upon reaching extreme depths characterized by elevated temperatures and pressure, thermal stability of the drilling fluid becomes stringent requirement which can be attained by the use of nanofluid of suitable nano-material to have the optimum performance [15]. In 2022, Alkalbani et al., investigated the effect of various sizes of ZnO NPs on rheological properties of WBM at both surface conditions and downhole ones with maximum temperature reached 90^{o}C. Results showed the addition of ZnO NPs to WBM achieved (40% - 65%) improved rheological properties, and bigger sizes of ZnO NPs from (30-45) nm showed more rheological improvement compared to smaller sizes (10-30) nm. Additionally, bigger ZnO NPs sizes formed more stable fluid at elevated temperatures [16]. In this paper, bio-based ZnO nanoparticles prepared from celery leaf plant extract are going to be applied into pre-hydrated water-based drilling fluid as a green additive and investigate the effect of different concentrations of these nanomaterials on the thermal stability and filtration properties of the water-based mud.

2- Experimental Work

2.1. Mixing Pre-Hydrated Bentonite Water Based Mud with ZnO NPs

Firstly, the base mud was prepared by mixing 500ml of distilled water using Hamilton Beach Mixer for 10 min to ensure base fluid consistency. Then, 27g of bentonite (viscosifier agent) was added to the base fluid and mixed for 30 min. the mixture was let to fully hydrate for 20 hours at room temperature. After the hydration period, about 0.2 g and 0.65 g of soda ash and caustic soda were added respectively and each mixed for five minutes. Lastly, different concentrations of ZnO Nanoparticles namely (0.15, 0.3, 0.45, 0.6 and 1) grams were added to each mud cup sample separately and mixed for 20 min to ensure proper nanoparticles dispersion within the drilling fluid mixture. The Bio-Based ZnO nanoparticles were chosen for their low toxicity as the zinc element is used in numerous parameters of metabolism activities, hence, it has better biodegradability, relatively cheap materials as well as being least susceptible to temperature variation. The selected ZnO NPs are characterized to be having an average particles diameter size of 35 nm, purity up to 93% and grey powder form with hexagonal wurtzite structure.

2.2. Mud Density Test

Standard mud balance is used to perform this test as. The mud cup is filled with drilling fluid sample in away ensuring some of it is expelled from the top cap hole. The cup is then firmly held with cap hole covered with thumb and outside of the cup is wiped until clean and dry. Lastly, the beam is placed on the base support and balanced by using the rider along the graduated scale. Balance is achieved when the bubble is directly under the center line.

2.3. WBM Rheology for Thermal Stability Test

The thermal stability of drilling fluid is reflected in the behavior mud rheological properties at high temperatures along with the intrusion of active solids which is normally encountered during the operations geothermal drilling job of deep oil and gas wells. High temperatures affect the chemical and physical properties of drilling fluid in a way that causes excessive gelation and formation damage problems. Total circulation loss, well instability stuck pipe and difficulty in cementing jobs are all associated problems with elevated temperatures as drilling proceed further below subsurface [17]. The OFITE 800 viscometer is used to test the rheological behavior of drilling fluid at elevated temperatures and investigate the thermal stability of the mud at such conditions. Firstly, the mud sample is poured into the viscometer mud cup and then mounted into the heating cup. Let the sample mix using the speed setting “STIR” until the desired temperature is reached. The knob is then rotated to desired speed setting, e.g., 600 and waited for the reading to stabilize and recorded the dial speed in the data sheet. It should be noted that the proper way to take rheology readings is to start from the highest speed and continue to the next lower speed and so on till full readings are attained. Rheological measurement from dial readings can be taken directly.

- The Apparent Viscosity (AV) measured in centipoise and calculated by:

$$AV = R_{600}/2$$

- The Plastic Viscosity (PV) measured in centipoise and is calculated by:

$$PV = R_{600} - R_{300}.$$

- The Yield Point is measured in lb/100ft^2 and is calculated by:

$$YP = R_{300} - PV$$

To test the gel strength of drilling fluid, the following steps are involved: after taking all the readings at different shear rates, the mud is allowed to shear at 600 rpm for a few seconds. Then, the rotating shaft is stopped, and timer is turned on for 10 seconds. After 10 seconds, the gear is immediately switched on to shear at 3 rpm and. The maximum reading that the needle reaches is recorded as the gel strength for 10 seconds. The same steps are repeated for 10 minutes gel strength.

2.4. Low Pressure Low Temperature (LPLT) Filtration Test

The amount of fluid lost into drilled formation, together with filter cake, are essential characteristics to identify for any drilling fluid before practical field application. This test was conducted using the OFITE dead-weight hydraulic filter press. The OFITE low pressure filter press helps the drilling mud engineer to correctly measure fluid loss and filter cake thickness. The device is integrated with a dead weight hydraulic assembly that provides suitable hydraulic pressure of 100 psi exerted on drilling mud sample inside pressure test cell at room temperature.

3- Results and Discussion

3.1. Effect of Bio-Based ZnO nanoparticles on WBM Density

The results showed that the addition of the synthesized ZnO nanoparticles has almost no effect on the density of the mud, as shown in Fig. 1. This is an advantage for the added nanoparticles as they help maintain better equivalent circulating density (ECD) when drilling into deviated wells. It is also a privilege when dealing with well kicks or in wells having narrow window between fracture gradient and pore-pressure gradient, as no increment is observed in mud density when adding the ZnO nanoparticles.

3.2. Effect of Bio-based ZnO NPs on WBM Filtration Properties

The effect of different concentrations of the synthesized ZnO nanoparticles on filtration properties of the pre-hydrated bentonite drilling fluid is shown in Fig. 2. It was observed that the addition of ZnO nanoparticles improved the filtration properties of the WBM by reducing the rate of fluid loss over the period of 30 minutes. The maximum recorded improvement for fluid loss was attained with 0.45g of ZnO nanoparticles, which reduced the amount of fluid loss from 19.6 ml to 13.2, equivalent to a fluid loss reduction rate of 32.6%.

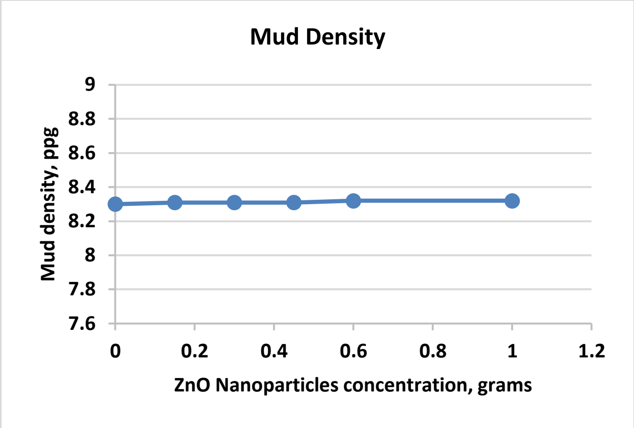


Fig. 1. Mud Density with Different Concentrations of ZnO NPs

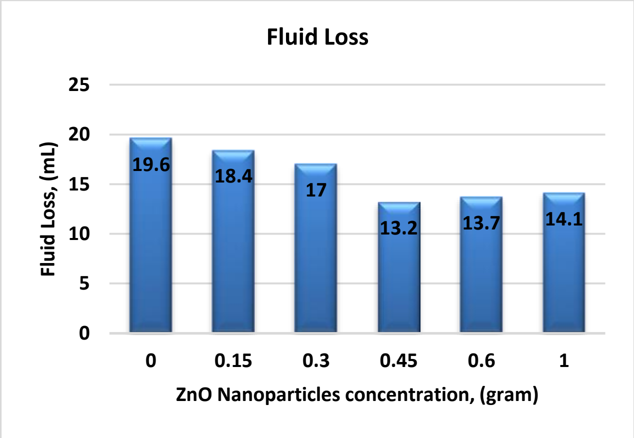


Fig. 2. Fluid Loss vs. Different Concentrations of ZnO NPs

It is also remarkable to mention that concentrations higher than 0.45g of ZnO nanoparticles showed a similar amount of fluid loss. Furthermore, a thinner and less permeable mud cake was obtained as concentrations of ZnO nanoparticles increased compared to base mud. The ultra-fine size of the nanoparticles can physically plug the formation throats and thus reducing the volume of fluid loss. The dispersed nano-sized particles among other micro-sized components of drilling mud act as bridging agents and seal porous voids effectively, producing a firmer, thinner, and crack-free surface of the mud cake. In terms of efficient drilling operations, less fluid filtrate, which means less fluid invasion into drilled formation and minimized formation damage. Additionally, thinner mud cakes reduce the likelihood of differential sticking problems. Severe stuck pipe problems impose costly operations to free and retrieve stuck pipe, which further increases non-productive time by increasing the duration of drilling program. Enhancing drilling fluid filtration properties by enabling the mud to preserve its aqueous phase throughout drilling operations would greatly enhance the wellbore stability, particularly when drilling into water-sensitive formations and improve the rate of penetration, ultimately improving the overall drilling program to reach targeted depths. From Fig. 3, the results show that the optimum concentration of the applied bio-based ZnO nanoparticles is 0.45 g, at which the thinnest mud cake and lowest fluid loss volume are obtained among other applied concentrations.

3.3. Effect of ZnO NPs on WBM Thermal Stability

Thermal stability of pre-hydrated water-based mud was tested at various aging temperatures, namely (60°C, 70°C, 80°C, and 90°C). The thermal stability of drilling fluid is directly reflected in the behavior of mud rheological properties at elevated temperatures. Therefore, the performance of the synthesized ZnO nanoparticles at elevated temperatures, namely the rheology of WBM sample containing the optimum concentration of ZnO nanoparticles, was subjected to various aging temperatures, and was compared to rheology of base mud at same temperatures. Based on previous tests, the optimum concentration for the ZnO nanoparticles was identified to be 0.45 g, at which optimal drilling fluid properties were obtained, as beyond this concentration, the effect of ZnO nanoparticles seems to be very minimal compared to the specified concentration. The investigated rheological parameters included PV, YP and Gel strength. Detailed results for the effect of ZnO nanoparticles on WBM rheology at elevated temperatures are shown in Table 1.

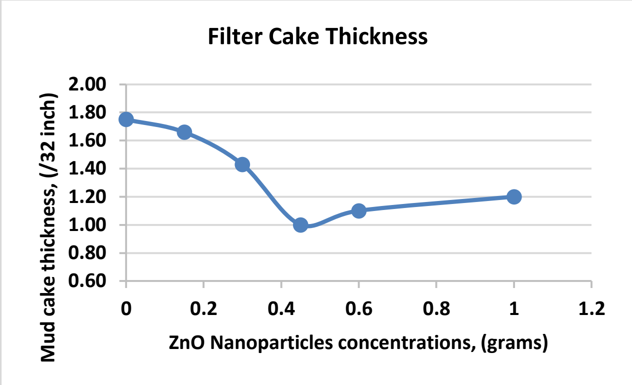


Fig. 3. Filter Cake Thickness vs. Different Concentrations of ZnO NPs

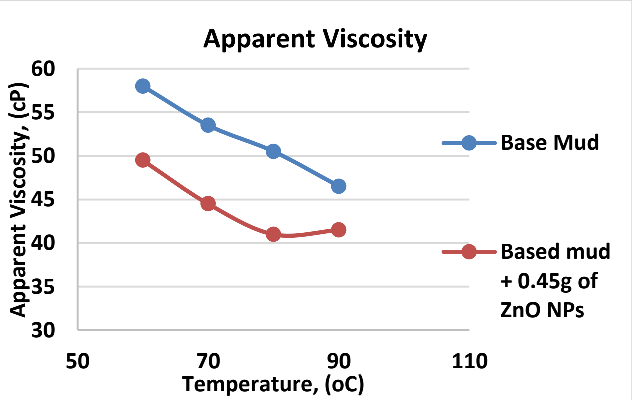
Table 1. Results for WBM Rheological Properties at Elevated Temperatures

Rheological Parameters	Base Mud				Base Mud + 0.45 g of ZnO NPs			
	at 60°C	at 70°C	at 80°C	at 90°C	at 60°C	at 70°C	at 80°C	at 90°C
600 RPM	116	107	101	93	99	89	82	83
300 RPM	101	89	68	58	86	75	66	63
200 RPM	91	76	60	48	78	70	60	57
100 RPM	84	71	54	44	73	63	54	52
6 RPM	80	68	50	41	67	55	50	48
Apparent Viscosity (AV), cP	58	53.5	50.5	46.5	49.5	44.5	41	41.5
Plastic Viscosity (PV), cP	15	18	33	35	13	14	16	20
Yield Point (YP), lb/100 ft^2	86	71	35	23	73	61	50	43
Gel 10 sec, lb/100 ft^2	53	41	20	6	69	53	43	35
Gel 10 min, lb/100 ft^2	66	58	38	25	78	69	61	55

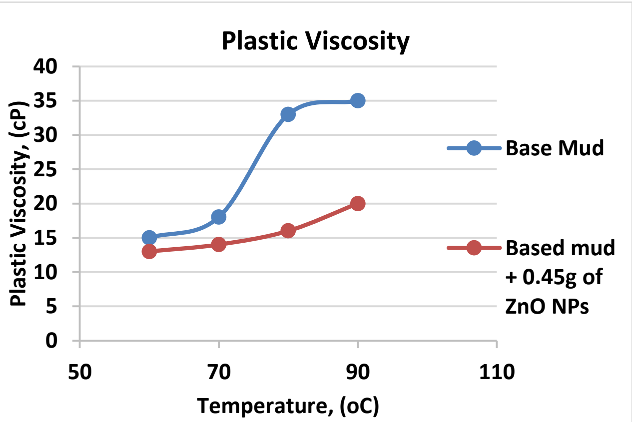
3.4. Apparent and Plastic Viscosity of WBM at Elevated Temperatures

Results for apparent viscosity (AV) and plastic viscosity (PV) at elevated temperatures are shown in Fig. 4 (a) and Fig. 4 (b). It was observed that with increasing temperature decreased the AV of both the base mud and nano-based mud. In contrast, the PV of both the based mud and nano-mud increased with increasing mud temperature. Results showed that the AV values of the base mud decreased from 58 cP to 46.5 cP at temperatures of 60°C and 90°C, whereas the nano-based mud showed a decrease in AV from 49.5 cP to 41.5 cP under the same temperature conditions. This clearly shows that ZnO NPs enhanced the thermal stability of the WBM by maintaining a lower declining rate of AV with increased temperatures compared to the rate of AV decrement of the base mud at the same temperatures.

The increment of PV for the base mud incurred abrupt changes, especially for temperatures greater than 70°C, indicating mud failure at such temperatures. The PV of the base mud increased rapidly and almost doubled from 18 to 33 and 35 cP at temperatures of 70°C, 80°C, and 90°C, respectively. The behavior of PV increment with increasing aging temperature reflects the fact that higher temperatures cause increasing clay hydration, and increased viscosity indicates the increasing attractive forces as well as increasing the internal and mechanical friction between particles at elevated temperatures. On the other hand, the effect of ZnO nanoparticles is clearly showing a more stable and uniform increment of PV at elevated temperatures represented by the smooth curve, no abrupt changes, and a controlled rate of PV increment. When the base mud showed a sudden change in PV at temperatures between 70°C to 80°C and up till 90°C, the nanoparticles improved the PV at such temperatures by maintaining a reasonable increase in PV values with only a few centipoises, namely from 13 cP at 60°C to 20 cP at 90°C. Therefore, the addition of ZnO nanoparticles improved the thermal stability of water-based mud, i.e., the water-based mud with nanoparticle additives can function properly as designed properties will be maintained within the safe limit of changes. For instance, at the temperature of 90°C, WBM with 0.45g of ZnO nanoparticles has a PV value of 20 cP, which is quite similar and close to the PV value of 18 cP of the base mud at 70°C.



(a)



(b)

Fig. 4. (a) – Effect of ZnO NPs on AV of WBM at Elevated Temperatures, (b) – Effect of ZnO NPs on PV of WBM at Elevated Temperatures

3.5. Yield Point of WBM at Elevated Temperatures

Results for yield point (YP) at elevated temperatures are shown in Fig. 5. It was observed that as the aging temperature increases, the YP decreased for both base mud and nano-mud. It can be clearly seen that the base mud deteriorates and loses its electrochemical forces at temperatures greater than 70°C. This is another indicator that the mud is practically losing its rheological properties at elevated temperatures, represented by the sharp decrease in YP values at temperatures between 70°C to 80°C, from 71 lb/100ft^2 to 35 lb/100ft^2 respectively. The reduction in YP values with increasing temperatures is due to reduced electrochemical forces between solid particles of the mud. in other words, the attractive forces are broken at higher temperatures. Such a reduction in YP will immediately affect the mud functionality, especially hole cleaning, as very low YP will have less efficient ability to carry cuttings.

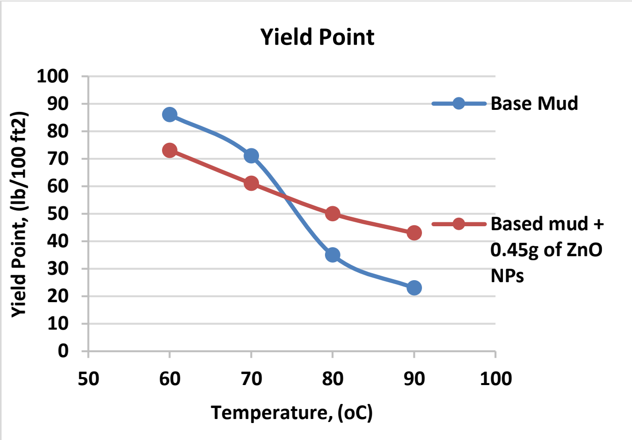
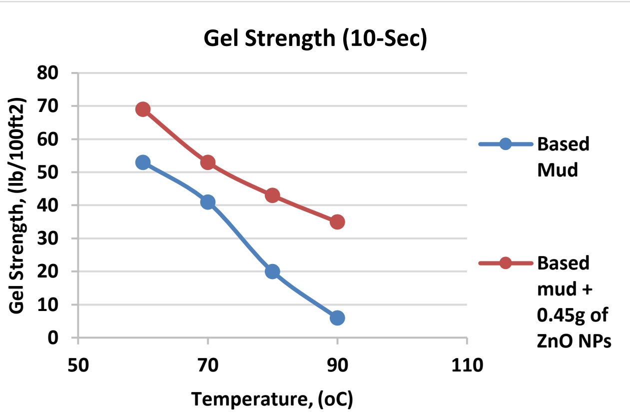


Fig. 5. Effect of ZnO NPs on YP of WBM at Elevated Temperatures

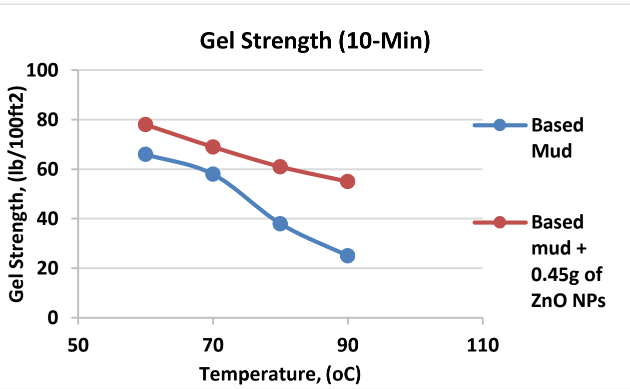
The addition of 0.45g of the synthesized ZnO nanoparticles improved the YP values, indicating enhanced thermal stability of the mud at elevated temperatures. As shown by results in Table 1, the lowering trend for the YP values of the nano-drilling fluid is more stable and still to be efficient at higher temperatures. For instance, the YP value of nano-drilling fluid at 90°C is equivalent to YP values of base mud at temperatures between 75°C -78°C. This trait of nanoparticles improved the thermal stability of the mud due to enhanced agglomeration of particles and enhanced shear stress. However, it is remarkable to mention that the bentonite mud structure can only tolerate temperatures lower than 95°C, after that, the mud will completely fail. Therefore, the role of nanoparticles was enhancing the rheological properties at elevated temperatures by sustaining reasonable rheological parameters that enable the mud to function properly.

3.6. Gel Strength of WBM at Elevated Temperatures

The 10-seconds and 10-minutes gel strength properties were investigated at elevated temperatures, and the results are shown in Fig. 6 (a) and Fig. 6 (b), respectively. Gel strength results showed a similar trend for YP with increased temperature. Generally, gel strength decreased with increasing temperatures for both based mud and nano-mud. Gel strength results also further confirm the deterioration of the bentonite water-based mud at temperatures higher than 70ºC after which, a sharp decrease in gelation properties is recorded. For instance, at 90ºC, gel strength recorded only 6 lb/100ft^2 and 25 lb/100ft^2 for 10-sec and 10-min, whereas, at 60ºC gel strength was 53 lb/100ft^2 and 66 lb/100ft^2 for 10-sec and 10-min. The sharp reduction in gel strength of the base mud at elevated temperatures threatens the cuttings suspension mud functionality and drill cuttings are expected to fall out of the mud and accumulate at the bottom of drill string when circulation is ceased. Such situation can lead to severe wear of bottom hole assembly (BHA), stuck pipe and chemical corrosion of the bit along with increased surge and swab pressure will be required to resume the mud circulation. ZnO nanoparticles enhanced the gelation properties of the bentonite water-based mud with sufficient gel strength values. For instance, at 90ºC the 10-sec gel strength of nano-mud is 35 lb/100ft^2, whereas the base mud has only 6 lb/100ft^2. Additionally, at 90ºC for both 10-sec and 10-min gel strength, the nano-mud has gelation properties equivalent to gelation properties of base mud at temperatures lower than 75ºC. In other words, the mud capacity to hold more rock cuttings at elevated temperatures is greatly improved with the addition of ZnO nanoparticle that ultimately result in overall enhancement of drilling operations.



(a)



(b)

Fig. 6. (a) Effect of ZnO NPs on 10-sec Gel Strength of WBM at Elevated Temperatures, (b) Effect of ZnO NPs on 10-min Gel Strength of WBM at Elevated Temperatures

The addition of bio-based ZnO nanoparticles to the bentonite water-based mud showed a thinning effect on YP and gel strength, with minor increased viscosity at higher temperatures. The nanoparticles were observed to boost mud functionality and resemble mud properties at temperatures lower than actual ones by 20 degrees. There were no signs of thermal degradation of the ZnO nanoparticles, as they kept improving the rheological properties of the water-based mud up to 90°C and gave good thermal stability enhancement.

Drilling fluid rheology is one of the most susceptible properties among other drilling properties especially when the drilling operations are executed in varying conditions of pressures and temperatures. Unstable drilling fluid rheology directly influence the efficiency of downhole cleaning and equivalent circulating density (the effective dynamic mud density that is slightly higher than static density). At the bottom of HPHT wells, drilling fluid will most likely lose its functional properties. Consequently, drill solids “cuttings” will fall out of suspension and accumulate near drill bit, causing severe downhole cleaning issue. Such situation will impose additional operations cost and increase the non-productive time. In directional and highly deviated wells the problems associated with thin drilling fluids are even more amplified and may eventually lead to total abandonment of the well.

4- Conclusions

In conclusion, the overall effect of the bio-based ZnO nanoparticles on basic water-based drilling fluid is to an effective green additive with significant improvement to filtration properties and enhanced the thermal stability of the mud at elevated temperatures. Summarized conclusions are as follows:

1. Minimal to zero effect on the density of the mud which is beneficial for drilling inro narrow fracture pressure formations.
2. Fluid loss rate was reduced by 33% and mud cake thickness was 1/32 inch with the addition of 0.45g of ZnO nanoparticles to water-based mud. The enhanced rate of fluid loss and thin mud cake positively contribute to more efficient drilling operations such as reducing the potential for differential sticking problems as well as minimizing formation damage by filtrate invasion.
3. Thermal stability of bentonite water-based drilling fluid was significantly improved by the addition of 0.45g of ZnO nanoparticles. Nanoparticles enhanced the rheological performance of the drilling fluid at elevated temperatures reaching up to 90ºC through maintaining controllable PV increment rate as well as more stable decrement in AV, YP and gel strength rheological parameters with no sign of thermal degradation.

Nomenclature

AV	Apparent Viscosity
cP	Centipoise
ECD	Equivalent Circulating Density
ºC	Degree Celsius
ºF	Degree Fahrenheit
g	gram
HPHT	High Pressure High Temperature
LPLT	Low Pressure Low Temperature
ml	Milli liter
PV	Plastic Viscosity
PP	Pomegranate Peel
$lb/100ft^2$	Pound per hundred square feet
psi	Pound per square inch
PFP	Prosopis Farcta Plant
RPM	Round Per Minute
R_{600}	Viscometer dial reading at 600
TiO_2	Titanium dioxide
UV	Ultraviolet
WBM	Water-Based Mud
wt%	Weight percent
YP	Yield Point
ZnO	Zinc Oxide

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تقييم خواص الترشيح والاستقرار الحراري لسائل الحفر بأستخدام مواد اوكسيد الزنك النانوية الصديقة للبيئة

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الخلاصة

المواد النانوية تعتبر من المواد المصنعة حديثا والتي تفتح مجالات وفرص قيمة في الصناعة النفطية خصوصا في عمليات استخراج النفط. وترتبط تطبيقات استخدام المواد النانوية في مكامن النفط والغاز الطبيعي بصورة مباشرة على حجمها الصغير النانوي الذي يتمتع بقدرات فريدة حيث انه يسمح لمثل هذه الجسيمات بالتدفق داخل صخور المكمن دون الخوف من الاحتفاظ بها بين المسام صغيرة الحجم والتي تكون بقياس المايكرون. تم دمج الجسيمات النانوية مع سوائل الحفر والاكمال بنجاح وأثبتت أنها مواد فعّالة تعمل على تحسين خصائص مختلفة مثل ريولوجيا الطين والترشيح والتوصيل الحراري واستقرار هيكلية الابار النفطية. من الجدير بالذكر ان قابلية التحلل البايولوجي للمواد الكيميائية المكونة لسوائل الحفر أصبحت مشكلة عالمية حيث أن قطع الصخور الصغيرة الناتجة عن عمليات الحفر cuttings والتي تكون بالعادة مغلفة ببقايا سوائل الحفر تزيد من مخاوف السُمية والمخاطر البيئية عندما يتم التخلص منها, لذلك اصبح من المستحسن استخدام مواد كيميائية تميل الى التحلل البايولوجي وبصورة فعالة. ومن هذا المنُطلق يقدم هذا البحث التطبيق العملي لاستخدام مواد ZnO أوكسيد الزنك النانوية المحضرة كيميائيا من مستخلص نبات اوراق الكرفس كمادة مكونة نانوية صديقة للبيئة لسائل الحفر المائي (WBM). النتائج المختبرية أظهرت أن تأثير مواد ZnO الناونوية على كثافة الطين لها تأثير ضئيل يكاد يكون معدوم. لكن تأثيرها على الاستقرار الحراري للطين وخواص الترشيح كان فعال بصورة مدهشة حيث تم تحسين خواص طين الحفر وبتراكيز أقل من غرام واحد. حيث تم تقليل معدل فقدان سوائل ترشيح طين الحفر وبنسبة ٣٣ بالمئة وبأستخدام ٠,٤٥ غرام فقط وتم الحصول ايضا على mud cake ذات سماكة قليلة جدا. ومن ناحية الاستقرار الحراري للطين, عززت المواد النانوية بشكل كبير الخصائص الريولوجية ل WBM في درجات الحرارة العالية حيث ان معدل الزيادة في ال PV ومعدل التناقص في YP و الGel strength كان اكثر استقرار ويدل على تحكم ممتاز وفعالية عالية للمواد النانوية في طين الحفر مقارنة بطين الحفر الخالي من المواد النانوية عند درجات حرارة عالية وصلت الى ٩٠ درجة مئوية.

الكلمات الدالة: مواد اوكسيد الزنك النانوية، سوائل ترشيح طين الحفر، الاستقرار الحراري، طين الحفر المائي، خواص الريولوجيا عند درجات حرارة عالية.