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Synthesis of Alumina/Polyacrylamide nanocomposite and its influence on viscosity of drilling fluid

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ABSTRACT

Maybe viscosity in drilling fluid is the most important parameter because cutting removal from well are task of viscose fluid. If viscosity of fluid is less than particular value, cutting will settle down in well and drilling operation will be stopped. In this study, synthesis of Alumina/Polyacrylamide nanocomposite through solution polymerization method was performed. Rheological behavior of mud drilling fluid after addition different amount of synthetic nanocomposite was measured for different periods of time. One of the major disadvantages of polymeric fluid is shear thinning property, called thixotropy. In this work we also test the influence of additive nano alumina particle in reduction of thixotropic behavior of drilling fluid. Adding different amount of synthetic nanocomposite increases the viscosity of drilling fluid up to more than 300 cP for both fresh and salt water mud at only 4 wt% and about 100 cP at2 wt% also reduces the rate of thixotropic behavior more than 5% after adding nano particles instead of free nano particle polymer.

Keywords: *Alumina; Polyacrylamide; Polymerization; Nanocomposite; Viscosity.*

INTRODUCTION

The use of drilling fluid is one of the most important part of rotary drilling process. A wide variety of different types of chemicals and polymers are used in drilling fluid to achieve some functional requirements such as mud weight, density, mud activity, fluid loss control property and etc. Salt and organic compounds are used for reducing the sloughing of shale, minimizing dissolution of evaporation and control the fluid loss of drilling fluids [1]. Polymeric additives have been used in drilling fluid since many years ago. Polymers like CMC, Polyacrylate, Polyacrylamide and others have been used to enhance the rheological behavior of drilling fluid and stability of well due to improvement the stability of mud cake in Shelley formation and to decrease fluid loss in fracturing formations [2].

More over the above additives, Metallic oxides are used here due to its mechanical, tribological, barrier, and conductive properties. Their major functions in mud are: increasing mechanical strength of mud cake and increasing thermal performance to make bit cooler easily. Composite particle consisting of inorganic nano particle and polymers due to the possibility of combining the advantages of different materials, have attracted much attention of material scientists and researchers. Baba Hamed *et al.* used the xanthan gum and scleroglucan biopolymers to enhance the rheological properties of mud drilling [3]. Guo *et al.* examine KCl/polymer, KCl/lime/polymer as conventional inhibitive for hole-instability problem related to drilling fluids due to the highly reactive and dispersive shales [2]. Sayed *et al.* works with vanillin-modified polyoxyethylene surfactants to improve their rheological properties in water-based mud like: apparent viscosity, the plastic viscosity, the yield point, the gel strength, the thixotropy as well as the filtration properties [4]. İşçi *et al.* work on polymeric water soluble fluid to enhance the dispersion behavior of drilling fluid contains NaB and sepiolite [5]. Alsabagh and his co-workers use copolymers based on acrylic salts as circulation loss control agents [6]. Lahalih *et al.* used Sulphonated amino-formaldehyde polycondensates as mud dispersants and mud thinners for controlling the rheological properties of drilling fluids in deep drilling within the desired range [7]. Fereydouni *et al.* work on Polyanionic Cellulose Polymer Nanoparticles on Rheological Properties of Mud Drilling [8]. Saboori *et al.* use CMC nanoparticle to reduce the amount of water loss and mud cake thickness [9].

Podgornik and Perdih tried to polymerize Methyl Methacrylate in the presence of Ammonium Chloride via solution polymerization method [10]. Van Hook *et al.* worked on polymerization of Styrene and Methyl Methacrylate via solution polymerization [11]. Tanaka tried to copolymerize cationic monomers with acrylamide in an aqueous solution [12].

In this paper, polymerization of *γ*-aluminananoparticles with acrylamide monomer was performed to prepare nanosize Alumina/polyacrylamide composite particles by solution polymerization method. Also the variation of viscosity and thixotropic behavior of drilling fluid were measured at different times.

Textile dyeing effluents are composed by complex mixtures of dyes, auxiliary chemicals, salts, acids, bases, organochlorinated compounds and occasionally heavy metals [6].

EXPERIMENTAL

Material

Nano γ- Alumina was obtained from Tacnan Company. Acrylamide monomer and Potassium Peroxodisulfate were obtained from Merck chemical Company. High purity Nitrogen was obtained from Fars Gas industrial company. All materials were used without further purification.

Nano Alumina was characterized by the Dynamic light scattering PSA Analyzer (HORIBA – LB550) (Figure 1) from japan. Obtained Composites were characterized by the X-ray diffraction (XRD) on a Bruker D8 advance instrument and Fourier transfer infrared spectra (FTIR) on a PerkinElmer spectrum RX I. Viscosity of modified drilling mud was obtained by Brook field viscometer from U.S.A.

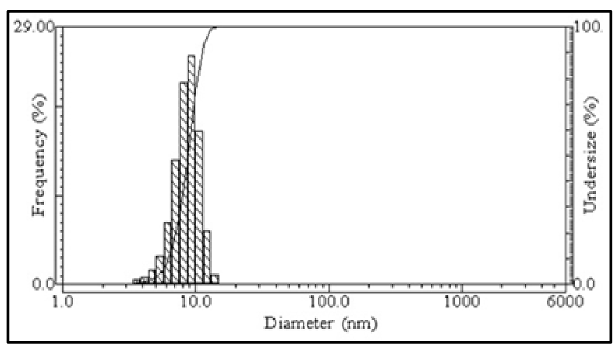

Fig.1. PSA analysis of γ-Alumina.

Synthesis method

Solution method used to prepare nanocomposite is as below:

At first one tenth of Acrylamide monomer, nano γ-Alumina will dispersed in specific amount of water by ultrasonic waves for 30 minute with specific power and frequency, Acrylamide monomer was dissolved in water too. Then they will be mixed in round bottom reactor. After adding cross link agent and Potassium Peroxodisulfate as initiator put reactor in warm water bath at 70℃ under the atmosphere of N_2 with a mechanical stirrer at 300 rpm. After 15-20 minutes, polymerization will do for drying use vacuum oven at 80℃ for at least 3 hours (Figure 2).

Mineralogical studies

Mineralogical composition for nanocomposite was determined by X-ray diffraction (XRD) by using Bruker X-ray diffraction equipment model D8 Advance with monochromator, Cu radiation (h=1.542 A°) at 40 kV and 40 mA and scanning speed 0.05°/s (Figure 3).

FTIR spectrum study

Figure 4 shows the FTIR spectrum of γ-Alumina/Polyacrylamide core-shell nanocomposite, in the case of polyacrylamide a broad absorption band at 3434 cm^{-1} is for the N–H stretching frequency of the NH_2 group. Two strong bands around 1679 and 1633 cm^{-1} are due to amide-I (C=O stretching) and amide-II (NH bending). Another band at 1724 cm^{-1} is due to the presence of free acid groups. The bands around 1398 and 2930 cm^{-1} are for the C–N and C–H stretching vibrations. Other bands at 1450 and 1318 cm^{-1} are attributed to CH_2 scissoring and CH_2 twisting. NH wagging vibrations occur at 618, 705, 768 and 816 cm^{-1}, respectively [13]. In the case of Alumina, the stronger broadening band 3800 - 3000 cm^{-1} occurs due to the hydrogen bond between the various hydroxyl groups in the product. The stronger broadening band 1000 - 400 cm^{-1} corresponds to Al-O vibration existed under the temperature of 750°C, one of them was between 1000 - 500 cm^{-1}, another one between 500 - 400 cm^{-1} [14]. The presence of an absorption band at 3449.52 cm^{-1} is due to the overlap of –OH stretching band of Alumina and –NH stretching band of PAM. A band at 1665.5 cm^{-1} is due to the overlap of amide-I band of the amide group of PAM and Al-O stretching modes.

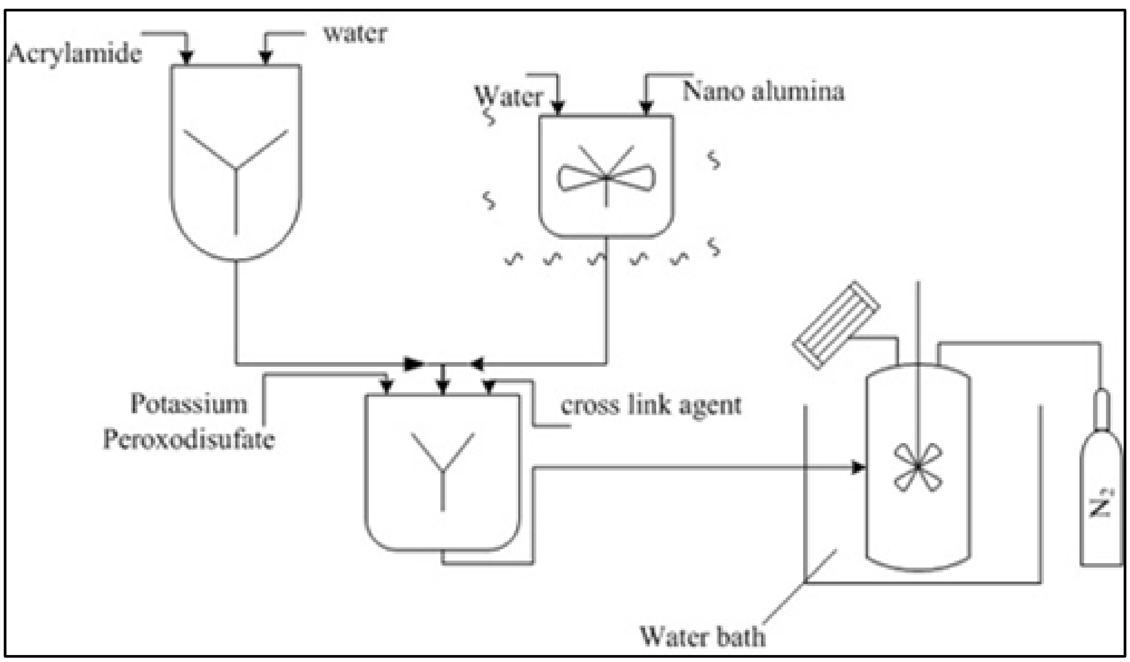

Fig. 2. Schematic of solution polymerization process.

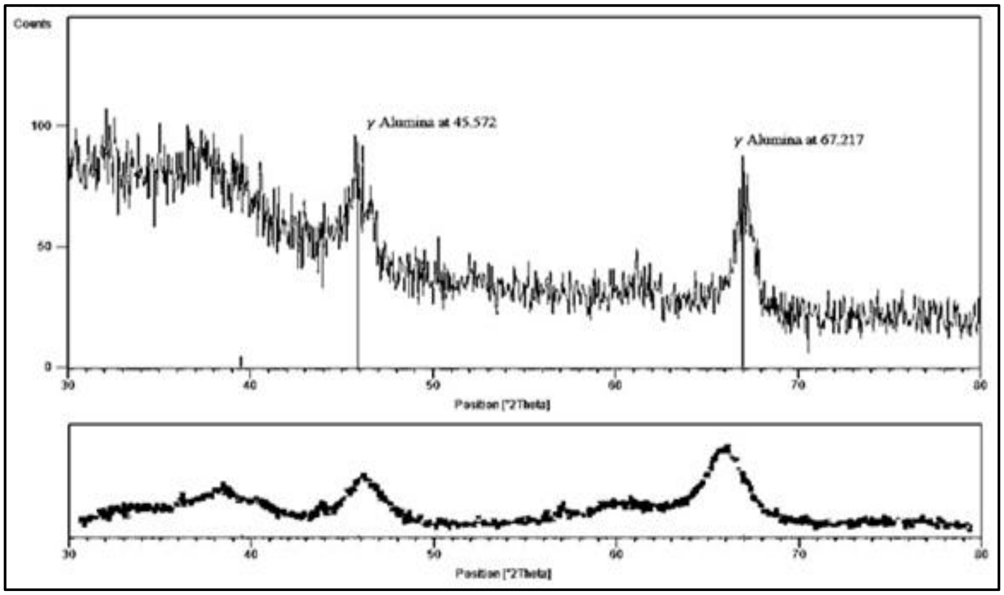

Fig. 3. XRD Spectrum of γ-Alumina/Polyacrylamide nanocomposite.

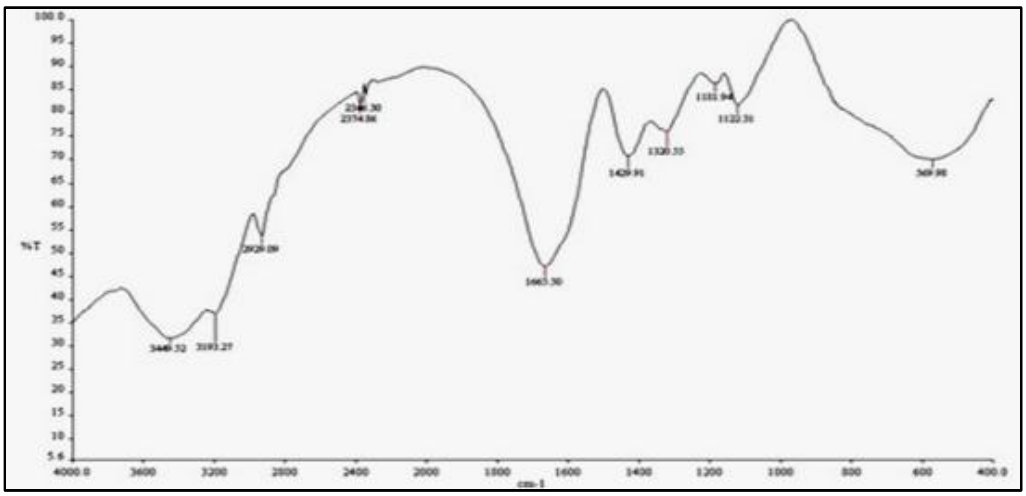

Fig. 4. FTIR spectrum of γ-Alumina/Polyacrylamide.

Mud rheological tests

Water based drilling fluid consists of 350 cc water plus 10 gr bentonite, were homogenized by a mixer. For its modification, additives were added to the mentioned mixture. Viscosity of modified drilling fluid in three different times includes: the first day, the 3th day and after two weeks were examined. It will be noted that modified mud will be prepared in distilled water and standard salt water (3.3 gr $CaCl_2$, 11.2 gr $MgCl_2$ and 1.2 gr NaCl in 200 ml distilled water).

RESULTS AND DISCUSSION

Viscosity measured at higher torque percent (for Brookfield viscometer) for the free nano particle polymer, 0% - 1.4% - 2% - 3.4% and 4wt% of base mud. Examination and result show a rapid decreasing in viscosity in the third or the fourth first day and reach a specific value then no or a little change in its value observed. Figure 5 shows the variation of viscosity with time in fresh water (Figure 5) and (Figure 6) in standard salt water.

Comparison between Figures 5 to 8 shows viscosity improvement about 15-20 % due to addition of nano particle in comparison with free nano particle polymer. Also, the influences of different salt have reduced viscosity up to 20-30 percent in comparison with fresh water mud. Because salt water is the most common water in drilling wells instead of fresh water, it is more realistic data for real drilling fluid. Increasing viscosity in polymeric fluid is common but here nano particles work as chain joiner points and let the chains have higher molecular weight and boosts viscosity increasing.

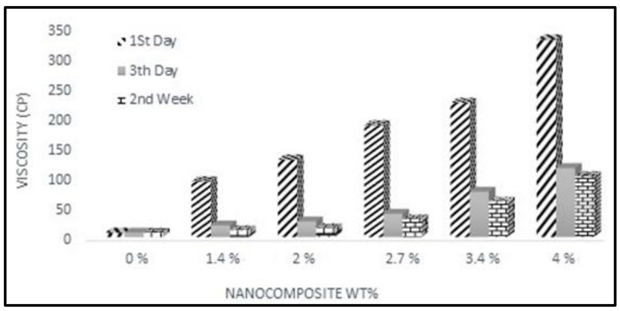

Fig. 5. Fresh water mud viscosity.

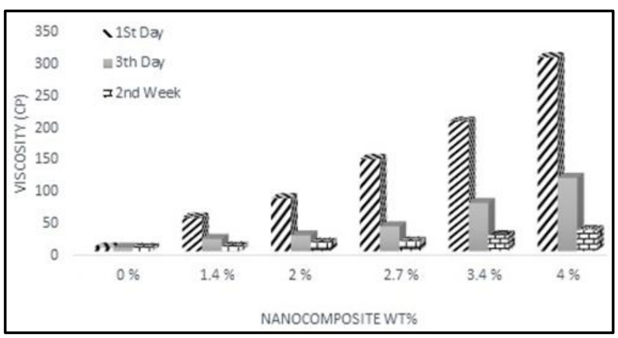

Fig. 6. Standard salt water mud viscosity**.**

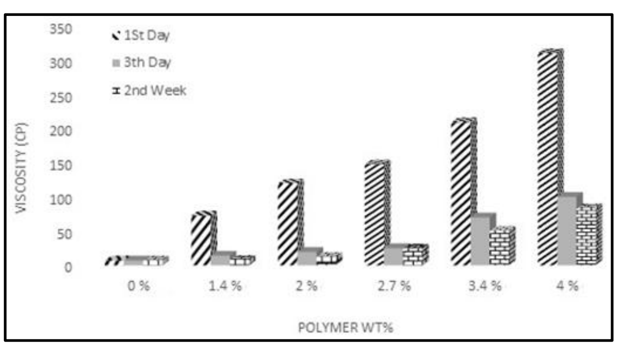

Fig. 7. Fresh water mud viscosity (free nanoparticle polymer).

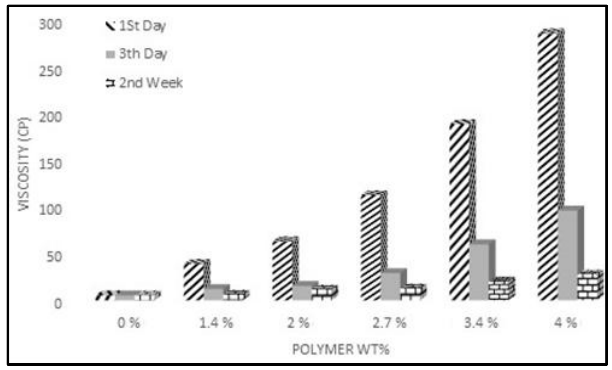

Fig. 8. Standard salt water mud viscosity (free nanoparticle polymer)

Figures 9 and 10 show the reduction of viscosity between the first and the third day in fresh and salt water mud respectively.The reduction of viscosity in polymeric viscous fluid called thixotropic behavior. Alumina nanoparticle reduces the amount of viscosity reduction and in other word thixotropicity, by more than 5%. Again chain joiner point role of nanoAlumina, reduces the amount of chain creeping and slows down the rate of decreasing viscosity of fluid.

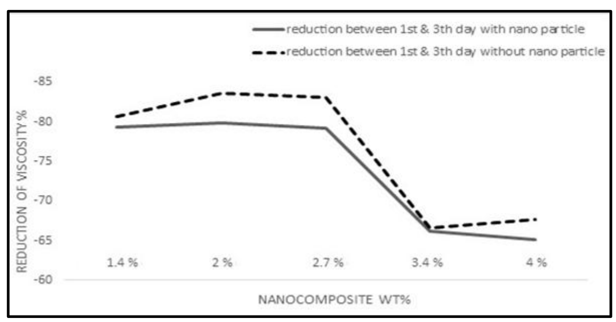

Fig. 9. Effect of thixotropicity reduction in fresh water mud.

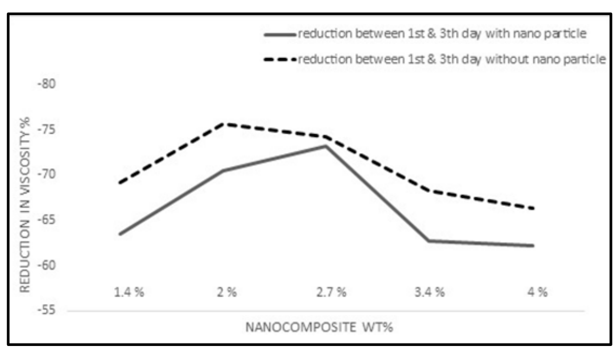

Fig. 10. Effect of thixotropicity reduction in standard salt water mud.

CONCLUSIONS

A polymeric nanocomposite was made through solution polymerization method to be used as an additive in drilling fluid. Combination of polymer and nanoparticles as a composite, enhance properties of both materials. Using polymer to control rheological properties of drilling fluid and nano particles for Improve and adjust Polymer defects, allows increasing viscosity and decreasing thixotropy simultaneously, by adding just one material.

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