

ABSTRACT AND REFERENCES

MATERIALS SCIENCE

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RESEARCH INTO COMPOSITION AND
PROPERTIES OF THE Ni–Fe ELECTROLYTIC
ALLOY (p. 4-10)

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Promising yet insufficiently studied is the new electrolyte based on methanesulfonate salts of the alloy-forming metals. Examining the laws that govern the electrodeposition of the Ni–Fe alloy with assigned physical-chemical properties from the methanesulfonate electrolyte is a relevant task. In the present work we established influence of the concentration of iron(II) ions in the electrolyte and of current density on the composition of alloy. The content of iron in the Ni–Fe alloy grows with an increase in the concentration of iron(II) ions in the methanesulfonate electrolyte. Dependence of the content of iron in the alloy on current density is of extreme character. The maximum corresponds to the current density of 1 A/dm². It is shown that the organic additive applied in the present work, sodium saccharinate, does not exert any substantial influence on the composition of alloy

at current density exceeding 2 A/dm². Sodium saccharinate increases microhardness of the coating with the Ni–Fe alloy whose values reach 500 kg/cm². When introducing into the methanesulfonate deposition electrolyte of the Ni–Fe alloy of 6 mmol/l of sodium saccharinate, practically unstressed precipitations precipitate. A reduction in the internal stresses leads to a decrease in the values of coercive force of the alloy. It is demonstrated that the investigated properties of the Ni–Fe precipitations are determined by the structure of coatings. Sodium saccharinate, being a surface-active compound under the conditions of electrolysis, changes the structure of the cathodic Ni–Fe alloy and improves functional characteristics of coatings. The established dependences represent a rather valuable basis for designing new technologies of the electro-deposition of polyfunctional coatings with the Ni–Fe alloy with enhanced mechanical and magnetic characteristics.

Keywords: electrodeposition, Ni–Fe alloy, sodium saccharinate, magnetic properties, internal stresses, microhardness, methanesulfonate electrolyte.

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STUDY OF EFFECTIVENESS OF HEAVY METALS IONS AS THE INHIBITORS OF STEEL CORROSION (p. 10-17)

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The effect of ions of d-metals on the processes of corrosion in a movable and immovable neutral aqueous environment has been investigated. It was shown that a number of ions, such as zinc, chromium, lead, under conditions of high aeration and temperature of 20 °C at concentrations of 2–5 mg/dm³, are effective inhibitors of steel corrosion. This is due to the formation of a passivation oxygen film on the surface of metal. The degree of corrosion protection is maintained at the level of 80–90 %. In the case of elevating the temperature to 50 °C, a significant (up to 40 %) decrease in the inhibitory properties of ions of d-metals is observed. This is due both to the destabilization of the oxygen passivation film and the growth of oxidation rate of steel with increasing temperature.

It was demonstrated that phosphonic acids, such as oxyethylididiphosphone acid, nitrilotrimethylphosphonium acid, due to the interaction of complexons with the surface of metals, stabilize the passivation oxygen film, providing a degree of protection against corrosion at 95–98 % at acid dose of 10 mg/dm³. However, when the temperature rises to 50 °C, a protective effect is reduced.

It was established that the use of compositions based on OEDPhA/NTMPhA and Zn/Pb/Cr ions in the range of temperatures 20–50 °C provides a degree of protection of steel from corrosion at the level of 90 %. This is explained by the formation of three-dimensional complexes of phosphonic acids with metal ions and corroded iron.

Keywords: corrosion, inhibitors, heavy metals, stabilizers of scale formation, closed water-circulation systems.

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INVESTIGATION INTO ACID-BASIC
EQUILIBRIUM ON THE SURFACE OF OXIDES
WITH VARIOUS CHEMICAL NATURE (p. 17-25)

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The acid-base equilibrium on the surface of CaO, MgO, FeO, Al₂O₃, Fe₂O₃, SiO₂, TiO₂ oxides was studied. As a result of the study, the main provisions have been formulated which made it possible to propose models of surface active centers and schemes of their acid-base equilibrium. The acid-base and energy equilibrium parameters of the active centers in the deprotonation reactions were calculated. Regularities of changes in the acid-base and energy parameters of the active centers were determined depending on the nature of the central element of the crystal lattice, the number of OH-groups and the number of hydration. Acidity of all considered types of active centers depends to a large extent on the nature of the central element, namely its charge and coordination number. It was found that with increase in the coordination number of the central elements with the same charge, pKa of anhydrous centers and the value of their Gibbs free energy in deprotonation reactions increase. Acidity of isolated anhydrous centers increases in a direct proportion as the number of OH groups increases. The obtained regularity preserves for the surfaces of all oxides considered. It was shown for all oxides that when the amount of adsorbed water molecules increases, acidity of the active centers of all types increases and this dependence is identical to the growth of acidity with an increase in the number of OH groups. This indicates identity of the nature of acidity growth with an increase in thickness of hydroxyl and hydration surface layers. The obtained results will ensure prediction of oxide filler behavior in compositions and adjustment of operating properties of composite materials.

Keywords: oxide filler, composite material, surface-active center, acid-base equilibrium.

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SILICON EFFECT ON THE FORMATION OF GRAPHITE INCLUSIONS IN GRAY CAST IRON
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Using conventional and high-temperature metallography, micro-X-ray spectroscopy and mass spectral analyzes, as well as the petrographic method, the study explores the effect of silicon on the morphology of graphite inclusions in gray cast irons.

So far, the role of silicon in the theory of graphite formation during the crystallization of cast irons remains unclear. Therefore, the disclosure of the mechanism of the influence of silicon on the formation of graphite inclusions can help fully control the structure and properties of cast iron castings and develop optimal technological processes for their production.

It has been established that the reaction in the silicon interaction with carbon monoxide in iron-carbon alloys, leading to the formation of a surface-active silicon monoxide, is caused by the temperature and physicochemical conditions of the melt. In gray cast iron, the rate and intensity of the course of this reaction have a direct effect on the morphology of lamellar graphite. The study has revealed four morphological forms of primary graphite (rosette, rectilinear-plate, ramiform, and vermicular), formed in various physicochemical conditions of the crystallization of gray cast iron.

Keywords: gray cast iron, lamellar graphite, morphology, silicon monoxide, metallography, petrography, micro-X-ray spectral analysis.

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THE PROPERTIES INVESTIGATION OF THE FARADAIC SUPERCAPACITOR ELECTRODE FORMED ON FOAMED NICKEL SUBSTRATE WITH POLYVINYL ALCOHOL USING
(p. 31-37)

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The electrode materials for positive electrodes of hybrid supercapacitors were deposited on the nickel foam substrate using cathodic template method. It has been demonstrated that prepared materials are composed of polyvinyl alcohol and X-ray amorphous α -like nickel hydroxide with a large number of lattice defects, that have a flat morphology with a grid of cracks. The optimal deposition times were found to be 10 and 20 minutes. It has also been demonstrated that the greatest effect on the capacity of nickel foam substrates was caused by the treatment itself and to not by its duration or polarization with the cathodic current. It has been demonstrated that with such deposition method, the resulting capacity is constituted by two components – the capacity of PVA-Ni(OH)₂ composite material and capacity of the nickel

foam substrate. The maximum specific capacity obtained at a current density of 320 mA/cm² is 2.26 F/cm². The maximum substrate capacity was achieved after treatment with KNO₃ solution for 10 minutes and is 1.58 F/cm² at a current density of 160 mA/cm².

Keywords: nickel hydroxide, Ni(OH)₂, supercapacitor, electrodeposition, cathodic template synthesis, polyvinyl alcohol, discharge capacity.

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STUDY INTO PROPERTIES OF THE RESOURCE-SAVING CHROMIUMCONTAINING BRIQUETTED ALLOYING ADDITIVE FROM ORE RAW MATERIALS (p. 38-43)

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It was determined that the original oxide chromium-containing ore raw material is represented by granules of rounded shape the size of 250–600 μm. Along with Cr and Fe, it revealed Mg, Al, Si, Ca, and Ti. They probably were included in the composition of oxide ore impurities and can exert an indirect influence on the reducing processes. Phase composition of the briquetted raw material after the carbon thermal treatment consisted mainly of Cr₂O₃ and metal Cr with the presence of carbides Cr₇C₃ and Cr₂C₃. Diffraction maxima of metal Fe and its compounds had no explicit manifestation, indicating the presence of Fe as substitution atoms in the chromium-containing phases and compounds. The structure is heterogeneous.

The content of residual oxygen confirms the presence, along with metal Cr, under-reduced oxide or oxy-carbide compounds. The residual oxygen could also be contained in the composition of oxide related ore impurities. This is confirmed by detection of the specified elements in the examined areas in the images of the microstructure. Excessive carbon content ensures the post-reduction of residual oxide component in a liquid metal in the process of alloying and enables protection against secondary oxidation of chromium.

Keywords: chromium-containing oxide ore raw materials, carbon thermal treatment, phase analysis, microstructure, resource saving, alloying.

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THERMOGRAVIMETRIC RESEARCH INTO COMPOSITES BASED ON THE MIXTURES OF POLYPROPYLENE AND MODIFIED POLYAMIDE (p. 44-50)

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We established in the present work the regularities for obtaining homogeneous nanocomposites based on the mixture of PP/PA-6 with montmorillonite modified using PVP. In these nanocomposites, PA-6 and MMT contribute to the increase in thermal resistance of the material, while PVP improves compatibility between polar PA-6 and hydrophobic PP.

The goal of the present work was to investigate by applying the methods of thermogravimetric analysis a correlation between thermal characteristics of the newly-created nanocomposites based on the mixture of PE/PA-6 with montmorillonite, modified using PVP, and to determine the optimal composition of a nanocomposite with enhanced thermal resistance and a wide temperature interval of the viscous-fluid state.

On the basis of experimental data, it was found that the mixtures of polypropylene with polyamide modified by the montmorillonite-polyvinylpyrrolidone mixture are distinguished by the higher thermal resistance compared with the starting PP. It is established that at a content of the modified polyamide in the mixtures with polypropylene within 30 % by weight, samples of the composite are characterized by the highest thermal resistance – weight loss of such composites in a temperature range of 218–322 °C is only 7.1 %, temperature of the onset of thermo-oxidation destruction is 300 °C. It is shown that the developed nanocomposites have wider temperature intervals of the viscous-fluid state – 126–300 °C. This makes it possible, by changing the modes of processing, to influence the structure and properties of products, especially taking into account the difference in crystallization of the material depending on the conditions and the method of processing. It is established that the most suitable for application and processing is the mixture of polypropylene with modified polyamide in the ratio 70:30 % by weight, respectively.

Keywords: polypropylene, polyamide, montmorillonite, polyvinylpyrrolidone, mixture, nanocomposite, modification, recrystallization.

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RESEARCH INTO KINETIC PATTERNS OF CHEMICAL METALLIZATION OF POWDERLIKE POLYVINYLCHLORIDE (p. 50-57)

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We present kinetic patterns of metallization of zinc-activated polyvinylchloride in the solution of chemical copper plating. The influence was studied of pH of the medium and the amount of metal of the activator on the copper deposition rate on the activated polymeric surface. It was established that in the case of activation of the polymeric surface with zinc, the solution undergoes two competing reactions of copper reduction. By using a volumetric method, we determined

that pH of the medium exerts a decisive impact on the reduction mechanism of copper. It is proved that with the growth of pH in the solutions of chemical copper plating and the amount of metal-activator, the amount of copper reduced as a result of exchange reaction with zinc increases. The optimal pH of the solutions for the course of reaction of copper reduction by formaldehyde is 12. The obtained samples of metalized powder-like polyvinylchloride contain a significant quantity of copper on the surface and could be used to create metal-filled composites.

The research conducted allows us to establish optimal conditions and effectively influence the copper reduction process on the activated polymeric surface in the solutions of chemical metallization. By changing the speed and efficiency of copper deposition on the polymeric surface, it is possible to control the content of metal in polymeric composites that are obtained from such materials, and thus control their properties.

Keywords: metallic polymeric composites, functional composites, polyvinylchloride, chemical reduction, reaction rate, metallic fillers.

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