ABSTRACT AND REFERENCES

TECHNOLOGY ORGANIC AND INORGANIC SUBSTANCES

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TECHNOLOGICAL FEATURES IN OBTAINING HIGHLY EFFECTIVE HYDROGEL DRESSINGS FOR MEDICAL PURPOSES (p. 6-13)

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The new technology of formation of hydrogel dressings for medical purposes, containing particles of silver was developed. To obtain metal-containing composite hydrogels, we proposed a high-tech single-stage method, which involves polymerization of polymer-monomer compositions based on polyvinyl-pyrrolidone and 2-hydroxyethylmethacrylate with simultaneous chemical reduction of silver ions from its nitrate by ethanol. It was found by the thermometric research that the temperature conditions needed for chemical reduction of silver ions are achieved due to the heat, which is released at the exothermic polymerization reaction. The temporal and temperature parameters of polymerization depending on the composition of the original polymer-monomer composition, the content of solvent and of the initiator, and silver nitrate concentration were determined. They include the initial temperature of polymerization, maximum exothermic temperature, the time of reaching the maximum exothermic temperature, and duration of effect gel. The use of combined initiating system of iron (II) sulfate + benzoyl peroxide makes it possible to implement the process of obtaining hydrogels, containing silver particles, at room temperature, in the open air. The synthesis is technologically simple and is executed without complicated apparatus design. The authors proposed a new technology of formation of hydrogel films with the use of the centrifugal method. Polymerization with silver deposition occurs in the centrifugal form simultaneously with film formation, which allows obtaining the materials with predictable properties that have a uniform distribution of the filler with equal thickness and high quality surfaces in the polymer matrix. The film products obtained as a result of the developed technology can swell in water and other polar solvents, are characterized by durability, elasticity, bactericidal and antifungal properties. The results of the clinical studies showed sufficient clinical effectiveness of using the developed hydrogel dressings for medical purposes based on hydrogels, containing silver particles. Such materials in combination with the integrated therapy help to increase the speed and intensity of treatment of trophic venous ulcers of lower limbs.

Keywords: hydrogel medical dressings, silver-containing hydrogels, centrifugal formation, metal-polymeric composites, trophic ulcers.

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OBTAINING, STUDYING THE PROPERTIES, AND APPLICATION OF ZIRCONIUM(IV) OXYMETHANESULFONATE (p. 1-19)

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The author has investigated the process to obtain zirconium (IV) oxymethanesulfonate via the interaction between methane sulfonic acid (CH_3SO_3H) (MSA) and zirconium (IV) oxocarbonate ($ZrOCO_3{\cdot}nH_2O$), and explored its basic physical-chemical and technological properties. The research was undertaken to address the lack of data on the chemistry of such a class of organic compounds as zirconium (IV), as well as to examine their possible application in modern materials science.

The methods of element, X-ray phase, thermal, and infrared analyses have confirmed that the product of interaction between zirconium (IV) oxocarbonate ($ZrOCO_3{\cdot}nH_2O$) and methane sulfonic acid is zirconium (IV) oxymethanesulfonate with the composition $ZrO(CH_3SO_3)_2{\cdot}4H_2O$.

It has been established that the synthesized zirconium (IV) oxymethanesulfonate is a white crystalline powder, which dissolves well in water while is weakly soluble in ethanol and isopropyl alcohol. It absorbs moisture in the open air. It thermally decomposes in the temperature range of 390–410 °C, forming a low-temperature cubic zirconium dioxide modification that, at temperatures above 750 °C, consistently passes into the monoclinic structure of zirconium dioxide. At the zirconium (IV) oxymethanesulfonate thermolysis there form the nanodispersed powders of zirconium dioxide whose size of primary particles is 20–50 nm, which, under the action of dispersion forces, agglomerate into aggregates of 200–400 nm. The specific surface of powders, determined based on a BET procedure, is 32 m^2/g. It has been shown that the aqueous-alcohol solutions of $ZrO(CH_3SO_3)_2{\cdot}4H_2O$ actively interact with solid surfaces thereby forming hyperfine near-the-surface polymerized films, from which, when treated thermally, the surface coatings are formed from zirconium dioxide. Thus, new data have been acquired on the chemistry of complex compounds of zirconium(IV). This paper shows promising application of zirconium (IV) oxymethanesulfonate for the needs of modern materials science.

Keywords: methane sulfonic acid, methane sulfonate, zirconium (IV) oxymethanesulfonate, complex compound, nanocrystalline powders, zirconium oxide, surface films.

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ANALYSIS OF PROPERTIES OF EPOXY COMPOSITIONS THAT OPERATE IN CONTACT WITH WATER AND OIL PRODUCTS (p. 20-26)

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We modified epoxy resin-based polymer solutions to increase durability in aggressive environments and to reduce costs. We achieved the objective via filling them with the multifractional mineral frame and modification with zeolite and furfural. We varied a content of furfural, a total content of the mineral frame and a proportion of individual components in the frame. The investigated compositions should work under conditions of influence of mixtures of water with oil products and other agents (in elements of structures for the transport service). We determined properties of compositions after exposure separately in air, in water and in two types of oil.

We applied an iterative procedure of random scanning of fields of material properties in five coordinates of varying factors in search for optimal compositions. We studied property fields using experimental statistical models obtained in field experiments. ES models serve to implement calculation experiments using the Monte Carlo method.

We confirmed the possibility for determining the optimal (by the set of criteria) multicomponent polymer compositions for different operating conditions using an iterative procedure of random scanning of property fields.

We obtained compositions for repair and protection of structures, which are in contact with water: paste (reduced viscosity composition without sand) and solution (with reduced epoxy resin consumption). We used compositions that ensure the preservation of the required properties of a protective solution after prolonged exposure to mixtures of water with oil products in the complete overhaul of railway crossing flooring.

Keywords: epoxy-rubber resin, zeolite, furfural, experimental statistical model, Monte-Carlo method, compromise optimization.

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THE EFFECT OF ADDITIVE ON COMBUSTION CHARACTERISTICS AND CYCLE TO CYCLE VARIATIONS ON SI ENGINE FUELED BY GASOLINE AND BIOETHANOL (p. 27-36)

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Currently, the main energy source is heavily dependent on fossil energy. The current transportation technology also uses fossil-derived energy sources to make vehicle engines are ignited. Also, the electricity that is currently enjoyed by billions of people resulted enormously from the use of fossil energy. Limitations of existing fossil energy sources and the issue of global warming have led many to expand on renewable energy and energy conservation to maintain energy availability. One of an alternative energy source that is currently being developed is the use of bioethanol as a mixture or replacement of fossil fuel. The use of bioethanol (C_2H_5OH) as a substitute for a mixture of fossil fuels affects the efficiency of the engine produced by fuel. This study examines the effect of a mixture of bioethanol gasoline (RON 80) on a single-cylinder spark ignition (SI) 125 cc engine that is carried out with variations in fuel mixtures (E0, E5, E10, and E15) with the addition of 0.5 vol % oxygenated cyclohexanol and this experimental test is carried out as much as 800 cycles for each fuel mixture, with throttle opening, maintained 100 %, and variations in engine speed at 4,000 rpm up to 8,500 rpm with engine speed increases every 500 rpm. Engine performance is measured by connecting a machine with a dynamometer, and the variation of cylinder pressure combustion is measured by a pressure transducer. The test results are expected to prove that the mixture of fuel with oxygenated cyclohexanol can reduce COV_{IMEP} in the cycle to cycle variations (E10++ which is 4.24 %), so that torque fluctuations do not occur which results in reliable engine performance or vehicle driveability increase, besides that the performance of both power and torque becomes better.

Keywords: bioethanol, oxygenated, cylinder pressure, coefficient of variation, cycle to cycle variations, power, torque.

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RESEARCH OF THE IMPACT OF THE METHOD OF HEATING OF HEAT UNITS ON THE QUALITATIVE CHARACTERISTICS OF TREATED MATERIALS (p. 37-43)

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An analytical method for calculating the chemical potentials of the components of the gas-solid system based on thermodynamic calculations of carbon potentials of the C–O–H–N gas mixture (combustion products of the methane-air mixture) and the solid phase (alloyed steel) is developed. Dependences describing the influence of the main parameters of heating the medium composition, flow rate, as well as their interaction, on metal losses associated with decarburization are obtained.

Thermodynamic calculations of carbon potentials of alloyed steel and natural gas combustion products of different composition (α=0.2÷1.2), metal and combustion products temperatures of 1,100÷1,500 K are performed.

Based on the analysis of the structure of the thermal and diffusion boundary layers, it is proved that the decrease in the temperature of the layer of combustion product flowing around the solid product and surface flow rate reduces the diffusion flow of carbon in the boundary layer. This effect reduces the decarburization of steel.

It is found that when heating the heat unit according to the principle of indirect radiant heating (IRH) during the operation of the flat-flame burner, the main gas volume, localized at the metal surface, has a temperature significantly lower than the layer adjacent to the lining. This reduces the metal loss with decarburization compared with furnaces of the traditional heating system.

Combustion of gas in flat-flame burners with an intense circulation of combustion products in the working space of the heat unit ensures that the heated products have a uniform composition of combustion products corresponding to a practically equilibrium one. This allows recommending flat-flame burners for widespread use in modern heat-power units in the industry.

Keywords: heat-treatment furnace, boundary layer, decarburization, flat-flame burner, temperature control.

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DEVELOPMENT OF A SOL-GEL TECHNIQUE FOR OBTAINING SINTERING ACTIVATORS FOR ENGOBE COATINGS (p. 43-51)

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We have developed a technology for manufacturing the glass ligaments-activators to intensify the sintering of ceramic materials, specifically engobe coatings. The comparative analysis has been performed into the glass ligaments obtained through a conventional glass melting and by applying the sol-gel synthesis. Large efficiency of the latter has been established related to the reduced energy costs required to thermally treat a composition (rather than melting glass at 1,300–1,400 °C, gel is to be thermally treated to 600 °C) as well as to the improved homogeneity of the glass ligament (chemical formulation of the composition is averaged at a molecular level).

Different sol-gel techniques for obtaining glass ligaments-activators have also been examined: a powder sol-gel technique without calcination; a sol-gel technique for the preparation of solutions of salts; a powder sol-gel technique with the composition melting. The specified techniques differ in the sequence and method for mixing the source components, while their dispersion in a gel-forming agent the ethyl silicate ETS-40 is mandatory. The chosen basic components of the activator were soluble salts $Al(NO_3)_3 \cdot 9H_2O$, $Ca(NO_3)_2$ and $NaNO_3$. We have investigated pattern in change of the phase composition of glass ligaments at their heating to 600 °C. It has been established that all obtained compositions approach the amorphous state at temperatures of ~600 °C. Further heating of the examined glass ligaments to 1,000 °C leads to their intensive melting. In this case, for the first two techniques, the viscosity and surface tension of melts are less compared to the melt of conventional glass, and, therefore, the wetting capacity of glass ligaments-activators is higher.

When introducing these sintering activators to the compositions of ceramic coatings, it was established that the most effective is the activator that was obtained by a technique for the preparation of salt solutions. It is the one that provides, after annealing at 1,170 °C, for the densest structure of the sintered coating with reduced water absorption (not exceeding 0.05 %) and high whiteness of the surface (87–88 %). The activators that we developed could become an alternative to conventional glass-ligaments whose melting requires considerable energy costs.

Keywords: sol-gel technique, sintering activator, engobe, annealing, water absorption

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AN IMPROVEMENT OF CRITERIA FOR ASSESSING THE QUALITY OF CLAY RAW MATERIAL FOR ARCHITECTURAL AND CONSTRUCTION CERAMICS (p. 51-57)

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The study analyzes the existing methods for assessing the suitability of clay raw materials for the production of architectural and construction ceramics and substantiates the need for their improvement in the direction of developing an indicator based on an analysis of the mineral composition of clays. Using the compositions of the kaolinite – montmorillonite – hydromica – quartz system, which simulate the composition of polymineral clays, the effect of clay-forming minerals and quartz impurities on the properties of the clinker ceramic materials has been established. It has been determined that the montmorillonite component of the compositions has a positive effect on the water absorption of materials, and kaolinite produces a favourable effect on the mechanical strength and frost resistance. The increase in the content of quartz in the composition of compositions from 30 % to 50 % leads to an increase in water absorption of materials, reducing their strength and frost resistance to a level unacceptable for ceramic clinker. It has been established that to obtain clinker ceramics, the quartz content in the compositions cannot exceed 40 %.

A diagram of the mineral composition was developed, clearly illustrating the ratios of the main rock-forming minerals in clays with a quartz content of 30 % and 40 %, acceptable for the production of modern clinker products. The diagram shows areas of the mineral composition of clays suitable for the production of facing, paving and road clinker of the M200–300 grades and road clinker of the M400 grade at a firing temperature of 1,100 °C. The diagram of the mineral composition complements the existing indicators of the suitability of clay raw materials for the production of architectural and construction ceramics and can serve as an additional criterion for assessing their technological quality. The diagram can be used to analyze the suitability of clays for the production of ceramic clinker, provided that only the mineral composition of clays is determined without establishing their chemical and particle size distribution.

Keywords: architectural and construction ceramics, clinker materials, mineral clay, criteria of technological quality, industrial application/use.

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STUDYING THE PHYSICOCHEMICAL REGULARITIES IN THE COLOR- AND PHASE FORMATION PROCESSES OF CLINKER CERAMIC MATERIALS (p. 58-65)

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The paper reports results of a comprehensive study, aimed at developing formulation-technological parameters for obtaining volumetrically dyed clinker ceramic materials with a wide range of colors. A possibility has been proven to obtain a ceramic clinker when using the polymineral clay raw materials at a temperature of 1,100 °C. The expediency has been shown to replace expensive ceramic pigments in the composition of masses with anthropogenic materials containing the oxides of metals with variable valency: wastes from alkaline earth syenite extraction, pegmatite enrichment, and production of ferrotitanium alloys. This shows possibilities for reducing the production cost of clinker ceramic articles. The influence of the formulation of raw materials compositions on the processes of color- and phase-formation of ceramic clinker has been investigated, depending on the character of furnace atmosphere. It was established that the brown coloration of clinker ceramics under conditions of oxidative annealing is predetermined by the presence of phases of hematite α-Fe_2O_3 and Mn_2O_3. At annealing in a reducing medium, products acquire color in the range from dark brown to black at the expense of formation of magnetite Fe_3O_4 and gaussmanite Mn_3O_4. The products' terracotta color is due to the presence of phases of hematite and hedenbergitis $CaFeSi_2O_6$. The condition for obtaining clinker ceramics of yellow color is to limit the formulation's content of Fe_2O_3 to 3 % by weight, as well as the presence of the SiO_2 rutile phase.

The paper illustrates the effect of the overall content of oxides of metals with a variable valence $S(Fe_2O_3+FeO+MnO+Mn_3O_4)$ on the coloration characteristics of clinker ceramics. The ratios have been derived between the phase-forming oxides $Fe_2O_3/(Al_2O_3+CaO)$, $(Fe_2O_3+Mn_2O_3)/(FeO+Mn_3O_4)$ and $TiO_2/(Al_2O_3+CaO)$, as well as the limits in their variation, providing for the formation of color-carrying phases responsible for obtaining products of the desired color under conditions of oxidative and reductive annealing.

Keywords: clinker ceramic materials, polymineral clays, anthropogenic materials, sintering intensifiers, color-carrying phases.

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