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INVESTIGATION OF THE PROCESSES OF FORMATION OF A FIRE RETARDANT COATING

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Fire protection is the primary task in the creation of building materials and structures. Wood is actively used in construction as load-bearing structures and finishing materials. Fire retardants for wood are known. Impregnating compounds require a large number of applications, coatings make it difficult to control the required thickness to create the desired degree of fire retardant efficiency, plasters are difficult to apply. Each type of coating has its own advantages and disadvantages; therefore it is effective to create a coating with a combined effect.

The aim of the work was to develop a fire retardant coating based on liquid glass with controlled porosity. According to the information, aqueous solutions of sodium silicate are strongly alkaline and can undergo hydrolysis. At $pH < 10.9$ they lose their stability and can partially release silicic acid. This fact leads to a detailed study of the processes of polycondensation of silicic acid and their influence on the formation of a fire retardant coating.

When the obtained gel is examined under a microscope in reflected light, a dense, colorless-cloudy gel matrix with evenly spaced inclusions of small, white prismatic crystals is observed. Considering that during the partial hydrolysis of sodium silicate, silicic acid is released, and also taking into account the information given on the processes of its polycondensation, we will consider the processes occurring in the studied gel based on sodium silicate and potassium carbonate.

When mixing a solution of water glass with a solution of potassium carbonate with the latter, silicic acid enters into a chemical reaction, which is an intermediate product of the partial hydrolysis of sodium silicate, with the formation of potassium silicate:

$$Si(OH)_4 + K_2CO_3 \rightarrow K_2SiO_3 + 2H_2O + CO_2. \quad (1)$$

This reaction proceeds until the potassium carbonate is completely consumed. The second reaction product (1), carbonic acid [$H_2O + CO_2$], can react with sodium silicate, also in solution, to form various carbonates:

$$Na_2SiO_3 + H_2O + CO_2 \rightarrow Na_2CO_3 + H_2SiO_3; \quad (2)$$

$$Na_2SiO_3 + 2H_2O + 2CO_2 \rightarrow 2NaHCO_3 + H_2SiO_3. \quad (3)$$

The presence of sodium carbonates in the mixture compensates the charge on the silicic acid particles and causes its polycondensation followed (2) coagulation of the mixture and gelation (3). The assumptions put forward are confirmed by X-ray: the diffraction pattern of the studied mixture contains clear diffraction maxima of weak intensity of aqueous sodium carbonate ($Na_2CO_3 \cdot H_2O$) and trone – double salt of carbonate and dihydrate sodium bicarbonate (Fig. 1). Diffraction maxima corresponding to aqueous sodium carbonate are less intense and more diffuse, which suggests an imperfect structure of this salt and its lower content in comparison with trone.

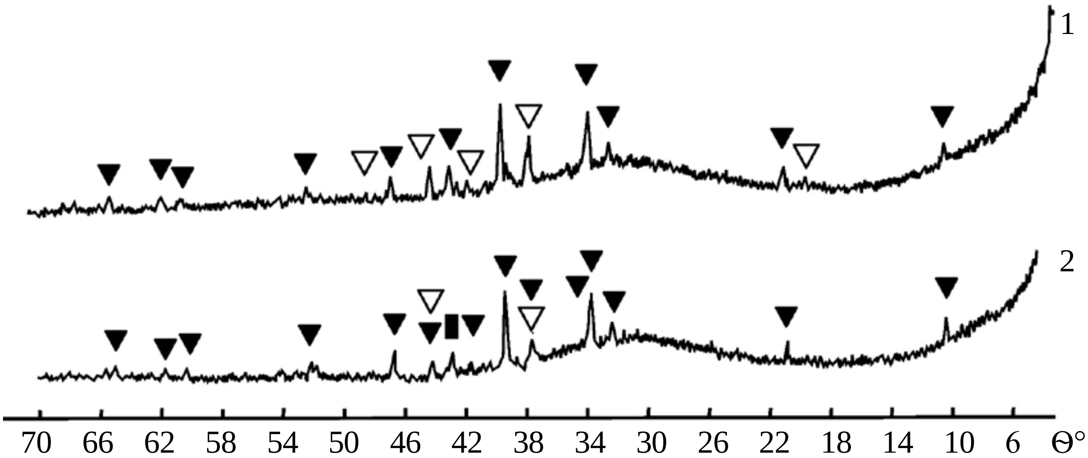

Fig. 1. X-ray phase analysis of a mixture of potassium carbonate and sodium silicate: 1 – without heat treatment; 2 – heat treatment 500 °C; ▽ – $Na_2CO_3{\cdot}H_2O$; ▮ – Na_2CO_3; ▼ – $Na_2CO_3{\cdot}NaHCO_3{\cdot}H_2O$

The presence of a halo in the diffractogram indicates the content of the X-ray amorphous component in the mixture under study. Taking into account the presence of a halo and the above reactions it can be assumed that the X-ray amorphous component of the obtained gel contains potassium silicate in a semi-amorphous state, as well as various intermediates of the metasilicic acid polycondensation process.

The heating curves for a mixture of sodium and potassium salts. The DTA curve shows a deep endothermic effect at 150 °C, accompanied by a significant (up to 45 %) weight loss. According to the information and results of X-ray phase analysis, it can be assumed that this effect corresponds to the removal of crystalline hydrate water from sodium carbonate, and also accompanies the decomposition of trone.

The use of a two-component gel composition based on water glass and potassium carbonate provides, due to its chemical characteristics, a consistent course of reactions for the formation of sodium carbonates. The sequential passage of these reactions ensures controlled gas evolution during heat treatment of the mixture and thereby ensures the integrity of the fire retardant coating.

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