ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 11, Issue 6, June 2024

Development and Research of the Properties of Multilayer Cross-Lined Polymer Materials for Drilling Fluids

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ABSTRACT: This article examines the synthesis of multilayer crosslinked polymers to enhance the thermal stability and efficiency of drilling fluids. The focus is on the selection of monomers and polymerization conditions, as well as the investigation of the properties of the synthesized polymers, such as viscosity, thermal stability, and structural characteristics. Optimal synthesis conditions include a pH of 7-8 and a temperature of 70-75ºC. The research results showed that the introduction of nano-SiO2 significantly improves the physicochemical properties of the polymers, including thermal stability and viscosity, making them promising for use in drilling fluids at high temperatures and pressures. The obtained data confirm the high efficiency of the synthesized polymers in enhancing the stability and efficiency of drilling operations.

KEYWORDS: crosslinked polymers, drilling fluids, thermal stability, viscosity, nano-SiO_2, polymerization, rheological properties.

I.INTRODUCTION

In modern drilling, significant attention is paid to the development of drilling fluids that can withstand high temperatures and extreme operating conditions. Multilayer cross-linked polymers represent a promising direction in this area, as they have a number of unique properties that can significantly improve the thermal stability of drilling fluids.

Organic polymers of natural or synthetic origin are the most developed. These polymers are obtained by chemical processing of natural macromolecular compounds or synthesis from low molecular weight substances. MM. Dardir and his colleagues proposed the use of a synthetic reagent (ether) in the composition of the drilling fluid, which is highly biodegradable and low toxicity [1] Polysaccharides, lignosulfonates, tannins and humates are natural polymers; cellulose ether is semi-synthetic, and synthetic polymers include petrochemical derivatives such as ethylene oxide and acrylic polymers [2]. F.T.G. Diaz and his colleagues showed the possibility of using modified starch in non-aqueous drilling fluids [3]. Polymer reagents are often improved by additional processing. The work presents the formula of a brine solution based on attapulgite treated with polyacrylamide, which improves both rheological and filtration characteristics [4].

The purpose of this research is to synthesize multilayer cross-linked polymers and study their characteristics to improve the thermal stability and efficiency of drilling fluids.

II. SIGNIFICANCE OF THE SYSTEM

This article examines the synthesis of multilayer crosslinked polymers to enhance the thermal stability and efficiency of drilling fluids. 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

Modern drilling technologies place high demands on the stability and efficiency of drilling fluids, especially under high temperature and pressure (HTP) conditions. Traditional drilling fluids often face problems associated with the deterioration of their rheological and filtration characteristics under extreme conditions.

The following monomers were selected as starting reagents for the synthesis of cross-linked polymers intended to improve the characteristics of drilling fluids: acrylamide (AA), acrylic acid (AA), acrylonitrile (AN) and N-hydroxyethyl acrylamide (NHAA). These monomers provide the formation of polymer chains with the necessary functional groups that help improve the thermal stability and rheological properties of drilling fluids.

The synthesis of cross-linked polymers was carried out by emulsion polymerization. At the beginning of the process, 1 g of octadecyltrimethylammonium bromide was added to 300 ml of deionized water and stirred until a homogeneous solution was obtained. Then, nano-SiO_2 (0,5 to 3 g) dispersed using ultrasound (20 kHz) was introduced for 5 minutes. After this, acrylic acid, acrylamide, acrylonitrile and N-hydroxyethyl acrylamide were added sequentially.

The content of HEAA in the monomer mixture system varied from 0,9 to 2%, and the remaining monomers from 0 to 99% to form a stable emulsion. The mixture was transferred to a three-neck flask and heated in a water bath. To create an inert atmosphere and remove air, nitrogen was introduced into the reaction medium, after which the temperature was increased to 50°C. Ammonium persulfate was then slowly added to initiate the reaction. The temperature was continued to be increased to 75°C and maintained at this level for 6 hours.

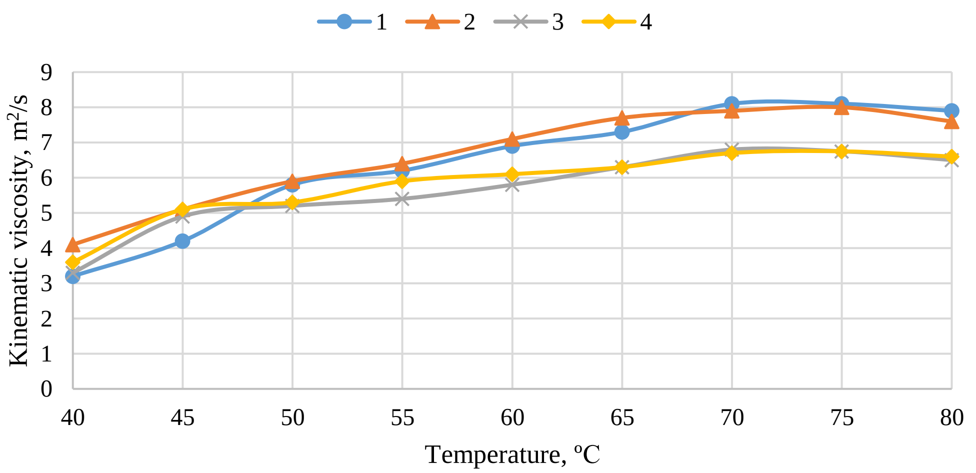
The study of the characteristics of the synthesized polymers included an analysis of their viscosity, thermal and structural properties. Viscosity was measured at various pH and temperatures. Thermal stability was assessed using thermogravimetric analysis (TGA) and differential thermal analysis (DTA)

IV. EXPERIMENTAL RESULTS

One of the key objectives of the study was to determine the effect of the composition of the reacting mixture on the viscosity characteristics of the synthesized polymers. In particular, the influence of AA, AA, AN and HEAA on the viscosity of the resulting solutions was studied. It was found that the best viscosity characteristics are observed at a pH of 7-8 and a synthesis temperature of 70-75ºC. These conditions make it possible to achieve maximum viscosity values, which indicates the high molecular weight and structural integrity of the resulting polymers.

Synthesized polymers containing nano-SiO2 showed significantly better results compared to polymers without this component. The introduction of nano-SiO2 improves thermal stability and viscosity, which makes such polymers promising for use as stabilizers for drilling fluids at high temperatures.

An analysis of changes in the viscosity of stabilizer solutions depending on the temperature of the reaction system is shown in Fig. 1 at different ratios of monomers AA, AN, AA and GEAA.



Rice. 1. Change in the viscosity of solutions of 0.5% stabilizers depending on the temperature of the reaction system at the ratio AA:AN:AK:GEAA: 1) 50:10:10:1; 2) 60:10:10:1; 3) 50:20:10:1; 4) 50:10:5:1. (70ºC, duration 5 hours).

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A study of the dependence of the viscosity of the synthesized polymers on the temperature and pH of the reaction medium showed that low pH values (below 4) and high pH values (above 9) negatively affect the viscosity. This is due to destabilization of the polymer network and a decrease in the molecular weight of polymers. Optimal viscosity values are achieved at pH 7-8 and synthesis temperature 70-75ºC.

The thermal stability of the synthesized polymers was investigated using thermogravimetric analysis (TGA) and differential thermal analysis (DTA). The results showed that polymers with nano-SiO_2 have higher onset temperatures of decomposition and lower weight loss upon heating compared to polymers without nano-SiO_2. This confirms that nano-SiO_2 improves the thermal stability of polymers.

Table 1 shows the results of thermal analysis of the samples, where a polymer based on acrylamide, acrylonitrile, acrylic acid, hydroxyethyl acrylamide and nano-SiO_2 (ANAHA) demonstrates the highest thermal stability among the studied samples, which makes it promising for use at high temperatures and pressures.

Table 1
Results of thermal analysis of samples.

Sample	Stages of destruction	Temperature range, °C	Mass loss, %
ANA	1	225-333	21,2
	2	335-400	44,6
ANAH	1	370-455	18,0
	2	460-515	33,2
ANAHA	1	205-410	9,0
	2	410-490	25,2
	3	490-595	31,2

V. CONCLUSION AND FUTURE WORK

A study of the characteristics of synthesized multilayer cross-linked polymers showed that the introduction of nano-SiO2 significantly improves their physicochemical characteristics, including thermal stability and viscosity. Optimal synthesis conditions include pH 7-8 and temperature 70-75ºC, which allows achieving maximum viscosity and structural integrity of polymers. The results obtained confirm the high efficiency of the synthesized polymers for use as stabilizers of drilling fluids at high temperatures and pressures, which helps to increase the efficiency and safety of drilling operations.

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