# Effect of Polyanionic Cellulose Polymer Nanoparticles on Rheological Properties of Drilling Mud

**M. Fereydouni[1] , S. Sabbaghi[1*], R. Saboori[2] , S. Zeinali[1]**

1- Nano Chemical Engineering Department, Faculty of Advanced Technologies, Shiraz University, Shiraz, I. R. Iran
2- Chemical and Petroleum Engineering School, Shiraz University, Shiraz, I. R. Iran

(*) Corresponding author: : sabbaghi@shirazu.ac.ir
*(Received:25 May 2012 and Accepted: 15 Aug. 2012)*

**Abstract:**
*Polyanionic cellulose polymer is used as an additive in drilling mud in order to decrease water loss and mud-cake-thickness. In this study effect of bulk and nanosize polyanionic cellulose on water loss and mud-cake-thickness in mud drilling is investigated. Polyanionic cellulose nanoparticles are made by using of ball milling. Size of nanoparticles is measured by Particle size analyzer. Polyanionic cellulose and polyanionic cellulose nanoparticles which were prepared by Hamilton batch mixer and with certain percent suggested by API, were added to water-based mud drilling. Filter press system is used to measure the amount of water loss and mud cake thickness. It was found that adding polyanionic cellulose nanoparticles in comparison with conventional polyanionic cellulose resulted in desirable reduction of amount of water loss and mud cake thickness.*
***Keywords:*** *Polyanionic cellulose, Nanoparticles, Mud drilling, Water loss, Mud cake thickness*

## 1. INTRODUCTION

Any of a number of liquid and gaseous fluids and mixtures of fluids and solids (as solid suspensions, mixtures and emulsions of liquids, gases and solids) used in operations to drill boreholes into the earth. Classifications of drilling fluids has been attempted in many ways, often producing more confusion than insight. One classification scheme, given here, is only based on the mud composition by singling out the component that clearly defines the function and performance of the fluid: (1) water-based, (2) oil-based and (3) gaseous (pneumatic). Each has a variety of subcategories that overlap each other considerably. [1, 2].

Just as drilling fluids are integral to the borewell drilling process, additives that are very much a part of their composition, have a unique role to play. Most of these additives have distinct properties that specifically help in countering certain challenges encountered during the drilling process. They help in accomplishing the drilling work with efficiency and precision. They also help in minimizing human hazards. [3, 4, 5].

PAC is one of the popular additives being increasingly considered for easing the challenges associated with borehole drilling mechanisms. PAC is basically a technical grade, low viscosity, and dispersible additive. Chemically, it is a Polyanionic Cellulose compound. It reduces the API filtration rate through minimum enhancement in viscosity with respect to aqueous drilling fluids.

Nanotechnology is the understanding and control of matter at the nanoscale, approximately at dimensions between 1 and 100 nanometers, where unique phenomena enable novel applications. It can be used to solve a lot of problems associated with drilling engineering. The nanoparticles have high area to volume ratio which gives them a high surface area for interaction with surrounding medium, hence for any application the quantity of nanoparticles required will be less and hence there is cost advantage when using nanoparticles. The applications of nanoparticles in drilling fluids are mainly to form a thin layer of non-erodible and impermeable nanoparticles membrane around the wellbore which prevents common problems like clay swelling, spurt loss and mud loss due to circulation [6].

Nanoparticles required will be less and hence there is cost advantage when using nanoparticles. The applications of nanoparticles in drilling fluids is mainly to form a thin layer of non-erodible and impermeable nanoparticles membrane around the wellbore which prevents common problems like clay swelling, spurt loss and mud loss due to circulation [7].

There are different methods for synthesis of nanoparticles. These techniques are divided into two categories namely dry and wet synthesis methods. Dry synthesis methods consists of jet milling, ball milling, micronizer whereas wet milling consists of solvent evaporation, emulsion/double emulsion method, spray drying, fluidized bed coating and others [8].

Ball milling can be used with or without a liquid. In this method, a rotating cylinder is filled with the material to grind and balls which collide with each other, and the grinding material to be ground and exert shear forces on the grinding material. This method causes a lot of friction and wear in the material so it is not ideal for the soft matter like biodegradable polymer. This method is useful for formation of micro/nano meter sized particles or composites where the distortions in the particles due to friction is not crucial [9].

In the present study, the effect of PAC polymeric nanoparticles produced by ball milling on the two main parameters of water-based-mud drilling which are mud cake thickness and water loss, are investigated.

## 2. EXPERIMENTAL

### 2.1. Material

Bentonite and Polyanionic Cellulose (PAC) were both highly pure.

### 2.2. Preparation of PAC nanoparticles

Ball milling with high energy production and transferring the energy to the balls, causes the nanoparticles to be produced according to the shear stresses forced with the balls. The amount of energy depends on slipping velocity, size and number of balls and residence time in ball milling. To produce the PAC nanoparticles with the ball milling method, PAC was feed and the mill was set on 400rpm rotational velocity for about 2hr to 2.5hr. The temperature of experiment remained at room temperature. The shear stress inserted by the balls on the PAC particles caused the gridding of the PAC particle and production of PAC nanoparticles. PAC powders size distributions before entering to the mill and after exiting from the mill are shown in Figure 1 and Figure 2.

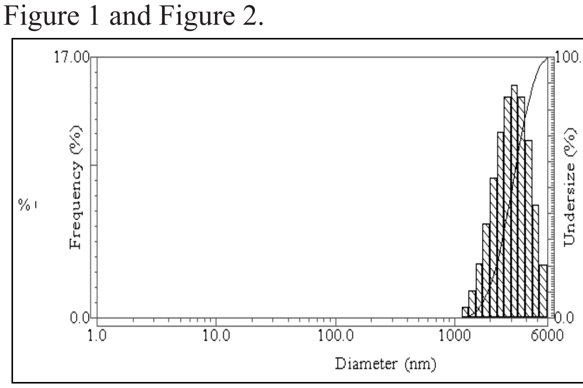


***Figure 1:*** *PAC particle size distribution*

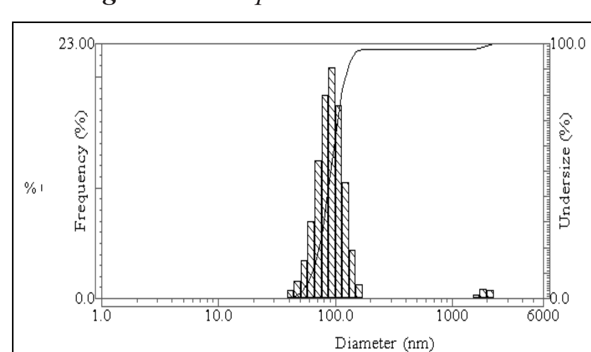


***Figure 2:*** *PAC nanoparticle size distribution*

### 2.3. Test section

In this work the effect of nanoPAC additives on the main parameters of water-based-mud drilling which are mud cake thickness and water loss was investigated. The experiments which were performed on the mud drilling were proposed by API. The water-based-mud based on 10gr Bentonite in $350^{CC}$ water was prepared by Hamilton Batch Mixer. PAC and nanoPAC with specific percents were added to mud drilling. The experiment related to the amount of water loss and mud cake thickness was done with the filter press device. In this device air was used as a pressure factor on the mud drilling. The pressure of the device was set on 100 psi for 30 minutes. The temperature remained constant at room temperature during the experiment.

## 3. RESULT AND DISCUSSION

PAC powder size distribution which was measured by particle size analyzer device is shown in Figure 1. In this Figure particle size distribution is in the rage of 1.7μm to 6μm with the average of 3.03μm.

NanoPAC powder size distribution which was measured by particle size analyzer device is showed in Figure 2. In this figure, particle size distribution is in the range of 65nm to 850nm with the average of 91nm. The range of particle size is narrow and it can be seen that ball milling method is an appropriate method for nanoparticles production. Having a narrow particle size distribution, the particles have more similar specifications. It should be noted that in the manning method accurate amounts for slipping velocity, residence time and also high temperature control are needed. Because as the slipping velocity is lower, the shear stress on the particles is decreased and the size of the produced particles is increased. Also as the residence time becomes lower, the particle size distribution is increased.

The results of experiments on water-based mud for PAC and nanoPAC are shown in Figure 3 and Figure 4. Increasing the area to volume ratio in nanoparticles causes the increase of the ionic group molecular weights for absorption on the clay particle surface and attaching the particles to each other also polymeric nanoparticles cause more colloidal particle formation by relating with solid particles which are present in the mud. Finally, the amount of water loss and mud cake thickness is decreased and the mud can preserve gel specification for longer time.

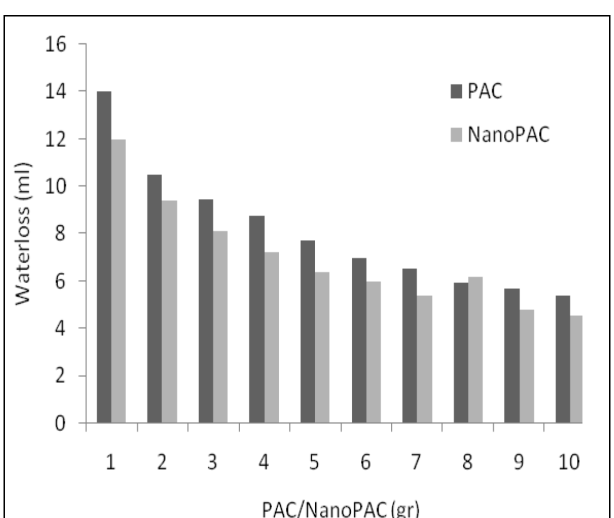


***Figure 3:*** *Amount water loss for mud drilling*

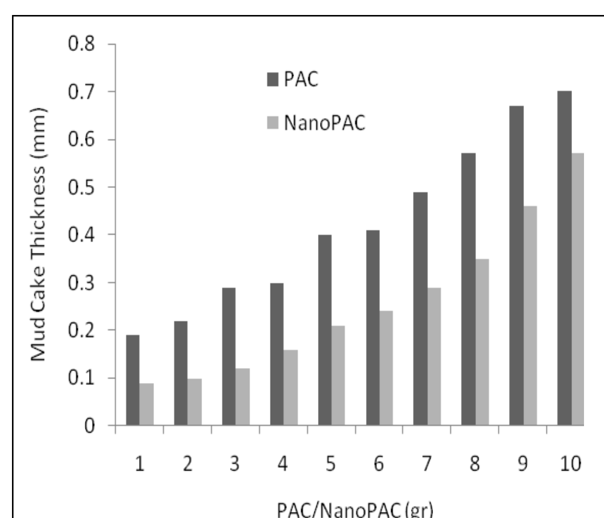


***Figure 4:*** *Mud drilling thickness for mud drilling*

## 4. CONCLUSIONS

In this work, PAC nanoparticles at 400rpm rotational velocity, 2-2.5hr residence time and room temperature were produced by the ball milling method. The PAC particle size before entering the milling and after exiting from the mill was measured by the particle size analyzer (Figure 1 and Figure 2). Specific percents of PAC nanoparticles proposed by API were added to the water-based-mud. The amount of water loss and mud cake thickness was measured by filter press device. Results are presented in Figure 3 and Figure 4 which show that existence of nanoparticle causes the amounts of water loss and mud cake thickness to be decreased.

## 5. REFERENCE


1. Neal J. Adams , pennwell Books, (1991) Neal J. Adams, pennwell Books,, Drilling Engineering.
2. Bourgoyne Jr. A. T., Millheim Keith K., Chenevert Martin E., Young Jr. F.S., (1991) Applied Drilling Engineering, second Edition.
3. Zhong, Zhengsong Qiu , Weian Huang, Jie Cao, Shale inhibitive properties of polyether diamine in water-based drilling fluid, Hanyi, Journal of Petroleum Science and Engineering, Vol. 78, No. 2, (2011), pp.510-515.
4. Md. Amanullah , Long Yu, Environment friendly fluid loss additives to protect the marine environment from the detrimental effect of mud additives, Journal of Petroleum Science and Engineering, Vol. 48, No. 3-4, (2005), pp. 199-208.
5. R. Saboori, S. Sabbaghi, D. Mowla, A. Soltani, Decreasing of water loss and mud cake thickness by CMC nanoparticles in mud drilling, International Journal of Nano Dimension, Vol. 3. No. 2, (2012), pp.101-104.
6. Thomas Gentzis , Nathan Deisman , Richard J. Chalaturnyk, Effect of drilling fluids on coal permeability: Impact on horizontal wellbore stability, International Journal of Coal Geology, Vol. 78, No. 3, (2009), pp. 177-191.
7. Jayanth T. Srivatsa, B.E, (2010) An Experimental Investigation on use of Nanoparticles as Fluid Loss Additives in a Surfactant – Polymer Based Drilling Fluid, Thesis of MS, Texas Tech University.
8. Midoux N, Hoek P, Pailleres L, Authelin J., Micronization of pharmaceutical substances in a spiral jet mill. Powder Technology., Vol. 104, No. 2, (1999), pp.113-120.
9. Takano K, Nishii K, Horio M., Binderless granulation of pharmaceutical fine powders with coarse lactose for dry powder inhalation. Powder Technology. Vol. 131, No. 2-3, (2003), pp.129-138.