ABSTRACT AND REFERENCES

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STUDYING CHEMICAL TRANSFORMATIONS OF THE MODIFIED DERMA COLLAGEN (p. 6-15)

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Chemical transformations of modified collagen for prediction of effective formation and stabilization of the derma structure with the use of montmorillonite dispersions treated by different modifying agents were studied. Identification of chemical interactions was estimated using infrared spectroscopic studies on gelatin, amino acid composition of which is close to collagen.

The existence of active in interaction carboxylic, amino-, peptide and hydrogen groups in the collagen structure contributes to effective structuring of derma. During processing of skins into leather, the transformation of bonds in collagen occurs. In this case, chemical materials interact with the functional groups of protein and form new chemical bonds. This contributes to stabilization of the structure of derma. This results in the formation of a capillary-porous structure with the required level of operational and hygienic properties of leather.

IR spectroscopic analysis revealed effective physical and chemical interactions between collagen and modified montmorillonite dispersions. This is proved by the formation of numerous bonds involving functional groups of gelatin and active centers of the mineral. The biggest changes are observed in high-frequency and low-frequency regions. Accordingly, the spectra characterize valence fluctuations involved in the formation of hydrogen, ionic and covalent bonds. This allows claiming that pre-chromed gelatin subsequently treated with aluminum-modified montmorillonite dispersion has more coordination bonds. This is caused by the hydroxo-complex ions of Cr (III) and Al (III), which are located between the silicate layers. At the same time, the presence of pre-chromed gelatin ensures the formation of additional intermolecular bonds, which can influence the stability of properties and structuring of derma collagen.

Thus, there are grounds to argue about the possibility of more efficient use of chromium compounds during the tanning process. Due to the introduction of the composition based of montmorillonite modified by aluminum compounds, a decrease in consumption of chromium compounds will be achieved. This will make it possible to solve the problem of making production ecologically friendly and to enhance safety of leather for children's footwear.

Keywords: chemical interaction, dispersion, montmorillonite, tanning, chromium and aluminum compounds, production of leather

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RESULTS OF EXPERIMENTAL STUDIES INTO THE DYNAMICS OF MASS-EXCHANGE PROCESSES DURING SYNTHESIS OF PROPANE HYDRATE (p. 16-24)

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Design diagram of experimental setup for studying the mass exchange processes occurring during formation of gas hydrates was presented. A procedure of performing studies and the use of equipment for conducting experiments in a diffusion mode with the use of slow stirrers with submerged and surface arrangement of the impeller, high-speed stirrers and the use of surfactants were outlined. Formulas for determining the specific intensity of mass exchange on the interphase surface were given.

The results of full-scale observations of intensity of mass exchange processes have shown that dynamics of mass exchange between gas and water in the mode of free diffusion is well approximated by a power dependence with exponent of –0.8. Quantitative indicators of dynamics of mass exchange on the propane-water interphase surface for various thermobaric conditions were determined. It was shown how intensity of the mass exchange processes decreases when thermobaric conditions enter the hydrate formation zone.

It was established that the use of low-speed stirring devices makes it possible to intensify mass exchange on the interphase surface ten or more times compared to the conditions of free diffusion. However, this effect is observed only at long-term stirring. Thus, the use of slow mechanical stirrers with a speed of up to 100 rpm can only be recommended as a means of moving the formed hydrate within the reactor.

Experimental studies have proved that the use of a stirrer with an impeller speed of 1,500 rpm can ensure an about 7–8 times increase in intensity of mass exchange in conditions of hydrate formation. Moreover, the maximum effect is observed at the beginning of mass exchange processes. It was proved that the use of surfactants makes it possible to further intensify the process of hydrate formation by increasing the area of mass exchange surface of gas bubbles in water.

The study findings can be used in designing and improving the equipment for gas hydrate synthesis.

Keywords: gas hydrates, specific mass exchange, experimental studies, hydrate formation rate, interphase surface.

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DEVELOPMENT OF THE UNIFIED MODEL FOR IDENTIFICATION OF COMPOSITION OF PRODUCTS FROM INCINERATION, GASIFICATION, AND SLOW PYROLYSIS (p. 25-31)

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This paper considers the processes of incineration, gasification, and slow pyrolysis. The common approach implies the use of individual models for the description of separate processes. When parameters acquire the values close to the boundary processes, the accuracy of description of the studied phenomena decreases. The specified processes do not have distinct boundaries between themselves and can smoothly transfer from one to another at changing external influences. While the physical and chemical processes are similar, the composition of the products of reactions, which are determined on the boundaries with the use of adjacent models, is different. In the most general form, the problems associated with incineration, gasification and slow pyrolysis are solved based on a unified model. The solution is complicated by the possibility of an unpredictable change in the composition of original substances. In addition, they can be located in various phase states: gaseous, liquid and solid.

The previously developed system of equations that describes the process of combustion of organic fuel of unknown composition was taken as a basis for the unified model. The partial pressures of the products of reaction are the parameters of the model. In this approach, their condition is considered to be gaseous. The feature of the proposed unified model is the possibility of taking into account the condensed phase (coaly residue) of reaction products that is characteristic of slow pyrolysis.

For a unified model, which describes the processes of incineration, gasification and pyrolysis, the calculation processes have differences. When studying the gasification and incineration processes, the temperature of the products of reaction is determined based on the equality of their enthalpy and the enthalpy of resulting substances. When studying the process of pyrolysis, the temperature of reactions and, respectively, of its products, is assigned. The found composition of the products and the assigned temperature allows calculating their enthalpy. The necessary amount of energy in the form of warmth to ensure the reaction of pyrolysis can be calculated based on the difference between the found enthalpy and the enthalpy of resulting substances.

To prove the adequacy of the model, the calculations of cases of incineration and gasification of gaseous (methane), liquid (ethyl alcohol) and solid (pine wood) substances were conducted. The calculation of slow pyrolysis was performed for pine wood. Coincidence of the results with the data available in literature proved the relative errors admissible for engineering calculations.

Based on the joint use of the model and previously developed method for determining the composition of gases mixture in the process of its incineration, the method of identification of the composition of hydrocarbon compounds of combustible substances in different aggregate states in real time mode was proposed.

Keywords: hydrocarbon raw materials, incineration, gasification, pyrolysis, unified model, identification of composition of products.

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INVESTIGATING THE INFLUENCE OF VOLUMETRIC HYDROPHOBIZATION ON THE FORMATION OF PHASE COMPOSITION OF CEMENT STONE AND ITS PHYSICAL-MECHANICAL PROPERTIES (p. 32-38)

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We have examined the influence of the most widely used silicon-organic surface water repellent GKZH-11K on the physical-mechanical properties and the phase structure formation of cement is the fact that the introduction of the surface water repellent GKZH-11K to the composition of cement slurry leads to the formation of dispersive water-repellent films of various levels (size). These films adsorb at the surface of cement grains, as well as at the surface of hydrated components of cement particles, Ca(OH)2, calcium sulphoaluminates. It was determined that the disperse hydrophobic films partially block the penetration of water into the surface of cement grains and alter the kinetics of hydration.

This leads to a decrease in the degree of hydration and the content of $Ca(OH)_2$ in cement stone, resulting in the reduced shrinkage at hardening. At the same time, the disperse films adsorbed on neighboring hydrated cement particles within the contacts occurred in the process of their condensation can form hydrogen and chemical relationships. This interaction between the particles' films, despite the reduction in the degree of hydration, leads to a decrease in water absorption, improving the strength of cement stone, which in this case is also determined by the number and area of contacts per unit volume of cement stone. The overlap of pores with hydrophobic chains decreases the permeability of cement stone throughout its entire volume, which contributes to the growth of operational reliability and durability of structures, particularly thin-walled. Using this admixture for volumetric hydrophobization could greatly prolong repair-free operation of thin-walled products and structures, as well as bring down cost as there is no need to apply materials to protect the surface of concrete.

Keywords: water-repellent admixtures, volumetric hydrophobization, shrinkage of cement stone, water absorption, compressive strength.

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STUDY OF LOW-EMISSION MULTI-COMPONENT CEMENTS WITH A HIGH CONTENT OF SUPPLEMENTARY CEMENTITIOUS MATERIALS (p. 39-47)

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The studies have established the influence of various types of supplementary cementitious materials on physical and mechanical properties and structure formation of low-emission multi-component cements. The results of the granulometric composition examination of main components of multi-component cements were obtained and a comprehensive estimation of their particle size distribution relative to volume and specific surface was performed. It was proved that increase in dispersity of supplementary cementitious materials leads to decrease in their bleeding and increase in activity but simultaneously increases water demand and power consumption for mechanical activation. Efficiency of mechanical activation of main non-clinker components having different characters of activity was compared.

Experimental studies have confirmed that the problem of increasing hydraulic activity of granulated blast-furnace slag is solved by increasing content of fractions up to 10 μm in size. However, when preparing highly active granulated blast-furnace slag, energy inputs for grinding significantly grow, especially in ball mills. It should be noted that a shortage of quality slag in the cement industry is expected in the coming years. This necessitates the search for new combinations of supplementary cementitious materials, namely natural zeolites and fly ash which possess excellent pozzolanic properties. Studies of partial and complete replacement of granulated blast-furnace slags in the composition of low-emission cements with clinker factor of 0.50 have shown that necessary indices of early and standard strength are ensured due to optimization of granulometric composition of pozzolanic additives. At the same time, binder strength increases significantly with the age of hardening and exceeds standard strength by 30 % in 90 days. This makes it possible to state that due to the pozzolanic reaction between superfine zeolite, fly ash and calcium hydroxide, the processes of formation of hydrate phases in the intergranular space are stimulated and microstructure of the cement matrix is compacted. It was shown that the use of low-emission multi-component cements modified with superplasticizers of polycarboxylate type provides technological, technical, economic and environmental effects.

Thus, there are grounds to state feasibility of obtaining clinker-efficient low-emission multi-component cements by optimizing granulometric composition of supplementary cementitious materials of various kinds in order to reduce power inputs in the technological processes of their production.

Keywords: multi-component low-emission cements, supplementary cementitious materials, granulated blast-furnace slag, super-zeolite, fly ash, clinker factor.

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THE AERATED CONCRETE BASED ON AN INTEGRATED FOAM CONCENTRATE CONTAINING IRON COMPOUNDS (p. 48-53)

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The chemical processes of Portland cement hydration enable the formation of concrete compressive strength. Under certain conditions, increasing the rate of cement hydration contributes to the improved strength of concrete at compression. This is especially true of the cellular concretes, specifically aerated concretes. The current work has investigated the influence of an integrated admixture that promotes gas formation in obtaining aerated concrete. The specified admixture consists of a mixture of hydrophobic surface-active substance – calcium oleate, perhydrol, and a nanomodifier, a mineral additive containing iron compounds. Feature of this research was the study into a simultaneous influence of hydrophobic surface-active substances, perhydrol, and mineral substances containing iron compounds, on a change in the strength of non-autoclave aerated concrete. The study was necessitated by the insufficient compressive strength of non-autoclave aerated concretes, whose manufacture employs aluminum powder or perhydrol as a gas-forming additive. Using aluminum powder does not provide for the homogeneity of its distribution throughout the volume of concrete; in addition, the cost of aluminum powder is rather high. It was established in the course of our study that the specified integrated admixture

changes the character of strength formation in aerated concretes, specifically it increases its magnitude. It has been proven that in order to control the processes of cement hardening and to form the strength of artificial stone, which is obtained in the process of cement hydration, it is possible, in the manufacture of aerated concrete based on perhydrol, to use the admixtures-nanomodifiers containing compounds of iron, thereby improving the absolute magnitude of compressive strength of such concretes at the age of 28 days. The most effective is to use the nanomodifiers that contain a mixture of iron compounds, which leads to an increase in the strength of aerated concrete by up to 50 %.

Keywords: non-autoclaved aerated concrete, surface-active substances, nanomodifier, strength of aerated concrete, perhydrol, iron compounds.

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MATERIAL SELECTION FOR THE MESH ELECTRODE OF ELECTROCHROMIC DEVICE BASED ON $Ni(OH)_2$ (p. 54-60)

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In this study, we propose changes to the cell design in order to reduce the cost of electrochromic devices. The modification lies in the replacement of the second electrochromic layer along with its conductive layer with the mesh metal-oxide electrode. This variant of the electrochromic device is proposed to be installed in light windows and upper parts of view windows.

For the proposed mesh electrode, a few possible electrochemical systems were proposed: $Cu|Cu_2O$, $Zn|ZnO$, $Ni|NiO$ and $Ag|AgO$. By means of cyclic voltammetry, the working parameters of these systems were found – working potential windows and specific peak current. Based on the obtained data, the silver electrode proved to be the most promising.

The chosen electrode was studied by means of cyclic voltammetry and galvanostatic cycling. It was found that the specific capacity of the silver electrode does not have a strong dependence on the current density of oxidation and reduction. Minimum and maximum specific capacities of the studied electrode were found, which in 0.1 M KOH were 0.075 $mA{\cdot}h/cm^2$ (cyclic voltammetry) and 0.082–0.042 $mA{\cdot}h/cm^2$ (galvanostatic cycling). It was also found that during electrochemical cycling in 0.1 M KOH, the following transformations occur $Ag \leftrightarrow Ag_2O$ and $Ag_2O \leftrightarrow AgO$.

Based on the obtained data, at the specific capacity of the main (electrochromic) electrode of 0.011 $mA{\cdot}h/cm^2$, it is proposed to use a mesh with a 2 × 2 cell and wire diameter of 0.5 mm. It was found that the cost of the silver mesh can be decreased by using a silver plated copper mesh instead.

Keywords: $Ni(OH)_2$, nickel hydroxide, electrochromic device, mesh electrode, counter-electrode, silver, silver oxide, specific capacity, skylights.

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