

Rheological properties of clay-polymer systems: application on water-based drilling mud

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Érkezett: 2022. 02. 20. ▪ Received: 20. 02. 2022. ▪ <https://doi.org/10.14382/epitoanyag-jsbcm.2022.21>

Abstract

The objective of this work is the study of the effect of the addition of anionic polymers on the rheological characteristics of a water-based drilling mud (WBM). The modified Cross model is successfully applied to fit the flow curves of WBM at different quantity of poly-salt. The incorporation of poly-salt in a concentration range between 0 and 1 wt% induces an increase in the yield stress τ_0 in the zero shear rate viscosity η_0 and in the infinite shear rate viscosity η_∞ of the WBM. It is also shown the addition of poly-salt between 0 and 1 wt% to WBM that may cause an increase of their degree of thixotropy. Finally the thixotropic behavior studied at different concentration of poly-salt added in WBM at 20 °C is analyzed by using a structural kinetic model (SKM) in order to investigate time dependent effect.

Keywords: bentonite, poly-salt, structural parameter, thixotropic, kinetic model

Kulcsszavak: bentonit, polimer só, szerkezeti paraméter, tixotróp, kinetikai modell

1. Introduction

Clay-polymer systems are commonly used as basic constituents of water-based drilling fluids to meet such requirements as fluid which facilitates the smooth running of operations [1-3]. First of all, the drilling fluids have an ability to create a hydrostatic pressure making it possible to ensure the stability of bored walls and to prevent the coming of fluids underground aquifers crossed [4-6]. Drilling muds have also a great importance to ride up the cuttings from the bottom of the well to the surface. The consistency of the drilling muds must therefore be sufficient to prevent sedimentation of these cuttings in the updraft. During stops circulation of drilling muds for manoeuvres, dispersed cuttings and solid particles must remain perfectly in suspension. This also has certain rheological properties which, however, must not hinder recirculation or hamper manoeuvres or have harmful influences during them. A prior knowledge of the rheological properties of the drilling fluid, as well as the success of modelling the pressure losses and the transport of cuttings which may occur there, are very essential to adapt the composition of the fluid and the flow parameters to the drilling conditions. For this reason, several studies have been carried out on the rheological properties of drilling mud and different additives to drilling mud for the most effective formulation which meets the requirements of drilling techniques. Thus, the effects of pH and electrolyte concentration on the rheological properties of water-based drilling have been studied by Kelessidis et al [7]. It was observed a maximum of the yield stress, flow

consistency index and apparent viscosity at the natural pH of the drilling muds, while there is monotonous decrease of these parameters with increasing of salt concentration. Moreover, the effects of sodium carboxymethyl cellulose, xanthan gum and sodium dodecyl sulfate on rheological properties of water-based drilling were studied by Benchabane and Bekkour [8]. It has been shown that for these additives make the apparent viscosities of the solutions increase with increasing concentrations. Hammadi et al [1] have investigated the effect of polyethylene Oxide (PEO) and the shear rate on rheological properties of water-based drilling mud. The authors demonstrated that addition of polyethylene oxide (PEO) to water-based drilling muds lead to the increase of yield stress and fluid consistency index of the mixture. Likewise, the authors explained that this trend was due to the interactions between clay particles and the viscous effect of the polymer solution. Recently, Ben Azouz et al [9] studied the effect of the temperature on the rheological properties of a complex bentonite-sodium carboxymethylcellulose. They observed that in the liquid like regime, the viscosity of the fluids decreased as the temperature increased and at low shear stresses, the solid-like regime have been observed. According to these authors the increase of temperature generates an increase of the Brownian motion. Salehnezhad et al [10] investigated the effect of ZnO nanoparticles and starch on rheological properties of drilling mud. The authors used the power law and Bingham-plastic models in order to modelling the effect of both additives on flow behaviour of the drilling mud. It was demonstrated that

the parameters of power law (consistency index and flow index) and Bingham-plastic models (plastic viscosity and yield point) are improved, when nanoparticles and starch were added to water-based drilling muds. Another study by Bayat and Shams [11] who demonstrated that the incorporation the quantity of titanium dioxide, silicon dioxide and zinc oxide between 0.01 and 0.5 wt% in drilling mud caused the increase on their plastic viscosity and yield stress so the adding of nanoparticles improved the rheological proprieties of drilling mud. Du et al [12] have shown the incorporation the concentration of $P_2O_7^{4-}$ between 0 and 8 wt% in 7 wt% bentonite-0.1 M KCl caused the decrease in yield stress. In fact, up to a quantity of transferred form 2 wt%, the yield stress stayed almost constant. Also the authors demonstrated that adding a quantity of $P_3O_{10}^{5-}$ between 0 and 8 wt% in 7 wt% bentonite-0.01M $MgCl_2$ caused the decrease in yield stress. From their part, Mudaser Ahmad et al [13] investigated the impact of copolymer of acrylamide and 2-acrylamido-2-methylpropane sulfonic acid and terpolymer of acrylamide, 2-acrylamido-2-methylpropane sulfonic acid on rheological proprieties of system deionised and salt water-bentonite. It was proved that the incorporation of the polymer in system deionised and salt water-bentonite at 25 °C and 85 °C caused a good improvement of their rheological properties compared to the copolymer. In order to minimize the fluid loss, Ahmed et al [14] incorporated the iron oxide or Hematite in KCl-Glycol-PHPA polymer to water based drilling mud system. It has been shown that the incorporation of the 3 wt% nanoparticles in KCl-Glycol-PHPA polymer to this system caused an increase of yield point by 3%. Likewise, the authors demonstrated that when 0.5 wt% of nanoparticles is added to the KCl-Glycol-PHPA polymer to this mud also, their API fluid filter reduce by 13.6% and their plastic viscosity increase by 10%. According to Kuma et al [15] the addition of carboxymethyl cellulose, sodium salt, PHPA polymer and polyacrylamide in water-based drilling mud improving their rheological properties (plastic viscosity and yield stress) and reducing the fluid loss. The same authors also proved that the NaCl is good additive for minimizing swelling phenomena. From the literature, different rheological properties of bentonite and the mixtures bentonite-sodium carboxymethylcellulose, bentonite-xanthan and bentonite-polyethylene. Oxide have been investigated and analyzed by various models [16-21]. Although many researchers have studied the rheological behavior of water-based drilling muds and polymer-water clays, the obtained results from this present article is quite different since we are proposing using new economical polymer as additive for the purpose of improving the rheological properties of water-based drilling mud.

2. Materials and methods

2.1 Materials and sample preparation

2.1.1 Materials

The poly-salt, as polymer chosen to this work, it can reduce the fluid loss and increase the viscosity of all WBM. It is especially applicable and economical in saturated salt and brine systems rather than others products which are not effective. The poly-salt as function in NaCl, KCl, $MgCl_2$, $CaCl_2$ and

complex brines. The poly-salt used in this work was supplied from Sonatrach society (Algeria). Table 1 presents the physical properties of the poly-salt used in this study.

Physical properties	Granular powder
Specific gravity	1.5
pH	7.0
Solubility in water	Soluble
Bulk density	561 kg/m ³

Table 1 Typical physical properties of the poly-salt used in this study
1. táblázat A tanulmányban használt polimer só tipikus fizikai tulajdonságai

The clay used is bentonite of Maghnia (Algeria) which is marketed by Bental Company. The main components of this sample are: SiO_2 (61.78%), Al_2O_3 (17.15%), Fe_2O_3 (3.82%), MgO (3.56%), CaO (0.26%).

2.1.2 Preparation of samples

Given that the way of preparation has a great influence on the final state of suspensions, and thus on the rheological behavior, all tests were carefully carried out under equal conditions to allow for comparison of the results.

For each mixture, the bentonite suspension has the same mass concentration (4 wt%). The bentonite powder was dispersed in the required amount of distilled water without any chemical addition. The homogenization was performed under continuous magnetic agitation for 24 h. The additives at different concentrations (0; 0.2; 0.4; 0.6; 0.8 and 1 wt%) were then added to the base suspension, afterwards, the system poly-salt-water-bentonite obtained were subjected to a continuous agitation for 24 h.

2.2 Experimental setup

The rheological measurements were performed by using a torque controlled rheometer (Discovery Hybrid Rheometer DHR2 from TA instrument), equipped with a cone-plate geometry (diameter: 60 mm; angle: 2°; gap: 54 µm). It has a Peltier temperature control system that allows having a very quick response to any change in temperature range to -40 at 150 °C. In order to prevent changes in composition during measurements due to water evaporation, a solvent trap was placed around the measuring device.

2.3 Experimental methods

2.3.1 Hysteresis loop

The hysteresis loop test consisted of four stages:

- The stress history was minimised by pre-shearing the sample at 4 Pa for 120 s,
- The shear stress was linearly increased for 0 to the maximum shear stress in 600 s,
- The sample was sheared at the maximum shear stress for 120 s,
- The shear stress was linearly decreased for maximum to 0 Pa in 600 s.

The maximum shear stress range depends on the mass concentration of poly-salt added to based bentonite. In this case, the concentration of poly-salt less than 1% of the maximum shear stress is 4 Pa, however, the concentrations greater or equal to 1% the maximum shear stress is 6 Pa.

2.3.2 Apparent viscosity evolution under constant shear rate

After a rest time (time during which the sample is left at rest time of 600 s under geometry, the samples were sheared during 180 s at different constant shear rates (25 and 50 s⁻¹) at constant temperature (20 ± 0.2 °C). A new fresh sample was used for each applied shear rate in order to avoid any irreversible evolution of the samples.

3. Results and discussion

3.1. Particles size distribution

Fig. 1 shows the particle size distribution of bentonite and poly-salt polymer measured by the light scattering technique with a Malvern Instruments Mastersizer 2000 system. In order to avoid the formation of aggregates during the measurements, the sample was submitted to ultrasound excitation. We observed in Fig. 1 the particle sizes of bentonite ranging between 0.12 and 138 µm were found with a symmetric distribution centered at about 46 µm, and particle sizes of poly-salt polymer ranging between 17 and 830 µm were found with a symmetric distribution centered at about 455 µm. We also observed the maximum volume distribution of poly-salt is greater than of maximum volume distribution of bentonite which means that this poly-salt is more flocculated compared to bentonite [21-23].

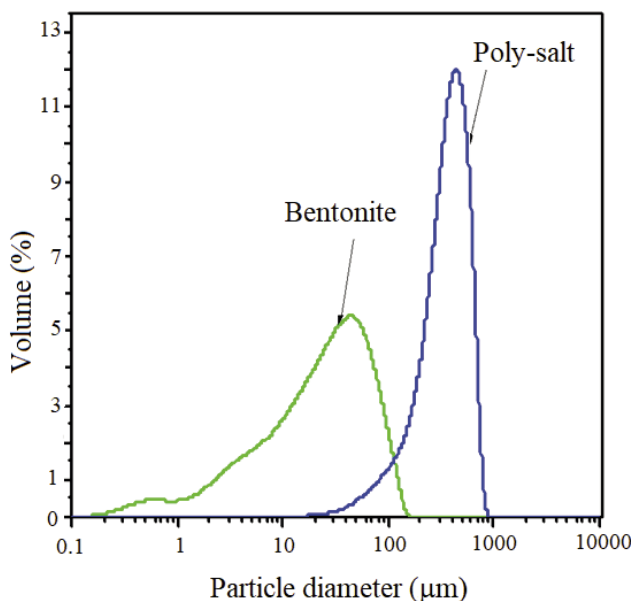


Fig.1 Particle size distribution of bentonite and poly-salt
1. ábra A bentonit és a polimer só szemcseméret-eloszlása

3.2 Hysteresis loop

The thixotropic loops of bentonite suspension-poly-salt with different concentration of poly-salt (0%, 0.4%, 0.6%, 0.8% and 1%) in bentonite suspension are shown in Fig. 2. It can be seen

in this figure that with concentration of poly-salt between 0% to 1% added to system poly-salt-water-bentonite, the downward curves are under the upward curves which represents positive thixotropy. For concentration of poly-salt equal 1% added in system poly-salt-water-bentonite, it is clearly found a crossover point that divide the loops into three sections: for the shear stress between 0 to 3.5 Pa, the downward curves are under the upward curves which represents positive thixotropy. However, for the shear stress between 3.5 Pa to 4.20 Pa, the upward curve is under the downward curve which indicates the negative thixotropic character; and finally, for shear stress between 4.20 Pa to 6 Pa the lower shear rate section, the downward curve is under the upward curve, which indicates positive thixotropic character.

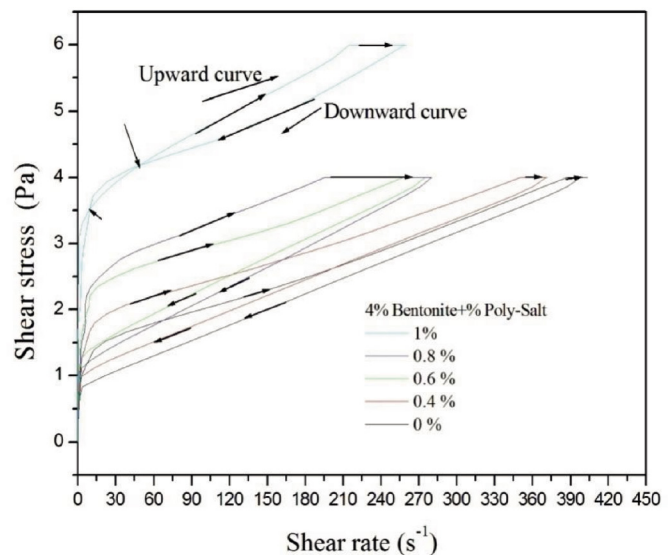


Fig. 2 Hysteresis loop of system poly-salt-water-bentonite at different concentration of poly-salt

2. ábra A polimer só-víz-bentonit rendszer histerézise különböző polimer só koncentrációknál

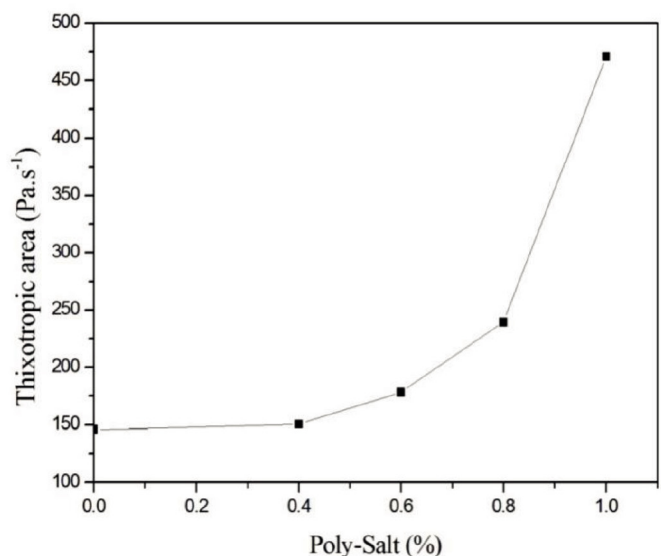


Fig. 3 Thixotropic area of system poly-salt - water - bentonite as a function of poly-salt additive

3. ábra Polimer só-víz-bentonit rendszer tixotróp területe a polimer só adalék függvényében

In this work, it is found that there is a great effect of poly-salt polymer on thixotropy of system poly-salt-water-bentonite, so the area between the upward and downward curves was calculated using the data analysis option of Trios V4.2.1. 36612 of TA instrument. Fig. 3 presented the area of hysteresis loops of bentonite suspension as a function of poly-salt concentration. It is clear that the degree of thixotropy increasing with increasing of poly-salt concentration in based water drilling mud, this behavior could be explained by increase the degree of flocculation caused by the poly-salt [24]. According to Shaikh et al [18] the increase of the flocculation degree (thixotropy) improves the stability of system poly-salt - water - bentonite.

3.3 Flow curve

The variation of the shear stress τ as a function of the shear rate $\dot{\gamma}$ at different concentration of poly-salt from 0 to 1% added in bentonite suspension clearly indicates two behaviors separated by a critical shear rate: a Non-Newtonian behavior after a yield stress followed by a plastic behavior (Fig. 4). Experimental data were fitted to modified Cross model (Eq. 1) developed by Grassi et al [25], which has been successfully employed for weak gel systems.

$$\tau = \tau_0 + \eta_{\infty} \dot{\gamma} + \frac{(\eta_0 - \eta_{\infty}) \dot{\gamma}}{1 + (\lambda_c \dot{\gamma})^m} \quad (1)$$

where τ_0 is the yield stress, η_0 is the zero shear rate viscosity (lower Newtonian plateau), η_{∞} is the infinite shear rate viscosity (upper Newtonian plateau), λ_c is a characteristic time and m is a dimensionless exponent. It should be noted here that, in the case of plastic systems, the zero shear viscosity η_0 represents the estimated value for the viscosity and the system would have if it maintained a typical solution behavior for low values of shear rate.

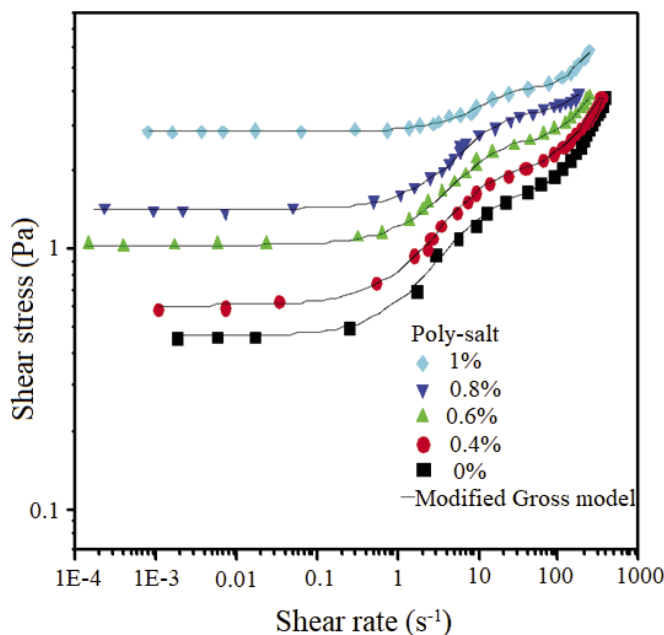


Fig. 4 Shear stress as a function of shear rate at different mass concentrations of poly-salt add (0, 0.4, 0.6, 0.8 and 1%) in bentonite suspension

4. ábra Nyírófeszültség a nyírási sebesség függvényében különböző tömegkoncentrációjú (0; 0,4; 0,6; 0,8 és 1%-os) polimer só adalékok esetén a bentonit szuszpenzióban

Fig. 5 and 6 show the variation of the parameters of the modified Cross model for bentonite-poly-salt mixtures system as a function of different concentration of poly-salt added to based bentonite suspension. We observe on Figs. 5 and 6, a rapid increase in the yield stress τ_0 , zero shear rate viscosity η_0 and the infinite shear rate viscosity η_{∞} with dose of poly-salt. The increase of yield stress τ_0 , zero shear rate viscosity η_0 and the infinite shear rate viscosity η_{∞} is occurred due to the adsorption of poly-salt by bentonite. This adsorption makes the specific surface highly rigid bentonite and causes an increase of interaction between the bentonite particles. The high particles size of poly-salt provoke the increase of hydrodynamic particle interactions, this hydrodynamic interactions caused the increase of the yield stress and viscosity's on the system poly-salt - water - bentonite. According to Guler et al [26] and Hammadi et al [1] the polymer chains formed network of aggregate and particles of the gel-like structures that made interactions between the bentonite particles and polymer which reinforce of the rigidity and the consistency of the mixture and also caused an increase of the yield stress and viscosity's. Moreover, Abu-Jdayil [27] explained that the increase in the yield stress they have observed is a direct consequence of an interconnected three dimensional network of flocs.

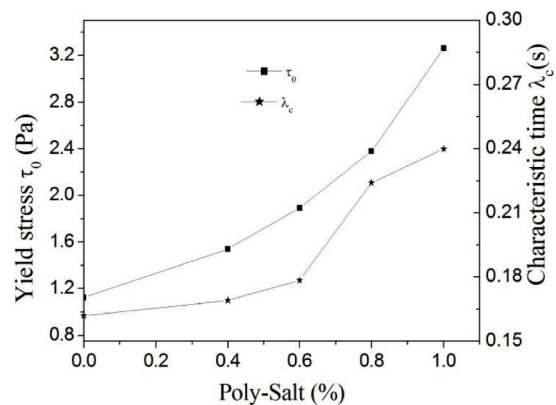


Fig. 5 Variation of yield stress and characteristic time of system poly-salt- water-bentonite at different concentration of poly-salt (0, 0.4, 0.6, 0.8 and 1%)

5. ábra A polimer só-víz-bentonit rendszer folyáshatárának és jellemző idejének változása a polimer só különböző koncentrációinál (0; 0,4; 0,6; 0,8 és 1%)

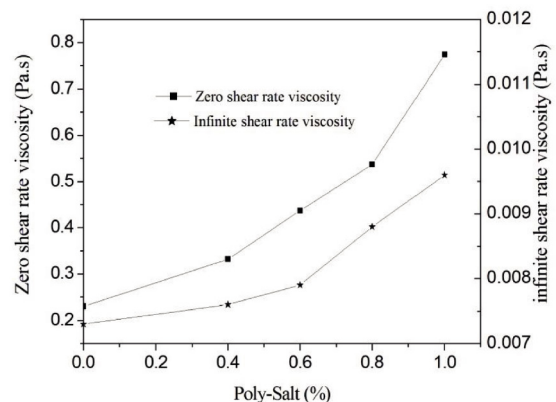


Fig. 6 Variation of zero shear rate viscosity η_0 and the infinite shear rate viscosity η_{∞} of system poly-salt- water- bentonite at different concentration of poly-salt (0, 0.4, 0.6, 0.8 and 1%)

6. ábra A nulla η_0 és a végtelen nyírási sebességű η_{∞} viszkozitás változása a polimer só-víz- bentonit rendszerben különböző polimer só koncentrációknál (0; 0,4; 0,6; 0,8 és 1%)

3.4 Apparent viscosity evolution under constant shear rate and determination of the structural parameter of system poly-salt - water- bentonite

Figs. 7 and 8 show time dependence of apparent viscosity for constant shear rates (25 s^{-1} and 50 s^{-1}) at different concentration of poly-salt (0, 0.2, 0.4, 0.6 and 0.8%) added to system water-bentonite. For all studied, quantities of poly-salt add in system poly-salt-water-bentonite and both shear rate, the viscosity decreases significantly with shearing time, particularly in the initial stages of shear. After approximately 100 s shearing period for shear rate of 25 s^{-1} applied on the mixtures and after approximately 120 s of shearing period for shear rate of 50 s^{-1} applied on the mixtures, the viscosity tends to an equilibrium value. Therefore the equilibrium state of system poly-salt-water-bentonite depends on the shear rate applied to the system. In order to determine the structural evaluation of the bentonite suspension-poly-salt, we applied the structural kinetic model (SKM) developed by Nguyen et al [28] (Eq. (2)), which has been successfully employed for starch pastes and concentrated suspensions of minerals.

$$\left(\frac{\eta - \eta_e}{\eta_0 - \eta_e}\right)^{1-n} = (n-1)kt + 1 \quad (2)$$

where η_0 is the initial apparent viscosity at $t=0$ (structured state), η_e is the equilibrium apparent viscosity as $t \rightarrow \infty$ (non-structured state). Note that, both η_0 and η_e are functions of the applied shear rate only [29] and $\lambda(t, \dot{\gamma}) = \frac{\eta - \eta_e}{\eta_0 - \eta_e}$ is the structural parameter ranged between the initial value of unity for zero shear time and the equilibrium structural $\lambda_e = \frac{\eta_e}{\eta_0}$ lower than unity. The initial apparent viscosity and the equilibrium apparent viscosity were found by fitting the time dependence of the viscosity (Figs. 7 and 8) by the second-order model SKM (Eq. (2) with $n = 2$). A good concordance was found between the model fitted results (solid line) and the experimental transient apparent viscosity data for all quantity of poly-salt add in system poly-salt-water-bentonite for the both shear rates applied.

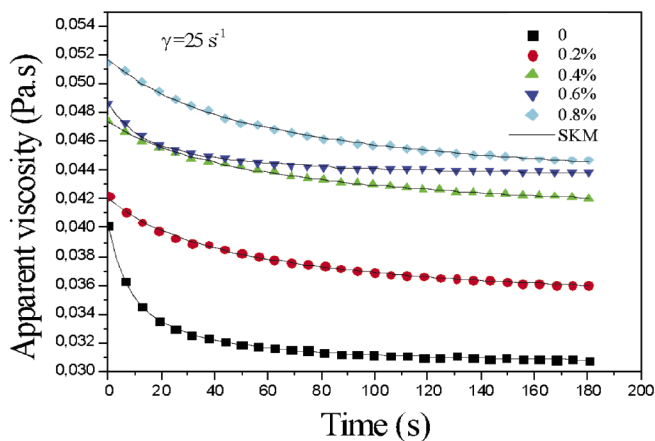


Fig. 7 Apparent viscosity data of poly-salt-water-bentonite mixtures as a function of shearing time at 20°C for different concentration of poly-salt added to system poly-salt - water- bentonite and for constant shear 25 s^{-1}

7. ábra Polimer só-víz-bentonit keverékek látszólagos viszkozitási adatai a nyírási idő függvényében 20°C-on, a polimer só - víz - bentonit rendszerhez hozzáadott különböző koncentrációjú polimer só esetén és 25 s^{-1} állandó nyírás esetén

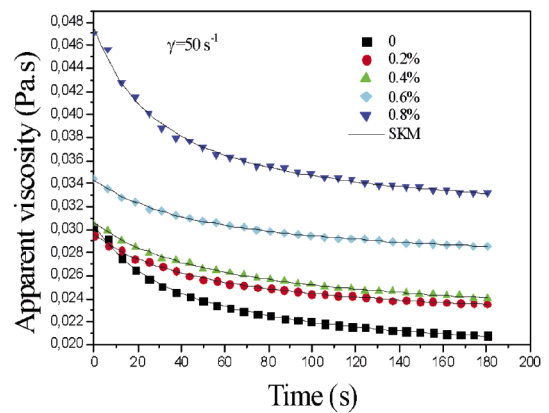


Fig. 8 Apparent viscosity data of poly-salt-water-bentonite mixtures as a function of shearing time at 20°C for different concentration of poly-salt added to system poly-salt-water-bentonite and for constant shear 50 s^{-1}

8. ábra Polimer só-víz-bentonit keverékek látszólagos viszkozitási adatai a nyírási idő függvényében 20°C-on a polimer só-víz-bentonit rendszerhez hozzáadott különböző koncentrációjú polimer só és 50 s^{-1} állandó nyírás esetén

Fig. 9 shows the variation of the rate constant k and equilibrium structural parameter λ_e as a function of the quantity of poly-salt added in system poly-salt-water-bentonite and for both shear rates applied. The rate constant, k can be considered as a measure of the rate of the structure breakdown, i.e. the degree of thixotropy. On other hand, the ratio of equilibrium to initial viscosity can be considered as an equilibrium structural parameter. We observed in Fig. 10 an increase of the degree of thixotropy with increase the quantity of poly-salt in system poly-salt-water-bentonite. This increase in the degree of thixotropy leads to an increase in the yield stress and the apparent viscosity of the system poly-salt-water-bentonite at rest [30]. For the same system, we also find that equilibrium structural parameter with increasing of the quantity of polymer added to the system. This behavior could be explained by the flocculation of mixtures particles in the water at high quantity of poly-salt add the mixture. As a result, there is a development of network or structure and also enhance organization of the particles of the mixtures concerning its microstructural level as it is investigated before by Wang et al [31].

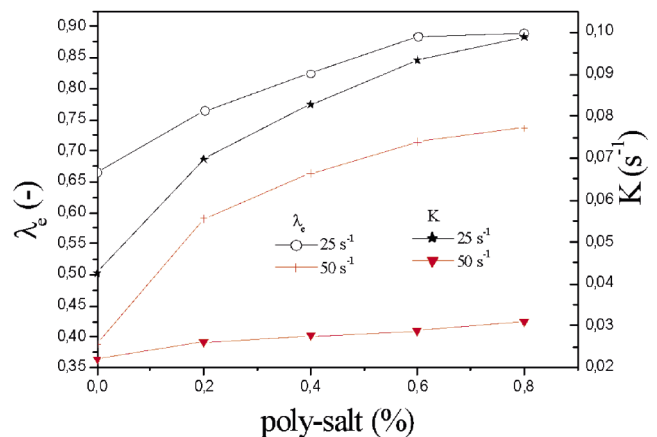


Fig. 9 Variation of the rate constant k and equilibrium structural parameter λ_e as a function of the quantity of poly-salt added to system poly-salt - water- bentonite for both shear rate applied

9. ábra A k sebességi állandó és a λ_e egyensúlyi szerkezeti paraméter változása a polimer só-víz-bentonit rendszerhez hozzáadott polimer só mennyiségének függvényében mindkét alkalmazott nyírási sebesség esetén

3.5 Comparison between poly-salt and others additives

Fig. 10 shows the evolution of apparent viscosity as a function of time of 4% bentonite suspension and 4% bentonite suspension-0.4% additives (poly-salt, CMC and HEC) under constant shear stress of 4Pa.

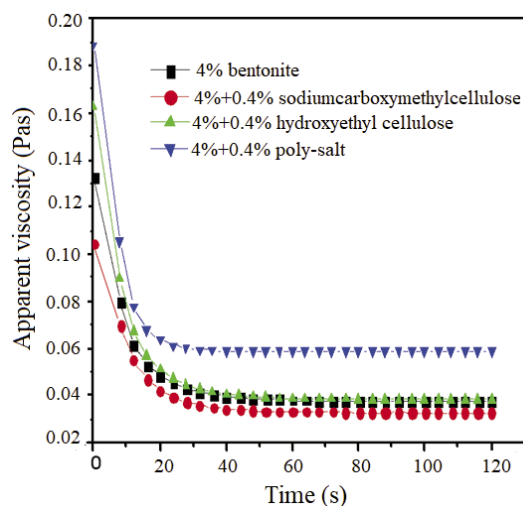


Fig. 10 Apparent viscosity as a function of time of 4% bentonite suspension and 4% bentonite suspension-0.4% additives (poly-salt, CMC and HEC) under constant shear stress of 4Pa

10. ábra A 4%-os bentonit szuszpenzió látszólagos viszkozitása az idő függvényében 4 Pa állandó nyírófeszültség és különböző adalékanyagok (polimer só, CMC és HEC) adalékolása mellett

The viscosity decreases significantly with shearing time, particularly in the initial stages of shear and tends to an equilibrium value after 60 s of shearing under shear stress of 4Pa. From the Fig. 10, adding the CMC caused decreasing in zero viscosity and infinite shear rate viscosity by 21% and 13% respectively, the incorporation of HEC in drilling mud improved their viscosity zero by 22% and infinity viscosity by 1.9% and finally the addition of the new poly-salt polymer in water-based drilling mud improve their zero viscosity by 42% and infinity viscosity by 54%. On one hand the decreasing of the zero viscosity and infinite shear rate viscosity of drilling muds caused by the CMC due to the high negative charge of CMC who favors the deflocculation of the mixture bentonite-CMC [16]. On the other hand the increase of the zero viscosity and infinite shear rate viscosity of drilling muds caused by HEC and poly-salt and this is due to the number of entanglement caused by long polymer chains [32].

3.6 FTIR spectra of bentonite and system poly-salt-water-bentonite

The infrared spectroscopic measurement of bentonite and bentonite-poly-salt were obtained using a PerkinElmer Spectrum Two FT-IR spectrophotometer at room temperature. The spectrum was collected over the spectral range of 4000–400 cm^{-1} . The IR spectrum of the bentonite and system poly-salt-water-bentonite is shown in Fig. 11. For bentonite the band at 3610.77 characterizes montmorillonite this is attributed to bending vibrations of the OH coordinated octahedral layer $Al + Mg$. The addition of poly-salt caused the shifting of this band to the band of 3313.60 which is correspondent

to the stretching vibrations of $Al - OH$ [33]. The absorption peaks of 3398.41 cm^{-1} and 1629.87 cm^{-1} are attributed to the stretching and bending vibrations of H-OH groups of water molecules adsorbed on the surface of bentonite, the addition of poly-salt in system water-bentonite shifted this absorption peaks to 1635.53 cm^{-1} and 1106.76 cm^{-1} respectively. The absorption peaks at 981.22 of system poly-salt-water-bentonite was attributed to $Al - OH - Al$ band corresponds to pure montmorillonite [34, 35]. The band at 507.35 of system poly-salt-water-bentonite is correspondent to absorption of the characteristic bond of Si-O-Al [34].

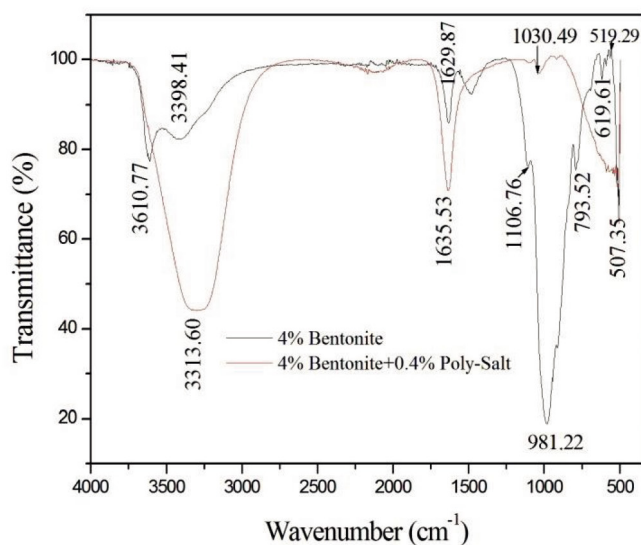


Fig. 11 IR spectrum of the bentonite and system poly-salt-water-bentonite
11. ábra A bentonit és a polimer só-víz-bentonit rendszer IR spektruma

4. Conclusions

The effect of new type of polymer the poly-salt on rheological proprieties of system poly-salt-water-bentonite was studied. The non-Newtonian stationary flow behavior of bentonite was successfully modeled by using the coupled Cross and Bingham models over the studied range poly-salt polymer.

The addition of poly-salt in a concentration ranging between 0 and 1% in system poly-salt-water-bentonite caused the increase in the yield stress, the zero shear rate viscosity, and the infinite shear rate viscosity with dose of poly-salt. The increase of these parameters was mainly related to the interaction between the solid particles and viscous effects. Then, the increase of the parameters of modified Cross model causes an increase in the friction and an increase in the viscosity of the system poly-salt-water-bentonite.

The increase of quantity of poly-salt in system poly-salt-water-bentonite causes an increase in the degree of the flocculation. This increasing of degree of the flocculation improved the rheological properties of system poly-salt-water-bentonite. The effect of poly-salt on break-down behavior of bentonite suspension was also examined. The time dependent viscosity decreased rapidly with shearing time and reached a steady state. The structural kinetic model (SKM) was successfully applied to analyze the time-dependent behavior of system poly-salt-water-bentonite. The rate of structure breakdown (degree

of thixotropy) under shear rate is increased with increasing quantity of poly-salt added to system poly-salt-water-bentonite. Finally, from this study it noticed that this poly-salt as an effective additive in drilling mud has many advantages for a large range of applications. It is very economic, highly effective in high salinity and high hardness brines. In addition, it minimizes filtration damage to production zones and it was mainly used to control filtration and rheology stability in the drilling mud. However, the use of poly-salt this in drilling mud is limited due their rapid degradation in temperature of 135°C and it cannot be used with zinc.

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Ref.:

Hathout, Safaa – Hammadi, Larbi – Boudjenane, Nasr-Eddine:
Rheological properties of clay-polymer systems: application on water-based drilling mud
 Építőanyag – Journal of Silicate Based and Composite Materials,
 Vol. 74, No. 4 (2022), 136–143. p.
<https://doi.org/10.14382/epitoanyag-jsbcm.2022.21>



Welcome notes to XVIII ECERS

The XVIIIth Conference of the European Ceramic Society will take place in Lyon, on 2-6 July 2023.

Lyon, where the Rhône and the Saône rivers meet, has always been a city of exchanges and industrial development, with major historic landmarks. 'Lugdunum' was founded in 43BC by the Romans and served as the capital of Gaul. It was also famous, as the world capital of silk, during the French Renaissance. Lyon's cuisine is famous all over the world, the cinema was invented by the Lumière brothers in this City of Lights, surrounded by prestigious wine areas where you can taste Beaujolais, Burgundy and Côtes-du-Rhône, not far from the Alps and of course Mont Blanc. Lyon is also the city of cutting edge industry and engineering, especially in the fields of chemistry and materials, biotechnology and medicine, mobility systems, with numerous schools and faculties created to answer technological and societal needs.

Thus, it is a great pleasure to welcome ceramists in the City of Lights, to share the latest discoveries in ceramic science and technology, reconnect with colleagues from around the world, in a convivial conference atmosphere. The conference, hosting ceramic experts from industry and academia, offering a unique opportunity to participate in an international event covering the development and applications of ceramic-based systems.

In addition to the now traditional symposia dealing with innovative processing, thermo-mechanical properties, modelling and ceramics for different high-tech applications, emphasis will also be given to advanced characterization techniques, silicate-based ceramics and materials for building applications, as well as the place of ceramics in necessary sustainable development. Lyon has been growing and evolving for 2,000 years: it is today a leading sustainable destination. Therefore, intent on reducing our environmental impact, we will make this XVIIIth ECERS conference a truly "think green" event.

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