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Comprehensive Experiment of Using Natural Products as Eco-Friendly Water-Based Drilling Fluid Lubricant

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Abstract: In order to solve the problem of high pollution of drilling fluid lubricant in Polymer system and CMC system, based on green chemistry, a comprehensive experiment of plant material as drilling fluid lubricant in Polymer system and CMC system was designed, and it were evaluated that the effect of adding plant material to Polymer system and CMC system on its lubrication performance. The experiment results in the combination of oilfield chemistry, green chemistry and practical application, which can rise the students undefined hands-on ability and improve the experimental teaching idea of the green and sustainable development of the students.

1. Introduction

Applied chemistry in oil and gas fields not only pays attention to the study and accumulation of chemical knowledge, but also emphasizes the basic subject of practical application. Green chemistry based on green is called environmentally sound chemistry, so that there is no impact on human health and no pollution to the ecological environment [1,2]. On the one hand, experimental teaching can cultivate students undefined ability to do hands, move eyes and use their brains; on the other hand, it can cultivate students undefined interest in oil field chemistry and improve students undefined experimental operation skills. This experiment which combine oil field chemistry, green chemistry and experimental teaching can help students accumulate chemical knowledge, cultivate green environmental protection concept and practical innovation. Hence, it is helpful for students to practice the concept of scientific and technological innovation and green development. In recent years, with the development of oil and gas exploration and various complicated conditions in the course of drilling, the use of complex structural wells such as horizontal well, large-angle well and high-temperature deep well is increasing. At the same time, the use of complex well in the oil field can rise the resistance of the drill string and reduce the mechanical rotating speed, so the lubricating property of the drilling fluid is provided with higher technical requirements[3-5]. The lubricant used in conventional drilling fluid may not achieve lubrication effect in the process of drilling, and the conventional drilling fluid lubricant, such as crude oil, white oil and liquid paraffin, has a great influence on environmental pollution. So it is not conducive to the popularization and application of drilling fluid lubricant material in the oil field[6]. In addition, due to the importance attached to environmental protection in China, it is bound to develop a green and environmentally friendly drilling fluid lubricant, and the lubricant should also have better lubrication performance. Li[7] developed a high-performance environment-friendly drilling fluid lubricant, HPRH, which can reduce the lubricating coefficient by 93.75% in the 4% fresh water base slurry, and the low foaming

rate. Liu[8] prepared an environment-friendly anti-wear lubricant AWR for drilling fluid, and the AWR has good sedimentation stability, biodegradability, high temperature resistance, extreme pressure film strength, good lubricating effect and compatibility. That Zhang[9] prepared the environment-friendly non-fluorescent biological lubricant ZYRH has good emulsifying stability, lubricating property and temperature resistance. Natural plant materials (Chinese yam, Okra and Aloe, etc. in Figure 1) based on the good lubricity and environmental protection is added to the drilling fluid of the Polymer system and the CMC system, and the lubricating effect and the action mechanism of the plant material are evaluated and analyzed.

The comprehensive performance is mainly reflected in the pretreatment of natural plant materials, the preparation and evaluation of drilling fluid (pH, rheological parameters, filtration loss, viscosity coefficient and density, etc.). The environmental protection is reflected in the fact that the experiment is based on natural plant materials, which has the advantages of environmental protection, biodegradability and good lubrication. For example, Yam is a mixture of polysaccharide protein, mainly composed of mucin and mannan, which has certain lubrication effect.

Figure 1 Natural plant materials

In this experiment, the natural plant was added to the drilling fluid of the Polymer system and the CMC system, and the properties of the natural plant material in the pulp were evaluated, and the mechanism of the natural plant material in the treatment of the pulp was analyzed by means of particle distribution, thermogravimetric analysis and scanning electron microscope. This experiment leads the students to master the method of measuring the performance of the drilling fluid, which is helpful to improve the students undefined ability of chemical theory and comprehensive experiment in oil field.

2. Design of the Experiment

2.1. Purpose

(1) Master the application steps of six-speed rotating viscometer, viscosity coefficient tester and high temperature roller heating furnace**.**

(2) Master the preparation of the drilling fluid base slurry;

(3) Learning to analyze the reasons for the change of lubricity in pulp by means of data analysis, literature inquiry and so on.

(4) The performance evaluation and mechanism analysis of the selected environmentally friendly lubricant in water-based drilling fluid are carried out.

2.2. Principle

The liquid lubricant mainly forms an adsorption film on the surface of the metal, the rock and the clay, so that the solid-solid friction generated by the drill string and the well wall rock is converted into friction between the oil film and the oil film, so that the friction force between the rotary drill string and the rock is greatly reduced, and the rotation resistance of the drilling tool is reduced[10-12]. Natural plant materials contain a large number of polysaccharides, which can be

used as drilling fluid additives to improve the lubricity of drilling fluid by interaction with clay.

2.3. Materials and Instruments

The medicines (Plant materials), such as Yam and Okra, were purchased from the market. Modified starch and PAM and CMC were supplied in domestic market. Bentonite was obtained from Changqing Chemical Engineering Group Co., Ltd., China. Extreme pressure and lubricity tester (Fann21200) and coefficient of viscosity tester (NZ-3A), as shown in Figure 2.

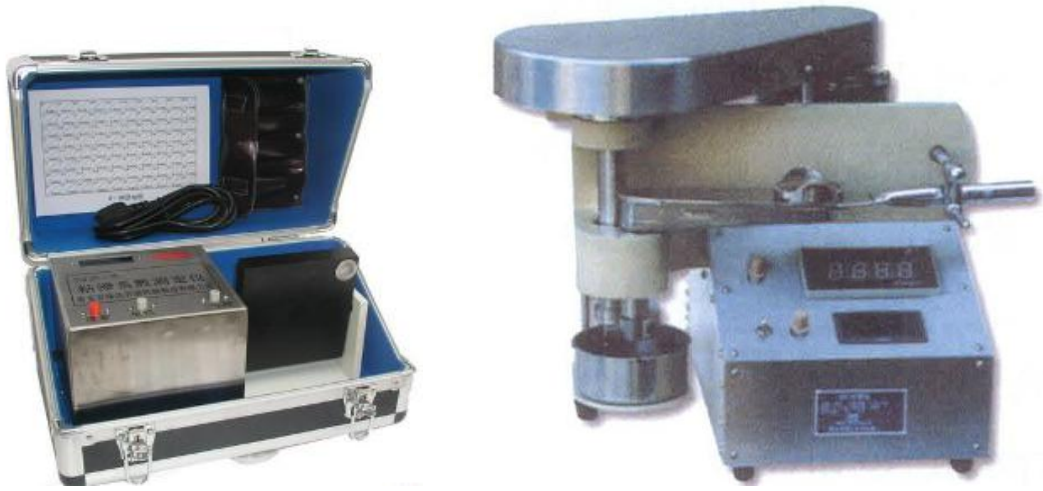

Figure 2 The main instruments for the lubricity evaluation

2.4. Methods

2.4.1. Plant Material Pretreatment

First, the fresh plant material was weighed and the quality was recorded. Secondly, the plant material was polished into pulp by juicer and added with sodium benzoate, in order to prevent the deterioration of plant material. Finally, the obtained material is packed in a wide mouth bottle.

2.4.2. Preparation and Evaluation of Drilling Fluid

2.4.2.1. Preparation of Base Slurry for Drilling Fluid

Adding 3500 mL of clear water into the slurry mixing barrel, then adding 0.2% of sodium carbonate and 4.0% of clay, stirring for 2h, and standing for 24h for backup (Preparation shall be made in advance before the test).

2.4.2.2. Effect of Plant Material on the Performance of Drilling Fluid-based Slurry

0.5%,1.0% and 1.5% of the treated plant materials were added to the 350 mL base slurry, respectively, and stirred at high speed for 30 min, aged at room temperature for 6 h and evaluated its performance.

2.4.2.3. Compatibility Evaluation

1.0% the treated plant materials were added to 1% CMC, 1% Modified starch and 1%PAM treated pulp, respectively. The treated pulp was aged at room temperature for 6h after high speed stirring for 30min,. The rheological properties, filtration and lubrication properties of the treated pulp were measured after uniform stirring at high speed.

2.4.2.4. Performance Evaluation of Drilling Fluid

The montmorillonite was dispersed in Sodium carbonate aqueous solution or tap water with a dosage of 4% (m/m), after stirring for 30min, it was handled for 16 hours at 298K, then the rheological performances and filter loss of drilling fluids were evaluated using a viscometer (ZNN-D6S, Haitongda, Co., Ltd., Qingdao), like AV(Apparent viscosity), PV(Plastic viscosity), YP (Yield point), FL(API Filtration) and tg (Friction coefficient). Depending on the National Standard GB/T 16783.1-2006 "Field testing of oil and gas industry drilling fluids-part 1: water-based drilling fluids", the performance of water-based drilling fluids was evaluated. The main evaluation properties include: apparent viscosity (AV), plastic viscosity (PV), dynamic shear force (YP), dynamic plastic ratio (YP/PV), filtration loss (FL), filter cake friction (tg) etc. [13].

2.4.2.5. Inhibitive Ability Evaluation

100mL 4% fresh water base pulp, 100mL 4% KCl solution and 100mL 1.0% treated plant materials drilling fluid were prepared respectively. First, the secondary sodium bentonite was dried in an oven at 105℃ for 4h. Secondly, 8.05g of the secondary sodium bentonite which had been dried was weighed and pressed by a tablet press at 10MPa for 5min to form a sample sheet. The sample was taken out and the sample thickness h2 was measured. Finally, the sample expansion amount h1 was measured within 2h by NP-01 normal temperature atmospheric pressure expansion tester and the sample was blanked with distilled water.

2.4.2.6. Particle Distribution Test

4% calcium bentonite and 0.2% sodium carbonate were added to the tap water of 350mL, stirred for 30 minutes and aged for 16 hours at 298K. The treated plant materials is added to the dispersion liquid before the test, and then the mixture is stirred for 30 minutes. then, according to the reported method ,the particle size of the treated plant materials was measured by a instrument (LS-13320, Beckman Coulter, Inc., USA) [14].

3. Data Processing[15]

The rheological parameters are calculated according to the following formula.

$$YP = 0.5(\Phi_{300} - PV) \quad (1)$$

$$AV = \frac{1}{2}\Phi_{600} \quad (2)$$

$$YP/PV = 0.5(2\Phi_{300} - \Phi_{600})/(\Phi_{600} - \Phi_{300}) \quad (3)$$

$$PV = \Phi_{600} - \Phi_{300} \quad (4)$$

According to the linear expansion rate formula, the linear expansion rate of clay in different solutions is calculated, and the relationship curve between linear expansion rate and soaking time of clay is drawn. The formula is as follows: $R(\%) = h_1/h_2 \times 100\%$ 。

The relationship curve between sample volume fraction and particle size is drawn by the data recorded by laser particle size analyzer, and the change of clay particle size is analyzed.

4. Questions and Exercises

What are the main chemical components that play a lubricating role in the plant materials used?

What is the function of the drilling fluid that can cause the performance of the drilling fluid to change?

What factors play a major role in the lubrication performance of drilling fluid in the experiment?

5. Conclusions

In this experiment, many properties of drilling fluid are investigated, which requires students to learn and improve their own knowledge. This experiment can not only cultivate the cooperative ability between students, but also enable students to master the basic operation of evaluating drilling fluid performance, in addition, it will also understand the role of drilling fluid in drilling process. During the implementation of the experiment, the problem of insufficient hands-on ability can be improved. During the period of literature review, it is beneficial to cultivate students undefined vision and improve their scientific research literacy. This experiment is to use plant materials as drilling fluid lubricant, so that students can understand the chemical composition of plant materials during the experiment, students can not only master professional chemical knowledge, but also enhance the personal concept of environmental protection.

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