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Investigation of Sulfur Removal from Drilling Fluid

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Abstract

The sulfur removal from drilling fluid for prevention from corrosion was studied, specially. ZnO nanoparticles are proposed as the coagulant. Turbidity of supernatant, the pH stability, settling time, the effect of auxiliary coagulants such as $FeCl_3$, $Fe_2(SO_4)_3$ and $Al_2(SO_4)_3$ on the treatment process are reported in this work. Fourier transform infrared spectroscopy (FTIR) and zeta potential is utilized to investigate the pH values related to the stable suspension. The optimum value of initial pH=8, final pH=9, amount of turbidity= 6.5 NTU is obtained after 15 days of the settling time, if the 15 g/l ZnO is used with 450 cc NaOH and Na_2CO_3 are used in coagulation process. Lowest zeta potential is 2 with using 15 g/l ZnO at the initial pH=9.5. The sulphur removal percentage is about 97% in this condition.

Keywords: Environmental pollution, nano particles, coagulation, treatment.

Introduction

1. Drilling fluid mud

Drilling fluid mud – is usually composed by water, clay, weighing material and a few chemicals [1]. Sometimes oil may be applied instead of water, or oil added to the water to give the mud certain desirable physical properties [12]. Drilling fluid is used to increase the cuttings made by the bit and lift them to the surface for disposal [3]. But equally important, it addition, provides a means of keeping underground pressures in check. The heavier or denser the mud, is the more pressure it exerts. Therefore, weighing materials – barite – are mixed to the mud to make it exert as much pressure as required to contain formation pressures [4]. The equipment in the circulating system consists of a large number of parameters. Drilling fluids are applied extensively in the upstream oil and gas industry, and are critical to ensuring a safe and productive oil or gas well. During drilling process, a large volume of drilling fluid is circulated in an open or semi enclosed system, at elevated temperatures, with agitation, preparing an important potential for chemical exposure and subsequent health effects [5]. When deciding on the type of drilling fluid system to use, operator well planners require conducting comprehensive risk assessments of drilling fluid systems, considering health aspects in addition to environmental and safety aspects, and strike a suitable balance between their potentially conflicting requirements [6]. The results of these risk assessments require to be made available to all employers whose workers may become exposed to the drilling fluid system.

2. Functions of drilling fluid

In the early days of rotary drilling, the primary function of drilling fluids was to bring the cuttings from the bottom of the hole to the surface [7]. Today it is recognized the drilling fluid has at least ten important functions: A). assists in making hole by: A-1). removal of cuttings; A-2). cooling and lubrication of bit and drill string; A-3). power transmission to bit nozzles or turbines. B). Assists in hole preservation by: B-1). support of bore hole wall; B-2). containment of formation fluids. C). It also: C-1). supports the weight of pipe and casing; C-2). serves as a medium for formation clogging. D). It must not: D-1). corrode bit, drill string and casing and surface facilities; D-2). impair productivity of producing horizon; D-3). pollute the environment [8–10].

3. The role of drilling fluid

Undoubtedly, the drilling fluid has vital role in drilling process [11, 12]. Two basic items included; frictions and in the recycling cycle.

4. Customized solutions

Despite the excellent track record demonstrated by invert emulsion fluids, operators continue searching for a water-based system that will give comparable performance [13–15]. Increasing concern is placed on environmental impact of operations, making water-based alternatives more attractive [16–18].

“Baroid Industrial Drilling Products” has engineered high-performance water-based fluids that emulate the performance of an invert emulsion fluid. Each fluid system is customized to address specific drilling challenges [19–21].

The amount of sulfur removal from waste drilling fluid with using the ZnO nanoparticles as novel coagulant is evaluated in this paper.

Material and methods

1. Equipment

Experiments are held in two PVC series tanks equipped by adjustable agitator. The treatment process is done in two series mixing reactors. 450 cc NaOH and 600 cc Na_2CO_3 is inserted in the drilling mud feed line. First reactor is a fast mixing reactor to insert a coagulant during 5 min with 120 rpm. The second slow mixing reactor vessel (60 rpm, 20 min) is equipped with hot water jacket and also is equipped with the hot air line which is inserted into the second reactor. Feed is 4 liters watery drilling mud.

2. Operating functions for prediction of treatment performance

Some functions which are evaluated in the treatment units are listed at the below. These functions state the quality of treatment process.

3. Fourier transform infrared spectroscopy (FTIR)

This is a proper and confident technique which is used to obtain an infrared spectrum of absorption, emission, photoconductivity or Raman scattering of fluid. The FTIR spectrometer simultaneously collects spectral data in a wide spectral range. This confers a significant advantage over a dispersive spectrometer which measures intensity over a narrow range of wavelengths at a time. The used FTIR has made dispersive infrared spectrometers all but obsolete (except sometimes in the near infrared), opening up new applications of infrared spectroscopy.

Results and discussion

1. The effect of wave number on the transmittance

Usually the drilling mud is drained in the pool under the ground, so the sulfur contaminates in the mud penetrate in the soil and affect the quality of soil in view of agricultural applications. Coagulation mechanism in softening process using nano ZnO particles with mineral coagulant is investigated experimentally. The pH value, turbidity, settling time and appearance of the fluid is also considered besides the amount of sulfur.

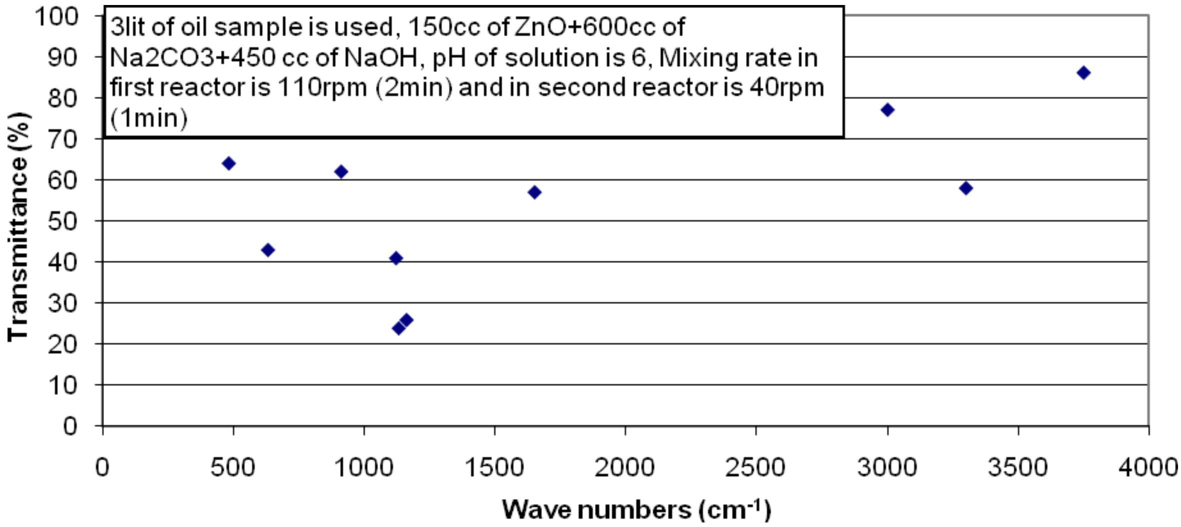

Figure 1. Transmittance versus wave number

The effect of wave number on the transmittance is shown in Figure 1. The distribution density of the transmittance is between 20% to 70% and the wave number is between 500 to 1650 cm^{-1}.

According to the Figure 1 some wave numbers illustrate the characteristic peaks at 920 cm^{-1} and 620 cm^{-1}, which are related to the bending vibration of Fe–OH–Zn bonds. The stretching vibration of Fe–O bond is overlapped up by the absorption peak caused by the bending vibration of Fe–OH–Zn bond. The peaks value at 490 cm^{-1} and 1162 cm^{-1} are assigned to the characteristic bands for Zn–O bond and Fe–O bond, respectively. The vast band of wave number indicates on the hydroxide band.

2. The effect of the nano particle concentration on the pH value

The pH value of the reaction environment affects the coagulation and flocculation process. So, Figure 2 shows the pH variation versus concentration of ZnO particles. The pH range is between 8 to 12 units during experiments. According to the results, the ZnO content in the solution is not important to obtain the specific pH value.

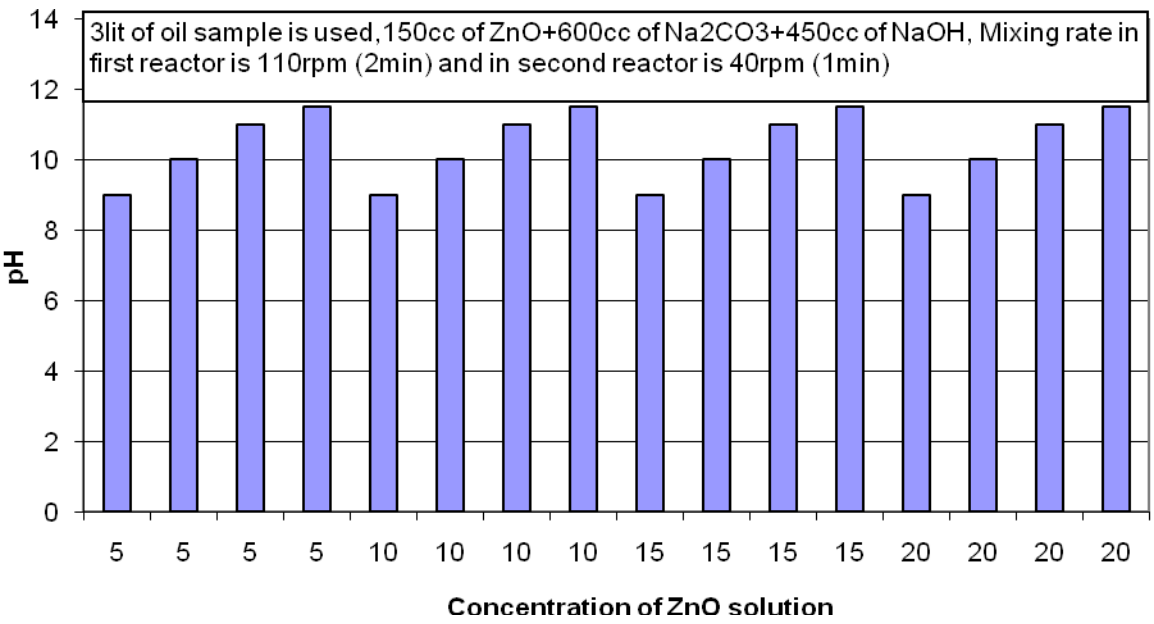

Figure 2. pH versus ZnO concentration

Conclusion

Drilling mud treatment by coagulation and flocculation applying ZnO nanoparticles is investigated, in this work. Drilling mud contains contaminants like sulphur after usage and is drained under the ground. So, surveying treatment methods to remove the contaminants from mud by nano ZnO particles is considered in this research. Two mixing reactor are used utilizing ZnO, NaOH and Na_2CO_3 as coagulants and related parameters are represented in Figures. Turbidity, pH, settling time, amount of ZnO, effect of axillary coagulants [$FeCl_3$, $Fe_2(SO_4)$, $Al_2(SO_4)_3$] are measured.

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