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Nanoparticles as Promising Additives to improve the drilling shale of the Kafr El Sheikh Formation in Temsah Field, Mediterranean Sea, Egypt

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Abstract

The problematic shale in the Mediterranean Sea such as the Kafr El Sheikh Formation, are considered as potential source of borehole instability. This study is focused on the analysis of the conventional drilling fluids used for drilling this shale and work to change its composition to prevent or reduce the borehole instability problems. Shale cuttings were collected from four different wells in Temsah concession. These wells were evaluated using X-ray diffraction, X-ray fluorescence and cation exchange capacity using methylene blue test. Swelling index of the shale was measured using linear swell meter. Nano-particles used in this study are Al_2O_3, TiO_2, nano shield and SiO_2 as inhibitors for shale swelling. The inhibitors are added to the conventional drilling fluids instead of potassium chloride. The inhibition of swelling for these shale cuttings using 7% KCl caused a dramatic decrease in swelling percentage of shale that reached to nearly one fourth the value of the drilling fluid-free inhibitor (blank fluid). These values ranged from 72% with blank fluid to 18% (with shale Temsah NW-10 well), from 50% to 12.5% (with shale Temsah SE-01 well), from 40% to 10% (with shale Temsah -03 well) and from 47.5% to 13.5% (with shale Temsah -09 well).

Keywords: *Nanotechnology; Drilling fluids; Shale swelling; KCl; Wellbore instability.*

1. Introduction

Today, nanotechnology stands as one of the most promising avenues for oil and gas industry solutions. Recently, the use of nanotechnology in several petroleum disciplines—such as exploration, reservoir, production, completion, drilling, and refinery—has helped to overcome many challenges. The term "nanofluid" describes a very small material known as "nanoparticles," which are made of oxides, carbides, metals, and base fluids including ethylene glycol, water, and oil. The particles' approximate sizes range from 1 to 100 nanometers. Unique and unusual features of nanofluid include its high conductivity through small-medium with high mechanical strength, large surface area, compact size, environmental friendliness, and chemical and thermal stability .

Shales are low-permeability rocks having a small pore radius, certain clay minerals, and other minerals like quartz and calcite [1]. Shales make up 75% of drilled formations in oil and gas drilling engineering and are responsible for 90% of wellbore instability issues, such as narrow holes, collapses, cavings, and trapped pipes [2-5].

Zhang *et al.* [6] mentioned that oil-based and water-based fluids have been extensively used in drilling operations. These fluids are used in oil and gas well drilling operations to accomplish a variety of tasks, such as (1) maintaining fluid rheology [7-10] and (2) avoiding hydration and shale formation swelling [11-16]. Drilling requires the use of water-based drilling fluids (WBDFs), yet these fluids have drawbacks [17]. The normal recovery rate for drilling and fracturing water is just around 50% [18], which creates problems, especially when active clays are present. These clays' reactions with the retained water cause clay swelling (hydration) [19-21], which exacerbates issues with wellbore instability, clay dispersion, aquifer contamination, and solid deposition in shale formations.

The petroleum industry has disturbed for over 50 years by troublesome shale. The main reason for borehole instability is the drilling of shale Formations and the potential event is abandoned and plugged the wells after several weeks of drilling. Generally, the wellbore-stability problems increase the costs from 10 to 15% of total drilling cost. In the same time from 70 to 90% of the wellbore instabilities problems happened while drilling is as a result of shale Formations drilling [22]. The worldwide assessment for the non-productive time cost due to shale problems are from 500$ to 600$ million annually [23].

The Temsah concession which comprises the study area is located in the eastern sub-basin as shown in Fig. 1, offshore Nile Delta, Egypt and is at about 65 km north-north-west of Port Said city and covers an area of 1155 km2, with water depth ranging from 70m to 120m. Such area is situated between latitudes 31° 59' 56" N and 31° 34' 57" N and longitudes 32° 00' 05" E and 32° 18' 00" E [24].

The Kafr El-Sheikh Formation is encountered while drilling in Mediterranean Sea wells and is considered as a wellbore instability potential source. It is composed of deep marine shale with local sandstone deposits. There are many drilling problems with this shale. The improper handling including selecting the correct fluid type to drill these reactive shale has lost completely many wells. So, selecting the right fluid to drill these reactive shale is a must [25].

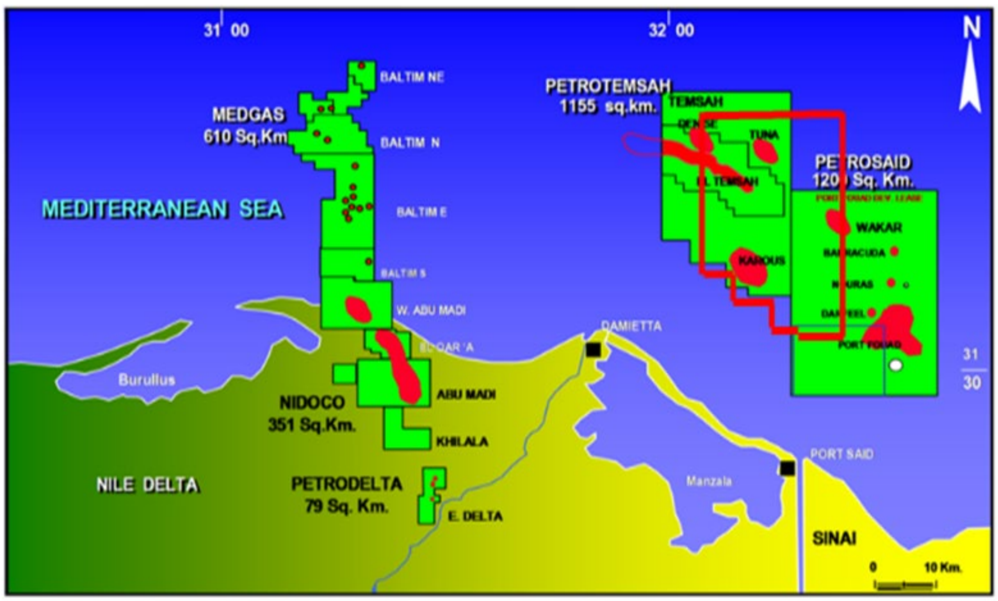

Fig. 1. Location map of the Temsah Field, adopted from Belayim Petroleum Company.

Nanotechnology involves using additives of 1–100 nm in different sciences and technologies like the drilling fluids. It plays an important role in solving some of the most common drilling problems. Nano-particles have a very high surface area to volume ratio; this will result in high reactivity and reducing the quantity desired for any applications which reduce the cost to a great extent [26].

The particle sizes of conventional mud systems additives are much larger than the pore throat sizes of the shale Formation [27]. The shale Formation with low (nano-Darcy) permeability, prevent the formation filter cake that causes the fluid invasion to the surrounding Formations [28]. The nano-particles size is less than the shale pore throat sizes to plug pore throat in shale and form an intermediate filter cake, which result in reduction of the shale permeability and decreasing the fluid invasion into the shale Formation. So, the drilling fluids with nano-materials will be more efficient to control shale problems and increase wellbore stability [27].

Based on [29], the particle sizes of the lost circulating materials in the range of 0.1 – 100 μm which will be effective to prevent the fluid loss in the porous Formation of 0.1 μm – 1 mm pore sizes. The pore throat size in shale Formations ranges from 10 nm – 0.1 µm, so the nano-materials are very suitable to enter these pore throats to plug and seal them. While the well completion, the mud cake can easily be removed by conventional cleaning methods.

There are many studies conducted on the Temsah field, Nile Delta, Egypt from many points of view, but this is the second time to perform this study on the shale/drilling fluids interaction of the Kafr El Sheikh Formation in this field. The target to design a drilling fluid system is to avoid many drilling problems and hence to reduce the drilling cost, and increases the enhanced of recovery from the reservoir.

2. Materials and experiments

All the chemical materials (bentonite, KCL, PAC LV, Barazan D Plus, Duo Vis, and Barite) used for this research are from MI-Schlumberger and Halliburton-Baroid except the nano-materials (aluminum oxide (Al_2O_3), silica oxide (SiO_2) and titanium dioxide (TiO_2)) which were sourced from MKnano Company (6382 Lisgar Drive, Missisauga, ON L5N 6X, Canada). But the Nanoshield was supplied by Baker Hughes Co. For the shale samples, the source is Belayim Petroleum Co. in Egypt.

2.1. Characterization of shale samples

2.1.1. Mineralogical analysis

The shale samples were depicted using (XRD) for bulk samples to identify the clay minerals and associated ones.

2.1.2. Chemo-physical analysis

The reactive clays (bentonite and/or drilled solids) present in a drilling fluid and the total cation-exchange capacity (CEC) of these solids can be determined by this test.
The CEC can be calculated by Eq. (1):

$$CEC\ (meq/100g) = \frac{Methylene\ Blue\ (mls)}{Weight\ of\ shale\ sample\ (g)} \quad (1)$$

The chemical composition of the four wells are studied by using Wavelength Dispersive X-Ray Fluorescence Spectrometry (XRF).

2.1.3. Preparation of blank drilling fluid

All the blank samples of drilling fluid (polymer mud is the blank mud) are based on the formulation of 350 mL (350 mL is equivalent to 1 bbl in laboratory test) of the fresh water. Then while being stirred at 11000 RPM by a commercial Hamilton Beach mixer then 10g of bentonite was added while being stirred for 20 minutes to provide primary viscosity and using xanthan gum to adjust the viscosity and suspension characteristics for weighting materials of the base fluid. This mixture was mixed using Hamilton Beach mixer for 30 min. The drilling fluids were made up in accordance with the formulas shown in Table 1.

Table 1. Barrel formulation of water base mud without nano-materials.

Product name	Concentration (Ib/bbl) - gm	Density (ppg)	Volume (mL)
Water		8.30	349.38
Barite	245.2	35	0.17
PAC Low Vis	4	1.5	0.06
Nano-material	0	1.5	0.00
Potassium chloride	24.5	2.0	0.29
Barazan D Plus/Duo Vis	0.15	1.5	0.00
Soda ash	0.5	20.9	0.00
Caustic soda	0.5	17.8	0.00
Bentonite	10	20.8	0.10
One lab. bbl			350

2.1.4. Nano-materials water-base drilling fluids preparation

By using the blank drilling fluid sample (without KCl) and replacing the KCl with different concentrations (0.15 ppb, 0.35 ppb, 0.55 ppb, 0.75 ppb, 1.00 ppb, 1.50 ppb, 2.00 ppb, 2.50 ppb) from each kind of nano-particles (aluminum oxide, silica oxide, titanium dioxide, and nano shield). All the samples at pH of around 9.5, KCl and nano-materials concentrations were selected randomly.

3. Results and discussion

The rheological properties, API fluid loss and mud weight were measured to the blank fluid, fluid mixed with KCl, and the fluid loaded by different concentrations of each type of nano-particles.

3.1. X-Ray diffraction (XRD) of shale samples

Sample of Temsah SE-01 well has the highest clay content. Barite does not affect cation exchange capacity (CEC) but the smectite in the clay does. It is shown that the sample of Temsah SE-01 well has high value of CEC. Sample of well Temsah -03 well has the highest concentration of barite. This concentration of barite is related to the drilling fluid in the hole while drilling.

The sharp peaks in the pattern belong to quartz and feldspars. The asymmetric broad peak at ~20° two-theta and the peak at ~62° two-theta are evidence of clay minerals. Kaolinite can be identified by its peak at ~12° two-theta (d-space=7.16Å) and the peaks in the interval between 200 and 25° two-theta. Weak broad peaks at ~6° (13°) and ~10° (10 Å) indicate the presence of illite and expandable minerals like smectite and/or mixed layer smectite-illite as shown in Fig. 2. The composition of shale sample of well of Temsah -03 is similar to sample of well Temsah -09 but the peaks of barite are more intense, indicating a large fraction of this mineral. Clay peaks are less intense, suggesting that clays are less abundant than in sample of Temsah -09 as shown in Fig. 3.

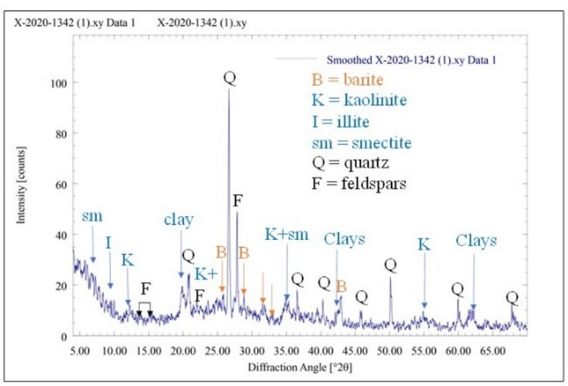

Fig. 2. X-ray diffractogram of shale sample of well Temsah -03 well.

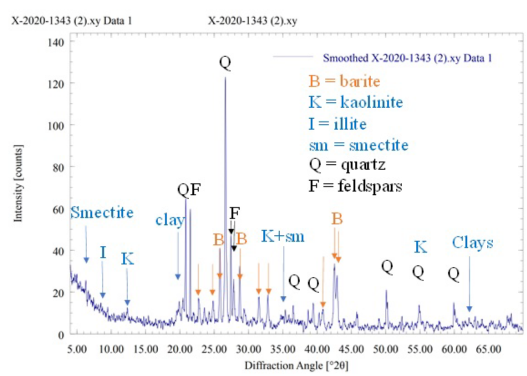

Fig. 3. X-ray diffractogram of shale sample of well Temsah -09 well.

The composition of shale sample of well Temsah NW-10 is in between well Temsah -09 and well Temsah -03. Barite peaks are less intense than in well Temsah -09 but more intense than in well Temsah -03. Clay content also seems intermediate between well Temsah -09 and well Temsah -03. Pyrite may be present, but because of overlapping and low peak intensity cannot be confirmed as shown in Fig. 4.

Shale sample of Temsah SE-01 well has a much larger fraction of clay minerals than shale samples of Temsah -09, Temsah -03 wells and well Temsah NW-10. Particularly, smectite, illite and possibly mixed layer are more abundant. This is an evident from the smectite peak at ~ 6 degrees two-theta and the more pronounced asymmetric peak at about ~20 degrees two-theta. Other clay peaks are also more intense. Barite is present, roughly in similar concentration as in well Temsah NW-10 well, shown in Fig. 5.

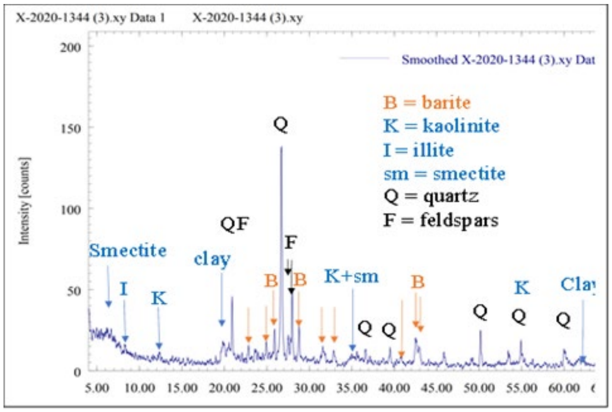

Fig. 4. X-ray diffractogram of shale sample of well Temsah NW-10 well

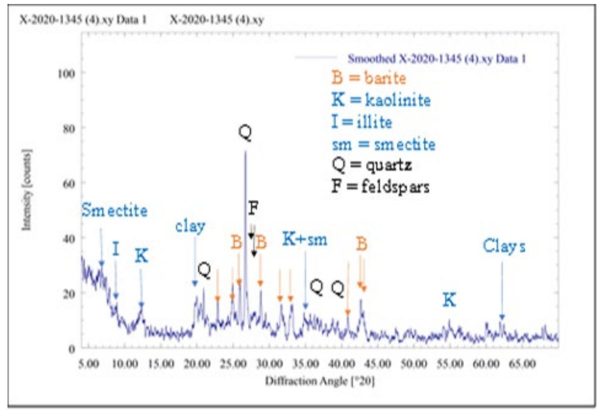

Fig. 5. X-ray diffractogram of shale sample of Temsah SE-01 well.

Another quantitative analysis was done on the Kafr Elsheikh shale to identify the clay minerals percentages (clay fraction <2μm). Identification of clay minerals was based upon X-ray diffraction of < 2μm fraction as shown in Table 2 [25].

3.2. Cation exchange capacity

According to [30] the CEC value that was determined by equation (1). The cation exchange capacity of the studied samples is collected in Table 3.

3.3. Chemical analysis

Table 4 show the chemical composition of the minerals that are present in studied wells using elemental analysis by Wavelength Dispersive X-Ray Fluorescence Spectrometry (XRF).

Table 2. XRD semi-quantitative analysis for the Kafr El Sheikh Formation shales [10].

Quartz, wt%	11	Barite, wt%	4
Potassium feldspar, wt%.	-	Smectite, wt%	52
Plagioclase feldspar, wt%	5	Illite, wt%	11
Calcite, wt%	-	Kaolin, wt%	13
Siderite, wt%	-	Chlorite, wt%	1
Sylvite, wt%	3	CEC, meq/100g	32

Table 3. Cation exchange capacity of studied samples.

Well name	CEC, (Meq/100g)
Temsah SE-01	25
Temsah -03	10
Temsah NW-10	25
Temsah -09	12

3.4. Rheological properties measurement

The rheological properties such as apparent viscosity, plastic viscosity, yield point and gel strength were measured using Fann viscometer according to API specifications at 120°F.

Table 4. Chemical analysis results for shale samples (XRF).

Constituents wt %	Temsah SE-01	Temsah -03	Temsah -09	Temsah NW-10
SiO_2	27.20	36.10	39.60	39.60
TiO_2	2.03	1.60	1.99	1.95
Al_2O_3	11.90	9.43	13.30	12.30
Fe_2O_3 tot.	23.50	11.80	15.50	15.20
MgO	1.35	1.53	1.89	1.56
CaO	4.90	5.91	3.76	3.57
Na_2O	0.871	1.86	1.01	0.927
K_2O	1.97	1.90	1.78	1.83
P_2O_5	0.291	0.170	0.272	0.235
MnO	0.228	0.113	0.168	0.163
Cl	0.340	1.92	0.243	0.236
Ba	0.053	0.490	0.375	0.666
L.O.I	19.50	19.80	18.30	19.90
Traces ppm				
S	11900	16600	5940	6060
Cr		262	227	270
V	....	....	92	...
Ni	148	42	128	133
Cu	114	227	123	96
Sr	834	634	368	463
Zn	379	204	223	214
Zr	605	854	521	584
Br	3310	35	577	169
Ru	805	750	615	810
Rh	5320	4450	3860	4610
Rb	....	64	44	96
Ag	....	855	770	988
I	530	....	304	448
Co	....	52	18	87
Ga	72	....	48	52

Adding 7% KCl on the blank fluid caused a progressive reduction in rheological properties as shown in Table 5.

Table 5. Rheological results of the blank fluid and KCl base mud.

	Apparent viscosity, cP	Plastic viscosity, cP	Yield point	Gel strength 10″	Gel strength 10′	YP/PV ratio
Blank fluid	54	39	30	6	12	0.77
7% KCl	29.5	25	9	3	5	0.36

The apparent viscosity was decreased from 54cP (in blank fluid) to 51cp, the plastic viscosity decreased from 39cP to 25cP, the 10-second and 10-minute gel strength values decreased from 6 to 3 Ib/100ft^2 and from 12 to 5 Ib/100 ft^2 respectively, the yield point also decreased from 30 Ib/100 ft^2 to 9 Ib/100 ft^2 and YP/PV ratio decreased from 0.77 Ib/100ft^2/cp to 0.36 Ib/100ft^2/cP. The rheological results of the nano shield base mud are illustrated in Table 6.

Table 6. Rheological results of the nanoshield base mud.

Nanoshield concentration	Apparent viscosity, cP	Plastic viscosity, cP	Yield point	Gel strength 10″	Gel strength 10′	YP/PV ratio
0.15	55	40	30	8	16	0.75
0.35	56	41	30	8	16	0.73
0.5	56.5	41	31	6	14	0.76
0.75	60	43	34	6	14	0.79
1	56.5	42	29	5	13	0.69
1.5	61	43	36	5	13	0.84
2	56	41	28	5	13	0.68
2.5	62	43	38	5	13	0.88

3.4.1. Effects of nano-particles on the apparent viscosity

The relationship of apparent viscosity with the nano-particles concentrations is not linear, where it increases with some doses of Al_2O_3, TiO_2, nano shield and SiO_2 and decreases with others as shown in Table 7.

Table 7. Apparent viscosity (cP) variation versus different concentrations of nano-materials.

Concentration	SiO_2	Nanoshield	TiO_2	Al_2O_3
0.15	46.5	55	40	51.5
0.35	46.5	56	38	51.5
0.5	48.5	56.5	38	50
0.75	59	60	38.5	48.5
1	50	56.5	38.5	49
1.5	61	61	38.5	48.5
2	53	55	38.5	48
2.5	64	62	39	71.5

3.4.2. Effects of nano-particles on plastic viscosity

The plastic viscosity of the blank fluid is reduced by using 7% KCl from 39cp to 25cP. The behavior of PV with the different concentrations of nano-particles is illustrated Fig. 6 and Table 8.

Table 8. Plastic viscosity(cP) variation at different concentrations of nano-materials.

Concentration	SiO_2	Nanoshield	TiO_2	Al_2O_3
0.15	25	30	28	27
0.35	27	30	26	27
0.5	29	31	24	28
0.75	30	34	23	27
1	30	29	23	28
1.5	32	36	23	29
2	32	38	21	28
2.5	36	38	20	47

3.4.3. Effects of nano-particles on yield point

The yield point of the blank fluid is reduced by the addition of 7% KCl from 30 Ib/100 ft^2 to 9 Ib/100 ft^2. This is not desirable behavior for the drilling fluids. As shown in Fig. 7 and Table 9, the YP values differ in its behavior with each concentration of nano-particle.

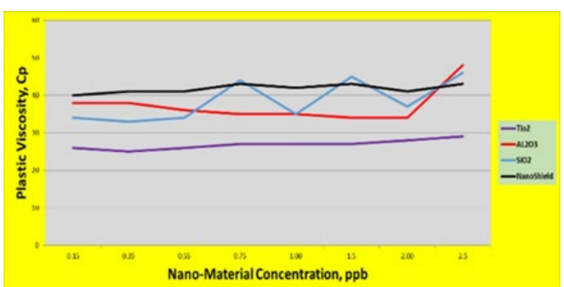

Fig. 6. Plastic viscosity variation with different types of nano-particles.

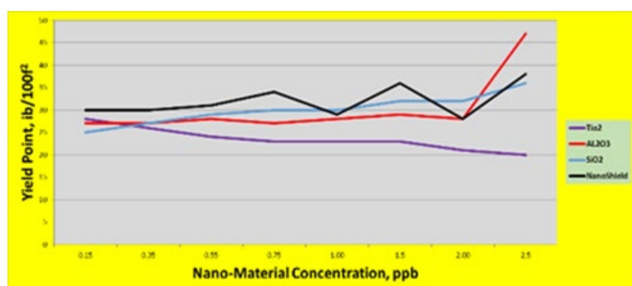

Fig. 7. Yield Point variation with different types of nano-particles concentrations.

Table 9. Yield point variation versus different concentrations of nano-materials.

Concentration	SiO_2	Nanoshield	TiO_2	Al_2O_3
0.15	34	40	26	38
0.35	33	41	25	38
0.5	34	41	26	36
0.75	34	43	27	35
1	35	42	27	35
1.5	45	43	27	34
2	37	41	28	34
2.5	46	43	29	48

3.4.4. Effects of nano-particles on gel strength

The 10-second and 10-minute gel strength values for the blank fluid are reduced after the addition of 7% KCl from 6 to 3 Ib/100ft^2 and from 12 to 5 Ib/100 ft^2 respectively. From the drilling operation point of view, this is not desirable to decrease the gel strength too much. Like Nanoshield, the TiO_2 does not affect the gel strength values. Table 10)collects all the gel strength readings against different concentrations from all the nanoparticles used.

Table 10. Gel strength variation at different concentrations of nano-materials

Concentration	SiO_2		Nanoshield		TiO_2		Al_2O_3	
	10″	10′	10″	10′	10″	10′	10″	10′
0.15	6	9	8	8	5	10	5	14
0.35	6	9	8	8	5	10	5	16
0.5	6	9	6	6	6	11	5	16
0.75	6	9	6	6	5	11	5	16
1	6	9	5	5	5	11	5	16
1.5	6	9	5	5	5	11	5	16
2	6	9	5	5	5	11	5	17
2.5	6	9	5	5	5	10	5	17

3.4.5. Effects of nano-particles on yield point – plastic viscosity (YP/PV) ratio

The YP/PV ratio for the blank fluid was 0.77 Ib/100ft^2/cp and after the addition of KCl become 0.36 Ib/100ft2/cp. Table 11 show the YP/PV ratio readings against different concentrations from all the nanoparticles used.

Table 11. YP/PV ratio at different concentrations of nano-materials.

Concentration	SiO_2	Nano shield	TiO_2	Al_2O_3
0.15	0.74	0.75	1.08	0.71
0.35	0.82	0.73	1.04	0.71
0.5	0.85	0.76	0.92	0.78
0.75	0.68	0.79	0.85	0.77
1	0.86	0.69	0.85	0.80
1.5	0.71	0.84	0.85	0.85
2	0.86	0.68	0.75	0.82
2.5	0.78	0.88	0.69	0.98

3.4.6. API fluid loss measurement

The fluid loss volume of the drilling fluid was subjected to a pressure of 100 psi and 80 F^0 for 30 mins through low-pressure filter press equipment and the filtrate was collected in a measuring cylinder. Filtrate loss of blank fluid increased with using 7% KCl from 4cc/30min to 7.5cc/30min so, it is considered from the side effects of using the KCl in drilling fluids to check the rheology and fluid loss properties after its addition.
Table 12 and Fig. 8, explain the results of mixing the different types of nanoparticles with different concentrations.

Table 12. The filtration volume (mL/30 min) variation at different concentrations of nano-materials.

Concentration	SiO_2	Nano shield	TiO_2	Al_2O_3	Blank	7% KCl
0.15	3.6	3.4	4	4.2	4	7.5
0.35	3.5	3.4	4.2	4	4	7.5
0.5	3.2	3.4	4.4	3.8	4	7.5
0.75	3.5	3.5	4.5	4	4	7.5
1	3	3.6	4.6	3.8	4	7.5
1.5	3.8	3.8	4.7	3.6	4	7.5
2	2.7	3.6	4.8	3.6	4	7.5
2.5	4	4	5	4.2	4	7.5

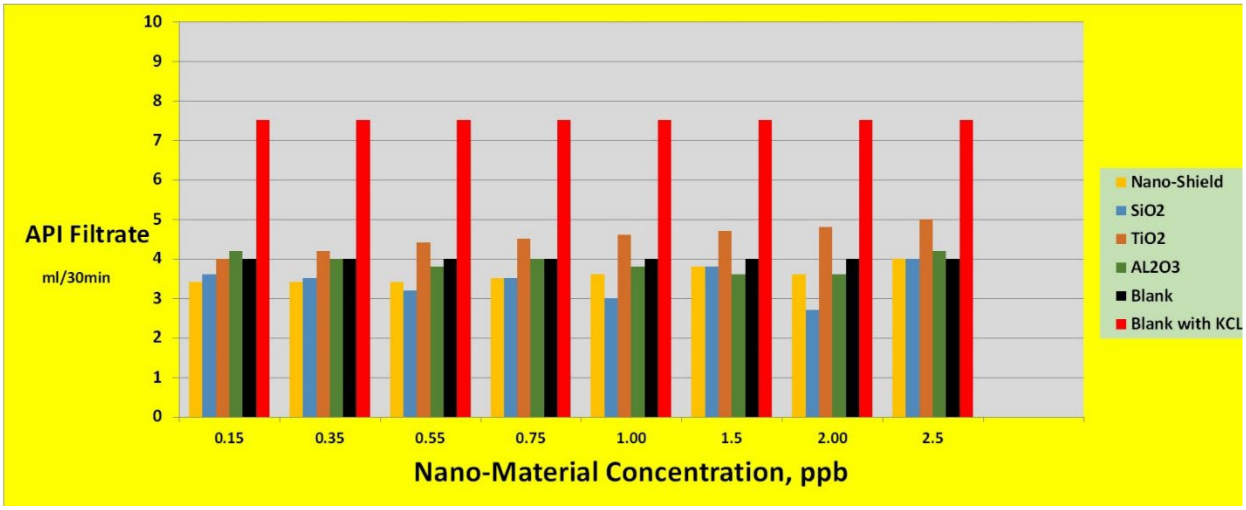

Fig. 8. The filtration volume variation with different types of nano-particles.

3.4.7. Effects of nano-particles on mud weight and pH

The mud weight remains almost constant with all the blends. The addition of nano-particles does not significantly increase the mud weight.

3.4.8. Effects of nano-particles on drilling fluids/shale interaction

The Linear Swelling Meter test (LSM) was conducted to compare the swelling degree differences for different shale samples after contact with various kinds of solutions for 72 hours. These solutions are blank fluid, blank fluid plus 7% potassium chloride which forms the conventional drilling fluid system used in this area by Belayim Petroleum Co., and blank fluid plus kind of nano-materials with different concentrations.

3.4.9. Effect of potassium chloride and nano-particles on shale swelling

Effect of KCl at 7% concentration as an additive to the blank fluid on swelling of shale samples of Temsah -03, Temsah -09, Temsah SE01 and Temsah NW-10 is shown in Table 13, Figs. 9, 10, 11, and 15. It is clear that 7% KCl is an optimum dose for inhibition swelling of shale.

Table 13. The effect of KCl on different shale samples versus blank fluid.

	Temsah-03	Temsah-09	Temsah SE-01	Temsah NW-10
Blank fluid	40	47.5	50	72
7% KCl	10	13.5	12.5	18

Fig. 9 show the effect of silica nano-particles SiO_2 as a shale swelling inhibitor for Temsah -09 shales. The effect of titanium oxide Temsah NW-10 shales is sown in Fig. 11 and Fig. 12. Fig. 13 represents a comparison between the effect of using 1.5ppb of titanium dioxide, aluminum oxide and silica oxide on shale of Temsah NW-10 well. It was found that the Al_2O_3 was more effective in minimizing the swelling percentage. The Swelling behavior of Temasah SE-01 shales was tested with aluminum oxide (Al_2O_3) as shown in Figs. 14 and 15.

Using different concentrations of nano-particles (Al_2O_3, TiO_2, nano shield and SiO_2) ranged from 0.15 up to 2.5 pound per barrel (ppb) caused more or less changes in rheological values of the blank fluid. Generally, the rheological properties are stable. Adding 7% KCl caused an increase in API fluid loss from 4 cc/30min to 7.5 cc/30min and this is considered as a negative effect for using KCl. The optimum concentration from SiO_2 with API fluid loss was 2ppb, from Nano shield were 0.15ppb, 0.35ppb and 0.55ppb, from TiO_2 was 0.15ppb and Al_2O_3 were 1.5ppb and 2.00ppb. Adding 7% KCl to blank drilling fluid achieved a very good impact on decreasing the swelling value from 72% with the blank fluid to 18% (shale Temsah NW-10) with a decreasing percent (-75%), from 50% to 12.5% (shale Temsah SE-01) with a decreasing percent (-75%), from 40% to 10% (shale Temsah -03) with a decreasing percent (-75%) and from 47.5% to 13.5% (shale Temsah -09) with a decreasing percent (-71.6%).

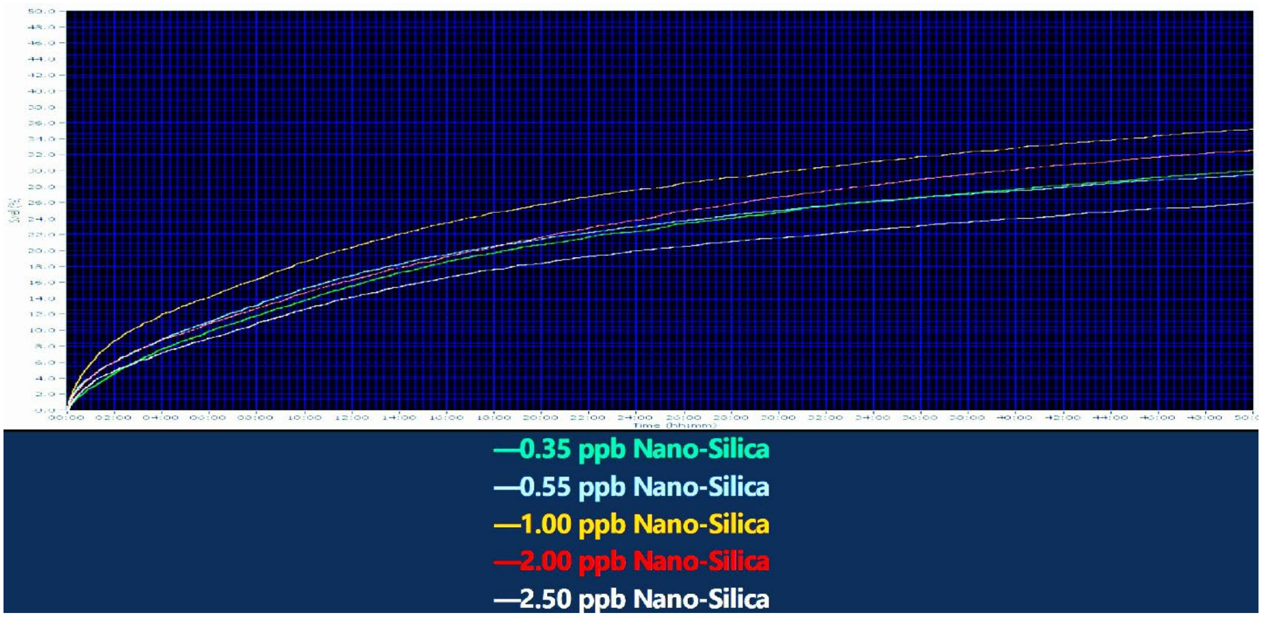

Fig. 9. The effect of KCl and SiO_2 on shale Temsah -09 well.

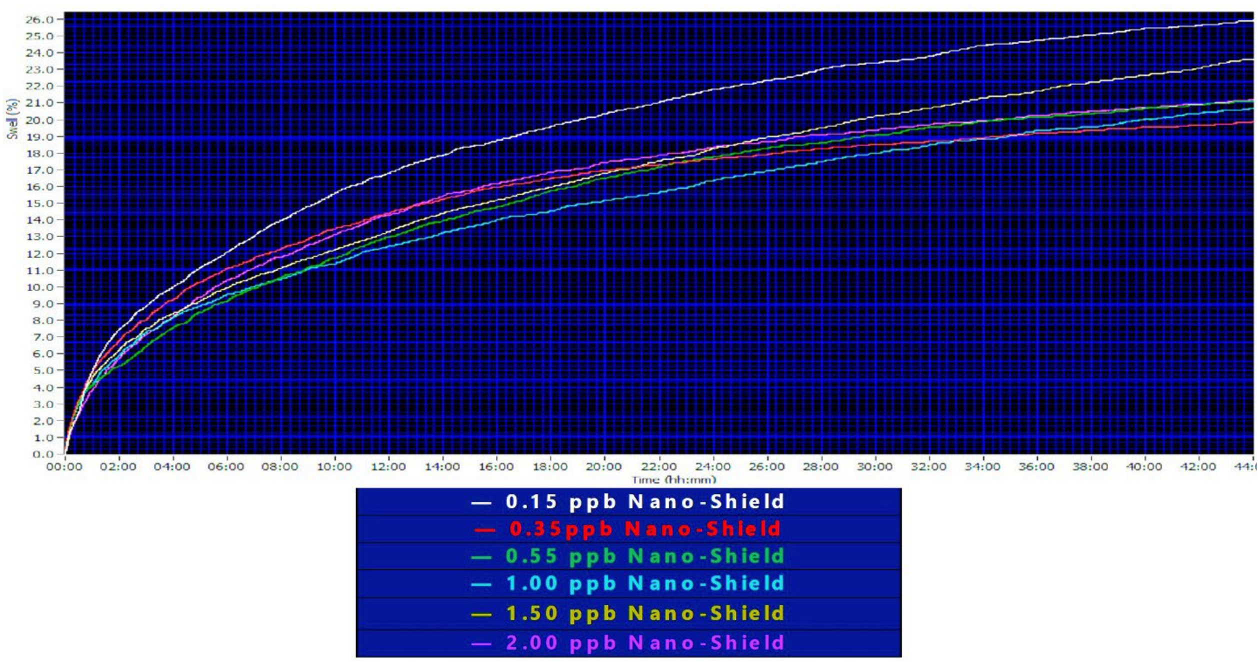

Fig. 10. The effect of KCl and Nanoshield on shale Temsah -03 well.

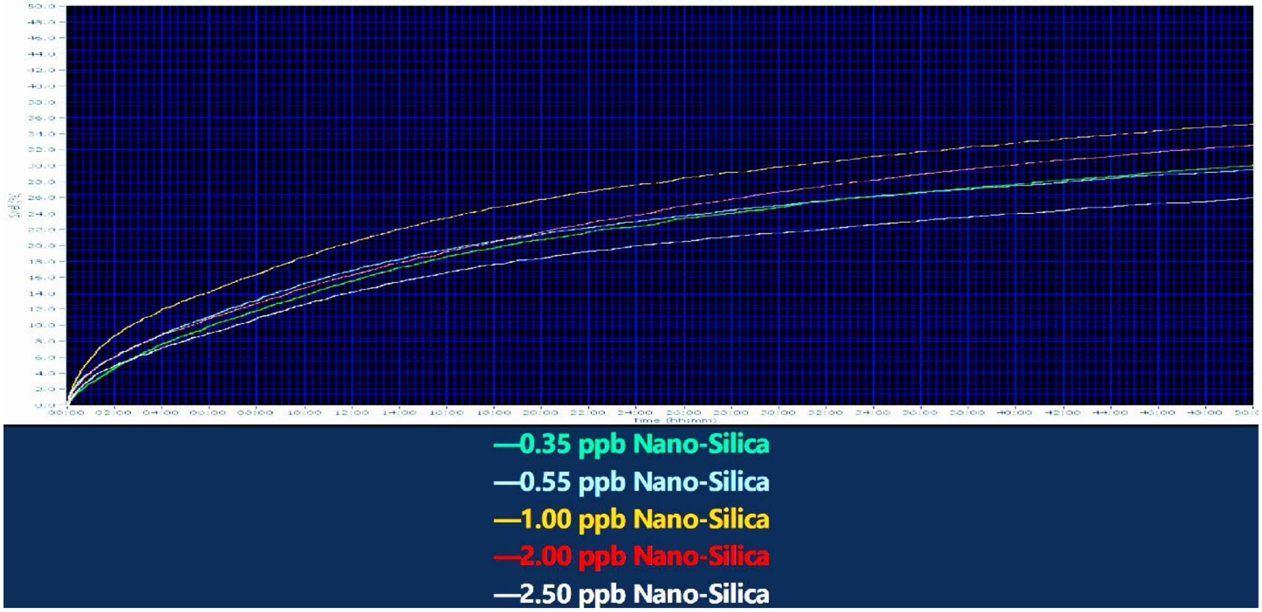

Fig. 11. The effect of KCl and titanium oxide on shale Temsah NW-10 well.

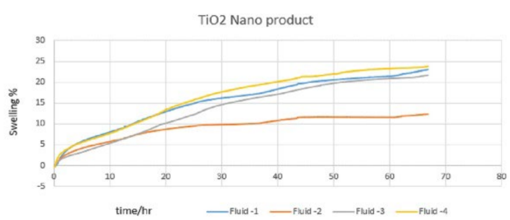

Fig. 12. The effect of TiO_2 (0.15ppb and 0.35ppb) on shale Temsah NW-10 well.

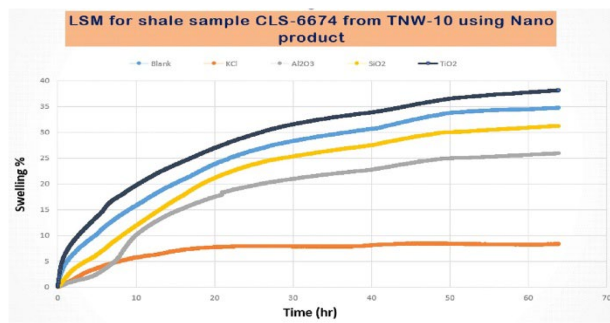

Fig. 13. The effect of 1.5ppb from TiO_2, SiO_2 oxide and Al_2O^3 on shale Temsah NW-10 well.

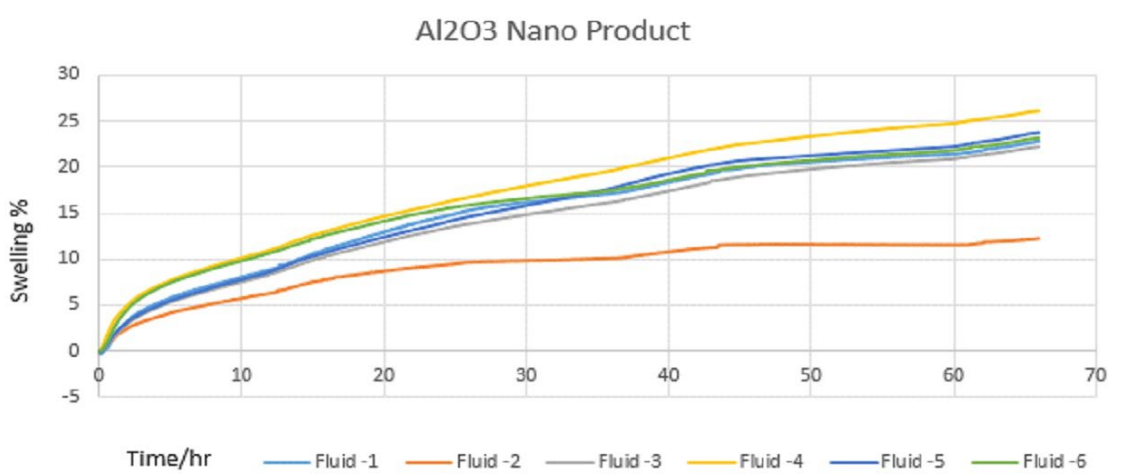

Fig. 14. The effect of Al_2O_3 (0.15ppb, 0.35ppb, 0.55ppb and 0.75ppb) on shale Temsah SE-01 well.

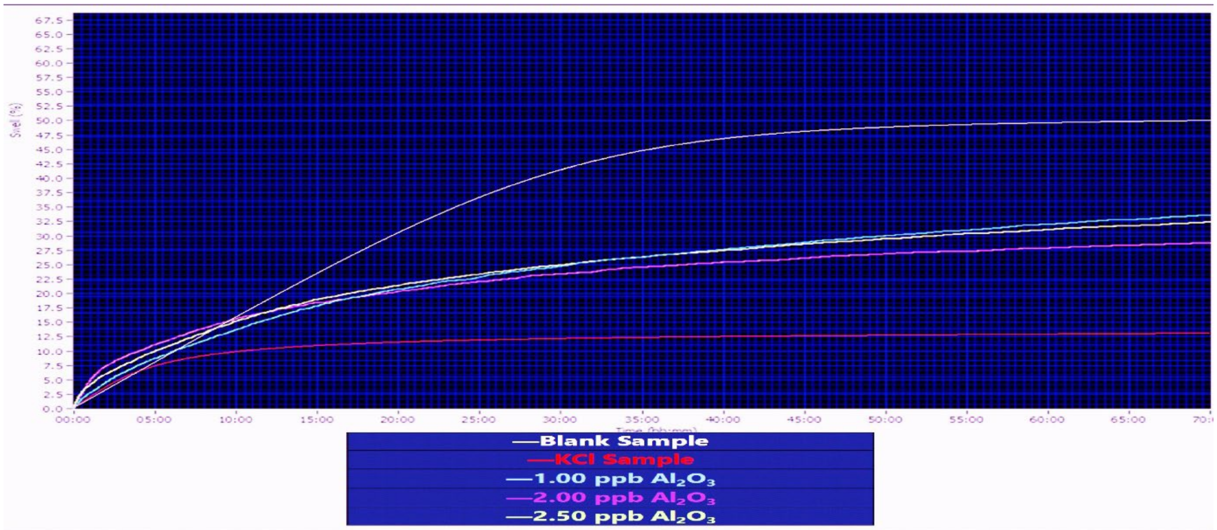

Fig. 15. The effect of KCl and Al_2O_3 (1.00ppb, 2.00ppb and 2.50ppb) on shale Temsah SE-01 well.

4. Conclusions

The experimental work showed that the KCl decreased the rheological properties of the blank fluid in comparison to nano shield which will lead to more treatment with drilling fluids chemicals to adjust the mud properties to be suitable for the drilling operations (more cost). Also, it is found that the KCl increased the fluid loss volume of the blank fluid. It is considered from the side effects of using the KCl in drilling fluids to check the rheology and fluid loss properties carefully before drilling process.

By comparing the results of the four nano-particles, it was found that the TiO_2 was more effective in minimizing the swelling percentage (69.58% with 0.15ppb) followed by Al_2O_3 (57% with 0.15g), nano shield (50.50% with 0.35g) and SiO_2 (45.50% with 2.5g), so the order of effectiveness is:TiO_2 > Al_2O_3 > nanoshield > SiO_2.

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Symbols

API	*American Petroleum Institute*
CEC	*Cation exchange capacity*
cP	*Centipoise*
^{o}F	*Degree Fahrenheit*
G	*Gram*
Ib/bbl	*Pound per barrel (ppb)*
KCl	*Potassium chloride*
Meq/100g	*Mill-equivalents of methylene blue per 100 g of dry clay*
nm	*Nanometer*
Nano	*One nanometer is equivalent to a billionth of a meter (10^{-9})*
Nanoshield	*Synthetic polymer*

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