



## Research of the Inhibitory Capacity of the Polymer Salt Drilling Fluids Based on Xanthan Gum



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**I**N the drilling process, the balance of the rocks composing the walls of the wells is disturbed. The stability of the walls depends on the original strength characteristics of rocks and their changes under the influence of various factors. Therefore, drilling mud plays large role.

It is known that the main role in the intensification of the process of softening clays is determined by original humidity, and the saturation of drilling mud filtrate under the action of the formation overburden. The absorption of the filtrate of drilling mud occurs not so much under the influence of pressure drop in the system well-reservoir, as a result of physical and chemical effects, growing in most clay rock. The most optimal from the point of view of stability of the borehole walls are cases where in the system the well-reservoir osmotic equilibrium is established, or osmosis is directed from the reservoir into the well.

The greatest influence of the osmotic pressure exhibited when saline drilling fluids are used. This paper examines the effect of polymer salt of drilling fluids clay swelling, i.e. inhibiting the ability of drilling mud.

**Keywords:** Drilling fluids, Polymer, Stability of the borehole, Drilling mud.

### Introduction

When drilling in rotational mode in the bore of the continuously circulating stream of liquid, which was previously considered only as a means for removal of destructed products (sludge). Currently, it is perceived as one of the main factors ensuring the efficiency of the whole drilling process [1-13].

In addition to the drilling mud to remove cuttings must perform other, equally important functions directed at the efficient, economical, and safe execution and completion of the drilling process [14-20]. For this reason, the composition of drilling fluids and evaluation of its properties was the subject of a large amount of scientific and practical research and analysis [21].

Now in world practice has been increasing depths of drilling, and as a result, and increased risk of various complications [4, 22-29]. In addition, the constantly rising demand for more complete and

efficient exploitation of productive rocks. In this regard, the drilling fluid must have a composition and properties which would provide an opportunity to deal with most of the possible complications and not have a negative impact on reservoir properties of productive horizons [30-36].

In conditions when the integrity of the rock, plays a big role rock pressure. Near of the well it occurs both in vertical and in horizontal direction [21, 37, 38]. Lateral pressure is the result of vertical and causes shear stresses that promote buckling of rocks, narrowing of wells and landslides. The magnitude of the shearing stresses depends not only on the rock pressure, but the pressure of drilling mud [39-43].

In drilling rock pressure always exceeds the hydrostatic pressure of drilling mud in the well and contributes to the destruction of the well walls if the strength of the rock is insufficient or significantly weakened by the impact of the

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Received 16/10/2019; Accepted 17/11/2019

DOI: 1 10.21608/EJCHEM.2019.18285.2121

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drilling fluid. The most intense deformation of the rocks directly at the wall of the wellbore where a lateral pressure is balanced by hydrostatic forces and the adhesion of rock [44, 45]. The nature of the change of the adhesion forces in the rock caused by geological and mineralogical features of rocks and its interaction with the drilling fluid, primarily physical and chemical [16,40,44].

Physical and chemical effects of fluids on rock manifests itself in three main forms [46, 47]:

- 1) active effect based on the processes of hydration, dissociation, ion exchange and chemical transformations;
- 2) adsorption effects;
- 3) osmotic effects.

The main negative impact of drilling mud on the strength of rocks is reduced to physical and chemical changes in the structure of rocks by the action of the filtrate [37, 46, 48, 49]. The action of the filtrate is accompanied by the dispersion of the clay component of the rock, the swelling, capillary and dynamic wedging [16, 50]. At the contact of drilling fluid with the walls of the well there is a chemical dissolution, leaching, hydro-mechanical destruction of rocks. The process is enhanced by the mechanical action of the drill string against the walls of the wells.

The mechanism of inhibition is as follows: when injected into the drilling mud inhibiting additives is a physical-chemical effect of clay and cation, which replaces the free, negatively charged areas in the crystal lattice of clay particles. When cation exchange activate previously passive sections of clays. Adsorbed on clay particles cation inhibiting reagent increases their resistance to moisture reduces swelling and softening of the clays [51].

It is established that the main role in the intensification of the process of softening clays plays the original humidity, and the saturation of drilling mud filtrate under the action of the formation overburden. The absorption of the filtrate of drilling mud occurs not so much under the influence of pressure drop in the system well-formation, because of physical and chemical effects, growing in most clay rock. The most optimal from the point of view of stability of the borehole walls are cases where in the system the well-formation osmotic equilibrium is established,

or osmosis is directed from the rock into the well. Despite the fact that in the case of the action of osmosis from the formation into the well there is a change of parameters of drilling fluid, it is much easier to manage and maintain them within specified limits than to deal with complications after the destabilization of the wellbore [24]. Therefore, the stability of clays will depend on well chosen compositions of chemicals and, primarily, by inhibiting the composition of the reactants. This is the main problem to be solved.

### **Materials and Methods**

To measure the swelling of clays device PNG-1 is used. For experiments were prepared the mixture of bentonite with a moisture content of 20 %. The mixture is placed in metal ring with inner diameter 50 mm. Height of clay  $h=10$  mm. the Ring with the clay is placed in the bath and is filled with drilling fluid. The value of the absolute deformation  $\Delta h$  is determined by the dial indicator. The testing time is 24 hours. The relative strain of the sample  $\delta$  is determined by the formula:

$$\delta = \frac{\Delta h}{h} 100 \%. \quad (1)$$

To determine the swelling clays following polymer salt solutions were used. As the polymer xanthan gum is used. As salts chlorides of sodium (NaCl), potassium (KCl), magnesium ( $MgCl_2$ ) and calcium ( $CaCl_2$ ) are used.

### **Results and Discussion**

To assess the inhibitory capacity of polymer-salt solutions were determined by the swelling of the clay placed in the drilling mud after 24 hours. The concentration of polymer in the solution is 0,5 %. As salt chlorides were used: sodium, potassium, magnesium and calcium. The dependence of the relative deformation of the salt concentration is shown in Fig. 1-4.

Recent developments in the field of water-soluble polymers, aimed at increasing the viscosity of an aqueous solution are considered in a very good review [52], from a comparison with which we see that our work is in the mainstream. Classic and novel associating water-soluble polymers for enhanced oil recovery applications are discussed along with their limitations. Particular emphasis is placed on the structure-property correlations and the synthetic methods. The observed

rheological properties are conceptually linked to the polymer chemical structure and topology. In addition, the influence of external parameters, e.g. temperature, pH, salt, and surfactant, on the rheological behavior is reviewed. Progress booked in deeper understanding of the structure–property relationship is thoroughly discussed. Furthermore, a critical overview of the synthetic methods as well as of the solution properties of these polymers is provided. In this respect the influence of “internal” (i.e. chemical structure) and “external” factors on these properties provide a conceptual toolbox for the rationalization of the response of water-soluble polymers to external stimuli. In turn, such rationalization constitutes the basis for the design of new polymeric structures for enhanced oil recovery applications.

The temperature and the ionic strength (the amount of electrolyte) of electrolyte, of the solution are triggers for the conformational transition. When testing at low shear, the rheology of the polymer solution is dependent on the conformation with the disordered conformation displaying higher solution viscosities [53]. Polymeric solutions employing xanthan gum display high viscosity at low shear rates [54] and thus the disordered conformation predominates at low shear rates. At high shear rates both conformations display similar rheological behaviors [53]. In addition, pseudoplastic behavior is observed for the polymer solutions [55, 56]. Unlike HPAM, xanthan gum displays good resistance to high temperatures. It was demonstrated that the solution viscosity of a polymeric solution employing a commercial xanthan gum remained relatively constant for more than 2 years at 80 °C [55]. Loss of solution viscosity occurs at temperature above 100 °C. Xanthan gum starts to lose its property above 120 °C due to hydrolytic and oxidative processes [57]. Therefore, the maximum thermal stability ascertained for the formulation was 120 °C. Combinations of xanthan gum with surfactants have also been studied. It has been demonstrated that the combination can be beneficial. According to Hoffmann [58] more than 50% of the residual oil (after a waterflood) can be recovered using xanthan gum and an alkyl propoxy-ethoxy sulfate (C12–15(PO)4-(EO)2-OSO<sub>3</sub><sup>-</sup>Na<sup>+</sup>) as the surfactant. The recovery of the residual oil using only a surfactant solution was lower

The results show that all the salts have inhibitory properties. With increasing salt concentration from 0 to 3 % decrease of relative deformation.

Minimum value of relative deformation observed when the salt concentration of about 3 %. Further, the increase of the deformation up to a certain value, and then a smooth reduction. The exception is calcium chloride which is more than 3% there is a gradual increase in deformation. The polymer initially has an inhibitory ability. By increasing the salt concentration reduces the relative deformation, thereby enhances their inhibitory capacity. The exception is, again, the calcium chloride which is a relative deformation at a concentration of from 6,5 to 10,5 % higher than that of mortar without polymer, but at higher concentrations there is a decrease in deformation.

### **Conclusion**

In the result of conducted research, the dependence of the swelling clays on the chloride concentration in the polymer-salt drilling fluids is justified. The concentration of salts increases the inhibitory ability of drilling fluids. Maximum this ability manifests itself when the concentration of chlorides: sodium and potassium 2-3 %, calcium 3-4 %, magnesium 3.5 to 5 %.

The mechanism of inhibition is associated with ion exchange, adsorption of polymer and osmotic pressure. Therefore, to determine the role of each of the factors needs further research.

This work shows that the successful design of new water-soluble polymers for a specific application in the oil industry requires an integrated multi-scale and interdisciplinary approach. Proper determination of the desired properties of the product in this case is crucial. Knowledge of the polymer-chemical architecture (and, consequently, the synthetic methods used) should be conceptually related to the required specifications and specific application and should ideally be related to the “nature” (that is, polymer architecture and general chemical composition) of the corresponding aqueous solution, which is demonstrated by our Job. The influence of external parameters (for example, pH and temperature) on rheological behavior should be combined with deep knowledge of the relationship between the chemical structure and the structure of the polymer and the rheological behavior. In this regard, the general correlation cannot be determined only as a function of the chemical / molecular structure. Rheological properties can be influenced by a combination of external parameters and the chemical nature and molecular structure of the polymer. Although there are many different water-

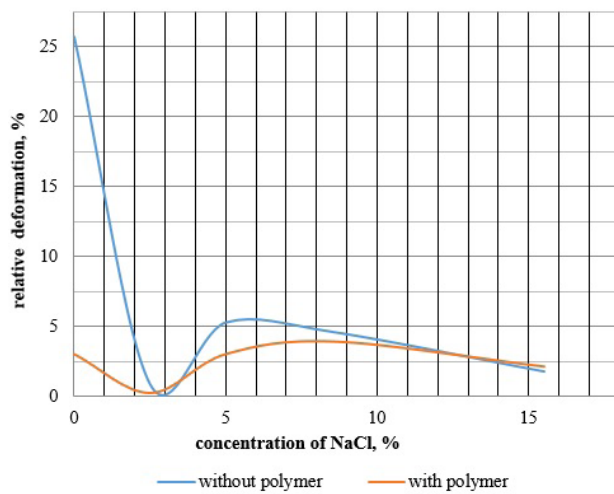


Fig. 1. Dependence of relative deformation of clay on the concentration of NaCl in the polymer salt solution of 0,5% xanthan gum

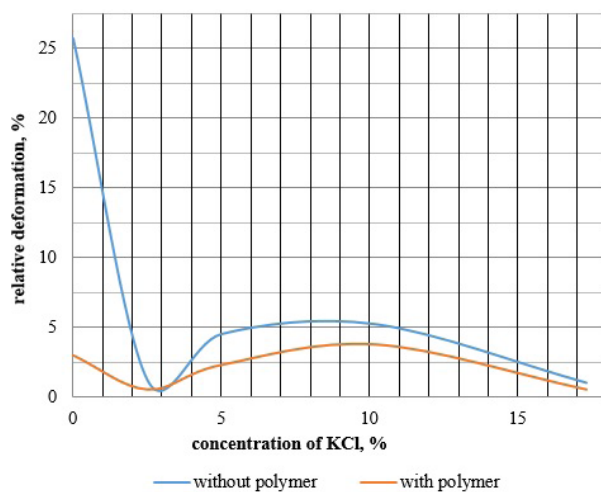


Fig. 2. Dependence of relative deformation of clay on the concentration of KCl in the polymer salt solution of 0,5% xanthan gum

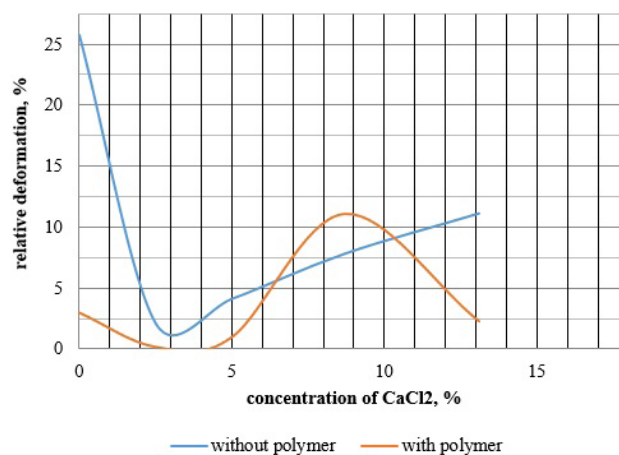


Fig. 3. Dependence of relative deformation of clay on the concentration of CaCl<sub>2</sub> in the polymer salt solution of 0,5% xanthan gum

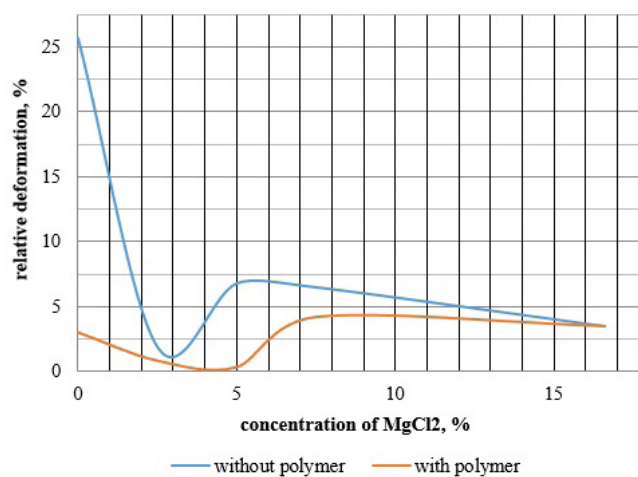


Fig. 4. Dependence of relative deformation of clay on the concentration of MgCl<sub>2</sub> in the polymer salt solution of 0,5% xanthan gum

soluble polymers that can increase the viscosity of a solution, it is important to understand their differences and analogies.

Different polymers demonstrate common differences in the principles of agglomeration, which determine their behavior in water. At the molecular level, the basic principle is indeed quite general: the presence of relatively weak inter (macro) molecular interactions (for example, hydrophobic association and hydrogen bonds) actually increases the molecular weight of the polymer coils. As a result, the viscosity of the solution increases. However, it is necessary to observe a careful balance, since predominantly weak interactions (both in terms of strength and their number) do not lead to the observed rheological differences, while excessively strong ones may violate the solubility of the system, leading, for example, to gel formation.

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