Development of inhibitory drilling fluid for drilling in clay layer

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Abstract. The article presents the results of research on the development of efficient compositions of inhibitory drilling fluid based on local raw materials and production waste. The efficiency of technological factors and composition of developed complex inhibitors on the physicochemical properties of emulsion and oil-emulsion drilling fluids have been studied.

1 Introduction

Ensuring high rates of oil and gas production is inevitably associated with the development of new deposits of hydrocarbon raw materials, characterized by both a deeper location of productive horizons and more complex mining and geological conditions in comparison with areas of mass drilling. In addition to the difficulties that have been caused by abnormally high reservoir pressure (abnormally high reservoir pressure), hydrogen sulfide aggression and the presence of thick strata of chromogenic deposits, well construction is accompanied by problems associated with drilling terrigenous rocks. Terrigenous rocks of the greatest thickness are confined to the post-salt complex. As the drilling experience shows, the clayey deposits of the post-salt complex are represented by red-colored clayey-siltstone formations, argillite-like clays, montmorillonite clays (smectite), in which most of the complications associated with the violation of the integrity of the wellbore walls occur. Complications of this type include talus, rock falls, formation troughs, cavities, narrowing of the wellbore, causing slurrying of the bottom, the formation of plugs and oil seals. This results in loss of mud circulation, tightening, landings, jamming, sticking and breaking of the drilling tool.

To prevent such complications in domestic and foreign practice, special drilling fluids have been developed and used, including inhibiting polar systems: lime and gypsum-lime, calcium chloride and potassium chloride, silicate, polymer, solutions with additives of aluminum, iron, chromium compounds and others; and also - non-polar liquids, i.e. oil-based systems. However, for a number of conditions, the problem of maintaining the stability of the borehole walls in clay deposits has not been fully resolved. Well, drilling in saline rocks is also accompanied by negative phenomena due to the negative effect of salts on the properties of the drilling fluid. Due to a decrease in the number of complications associated with mud desolation, gland formation and violation of the integrity of the wellbore in the practice of drilling unstable clay deposits, inhibited drilling muds treated

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with rare sodium, lime, aluminates and salt-resistant stabilizers lignosulfonates are used [1-3]. To reduce the intensity of the transition of cuttings into a clay solution, to increase the stability of the borehole walls, it is necessary to use inhibiting solutions, which include a surface-active substance, a modified hydrophobic polymer reagent, metal oxides and salts. Complex multi-component systems, including, in addition to clay and water, four essential reagents: lime, caustic, filtration reducers, protective colloid. They can also include oil or diesel fuel, weighting agents and various additives for special purposes.

2 Results and discussion

Multifunctional modified complex reagent (MCR) is a stabilizer, inhibitor, water repellent, neutralizer and lubricant component of various types of drilling fluids intended for drilling chromogenic and unstable clay deposits and high-quality penetration of productive carbonate and terrigenous reservoirs.

Gossypol resin is a viscous black substance. Soluble in most organic solvents. It is hydrophobic, soluble in methyl, ethyl, furfuryl, isopropyl and butyl alcohols, kerosene, white alcohol, diethylene glycol, dioxane, acetone, diethyl ether, ethyl acetate, chloroform, carbon tetrachloride, phenol, pyridine. The main substances are gossypol and gossypol resin, alcohols and fatty acids.

Gossypol is a two-core aromatic polyatomic compound-containing in the structure of molecules 2-aldehyde and 6 - atoms of phenolic groups, with the general chemical formula $C_{90}H_{30}O_8$.

In gossypol resin, 12% of nitrogen-containing compounds were found, 36% of the conversion products of gossypol, 52% of higher fatty and oxyfatty acids. The chemical composition of gassing resin consists of more than 30 different organic and inorganic compounds (Table 1).

Table 1. Composition and content of gassing resin fraction

X_i	Component	Composition, %,			
		Fraction			Initial reagent
		I	II	III	
x_1	Gossipol	17.26	-	-	0.98
x_2	Stearic acid	1.72	-	-	0.42
x_3	Myristic acid		-	-	1.63
x_4	palminic acid	2.16	-	-	-
x_5	linoleic acid	2.26	0.92	1.12	2.36
x_6	oleic acid	8.60	-	4.17	9.80
x_7	Glycerol	39.9	8.94	7.00-	-
x_8	hexacazanol	7.76	4.40	0.9	-
x_9	Okazanol	6.54	2.46	0.21	1.88
x_{10}	Trioctanol	4.49	5.50	0.33	1.86
x_{11}	Methylbutandiol MBD	0.96	0.54	2.96	5.32
x_{12}	β-sitosterol	0.64	0.69	0.12	0.43
x_{13}	B-amirin	1.11	4.76	-	0.13
x_{14}	Methylpentatriol	2.0	5.15	1.54	2.17
x_{15}	Oxyfatty acids	1.79	14.09	4.10	5.80
x_{16}	nitrogen-containing compounds	1.05	11.89	5.33	5.38
x_{17}	lactones	1.30	21.00	8.16	6.20
x_{18}	Carbohydrates C_{27}-C_{33}	0.43	2.77	38.91	31.61
x_{19}	Formaldehyde-dioxane alcohol	-	0.52	11.77	7.37
x_{20}	Formaldehyde-glycerin mixture	1.41	1.38	1.48	1.24
x_{21}	High molecular weight resins	-	-	9.20	9.86

The presence of phenolic groups determines the solubility of cotton sludge in aqueous alkaline solutions. Gossypol is characterized by a very high reactivity. Aldehyde groups give it the properties characteristic of this class of compounds. At the same time, the simultaneous presence of hydroxylic -OH and aldehyde -CHO- groups and their reciprocal influence somewhat alter the properties of a molecule of gossypol as phenol and aldehyde, as a result of intermolecular thermodynamic There are three types of water bonds: six-membered intramolecular cycle, five-membered intramolecular cycle, intermolecular cycle.

Improvement of structural mechanical, geological and filtration properties of mineral drilling fluids have been studied opportunity application multifunctional modified integrated reagents-CDM obtained by modification of gossypol resin with amine alcohol: Monoethanolamine (MEA) diethanolamine (DEA) with the name of modified integrated reagent MCR-1 and MCR-2. Studies have shown a high ability of its molecules to adsorb on clay particles and increase their coagulation threshold in the presence of electrolytes. A feature of the use of MCR for the preparation of inhibited solutions in drilling clay and chromogenic deposits is that in an alkaline medium, modified gossypol resin with mono- and diethanolamine molecules forms multifunctional compounds. In this case, a new compound is formed that is capable of forming strong bonds with the active centres of the clay mineral. As a result of chemisorption fixation of the metal-containing complex compound of gossypol on the clay, a protective hydrophobic screen is created around the reactive centres of the clay, which achieves a high inhibitory ability of the drilling mud. In addition, the presence of aromatic nuclei in the chain structure of the molecule determines the thermal stability of the drilling fluid up to 250 ^{0}C.

It was established that clays have different adsorption activity A, and the S-shaped character of the adsorption isotherm indicates the presence of polymolecular adsorption (Figure 1).

The nature of the changes occurring at the boundary of the clay-water phases in the presence of the MCR reagent was studied on the Shursu red clay using the methods of physicochemical mechanics. The research was carried out on the Weiler-Rebinder instrument according to the methods described in the works [4-6].

At a critical concentration of structural formation, experimental data indicate that an increase in the addition of MCR reagent increases the moduli of fast E1 and slow E2 of elastic deformations with noticeable structural control. Taking into account the foregoing, the stability of dispersions Ku and the energy state of the system Eω, reflecting the enhancement of intermolecular interaction, also increase. NA base of mathematical statistics was correlative counting relationship between changes composition and disperse system and content reagent MKR V quality criterion y, Po which estimated each other influence adopted module conditional deformation, which OH more whole characterized energy relations between clay parts.

It is known that aldehyde, phenolic and carboxylate groups, both at room temperature and at higher temperatures, are capable of chemisorption with the formation of ether-like compounds.

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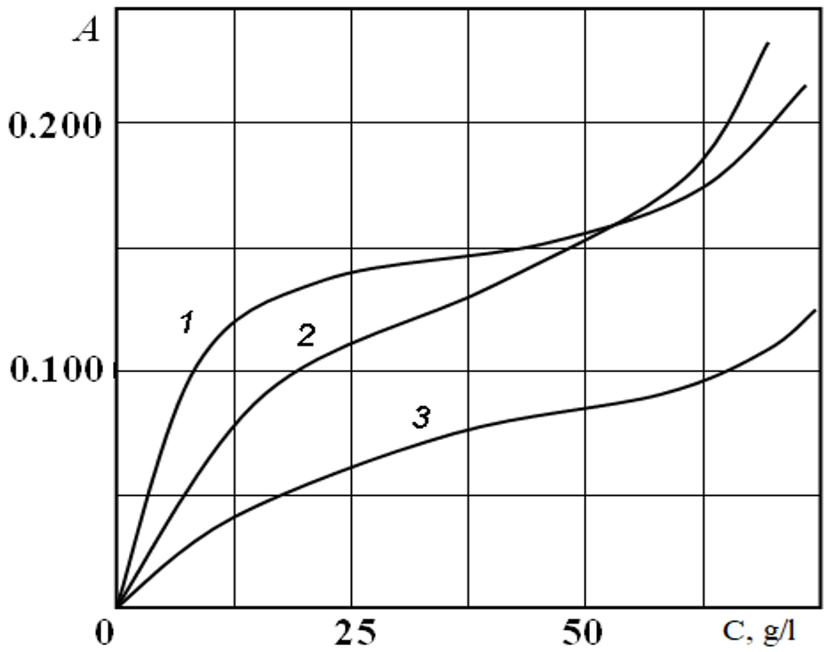

Fig. 1. Adsorption isotherms of MCR regent on clays (A-adsorption; concentration C): 1 – Kasantau bentonite; 2 - Navbakhar clay; 3 - Palygorscite

In such a manner, around the clay particles, powerful salt shells are formed, which interact through molecular and hydrogen bonds, enhancing the process of structure formation of molecules of stabilization of minerals the nature of the adsorption curves testifies to the formation of adsorbed polymolecular layers (Fig. 1). Salt shells prevent the electrolytic coagulation of clay particles, which is confirmed by the different filtration F of brown solutions depending on the concentration of electrolyte C and the composition of the dispersion medium (Fig. 2). So, boring solutions containing the MCR reagent are characterized by less filtration than basic ones. The processing of the solution with high-molecular substances increases the strength of the salt casing and additionally enhances the stabilization of the system, which leads to a decrease in filtration (Fig. 2 a, b). The most durable salt shell will form if the access of alcohol groups of gossypol molecules to the surface of the clay particles is spatially not difficult by other molecular groups;

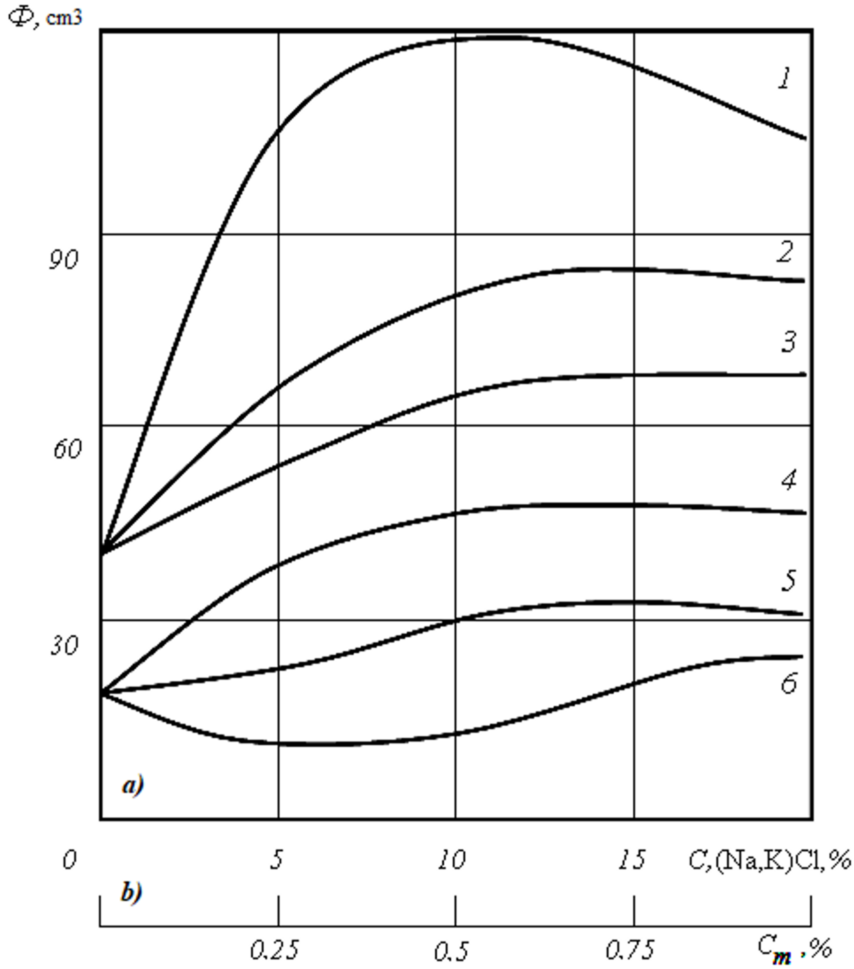

Fig. 2. Dependence of the filtration of mineralized solutions F from the concentration of electrolyte C and the composition of the dispersed medium (a), the concentration of the reagent of the stabilizer Cm (b) and the composition of the solution

The structural and mechanical characteristics of the clay solutions prepared by the proposed method are 2-3 times higher than the analogous characteristics of the other solutions given, and the filtration is lower. Doing research helps development of new technology of obtaining drilling fluids and scientific basing of purpose of processing mineral solution with reagents CDM with the purpose of effective regulation of properties and reduce expenditure high molecule polymer - inhibitory.

3 Conclusions

The use of MKR made it possible to increase the temperature limit of the system up to 250 ^{0}C. The use of a multifunctional reagent MKR, in comparison with the known one, provides the following advantages: reduction in the consumption of a diluent (oxil, KSSB, FHSL), a stabilizer (Gipan, Polisil, metas, etc.); reducing the time spent on the development of the narrowing of the wellbore and on drilling out the loose rocks - due to the inhibiting ability; reduction in the number of bits used - due to the number of wellbore reaming; reducing the time spent on the SPO - by reducing the number of chisels; reduction of transportation costs due to the transportation of reagents and bits.

References

1. Kok M. V.; Uyar T. T. A Geomechanical Wellbore Stability Assessment for Different Formations in Petroleum Fields. *Pet. Sci. Technol.* 2014, 32, 2355.10.1080/10916466.2013.829856.
2. Matsuura Y. Case studies of borehole stability problems-Drilling through shale and volcanic formation. *J. Jpn. Assoc. Pet. Technol.* 2002, 67, 475.10.3720/japt.67.475.
3. Zhao F.; Tang H.; Meng Y.; Li G.; Xu H. Study on the influence of micro geological features on the stability of hard and brittle mud shale well walls and countermeasures. *Drill. Prod. Technol.* 2007, 16–18.
4. Wan W.; Ge L. Research and application of high-performance water-based drilling fluid in Changning shale gas block. *Drill. Prod. Technol.* 2019, 42, 83–86.
5. Xianbin H.; Haokun S.; Jinsheng S.; Kaihe L.; Jingping L.; Xiaodong D.; Shaojie L. Nano laponite as a potential shale inhibitor in water based drilling fluid for stabilizing wellbore stability and mechanism study. *ACS Appl. Mater. Interfaces* 2018, 10 (39), 33252–33259. 10.1021/acsami.8b11419.
6. Zhong H.; Huang W.; Lin Y.; Qiu Z.; Liu G.; Zhang G. Performance evaluation of new polyamine shale inhibitor. *Pet. Drill. Technol.* 2011, 06, 48–52.
7. Wang Z.; Wang Z. Some knowledge about polyamine and "polyamine" drilling fluid. *China Foreign Energy* 2012, 17, 36–42.
8. Qiu Z.; Zhang D.; Fu J.; Tong S.; Zhong H.; Xing X. Research and Application of Polyamine Drilling Fluid in Long Open Hole Section of Tahe Oilfield. *J. Liaoning Univ. Pet. Chem. Technol.*2016, 6, 33–38.
9. Zhang G.; Xu J.; Zhan M.; Liu G.; Zhong H.; Ma P. Research and application of new polyamine water-based drilling fluids. *Drill. Fluid Completion Fluid* 2013, 30, 23–26.
10. Li Y.; Yang G.; Fan Z.; Wang Q.; Wang F.; Wang X.; Chen G. Research on polyamine inhibiting anti-collapse drilling fluid and its application in western Sichuan. *J. Oil Gas Technol.* 2014, 36, 137–142.
11. Tian L.; Li S.; Wang B.; Xue Y.; Li T. Application of Polyamine Drilling Fluid System in Dingbei Block. *Drill. Prod. Technol.* 2014, 37, 97–99.
12. Rana A.; Arfaj M. K.; Saleh T. A. Advanced developments in shale inhibitors for oil production with low environmental footprints - A review. *Fuel* 2019, 247, 237–249. 10.1016/j.fuel.2019.03.006.
13. Du W.; Sun J.; Pu X.; Zhang J.; Chen G. Research status and development trends of clay hydration inhibitor athome and abroad. *Chem. Ind. Eng. Prog.* 2018, 37, 4013–4021.
14. Hou J.; Liu Y.; Song G.; Song T.; Yan J.; Zhao X. Synthesis and application of a new high temperature high performance salt resistant shale inhibitor. *Drill. Fluid Completion Fluid* 2016, 33, 22–27.
15. Zhang H.; Zuo F.; Tian Ye; Jia D.; Liu Y.; Wen J.; Zhang L.; Song L. Investigation and application of new amine salt inhibitor. *Oilfield Chem.* 2012, 4, 390–393.
16. Zhong H.; Qiu Z.; Huang W.; Lin Y.; Li H.; Zhang G. The Development and application of a novel polyamine water-based drilling fluid. *J. Xi'an Shiyou Univ., Nat. Sci. Ed.* 2013, 28, 72–77.

17. Wang Z.; Zhang X.; Zhang P.; Wang X.; Ma C. Synthesis and application of zwitterionic shale inhibitor LM-1. *Sci. Technol. Eng.* 2020, 2, 563–568.
18. Wang W.; Yu H.; Li D.; Wang Y. Synthesis and performance of hydroxylamine shale inhibitor. *Adv. Fine Petrochem.* 2019, 20, 4–7.
19. Li X.; Li B.; Fan J.; Li J. Study on new methods of biological toxicity detection and toxicity classification standards for oilfield chemicals and drilling fluids. *Drill. Fluid Completion Fluid* 2004, 06, 46–48.
20. H.Y. Zhong et al. Inhibiting shale hydration and dispersion with amine-terminated polyamidoamine dendrimers
21. J. Nat. Gas Sci. Eng. (2016) H.Y. Zhong et al. Inhibitive properties comparison of different polyetheramines in water-based drilling fluid.
22. Appl. Clay Sci. (2012) H.Y. Zhong et al. Shale inhibitive properties of polyether diamine in water-based drilling fluid.
23. J. Pet. Sci. Eng. (2011) 5. X.Y. Yang et al. Influence of salt solutions on the permeability, membrane efficiency and wettability of the Lower Silurian Longmaxi shale in Xiushan, Southwest China.