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FULL LENGTH ARTICLE

A comparison of nano bentonite and some nano chemical additives to improve drilling fluid using local clay and commercial bentonites

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Abstract The use of nano-additives in improving drilling fluid properties in order to meet the modern drilling process requirement is still being debated till date. In this study, nano bentonite and nano chemical additives are used to improve the rheological and filtration properties of drilling fluid using local and commercial bentonite. In the first part of this work, the feasibility of using Iraqi clay as a source of drilling fluid was investigated at 6, 10, 15 and 20 wt% concentrations and mixed with nano commercial bentonite and nano Iraqi clay at 1, 2, 3, and 4 wt% concentrations. The results showed that this addition did not improve the properties of drilling fluid and its quality in order to meet the API standards.

In the second part, a commercial bentonite was used and mixed with nano commercial bentonite and nano chemical materials (MgO, TiO_2, and graphene) at 0.005, 0.01, 0.05, 0.1, 0.2 and 0.4 wt% concentrations. The results showed that nano commercial bentonite gives the same filtration behavior of graphene, whereas, the plastic viscosity, yield point and apparent viscosity were the same when using nano commercial bentonite, TiO_2 and graphene. The best results were obtained with MgO addition, whereby the filter loss decreased to 35% with a higher value of yield point.

1. Introduction

Drilling fluid plays an important role in drilling process as it affects the rate of penetration of bit, caving shale, pipe sticking, loss of circulation as well as formation evaluation and the subsequent productivity of well. The selection of drilling fluid type is also important to effectively overcome problems plaguing drilling processes like wellbore instability, reduction torque, and drag.

In order to improve physical properties of drilling fluid and to meet its functional requirement of rheology that satisfies the drilling process and reservoir conditions, different additives such as chemicals, polymers, and nanoparticles were used.

Nanoparticles are defined as a small collide particles with sizes ranging from 1 to 100 nm [1]. The use of these particles

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has gained great attention over the recent years with many researchers investigating its effect on drilling fluid. Yee et al. and Amanullah et al. studied the importance of nano-additives on lubricity, gelling characterization and drag reduction [2]and [3]. Mohammad et a. studied the effect of nanoparticles on lost circulation [4]. Katherine et al. showed the feasibility of using nano graphene, carbon nanotube and nano silica to improve shale stability [5]. Abdou et al. investigated the use of nano-local bentonite in drilling fluid and compared it with API bentonite [6]. Adul Razak et al. and Maratha and Waleed studied the effect of carbon nanotube and nano additives on the rheological properties of drilling fluid at high pressure and high temperature conditions [7] and [8]. Lastly, Noah et al. proposed a solution to one of the most important challenges of drilling fluids in high temperature high pressure HTHP wells using Multiwalled Carbon Nanotubes (MWCNTs) [9].

In spite of the above researchers, more study should be conducted in this field. Hence, in this work, an attempt to improve local clay properties (which is used as a base for drilling fluid) using nanotechnology will be made. Additionally, a comparison between using nano bentonite and nano chemical materials at different concentrations to improve the drilling fluid of local clay and commercial bentonite will be made.

2. Experimental work

2.1. Materials

2.1.1. Iraqi clay

The Iraqi clay was supplied from the state company for geological survey and mining from the Bshera valley/Fallujah. This clay was crushed and grinded to powder with an average particle size of $< 75\ \mu m$ micro Iraqi clay (MIC). The nano Iraqi clay (NIC) was prepared using ceramic ball miller. This clay was analyzed using X-ray (fluorescence and diffraction) and SPM (scanning probe microscope).

2.1.2. Commercial bentonite

Commercial bentonite was equipped from South Oil Company (SOC). The nano commercial bentonite (NCB) was prepared using ceramic ball miller. The clay was characterized using X-ray (fluorescence, diffraction) and SPM (scanning probe microscope).

2.1.3. Nano chemical materials

The chemical additives that are used in this work are graphene (black powder with an average diameter of 6–8 nm), titaniumoxide (TiO_2) (white powder with an average diameter of 10–30 nm) and magnesium oxide (MgO), (white powder with an average diameter of 20 nm). They were supplied by the SkySpring Nanomaterials, Inc.

2.2. Experiments

The experiments were divided into two parts, as shown in Table 1. In the first part, an evaluation of Iraqi clay was made using micro particle size of Iraqi clay (MIC) at the concentrations of 6, 10, 15 and 20 wt%. A blank solution of 6wt% (22.5 g of MIC and 350 ml water) was mixed with NIC at different concentrations 0.5, 1, 2, 3 and 4 wt%. Another similar blank solution was used to mix nanoparticles of commercial bentonite (NCB) at the same concentration levels used for previous mixture.

The second part evaluates commercial bentonite at the concentrations of 3, 4. 5, 6 and7 wt%. In order to improve its performance, through taking a blank solution of 22.5 g of commercial bentonite and 350 ml of water and mixed it with NCB at different concentrations (0.005, 0.01, 0.05, 0.1 and 0.2) wt%. Also, the same blank solution was mixed with nano chemical materials of Graphene, MgO and TiO_2 at concentrations (0.05,0.01, 0.05, 0.1, 0.2 and 0.4) wt%.

The prepared drilling fluid was mixed using Hamilton Beach mixer for 30 min, whereas, the nanoparticle solutions were first mixed using Hamilton Beach mixer and were

Table 1 The flow scheme of the experiments work.

First part
- Iraqi Ore Clay (6, 10, 15, 20) wt%
- Blank solution of Iraqi Ore clay (6 wt%) + Nano Iraqi clay and NCB at different concentrations (0.5, 1, 2, 3 and 4) wt% respectively

Second part
- Commercial bentonite at (3, 4, 5, 6 and 7) wt%
- Blank solution of commercial bentonite (6 wt%) + NCB, Gr, TiO_2 and MgO at different concentrations (0.005, 0.01, 0.05, 0.1, 0.2 and 0.4) wt% respectively

Table 3 The X-ray diffraction analysis of Iraqi clay and commercial bentonite.

Constituents	Iraqi clay	Commercial bentonite
Major	Gypsum, Quartz, Calcite	Montmorillonite, Quartz
Minor	Montmorillonite, Palygorskite	Gypsum, Calcite

Table 2 The X-ray fluorescence for Iraqi clay and commercial bentonite.

Constituent	SiO_2	Al_2O_3	CaO	Na_2O	MgO	K_2O
Iraqi clay	46.71	14.34	8.88	1.04	3.6	0.99
Commercial bentonite	64.97	12.59	1.03	2.75	2.49	1.12

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