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The Impact of MWCNT on XG Polymer /Salt Treated Laboratory Water Based Drilling Fluid

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ABSTRACT

In this paper, multi-walled carbon nanotubes (MWCNT) were added in the laboratory water based drilling fluid to study its effect on the properties of the drilling fluid.

The experimental test results show that addition of 0.02 wt. % and 0.38wt. % MWCNT reduced the friction coefficient of drilling fluid by 30 % and 50 %, respectively. This reduction consequently contributes to lower torque and drag. In addition, nanoparticles also improved the rheological properties of the drilling fluid.

1. INTRODUCTION

Nanotechnology has been applied in the field of electronics, biomedince and material science and have shown improved performance. Nanotechnology creates materials with improved properties due to their tunable electronic, physical, chemical, electrical, thermal, mechanical and optical properties. [1].

Several research papers reported the positive impact of nanoparticles in drilling fluids. For instance nanoparticles improves the properties of drilling fluid like rheology (*Vryzas et al, (2016)),* [2] *Parizad and Shahbazi* [3], reduces filtrate loss and mud cake thickness (*Vryzas et al, (2016)* [2], *Parizad and Shahbazi* (2016) [3], Ismail et al (2014) [4], *Zakaria, Husein et al, (2012*) [5]), reducing permeability of the shale (*Sharma et al, (2012)* [6]), increasing lubricity (*Taha et al. (2015*) [7]) and increasing well strength (Charles et al, (2013) [8]).

Multiwalled carbon nanotube (MWCNT) has shown improved rheological properties of drilling fluid *Ismail et al (2014)* [4] and in cement (*Santra et al, (2012)* [9] and *Shah et all, (2009)* [10]). In the present paper, the performance of 20-40nm MWCNT's were tested to investigate its effect on lubricity and rheological properties of the drilling fluid.

2. EXPERIMENTAL INVESTIGATION

Nanoparticle free reference (or base fluid) laboratory drilling fluid was formulated by mixing bentonite, salt and polymer in water. The impact of nanoparticle on the reference system were studied by adding 0.0095-0.38 wt. % of nanoparticle. The following section presents the description of drilling fluid formulation, testing and characterization.

2.1 MWCNT nanoparticle description

Carbon nanotube (CNT) is a cylindrical molecule that is composed of carbon atoms. In carbon nanotubes, each neighbouring atoms are bonded with strong covalent bond. CNT's are light weight materials having good electrical, thermal and mechanical properties as well as shows resistance to corrosion. [*Ruoff et al. (2003) 11]*. **Figure 1** shows the SEM image of carbon nanotubes having size in the range of 20-40nm and 2.1gm/cc. EPRUI Nanoparticles and Microspheres Co. Ltd provided the nanotubes which were used in this study. [12].

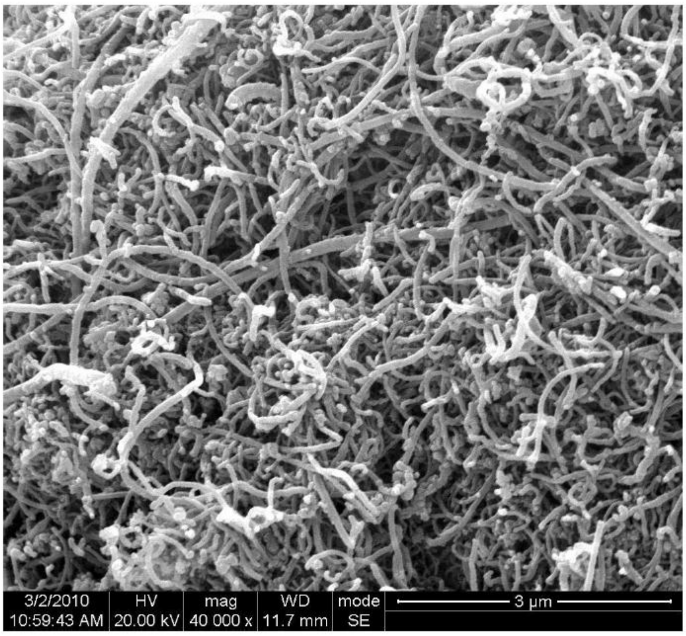


Figure 1: Morphology of MWCNT particles – SEM photograph.

2.2 MWCNT nanoparticle treated drilling fluid formulation

Based on the field case studies performed by Ahmed et al's [13], the concentration of bentonite in the water based drilling fluid is about 5% with respect to the weight. In this paper, the conventional laboratory drilling fluid was formulated by mixing 500ml of fresh water, 2.5g of salt (KCl), 0.5g of xanthan gum (XG) polymer and 25g of bentonite (i.e. 5wt.%). This drilling fluid formulation was termed as reference fluid that is nanoparticle free fluid (Base fluid). Nanoparticle based drilling fluids were prepared by mixing nanoparticles in the reference drilling fluid formulation. The drilling fluid ingredients were mixed with a high speed Hamilton beach mixer, and were aged for 48 hours in order to swell bentonite. All the tests were carried-out according to API RP 13B-1 [14]. **Table 1** shows the test matrix of drilling fluids treated with MWCNT.

Table 1: Test matrix of MWCNT nanoparticle in XG/KCL system

Additives	**Base fluid**	**Base fluid +0.05g MWCNT**	**Base fluid + 0.10g MWCNT**	**Base fluid + 0.15g MWCNT**	**Base fluid + 0.20g MWCNT**	**Base fluid + 2.0g MWCNT**
Water [ml]	500	500	500	500	500	500
XG polymer [g]	0.5	0.5	0.5	0.5	0.5	0.5
KCl [g]	2.5	2.5	2.5	2.5	2.5	2.5
MWCNT [g]	0	0.05	0.1	0.15	0.2	2.0
Bentonite [g]	25	25	25	25	25	25

2.2.1 Rheological parameters evaluation

Figure 2 displays the Fann© model 35 Viscometer responses of the drilling fluids presented in the Table 1. As can be seen in the figure, all the MWCNT nanoparticles based drilling fluids increases the viscometer responses and shear stress values as compared to the nanoparticles free reference drilling fluid. However, the viscosity response is nonlinear as the concentration varies.

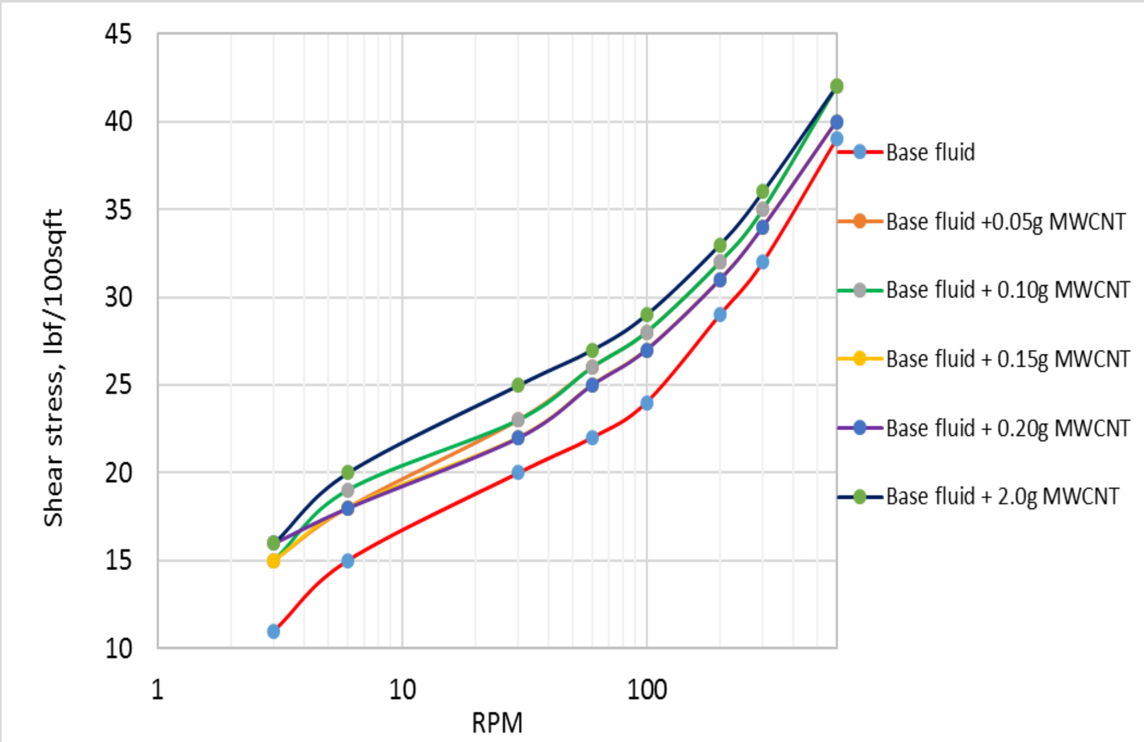
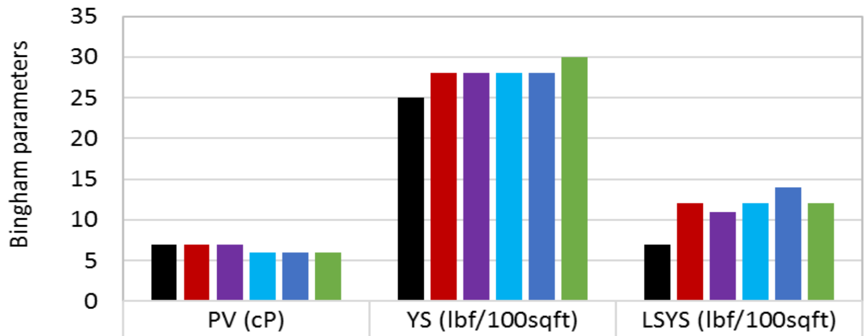


Figure 2: Viscometer measurement of test matrix –Table 1

There are several rheology models documented in the literatures namely, Bingham, Power law, Herschel-Bulkley, and Robertson-Stiff models can be mentioned among others. The shear stress-strain of the measured drilling fluids do not behave as the API Bingham and Power law. However, for the analysis of the impact of MWCNT on the rheological properties, the API models were considered.

Figure 3 shows the Bingham plastic parameters of the drilling fluids. The results indicated that addition of nanoparticles having concentrations in the range of (0.15g, 0.2 & 2 g) the plastic viscosity of drilling fluid is being reduced by about -14%. The lower concentrations in the range of (i.e. 0.05g - 0.2g) and the higher concentration (2 g) of nanoparticles increased the yield strength by 12% & 20%, respectively. Similarly the lower yield strength (LSYS) increased nonlinearly in the range of 71-100%, which is positive with respect to barite/solid sagging control.

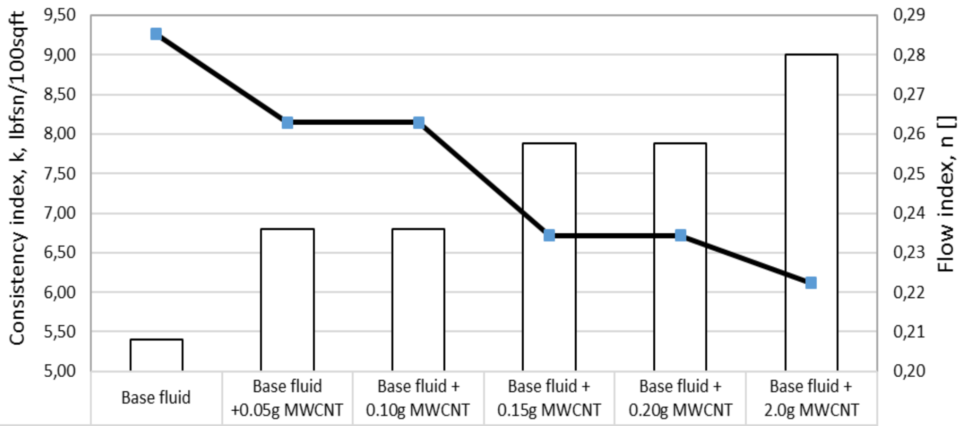


	PV (cP)	YS (lbf/100sqft)	LSYS (lbf/100sqft)
Base fluid	7	25	7
Base fluid +0.05g MWCNT	7	28	12
Base fluid + 0.10g MWCNT	7	28	11
Base fluid + 0.15g MWCNT	6	28	12
Base fluid + 0.20g MWCNT	6	28	14
Base fluid + 2.0g MWCNT	6	30	12

Drilling fluids

Figure 3: Drilling fluids Bingham parameters

Figure 4 displays Power law parameters (consistency index (k) and flow index (n)) of the drilling fluids. The results show that nanoparticles increased the k-value but decreased the n- values. However, 0.05 g and 0.1 g MWCNT shows the similar trends. With the increase in the concentration of nanoparticles from 0.15 g and 0.20 g, the k-value and n-values remain almost the same. Impact of the nanoparticles on the Bingham and Power law parameters is reflected on the hydraulic and hole cleaning performances of the drilling fluids.



	Base fluid	Base fluid +0.05g MWCNT	Base fluid + 0.10g MWCNT	Base fluid + 0.15g MWCNT	Base fluid + 0.20g MWCNT	Base fluid + 2.0g MWCNT
k, lbfsn/100sqft	5,40	6,79	6,79	7,89	7,89	9,00
n, []	0,29	0,26	0,26	0,23	0,23	0,22

Drilling fluids

Figure 4: Drilling fluids Power law parameters

2.2.2 Coefficient of friction evaluation

CSM tribometer [15] was used to measure the lubricity of the drilling fluids. For the measurement, 6 chromium steel ball was used on the plate surface. The experiments were lasted for 10min with the linear speed of 3cm/s. For all tests, a constant normal force of 5N was applied on the tribometer arm. The lubricity of the formulated drilling fluids have been measured at 22^0C. Repeat tests were performed to achieve reproducable results and the average values are reported as shown in the **Figure 5**. As shown, addition of 0.02 wt % and 0.38wt.% MWCNT decreased the coefficient of friction of the base drilling fluid by 30% and 50%, respectively. This has positive impact on torque and drag load reductions.

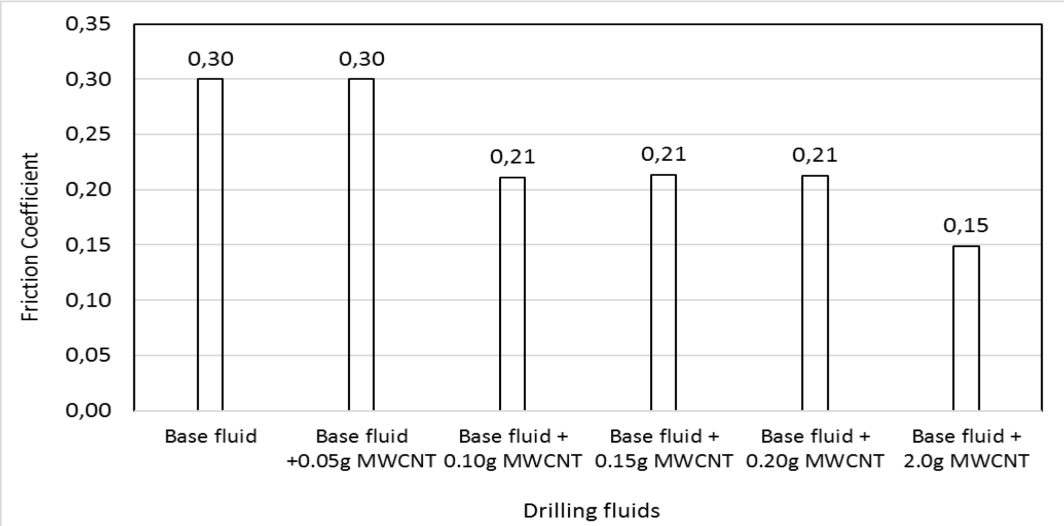


Figure 5: Friction coefficient of MWCNT treated- and reference drilling fluid

4. SUMMARY

In this paper, the effect of MWCNT nanoparticles in laboratory drilling fluid were evaluated. The drilling fluids were characterized at temperature of 22^oC. Based on the drilling fluid properties (rheology, lubricity) results, the main observations can be summarized as:

- Addition of 0.020wt. % and 0.38wt. % MWCNT reduced the average coefficient of friction by 30% and 50%, respectively.
- These additives also improve the Bingham and Power law parameters significantly.

Nanoparticle treated drilling fluids believed to have a potential to reduce drilling related problems and improve drilling fluid performances. For instance, reduction in the friction coefficient can be beneficial to reduce torque and drag.

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