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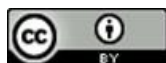
Utilizing Nanotechnology to Solve Drilling Problems in Iraqi Oil Fields

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Abstract

Nanotechnology is a recent technology which is used in all industry sectors. In the oil and gas industry, this technology is commonly used due to its importance in solving the problems encountered while drilling operations and production stages. Nanotechnology can be used to improve the drilling process by adding nano-materials to drilling fluids in order to reduce drilling problems. This research is extended to previous research that published in journal of petroleum research and studies to compared the effect of nano-materials [Commercial nano-materials Multi Walled Carbone Nano Tube (MWCNT) and nano silicon oxide (SiO₂) with nano-silica (rice husks, that prepared in PRDC labs) on water base drilling mud properties].

All characterization tests were achieved by the Nanotechnology and advanced materials researches center it is belongs to the University of Technology. The investigated properties of drilling mud included rheological properties and filtration. All tests are conducted according to API specifications (American Petroleum Institute).

The results show an improvement in the rheological properties (plastic viscosity, yield point, apparent viscosity and gel strength) and filtration after adding the commercial MWCNT, nano silicon dioxide(SiO₂) and the prepared nano-silica (rice husks) to the water based mud. The results of plastic viscosity of MWCNT, SiO₂ and nano silica(rice husks) are 12,20,8 cp after adding 0.7 gm to the water base mud while the amount of filter is 11.8 ml after adding nano particle size of MWCNT , nanoSiO₂ and 11.6 after adding nano silica(rice husks). The prepared nano silica (rice husks) gave results similar to the results of the commercial nano silicon dioxide (SiO₂). Therefore, using of nano silica (rice husks) can be cost effective due to producing these materials locally instead of using the commercial nano SiO₂.

Keywords: nano-materials, drilling mud, MWCNT, SiO₂, nano-silica (rice husks).

1. Introduction

1.1 Drilling Fluids

Drilling fluid a heavy and viscous fluid mixture that is used in drilling operations to carry rock cuttings to the surface, controlling pressure, stabilizing exposed rock, providing buoyancy and to lubricate and cool the drill bit.

1.2 Effects of Nano Particles on Drilling Fluids

Nano-fluids can be designed by adding nano-sized particles in low volumetric fractions to a fluid. The nano-particles can be improving the rheological properties, thermal and mechanical properties [2] .There is some applications of nanotechnology in drilling fluids:

1.2.1 Rheological Properties

Rheology is a part of science of deformation and matter flow. It can help to understand and explain the behavior of the fluids under a verity of conditions temperature, external forces and pressure. Rheology is important parameter of drilling-fluid performance. Modification of drilling fluid rheology can be a solution key to many drilling problems like loss circulation, pipe sticking and formation damage. Most of the drilling fluids behave as non-Newtonian fluids(fluid flows as a liquid and under other conditions, it exhibits plasticity, elasticity and strength similar to a solid), time dependent known as shear thinning or pseudo plastic behavior, in which the fluid viscosity decreases with increasing shear.

Using nanoparticles to improve the performance of drilling fluids is a recent development [3].

1.2.2 Wellbore Stability and Fluid Loss Control

The filter cake developed during the nano-particles based drilling fluid filtration is very thin, for reducing formation damage and differential pressure sticking problem while drilling operation. Nano-particles can be added to the drilling fluid to minimize shale permeability through plugging the nanometer-sized pores and shut off water loss [2].

1.2.3 Torque and Drag:

Because of nanomaterials can form thin films and fine, nanoparticle can reduce the frictional resistance between the pipe and the borehole wall after adding to the drilling

fluids by forming a continuous thin films to lubricate at the wall/pipe interface. Nanoparticle-based fluids could be useful in reducing the torque and drag problems in horizontal, multilateral, and coiled-tubing drilling.

1.3 The Aim of the study

The aim of this study is to examine the effect of nano-material by adding it to water based drilling mud and the performance of this nanomaterial on the filter loss and rheological properties of water based drilling mud.

2. Theoretical Background

The drilling fluid is related either directly or indirectly to almost every drilling problem. Selection and application of the drilling fluid are key factors in success of drilling operation. All drilling fluids can have a wide range of chemical and physical properties. These properties are specifically designed for drilling conditions and the special problems that must be handled in drilling a well [4].

2.1 Nano-Materials

Good formulations of drilling fluid properties are required in the drilling operations. Choosing of suitable drilling fluid additives are important in performing of drilling fluid. The nano-materials are selected due to its extremely high surface area to volume ratio and high thermal conductivity. This research focuses on use of nanosilicon materials, nano silica (rice husks) and the multi-walled carbon nanotubes (MWCNT) to investigate the effect of these nano-additives on filter loss and rheological properties of water based drilling mud. Nano-materials are considered the most promising material for smart fluid design due to different and highly enhanced physio-chemical, electrical, mechanical, thermal, properties and interaction potential of nano-materials compared to other materials. Physically, particle size of nano has a dimension that is thousand millionths of a meter. Hundred nanometer fibers or particles have diameters that are about 800 to 1000 times smaller than the diameter of a human hair [5]. Based on the number of particle size additives in the fluid, these fluids can be classified as simple and advanced nano-fluids. Nano-fluids with one nano of sized additive are defined as simple nano-fluids; nano-fluids with more than one nano-sized additive are classified as advanced nano-fluids. A nano-material could be single or multifunctional. A

multifunctional nano-additive can perform several jobs in the fluids systems to complete the functional tasks of the fluid with a reduction in total solids and/or chemical content of a mud and also the overall fluid cost. The natures of a nano-material have a very high specific surface area with enormous area interactions just require very low concentration of a nano-material to provide good enhancement in fluid properties [6].

The following nano-materials were used in this research:

2.2.1 Multi-walled nanotube (MWNT)

MWNT consist of multiple rolled layers of grapheme [7]. There are two models to describe the structures of MWNT. Russian Doll model, sheets of graphite are arranged in concentric cylinders and Parchment model, a single sheet of graphite is rolled in around itself.

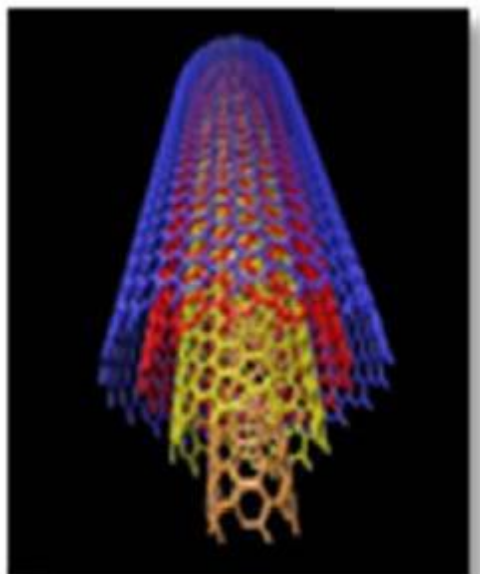


Fig. (1) Multi-walled nanotubes (MWNTs)

2.2.2 NanoSilicon

Silicon dioxide nano-particles are the basis for a great deal of biomedical research due to their low toxicity, stability and ability to be functionalized with a range of molecules and polymers. Nano-silicon properties can be categorized as follows:

2.2.2.A Physical properties: Silicon dioxide nano-particles appear as a white powder. Molar mass is 59.96 g/mol and density is 2.4 g/cm³ and

2.2.2.B Chemical properties: silicon dioxide are Chemical symbol SiO₂, Group (Silicon 14, Oxygen 16)

2.2.2.C Thermal properties: boiling point 2230°C, and Melting Point 59.96 g/mol of nano silicon dioxide [8]. In this research, two types of nano-silica were used as follows:

2. Nano Silica (Rice).
3. Silicon Dioxide (SiO₂).

3. Apparatus and Experimental Work

many tests carried out in laboratory to investigate the effect of adding nano-materials on the rheological properties and filter loss of drilling fluids.

3.1 The Laboratory Apparatus

Many of apparatus are used such as Viscometer (model 800), mud balance, low pressure filter loss and pH meter.

3.2 Materials

A brief description of additives and chemicals that used in our research is listed below:

3.2.2 Bentonite

It is considered the most widely additive that use in the drilling fluids. Bentonite is consisting from fine-grained clays that contain not less than 85% Montmorillonite. Bentonite is classified as sodium or calcium bentonite, depending on the exchangeable cation. In fresh water, sodium bentonite is more reactive than calcium bentonite [10].

3.2.3 Caustic Soda or Sodium Hydroxide (NaOH)

It is used to raise pH in water based drilling fluid, to solubilize Lignite, Lignosulfonate and tannin materials, to neutralize Hydrogen Sulfide and to counteract corrosion

3.2.4 MWCNTs

It is used to enhance of rheological properties in water-based drilling fluid. This material is commercial and its specification satisfies the nano-material properties

3.2.5 Silicon Dioxide (SiO₂)

It is a powder that used to improve the rheological properties and filter loss with OD >40nm. SiO₂ is commercial and its specification satisfy nano-material properties.

3.2.6.1 Chemical Preparation of Nano-silica (rice husks)

The procedure of preparing the nano-silica (rice husks) as follows:

- 1- The rice husk soaked in distilled water overnight and washed thoroughly with distilled water to dry overnight in an oven at 90°C.
- 2- The dried rice husk was treated with 1N solution of HCl at 75°C for 1 hour in a hot water bath to remove impurities.
- 3- The suspension was filtered and the solid residue washed thoroughly several times by distilled water to remove the metallic ions.
- 4- Dried the rice husk again overnight at 90°C in an oven.
- 5- 40 g of rice husk immersed in 600 ml of sodium hydroxide solution and heated in a water bath for 1 hr at 90°C to extract silica from rice husk.
- 6- A resultant sodium silicate solution was obtained after filtering the rice husk.
- 7- In the precipitation process nitric acid was added until pH of sodium silicate solution drop to 8 and further stirred another 45 minutes.
- 8- Sodium silicate solution transferred to centrifuge tubes and centrifuge for 5 minutes at 4000 rpm, this operation is repeated until get whitish particles.
- 9- The particles were collect from all centrifuge tubes and placed in a bowl then heated at 600 oC for 30 min in a furnace.

Figure (2) shows the flow chart of preparation steps.

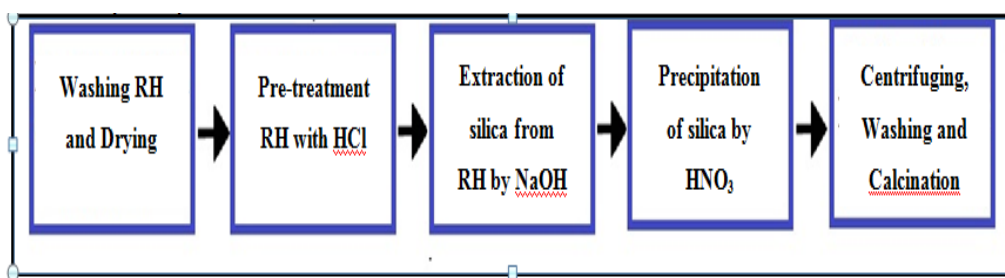


Fig. (2) Preparation steps of nano-silica (rice husks)

3.2.6.2 Characterization of Produced Nano-Silica

3.2.6.2a Results of XRD

Many tests such as XRD were achieved to determine the properties and the crystal composition of the produced nano-silica. This technique depends on monitoring of the scattering X-ray beam that falls on the sample to deviate towards different directions. Figure (3) shows the test of XRD of the prepared nano-material by the chemical method.

All characterization tests were achieved by the Nanotechnology and advanced materials researches centre which belongs to the University of Technology.

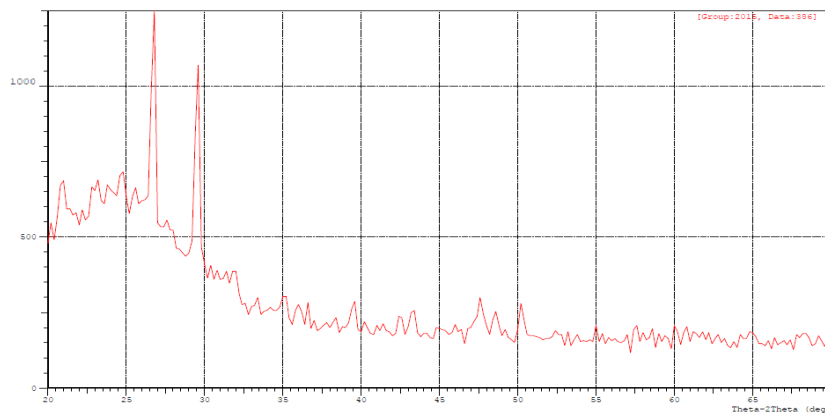


Fig. (3) XRD nano-silica

3.2.6.2b Results of Scanner Electronic Microscope (SEM)

SEM test has been achieved to determine the surface type, form and size of the prepared material.

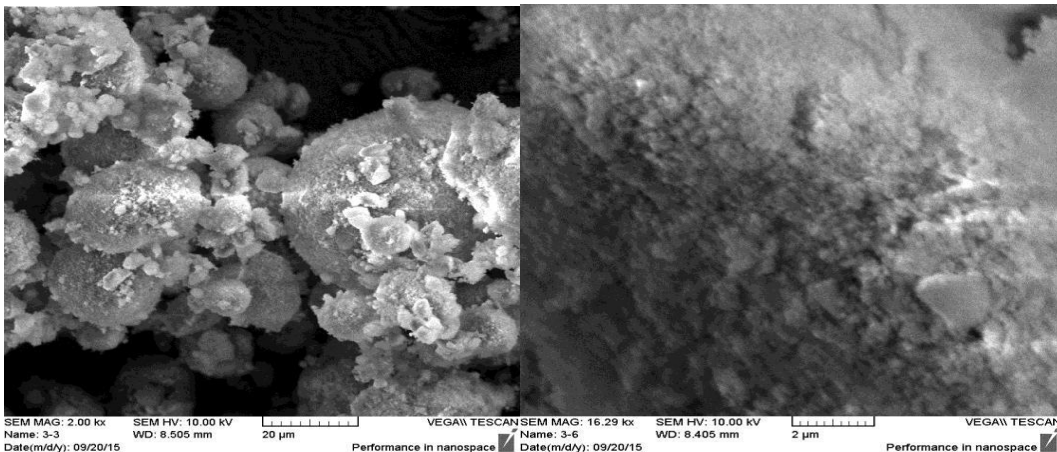


Fig. (4a) Resolution (20 µm)

Fig. (4b) Resolution (2 µm)

Figure (4a) and (4b) illustrate the SEM with resolution (20 μm) and (2 μm) respectively. From these figures, it can be noticed that silica SiO_2 as spherical nanoparticles with a diameter 100-150 nm. The form and the composition of the nanomaterial depend on the preparation method, type and purity of the chemical materials.

3.2.6.2c Results of FTIR test

Figure (5) illustrates the FTIR results, it was noted that many oxides in the chemical composition of sand through the beam of 800-1300 cm^{-1} and SiO_2 was noted at 1100 cm^{-1} that represents high ratio of silica. Also, the surface area test was achieved to get 242.549 m^2/gm .

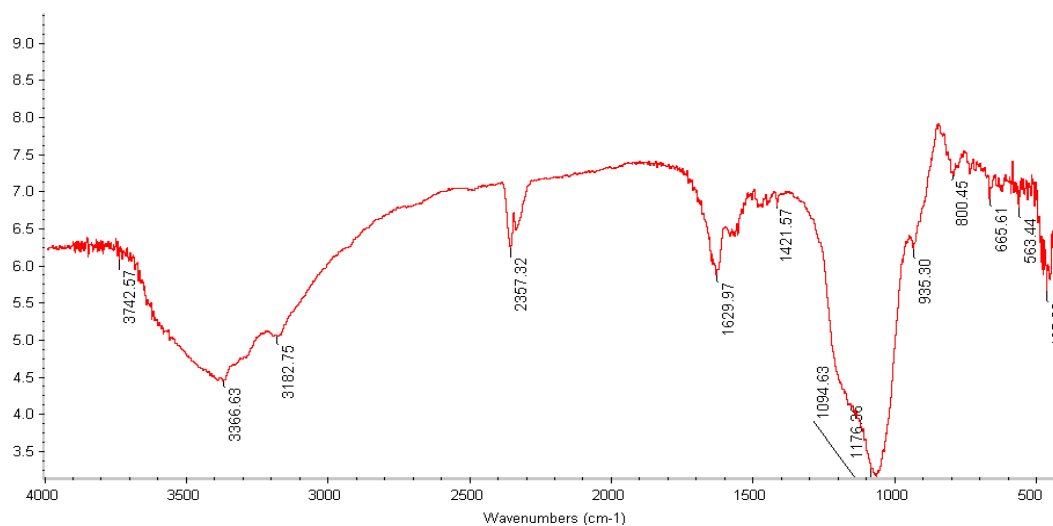


Fig. (5) Results of FTIR

4. Results and Discussion

4.1 Adding MWCNT the Water Based Mud

After the preparation of the samples and aging for 16 hrs for hydration, the measurements of viscosity, mud weight, pH and filter loss at laboratory condition for different concentrations. The results were taken as shown in Table (1).

Table (1) Results of MWCNT [11]

water, ml	350	350	350	350	350	350	350
Bentonite, gm	22.5	22.5	22.5	22.5	22.5	22.5	22.5
MWCNT (gm)	Blank	0.05	0.1	0.3	0.5	0.7	0.9
R600/R300	50/40	57/47	57/47	58/48	63/52	66/54	77/61
R200/R100	38/37	46/45	45/45	46.5/46	51/51	50/50	61/60
R60/R30	37/36	44/44	44/44	46/45	51/50	49/49	60/60
R6/R3	30/29	42/41	40/39	42/41.5	47/46	46/46	55/55
AV, cp	25	28.5	28.5	29	31.5	33	38.5
PV, cp	10	10	10	10	11	12	16
YP, lb/100ft ²	30	37	37	37	41	42	45
Gel 10sec/10min lb/100 ft ²	34/37	40/45	44/46	42/47	51/50	52/51	56/60
Mud weight, gm/cc	1.03	1.03	1.03	1.03	1.03	1.03	1.03
Filter loss, ml	12.4	12.2	12	12	11.8	11.8	11.6
pH	10	10	10	10	10	10	10

4.2 Effect of Adding Nano Silicon Dioxide (SiO₂) to the Water Based Mud

The results of adding the nano SiO₂ are shown in Table (2).

Table (2) Results of nano-silicon dioxide (SiO₂) [11]

water, ml	350	350	350	350	350	350
Bentonite, gm	22.5	22.5	22.5	22.5	22.5	22.5
Nano-silicon dioxide (SiO ₂), gm	Blank	0.1	0.3	0.5	0.7	0.9
R600/R300	50/40	56/43	59/44	68/49	70/50	74/53
R200/R100	38/37	41/39	43/40	43/39	46/43	46/42
R60/R30	37/36	38/38	38/37	38/37	42/40	41/40
R6/R3	30/29	35/35	34/34	33/32	38/37	36/35
AV,cp(Apparent viscosity)	25	28	29.5	34	35	37
PV,cp(plastic viscosity)	10	13	15	19	20	21
YP, lb/100 ft ² (yield point)	30	30	29	30	30	32
Gel 10sec/10min lb/100 ft ²	34/37	35/44	35/48	35/49	36/50	40/50
Mud weight	1.03	1.03	1.03	1.03	1.03	1.03
Filter loss, ml	12.4	12	11.8	11.8	11.8	11.6
pH	10	10	10.1	10	10.2	10

4.3 Adding Nano Silica (Rice Husks) to the Water Based Mud

After the preparation of the samples and aging for 16 hrs for hydration, the measurements of viscosity, mud weight, pH and filtration at laboratory condition for different concentrations. The results of adding nano-silica (rice husks) was depending as shown in Table (3).

Table (3) Results of nano-silica (rice husks)

water, ml	350	350	350	350
Bentonite, gm	22.5	22.5	22.5	22.5
Nano-silica, gm	0	0.2	0.5	0.7
Mixing time, min	20	20	20	20
R600/ R300	51/44	58/51	57/50	62/54
R200/R100	42/39	48/45	49/44	53/48
R60/R30	37/36	43/42	43/41	47/46
R6/R3	35/34	40/39	38/38	43/42
AV, cp(Apparent viscosity)	25.5	29	28.5	31
PV, cp (plastic viscosity)	7	7	7	8
YP, lb/ft ² (yield point)	37	44	43	46
10 sec.gel lb/100 ft ²	30	39	37	42
10 min.gel lb/100 ft ²	38	41	40	46
pH	9.79	9.88	10	9.83
API filter loss(30 min),ml	12.4	11.6	11.6	11.6

The apparent and plastic viscosity of water based mud with MWCNT was higher than conventional water base fluids without nano-particles. Because of nano-particles consist of high surface areas per volume and it will increase the interaction of the particles with the matrix and surrounding water based fluid. Generally, the yield points of MWCNT based drilling fluids became slightly higher than conventional water based fluids by increasing in the concentration of MWCNT. The higher yield point will provide better dynamic suspension of drilling cuttings and efficient cleaning of the wellbore while drilling operations.

The effect of adding MWCNT on gel strength at different concentrations showed an increasing trend as concentration increased. This occurs due to the electrostatic force

between the particles of nano and linked together with base fluid within 10 min period to form a rigid structure.

The effect of the MWCNT on filter loss was also studied. The amount of the filtrate of the conventional mud after 30 min was 12.4 ml this value changed to 12.2 ml after adding 0.05 gm of the MWCNT to the mud. That means the amount of the filtrate decreases by increasing the amount of MWCNT. Filter loss must be low (not be exceeded 15 ml according to API specification) to prevent excessive filter cake thickness and reduce the change of differential pressure sticking

The results indicates that the nano-silica (rice husks prepared in PRDC labs) and the commercial nano-silica SiO_2 similar results to improve the mud properties. Therefore, a comparison was made between those two materials.

The comparison of apparent viscosity (AV) of the conventional mud and nano-silica (rice husks) with water-based mud and nano-silicon dioxide (SiO_2) were investigated and shown in Figure (6). The apparent viscosity (AV) of nano-silica (rice husks) and nano SiO_2 were slightly higher by increasing the concentration of nano-silica (rice husks) and the commercial nano SiO_2 than that of the conventional water-based fluids.

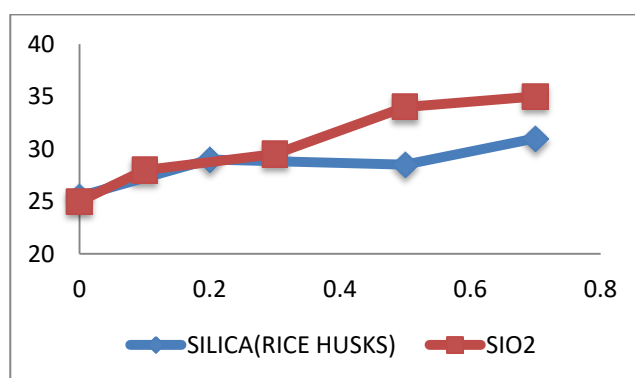


Fig. (6) Apparent viscosity after adding prepared nano-silica (rice husks) & commercial nano SiO_2

PV of water based mud with nano-silicon dioxide (SiO_2) was slightly higher than water based mud with nano-silica (rice husks) as shown in Figure (7).

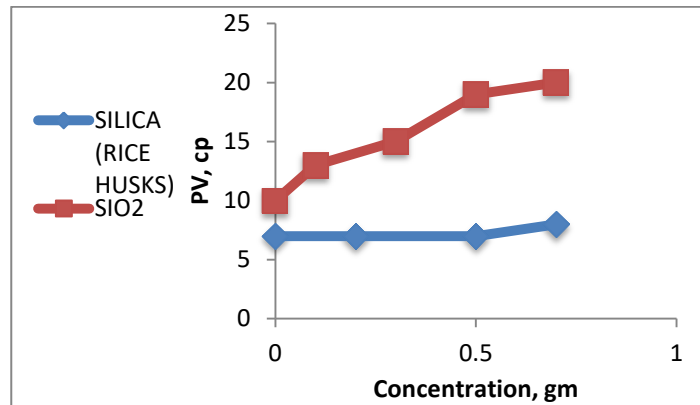


Fig. (7) Plastic viscosity after adding prepared nano-silica (rice husks) & commercial nano SiO₂

The yield point (YP) of water based mud with nano-silica (rice husks) was slightly higher than water based mud with nano-silicon dioxide (SiO₂) as shown in figure (8).

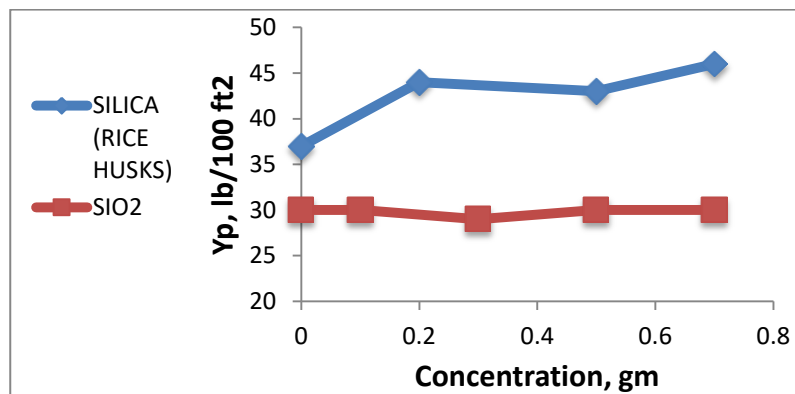


Fig. (8) Yield point after adding prepared nano-silica (rice husks) & commercial nano SiO₂

Figure (9) shows the effect of nano-particles on gel strength at different concentrations. Both nano-silica (rice husks) and nano SiO₂ gave an increasing trend as concentration increased.

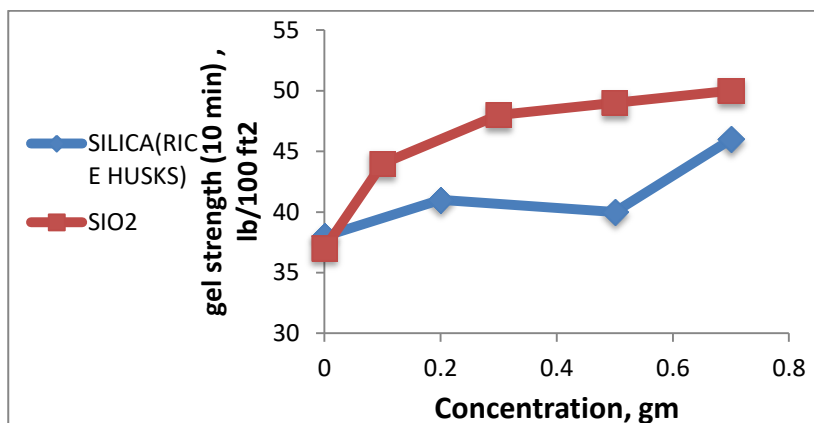


Fig. (9) Gel strength after adding prepared nano-silica (rice husks) & commercial nano SiO₂

The effect of the nano-silica (rice husks) and nano SiO₂ in amounts of filtrate was also studied. The results are shown in Figure (10). The amount of the filtrate decreases by increasing the concentrations of nano-silica (rice husks) and nano SiO₂.

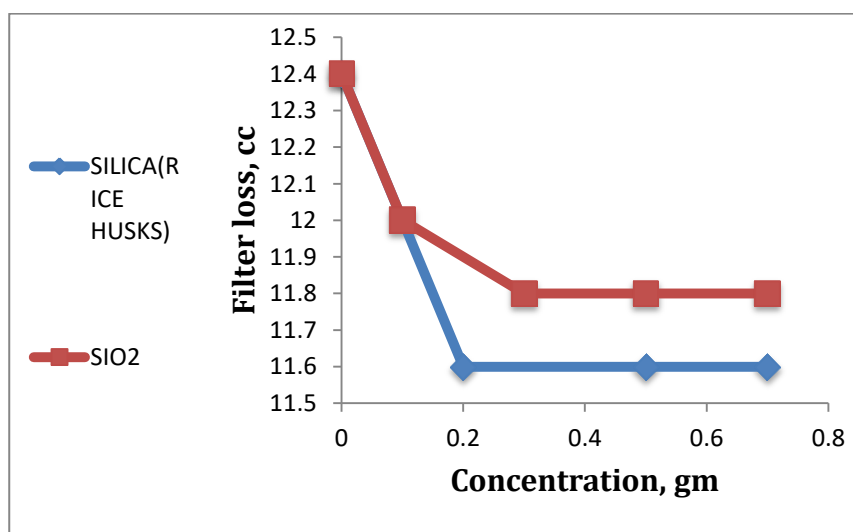


Fig. (10) Filter loss after adding prepared nano-silica (rice husks) & commercial nano SiO₂

5. Conclusions

1. Rheological properties (plastic viscosity, yield, point apparent viscosity and gel strength) show better improving with the addition of commercial nano-materials [MWCNT and nano-silicon dioxide (SiO_2)] to the water based mud.
2. MWCNT and nano-silicon dioxide (SiO_2) were added to the water based mud that reduced of amount of filtrate which leads to decreasing in the filter cake thickness due to the large surface area per volume of nano-particles. That builds structural barriers to the pore spaces to block the porous media.
3. Rheological properties (apparent viscosity, plastic viscosity, yield point, and gel strength) show better improving with the addition of the prepared nano-material [nano-silica (rice husks)] to the water based.
4. Adding nano-silica (rice husks) to the water based mud resulted in reducing the fluid loss which means less thickness of the filter cake.
5. The commercial MWCNT, SiO_2 and the nano-silica (rice husks prepared in PRDC labs) gave better results to improve the mud properties than other nano-materials used in this research.
6. The prepared nano-silica (rice husks) gave similar behavior as the commercial nano SiO_2 . Therefore, the nano-silica (rice husks) can be used instead of the commercial nano SiO_2 to reduce the cost.

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