**ABSTRACT**

on dissertation for the Doctor of Philosophy degree (PhD)

on specialty 6D073900 – "Petrochemistry"

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**Synthetic and natural polymers for oil production and development**

**of drilling fluids**

The dissertation is devoted to the study of physico-chemical, rheological, thermal, morphological and mechanical properties of gellan, xanthan, carboxymethylated cornstarch, polyacrylamide and their mixtures in solution and gel state for the further formulation of drilling fluids and polymer flooding reagents.

**The relevance of the research topic.**

Polymers from renewable vegetable feedstock attract an increasing interest of researchers predominantly due to environmentally friendliness, while synthetic polymers are mainly produced from non-renewable petroleum resources.

To solve the problems of drilling, oil recovery, oil treatment and transportation of oil the solutions and gels of natural and synthetic polymers possessing a high viscosity, ability to gelation, thixotropy and pseudoplasticity are widely applied.

Polysaccharides are widely applied for oil recovery as key components of water-based drilling fluids, workover substances and completion fluids. Wellbore instability problems significantly increase the cost of drilling and operations in the oil and gas industry. They are used as drill bit cooling, cleaning and protecting agents, and as drag reducing fluids intensifying drilling speeds.

Excessive water cut of oil reservoirs shortens the production life of wells and leads to intensive corrosion of equipment. High water cut (up to 90% and more) due to the geological heterogeneity of the reservoirs and long-continued water flooding process is the main reason behind low production rates at mature oilfields.

Injection of polymer solutions into the oil reservoir allows to increase considerably oil recovery in comparison with conventional water flooding. However, synthetic polymers such as polyacrylamide and hydrolyzed polyacrylamide in combination with chromium salts that are widely used in oil recovery may cause harmful effect to environment and require utilization according to ecological standards. While polysaccharides are eco-friendly and obtained from renewable resources and can be alternative to synthetic polymers. Polysaccharides that are characterized by gelation properties, stability to high mineralization and temperature are perspective reagents for oil recovery.

The dissertation is devoted to investigation of solution properties and gelation of gellan, xanthan, carboxymethylated cornstarch, polyacrylamide as well as their mixtures for development of drilling fluid formulation and flow deviation or plugging reagents in oil recovery.

**The purpose of the dissertation** is to study the solution properties and gelation process with participation of gellan, xanthan, carboxymethylated cornstarch, polyacrylamide as well as their mixtures for formulation of drilling fluids and development of reagents for oil recovery. To achieve this goal the following tasks were formulated:

- The literature survey on investigation of the polysaccharides – gellan, xanthan, carboxymethylated cornstarch, composition and properties of drilling fluids and technology gel-polymer flooding with participation of polysaccharides;

- Investigation of physicochemical, rheological, gelforming and mechanical properties of gellan in the presence of low-molecular -weight salts and oilfield water;

- Study of the behavior of aqueous solutions of gellan, xanthan, carboxymethylated cornstarch and polyacrylamide as well as their mixtures in oil reservoir conditions;

- Obtaining of water-soluble derivatives of corn starch by chemical modification, investigation of its physical chemical properties in aqueous and aqueous-salt solutions, formulation of drilling fluids;

- Selection of optimal drilling fluids formulation and reagents for oil recovery based on polysaccharides and analysis of the results of oilfield tests.

**Objects of the research.** Gellan, xanthan, carboxymethylated cornstarch and their physicochemical properties. Low molecular weight salts. Oilfield water. Mineral dispersed phases. Core samples. Sand packs models. Drilling fluids and reagents for oil recovery based on polysaccharides.

**The scientific novelties of the study are as follows:**

* Conformational, sol-gel and gel-sol phase transitions of gellan and gellan-xanthan mixture in the presence of low-molecular-weight salts and oilfield brine water for application and development of drilling fluids and flow deviation technology – gel-polymer injection of polymer reagents into low-permeable reservoir;
* Formulation of novel drilling fluids and oil recovery reagents based on polysaccharides that are produced in Kazakhstan to provide wellbore strengthening during drilling of unstable rocks and to produce additional oil.
* Chemical modification of domestic product – corn starch from Zharkent corn syrup plant for preparation of high viscous water-soluble polymer as key component of drilling fluids.

**Practical significance of the study.**

The results of laboratory research are scaled and adapted to the conditions of field tests as drilling fluids and reagents for enhanced oil recovery.

Novel polysaccharide-based drilling fluids can be for drilling of the directional and horizontal wells of oil & gas reservoirs as well as for drilling of ore deposits in difficult mining and geological conditions.

The formulated drilling fluids can be recommend to JSC “Volkovgeologiya” for drilling of uranium deposits.

Gel-polymer technology of injection of gellan into the oil reservoir can be applied for isolation of discrete channels with high fractures and permeability.

**As a result of the conducted research the following theses are put forth to be defended:**

1. The conformational and sol-gel phase transitions of gellan and gellan-xanthan in model aqueous-salt solutions and oilfield saline water have been established. It is shown that the efficiency of gelation, Young’s modulus and breaking stress of gellan are enhanced in the following order: oilfield water > BaСl2 > СaCl2 ≈ МgCl2 >KCl>NaCl.
2. By chemical modification of cornstarch – domestic product of Zharkent corn-syrup plant – the water-soluble carboxymethylated cornstarch possessing a high modification degree, viscosity and hydrodynamic size has been synthesied. The structure, composition, thermal properties, and morphology of carboxymethylated cornstarch have been established by NMR- and FTIR spectroscopy, differential scanning calorimeter and scanning electron microscope.
3. Based on rheological measurements of gellan, xanthan and carboxymethylated cornstarch in the presence of low-molecular-weight salts and bentonite the drilling fluids were formulated that are able to carry up drilled rock particles from the bottom hole of the well to the surface. The optimal compositions of water solutions containing the mixture of polysaccharides, Water-based optimal drilling fluids composed of various polysaccharides, low-molecular-weight salts and bentonite were suggested to provide the oilfield tests.
4. The sol-gel phase transition of gellan and mixture of gellan-xanthan oilfield saline was applied for plugging of drainage high-permeable channels in cores and sand pack model in conditions of laboratory experiments.
5. The drilling fluids were tested in the field conditions by JSC “Volkovgeology” from July 14 to July 20, 2017 at the Irkol drilling site (Shieli, Kyzyl-Ordinsk region). In the positive ACT of tests it is outlined that the main advantage of suggested drilling fluids in comparison with traditionally used drilling fluids the simple and quick preparation.
6. In July 2017 the gellan was injected to oil reservoirs of “Kumkol” with participation of JSC “Turgay-Petroleum” and JSC “NIPIneftegaz”. The common technological efficiency during 6 months was equal to 5805 tons of additional oil recovery.

**Relationship of the investigation with other research works.** The researches were carried out in the frame of the commercialization project (SSRG 161) of the Ministry of Education and Science of the Republic Kazakhstan and World Bank “Development and commercialization of polymer flooding technology for enhanced oil recovery” (2012-2015) and grant No.4410/GF4 of the Ministry of Education and Science of the Republic Kazakhstan «Justification of drilling technology by providing automatic stability of the wellbore under unfavorable geological conditions» for 2015-2017.

**Approbation of the thesis.** The results have been published in 30 publications, including 2 papers in the journal of Scopus database, 5 papers in the National journals of the Committees list and 21 abstracts in the materials of International and Republican Symposiums and Conferences and 1 innovation patent of the RK.