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Colloid-Chemical and Filtration Characteristics of Suspensions Based on Organobentonites with Electrolyte Additives

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ABSTRACT: This article presents the results of studies aimed at studying the effect of adding polymer reagents and electrolyte salts on the colloidal chemical and filtration properties of clay suspensions. In the experimental part of the work, suspensions of organobentonite and enriched bentonite were used, which were modified with various concentrations of electrolytes NaCl and $CaCl_2$, as well as filtration reducers CMC-700, polyacrylamide (PAA), and MAAG-Na. The main goal of the study was to determine optimal conditions for improving the structure-forming and stabilizing properties of clay suspensions used in drilling fluids. The results showed that the presence of electrolytes and polymer reagents has a significant impact on the structural and rheological parameters of suspensions, including viscosity, stability and filtration properties.

KEYWORDS: Organobentonite, clay suspensions, colloidal chemical properties, water loss, stability, daily sediment.

I.INTRODUCTION

Modern industrial processes often involve the use of clay suspensions, the functional properties of which are determined by their colloidal chemical and filtration characteristics. Systematic study of organobentonite suspensions with additions of polymer reagents and electrolyte salts opens up new prospects for optimizing their use in such critical areas as drilling, engineering geology and environmental protection [1-3].

The presence of polymer reagents in clay suspensions can significantly modify their rheological and filtration properties, providing improved stability and control over sedimentation processes [4-7]. In addition, the use of electrolyte salts can affect the charge characteristics of particles and interparticle interactions, which are critical for controlling the structure and permeability of suspensions [8-10].

The purpose of this study is a comprehensive analysis of the main colloidal chemical and filtration characteristics of clay suspensions in the presence of selected polymer reagents and electrolyte salts. Particular attention is paid to the study of the dependence of viscosity and fluid properties on the concentration and type of added polymers and salts, as well as the study of the mechanisms underlying the observed changes.

II. SIGNIFICANCE OF THE SYSTEM

This article presents the results of studies aimed at studying the effect of adding polymer reagents and electrolyte salts on the colloidal chemical and filtration properties of clay suspensions. The study of methodology is explained in section III, section IV covers the experimental results of the study, and section V discusses the future study and conclusion.

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III. METHODOLOGY

In the experimental part of the study, a thorough study of the issues of regulating the processes of structure formation and stability of clay suspensions used in drilling practice was carried out. Organobentonite (HDTMA-KR) based on Krantau clay and hexadecyltrimethylammonium bromide and the original enriched bentonite (KR) from this deposit were studied as a structure-forming agent [1-15]. The study involved studying the influence of electrolytes NaCl and $CaCl_2$, as well as various filtration reducers, in particular carboxymethylcellulose CMC-700, polyacrylamide (PAA) and PAA modified with maleic acid (MAAG-Na), on the parameters of clay suspensions. For the experiments, initial suspensions were prepared based on organobentonite with a concentration of 1,5% and enriched bentonite with a concentration of 5%. The preparation of suspensions was carried out according to standard methods ensuring reproducibility and comparability of results.

The experiments involved assessing viscosity (VBR-2M), density (pycnometer), filtration time (VM-6) and other key parameters that made it possible to evaluate the influence of the introduced components on the properties of drilling fluids. The influence of the concentration and ratio of added chemical reagents on the processes of structure formation in clay systems was also studied.

IV. EXPERIMENTAL RESULTS

A study of the effect of sodium chloride (NaCl) on the stability of clay suspensions revealed a number of significant patterns. Figure 1 presents a graph that illustrates the effect of sodium chloride (NaCl) concentration on the daily sediment (SD) of 5% suspensions of two clay samples: KR (1) and HDTMA-KR (2). It was found that with an increase in NaCl concentration in the KR sample (line 1), a significant increase in daily sediment occurs. Starting at about 5% NaCl, CO increases sharply, reaching more than 20% at a concentration of 20% NaCl. This indicates that when NaCl is added above a certain concentration, a given type of clay increases its tendency to settle.

In the case of HDTMA-KR (line 2), an increase in NaCl concentration also leads to an increase in daily sludge, but the changes occur less intensely. The CO value of this sample reaches only about 5% at a concentration of 20% NaCl.

Based on this, it can be concluded that HDTMA-KR exhibits better stability in the presence of NaCl compared to KR. This may indicate that the modified HDTMA-KR sample is more resistant to electrolytes, making it potentially more suitable for use in conditions where there is a high salt concentration.

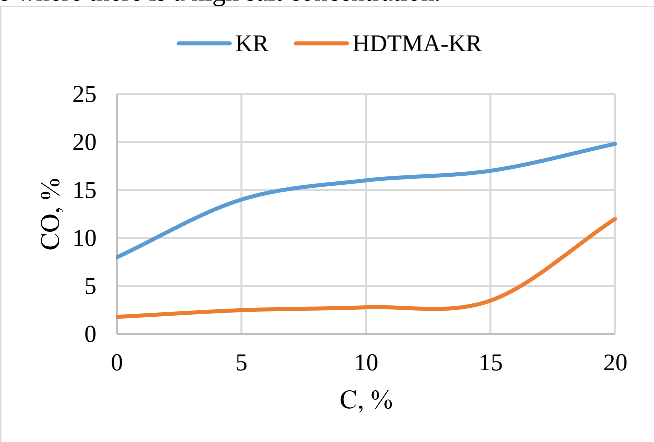

Fig. 1. Effect of concentration (%) of NaCl on CO of suspensions of clay samples

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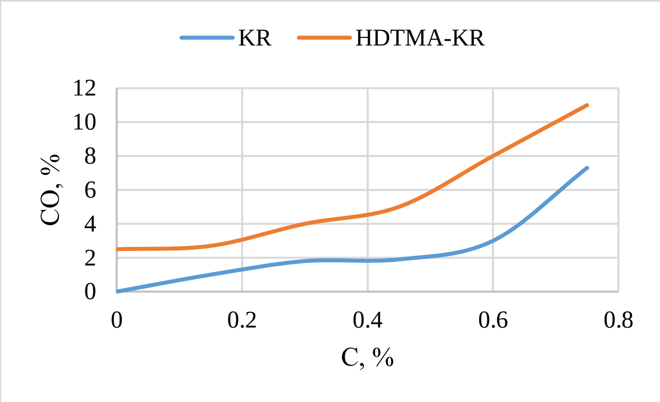

Fig. 2. Effect of concentration (%) of $CaCl_2$ on CO of suspensions of clay samples.

In the presented fig. Figure 2 shows two curves that show the effect of the concentration of calcium chloride (CaCl2) on the daily sediment (SD) of suspensions of two clay samples: KR and HDTMA-KR.

The HDTMA-KR sample line shows a smoother increase in CO with increasing CaCl2 concentration, while the KR line shows a sharper increase in CO, especially after a concentration of 0.4%. This indicates that the presence of CaCl2 in higher concentrations has a stronger effect on the stability of the suspension of the KR sample, in comparison with the modified HDTMA-KR sample.

The graph shows that the HDTMA-KR suspension has better stability and is less susceptible to sedimentation when the $CaCl_2$ concentration is increased to about 0.5%. After this point, the curve for HDTMA-KR begins to rise faster, which may indicate the approach of the stability limit of this modified suspension.

Both curves demonstrate that an increase in the CaCl2 concentration in the suspension leads to an increase in CO, but the effect on HDTMA-KR occurs later and less sharply than on CR, which may indicate better resistance of the modified suspension to calcium ions.

During the experimental work, it was revealed that the stability of clay suspensions has a significant impact on their filtration characteristics. It was found that a violation of the stability of the system leads to a deterioration in water yield, that is, to an increase in the amount of water separated from the suspension. Thus, the less stable the system, the worse its filtration properties and, accordingly, the higher the water loss indicators.

To maintain optimal filtration characteristics in the presence of mineralization in suspensions, it is necessary to use special chemical reagents that can reduce filtration. In this context, the influence of polymer compounds, which can act as filtration and viscosity reducers, was considered. When macromolecules of these polymers are adsorbed on the surface of clay particles, changes occur in the structure of the suspension, affecting its rheological and filtration properties.

As a result of experiments, it was determined that the introduction of various polymer compounds leads to a change in the viscosity of the suspension, its structural and mechanical properties (SMP) and fluid loss. The effectiveness of polymers as modifiers of suspension properties was quantified by measuring the viscosity, SHC and fluid loss of suspensions based on HDTMA-KR clays. The data obtained during the research made it possible to formulate the dependence of these indicators on the concentration of polymer reagents in the system.

From the presented fig. Figure 3 shows that the nominal viscosity of HDTMA-KR suspensions varies depending on the concentration of added polymer reagents. CMC-700 has the least effect on the increase in relative viscosity compared to PAA and MAAG-Na. With increasing concentration of polymers, the relative viscosity of suspensions increases, which indicates an increase in the structure-forming properties of polymers.

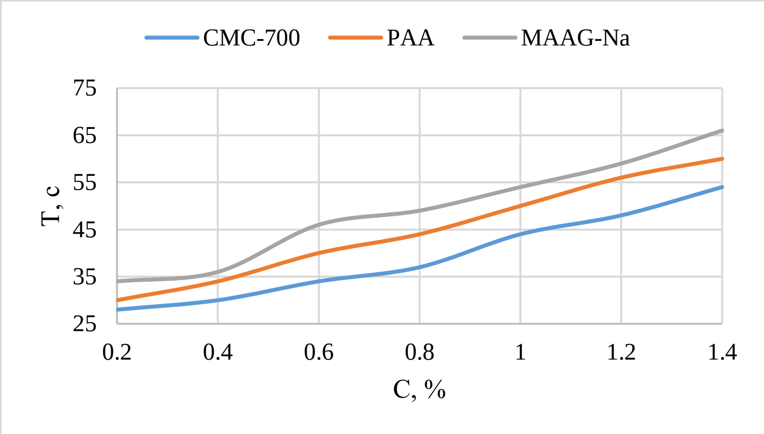

Fig. 3. Effect of polymer concentration on the relative viscosity (T, s) of HDTMA-KR suspensions.

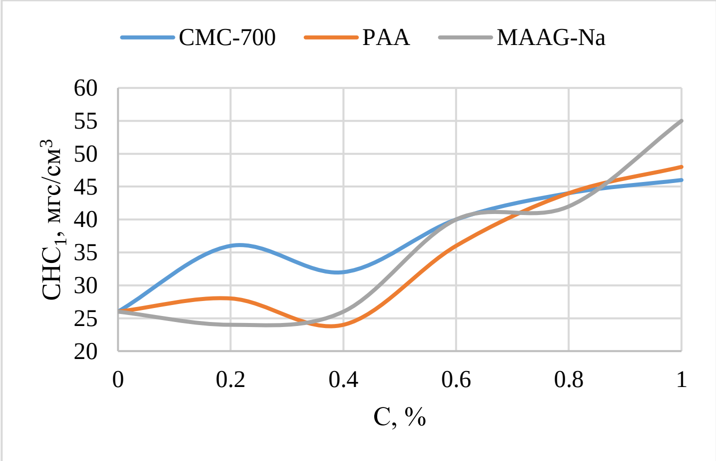

Fig. 4. Effect of polymer concentration on the SNA of HDTMA-KR suspensions.

PAA shows intermediate viscosity increases, while MAAG-Na is most effective in increasing suspension viscosity, especially at high concentrations. This suggests that MAAG-Na may be a better option for applications requiring higher drilling fluid viscosity, such as maintaining solids in suspension and preventing them from settling.

The presented figure shows the effect of the concentration of various polymers on the static shear stress (SSS) of HDTMA-KR suspensions. SNS is a measure of the structural strength of a suspension, indicating the resistance of the material to the initiation of movement under the influence of applied force.

The graph shows that all three polymers - CMC-700, PAA and MAAG-Na - have different effects on the SNA of suspensions. CMC-700 initially increases the SNA of suspensions at low concentrations, after which, with increasing concentration, the SNA decreases and begins to increase again at higher concentrations. This may indicate that in a certain concentration range, CMC-700 improves the structural strength of suspensions, but with a further increase in concentration, a loosening effect on the structure begins.

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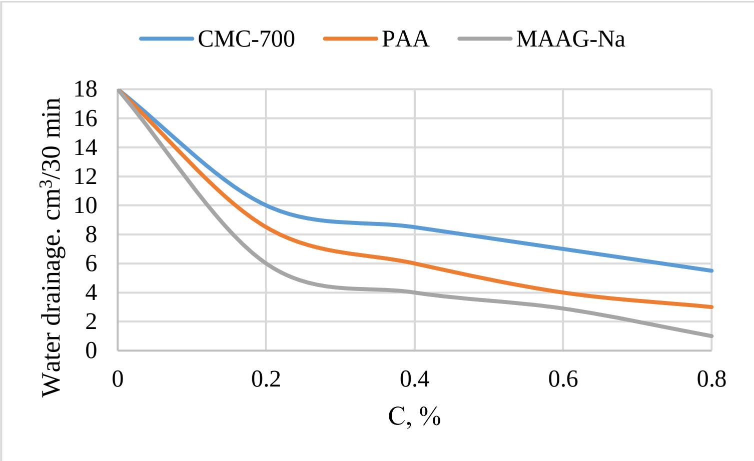

Fig. 5. Influence of polymer concentration on fluid loss of HDTMA-KR suspensions.

PAA demonstrates a more gradual increase in SNA with increasing concentration, which may indicate a stable enhancement of the structure-forming properties of this polymer over a wide range of concentrations. MAAG-Na shows a more pronounced increase in SNA at high concentrations, which may be a result of the formation of stronger interparticle bonds in the presence of this polymer.

Water loss is an important indicator when assessing the quality of drilling fluids and reflects the ability of a suspension to lose water under the influence of filtration pressure.

The graph shows that with increasing concentration of polymers CMC-700, PAA and MAAG-Na, the fluid loss of suspensions decreases. This indicates that polymer additives help improve the filtration properties of the suspension, reducing water loss and thereby increasing its stability.

At the beginning of the graph (at low polymer concentrations), the curves for all three polymers are almost parallel, which may indicate a similar effect of these polymers on the properties of suspensions in this concentration range. With a further increase in concentration, water loss decreases more intensely for MAAG-Na, which may be due to the higher efficiency of this polymer in forming the structure and reducing the permeability of the suspension to water.

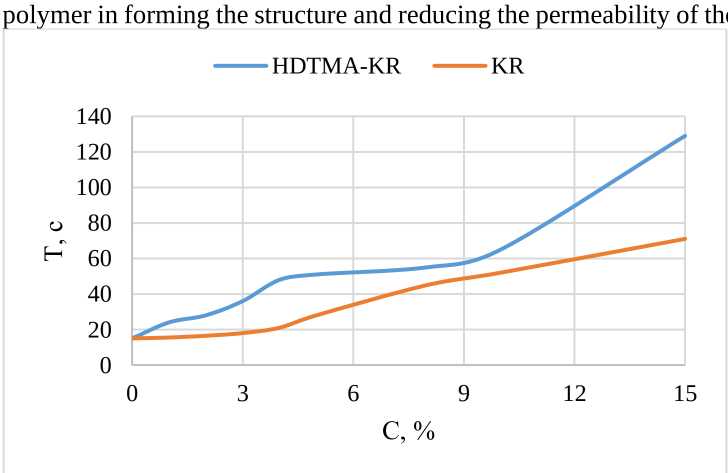

Fig. 6. Changes in the relative viscosity of clay suspensions of various concentrations from the addition of MAAG-Na in an amount of 1%.

The polymer KMC-700 shows the most stable decrease in water loss throughout the concentrations presented in the graph. PAA, on the other hand, demonstrates a slower decrease in fluid loss at low concentrations and a more noticeable decrease at high concentrations, which may indicate different mechanisms of action on the structure of suspensions depending on the concentration.

Based on these data, it can be concluded that MAAG-Na at high concentrations may be preferable for reducing fluid loss of suspensions, while CMC-700 provides a more uniform improvement in the filtration properties of suspensions over a wide range of concentrations.

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From Fig. 6 shows that both suspensions show an increase in relative viscosity with increasing concentration of added MAAG-Na. The HDTMA-KR suspension starts out with a lower viscosity compared to CR at low concentrations, but as the concentration of MAAG-Na increases, the difference decreases, and after a concentration of approximately 7%, HDTMA-KR exhibits a higher viscosity compared to CR.

For HDTMA-KR, starting at a concentration of 0% and up to approximately 7%, an almost linear increase in viscosity is observed, after which the curve becomes steeper, indicating a more pronounced increase in viscosity with the addition of higher concentrations of MAAG-Na. For CR, the increase in viscosity is less intense and almost linear throughout the entire concentration range under consideration.

V. CONCLUSION AND FUTURE WORK

The studies carried out on the basic colloidal chemical and filtration properties of clay suspensions with additions of polymer reagents and electrolyte salts made it possible to obtain valuable data on the behavior of these systems under various conditions. It was found that the concentration of electrolytes has a significant effect on the stability of suspensions, and the addition of NaCl in high concentrations reduces their kinetic stability, especially for suspensions of enriched forms of CR. At the same time, an increase in daily sludge and a change in rheological properties are observed.

A study of the influence of various polymer compounds showed that they effectively influence the viscosity and filtration characteristics of clays, significantly changing the properties of suspensions. The results indicate the potential of using organobentonites and polymer reagents to create drilling fluids with desired properties, ensuring efficient drilling and minimizing environmental impact.

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