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ANGREN SECONDARY KAOLINITE CLAYS IN THE PRODUCTION OF ALUMINOSILICATE PROPPANTS

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Abstract

The article presents the results of studying the chemical-mineralogical and physical-mechanical characteristics of Angren secondary kaolin and kaolinite clay and their suitability for obtaining aluminosilicate proppants. It was found that the melting point of Angren secondary kaolin is 1540 °C and the compressive strength in the fired at a temperature of 1400 °C reaches up to 105 MPa, and for kaolinite clay these indicators showed 1505 °C and 109 MPa, respectively. The obtained indicators suggest that these clay materials can be used as the main component for obtaining aluminosilicate proppants.

KEYWORDS: kaolin, proppant, kaolinite, phase transformations, X-ray analysis, crystal structure, mullit.

INTRODUCTION

Proppant is a granular, wedging material used in the oil industry to improve the efficiency of wells using hydraulic fracturing (HF) technology. It serves to maintain the permeability of cracks obtained during HF. It is granules of similar size, with a typical diameter of 0.25 to 2.5 mm [1, 2].

The physical characteristics of proppants that

affect fracture conductivity include parameters such as strength, size and shape of granules, particle size distribution, presence of impurities, solubility in acids, and density [3].

Ordinary quartz sand, artificially synthesized on the basis of the mineral bauxite and obtained on the basis of aluminosilicate compounds, is used as

proppants [4].

Recently, proppants have been synthesized based on various natural raw materials and waste [5]. Among them, proppants synthesized based on kaolin raw materials are characterized by a density close to ordinary quartz sand, higher strength compared to sand and cheaper than proppants obtained based on bauxite.

Taking this into account, this article studies the physicochemical and technological properties of Angren secondary kaolin and kaolinite clays in order to determine the possibility of their use for obtaining aluminosilicate proppant.

METHODS

The material composition of kaolin samples was determined by the method of silicate chemical analysis using the accelerated method [6]. The mineralogical composition of basalt samples was

determined by X-ray phase analysis, which was carried out by the powder method on a Shimadzu LABX XRD-6100 X-ray diffractometer with CuK α radiation. Identification of mineral phases and analysis of the results were carried out using reference books and the generally accepted ICDD PDF-2 database [7, 8].

RESULTS AND DISCUSSION

In the republic, geological reserves of kaolinite clays are located at the Angren deposit of brown coal, refractory clay and kaolin, where the recorded reserves of secondary kaolin in this area are about 350 million tons [9, 10]. The volumes of industrial reserves of secondary kaolin and kaolinite clay make it possible to select it as a raw material component for the production of aluminosilicate proppants. Table 1 shows the results of chemical analysis of secondary kaolin and kaolinite clay.

Table 1
Chemical compositions of the samples under study

Name of raw material	Oxide content, wt. %								LOI, wt. %
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	Na ₂ O	K ₂ O	SO ₃	
Angren secondary kaolin	66,31	19,37	1,29	1,67	0,23	0,52	0,81	0,17	9,63
Kaolinite clay	53,48	24,89	5,91	1,12	1,11	1,09	1,02	1,24	10,14

The results of chemical analysis showed that the content of Al₂O₃ in Angren secondary kaolin is 19.37 wt.%, and in kaolinite clay - 24.89 wt.%. It should be noted that kaolinite clay is distinguished by the fact that the content of iron oxide is higher than that of secondary kaolin (5.91 wt.%).

In order to study the change in the oxide content in the chemical compositions of the initial raw materials, heat treatments were carried out at 1000°C with a holding time of 60 min. The results obtained are given in Table 2.

Table 2
Chemical compositions of the studied samples, in terms of calcined substance

Name of raw material	Oxide content, wt.%						
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O
Angren secondary kaolin	73,51	21,47	1,43	1,85	0,25	0,58	0,90
Kaolinite clay	60,35	28,09	6,67	1,26	1,25	1,23	1,15

The results show that after heat treatment at 1000°C with a holding time of 60 min, an increase in silicon and aluminum oxides is observed for Angren secondary kaolin to 73.1% (SiO₂) and 21.47% (Al₂O₃), and for kaolinite clay to 60.35% (SiO₂) and 28.09% (Al₂O₃) respectively.

The phase composition of the test samples was determined by X-ray analysis. The results of the X-ray phase analysis are shown in Fig. 1.

X-ray phase analysis of the kaolinite clay samples (Fig. 1a) shows that this clay mainly contains diffraction maxima related to the minerals kaolinite $d=0.718$; 0.445 ; 0.337 ; 0.279 ; 0.256 ; 0.249 ; 0.234 ; 0.228 ; 0.199 ; 0.173 ; 0.167 nm and quartz with diffraction lines $d=0.425$; 0.334 ; 0.245 ; 0.228 ; 0.223 ; 0.212 ; 0.198 ; 0.181 ; 0.154 nm, and lines with less intensity related to the mineral hematite $d=0.268$; $d=0.249$; $d=0.167$ nm.

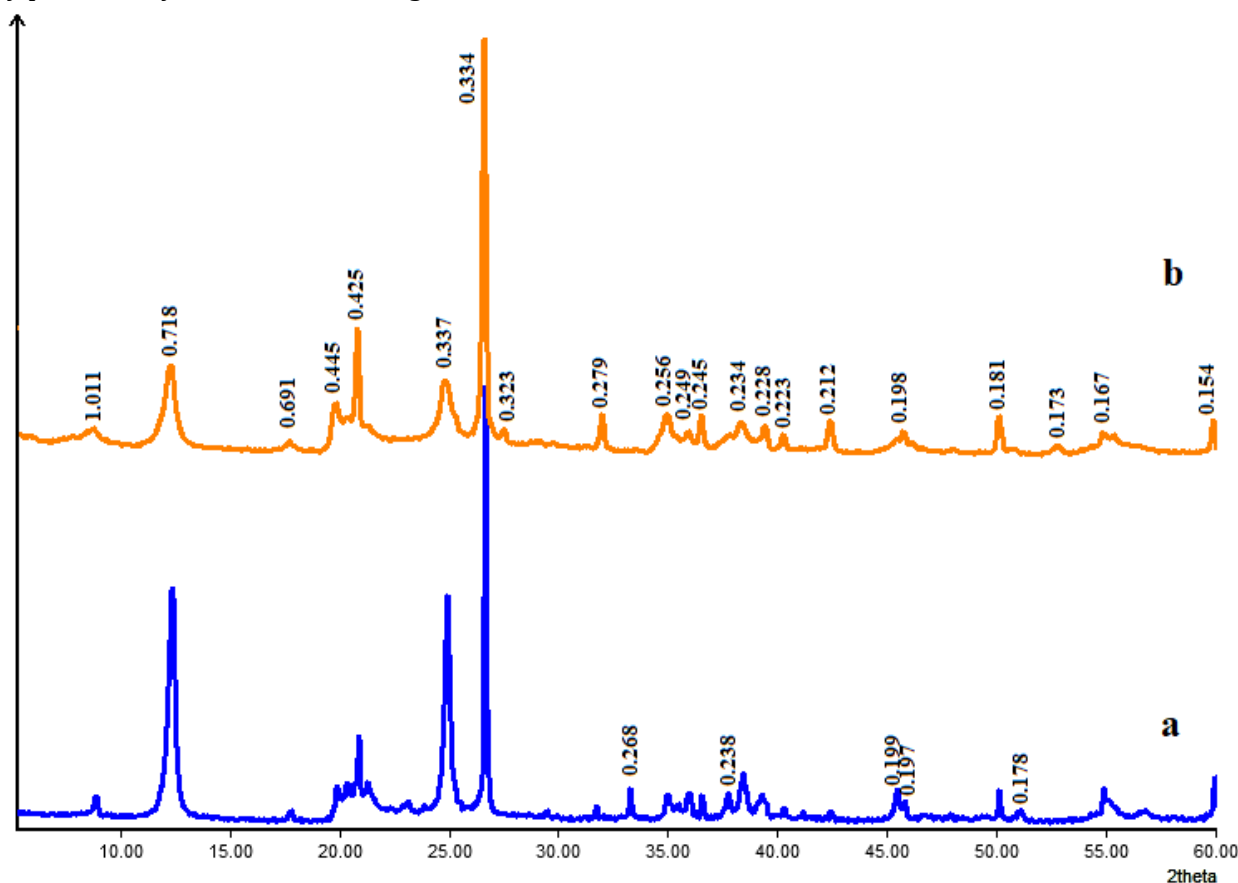


Fig. 1. X-ray diffraction patterns of the studied samples:

a) kaolinite clay; b) Angren secondary kaolin

The X-ray diffraction pattern of the Angren secondary kaolin sample (Fig. 1b) also revealed diffraction maxima related to the minerals kaolinite and quartz, as well as a small amount of the mineral feldspar ($d=0.323$; $d=0.245$) and muscovite ($d=1.011$; 0.498 nm).

It is known that the sintering and melting temperatures of raw materials are affected by the material, chemical and mineralogical compositions, structures and their other physical and chemical characteristics. It should be noted

that, especially when developing ceramic masses for obtaining aluminosilicate proppants, the temperature of the end of sintering and the beginning of melting, as well as physical and mechanical characteristics, are of particular importance.

In this regard, the temperature of the beginning and end of melting of raw materials, as well as their physical and mechanical characteristics after firing at a temperature of 1400°C , were determined. The results obtained are given in Table 3.

Table 3

Temperatures of the beginning and end of melting of samples, and their physical and mechanical characteristics when fired at 1400°C

Name samples	Melting point, $^{\circ}\text{C}$		Temperature range, $^{\circ}\text{C}$	Compressive strength, MPa	Mohs hardness
	Begin	End			
Angren secondary kaolin	1540	1610	50	105	7
Kaolinite clay	1505	1580	65	109	7

The obtained results showed that the temperatures of the beginning and end of melting of Angren secondary kaolin are 1540 and 1610°C , respectively, and kaolinite clay 1505 and 1580°C . At the same time, the compressive strength in the fired at a temperature of 1400°C reached 105 - 109 MPa.

CONCLUSION

Thus, the chemical-mineralogical and physical-mechanical characteristics of Angren secondary kaolin and kaolinite clay and their suitability for obtaining aluminosilicate proppants were studied. It was found that the melting point of Angren secondary kaolin is 1540°C and the compressive strength at a temperature of 1400°C reaches up to 105 MPa, and for kaolinite clay these indicators showed 1505°C and 109 MPa, respectively. According to these indicators, it is assumed that

these clay materials can be used as the main component for obtaining aluminosilicate proppants.

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