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Case study

Structure and properties of synthesized additive based on amorphous aluminosilicates

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ABSTRACT

The article contains data on the structure and properties of synthesized additives for lime finishing compounds. It is observed that the samples, based on lime combined with synthesized additive, show rapid growth of durability at the initial stage.

1. Introduction

As a rule, lime compositions are used for historical buildings restorations. Given that lime compositions are characterized by slow curing periods and have insufficient water resistance, the use of nanosized additives – synthesized hydrosilicates, aluminum silicates, silica sol, organo-mineral additive (Loganina et al., 2014a,b,2015a,b) – is suggested. The research shows that such synthesized additives combined with lime based finishing compounds increase water- and frost-resistance of finishing coatings.

2. Results of researches

During further research, we found the possibility of using synthesized aluminosilicates in the formula of lime compositions. Aluminosilicates are synthesized by adding microfine aluminum powder to sodium silicate at 60 °C for 90 min.

The synthesized additive is lightweight powder of light gray colour (powder size 2–20 μm), with bulk density of 0.55 ± 0.05 g/cm^3. A large amount of gaseous molecular hydrogen appears during the process of additive synthesis. As a result, pores of different size and forms appear in the additive. Yield of the product is 90%. The chemical composition of the additive is shown in Tables 1 and 2.

The analysis of the data presented in Table 1 shows that the prevailing elements are C, O, Al, Si, Na.

X-ray diffraction analysis (XRD) showed that the mineralogical composition of the additive, is mainly represented by crystalline aluminum hydroxide—bayerite – α-$Al(OH)_3$ and boehmite – γ-$AlO(OH)$. The amorphous phase is represented by sodium aluminosilicates.

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Table 1
The chemical composition of the synthesized additive.

Variation interval	Elements (%)												
	C	O	F	Na	Mg	Al	Si	S	Cl	K	Ca	Fe	Cu
Max	16.35	47.48	0.51	29.10	0.02	28.13	19.94	0.06	0.06	0.03	0.08	0.07	0.25
Min	12.12	34.86	0.08	6.15	0.00	3.55	3.26	0.00	0.02	0.00	0.03	0.0	0.08

Table 2
Oxide content in the additive composition.

Oxide name	Content (%)
Al_2O_3	51.03
SiO_2	36.36
Na_2O	11.89
Fe_2O_3	0.110
CaO	0.107
MgO	0.105
SO_3	0.0290
TiO_2	0.0124
K_2O	0.0112
Σ	99.6546

Fig. 1 shows electron micrograph of the additive. The picture analysis shows that the structure is represented by lamellar and needle-shaped formations 0.11–10.49 μm in size.

In addition, the mineralogical composition was estimated by differential thermal analysis done with "Termoskan-2". Thermal analysis (TA) of the samples was carried out at the temperature range of 20-1000 °C in air, at the heating rate of 10 °C/min. Fig. 2 shows the thermogram of the additive.

The additive thermogram analysis shows, that the heat effect at temperatures 100–135 °C results from free water loss. The moisture loss makes 5%. Small heat effect at temperatures 200–240 °C, (0.42 J) results from the beginning of bayerite $Al(OH)_3$ dehydration; the sample weight change makes 11%. The heat effect at temperature 310–350 °C results from partial dehydration of bayerite turning into boehmite AlO(OH). The sample weight change makes 15.5%.

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The curves of differential-thermal analysis (DTA) have exothermic effect with a maximum at 689 °C, caused by formation of Al_2O_3. The thermal effect makes 12.83 J. At temperature 850 °C we can see a diffused peak, showing the exoeffect and transition of γ-Al_2O_3 into α-Al_2O_3. The weight loss makes 18%.

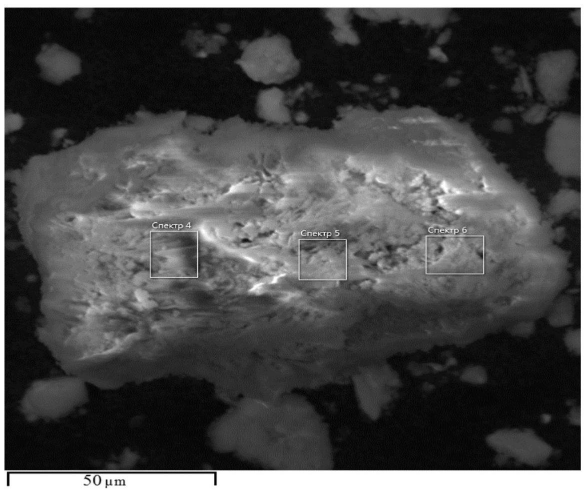

Fig. 1. Electron micrograph of the additive.