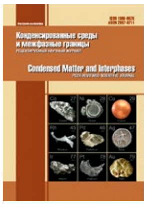

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Review

Review article
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The role of polymeric surfactants in enhanced oil recovery: a review

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Abstract

Objective of the article: The continuously increasing demand for oil and petroleum products necessitates the further development of enhanced oil recovery (EOR) methods, including physicochemical techniques such as polymer flooding. Currently, billions of tons of oil remain dispersed and scattered within water-flooded reservoirs. This article provides a review of the literature on the synthesis and application of surfactant solutions and their mixtures with various components (polymers, salts, acids, etc.) in EOR processes.

Experimental section: The use of surfactants contributes to reducing interfacial tension and increasing wettability. Polymeric surfactants represent a promising alternative to modern systems employed in chemical EOR. They can combine the necessary rheological and interfacial properties in a single component, whereas typically, this requires mixtures of several chemical substances. Improved flooding properties using polymeric surfactants are essential for recovering residual oil. In addition to their unique characteristics, it is important to ensure synergy between the surfactant or polymer and other components that meet strict technical requirements. Furthermore, EOR based on polymeric surfactant systems is technologically compatible with conventional water flooding and does not require significant capital investment.

Conclusions: It should be noted that numerous studies have been devoted to the processes of EOR. The presented article emphasizes the efficiency and feasibility of using surfactants based on the results of tests studying the physicochem.

Keywords: Enhanced oil recovery; Polymer surfactant; Ionic liquid; Surface tension; Wettability

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Review article
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Azeotropism of clathrate hydrates: a brief overview

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Abstract

Objectives: The objective of this work was to provide a review of the specific features of azeotropism manifestation in hydrate-forming mixtures. The physical basis of azeotropic behavior in clathrate hydrates and its relation to molecular structures and intermolecular forces are analyzed. The influence of hydrate system stability on azeotropic properties is considered, along with the effects of individual component characteristics such as molecular size and structure on azeotropy.

Experimental: Experimental methods for identifying azeotropy in clathrate hydrates are reviewed. Computational approaches to determining the azeotropic point are analyzed, and theoretical predictions are compared with experimental data for known azeotropic hydrates. A concise overview of hydrate-forming mixtures exhibiting azeotropic behavior is also presented.

Conclusions: Possible applications of azeotropic behavior in hydrate systems are discussed, highlighting its significant potential in practical and industrial contexts.

Keywords: Azeotropism, Azeotropic behavior, Azeotropic mixture, Clathrate hydrates, Hydrate-forming

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Original articles

Research article
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Structural, optical and magnetic properties of $CoFe_{2-x}Eu_xO_4$ nanoparticles prepared by simple co-precipitation route

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Abstract

Objectives: Nanoparticles of $CoFe_{2-x}Eu_xO_4$ (x = 0, 0.025, 0.05, 0.075, and 0.1) were successfully synthesized by simple co-precipitation method.

Experimental: Field emission scanning electron microscopy (FE-SEM) images revealed europium-doped cobalt spinel ferrite nanoparticles formed after calcination of the precursor at 900 °C for 1 h, with sizes of approximately 20–40 nm. Energy dispersive X-ray spectra (EDXS) confirmed the presence of Co, Fe, Eu, and O elements with no evident of impurities. Results calculated from powder X-ray diffraction (PXRD) data show that the average crystallite size and lattice parameters decrease with increasing europium content.

Conclusions: The doping of Eu^{3+} ions in the cobalt ferrite structure affects the optical and magnetic properties of the substrate material. In this case, the values of band gap energy (E_g), coercivity (H_c) and remanent magnetization (M_r) increase with increasing concentration of Eu^{3+} ion, while optical absorption and saturation magnetization exhibit an opposite trend. The excellent optical and magnetic properties of un-doped and Eu-doped $CoFe_2O_4$ nanoparticles suggest great potential for applications related to optics and magnetism.

Keywords: Co-spinel, nanoparticles, Eu-doping, Co-precipitation, Optical property, Magnetic parameters

For citation: Le N. K. N., Nguyen T. T. T., Nguyen H. H., Tran D. T., Vu T. N. A., Nguyen A. T. Structural, optical and magnetic properties of $CoFe_{2-x}Eu_xO_4$ nanoparticles prepared by simple co-precipitation route. *Condensed Matter and Interphases.* 2025;27(4): 555–564. https://doi.org/10.17308/kcmf.2025.27/13254

Research article
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Phase equilibria and some properties of solid solutions of $PbGa_2S_4$–$SmGa_2S_4$ and $PbGa_2Se_4$–$SmGa_2Se_4$ systems

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Abstract

Objectives: In connection with the transition to green energy, the search for, synthesis of, and investigation into alternative energy sources and the materials required for them are of great importance. One of the methods for obtaining such promising materials is the study of phase diagrams between isostructural compounds. In this regard, phase equilibria in the $PbGa_2S_4$–$SmGa_2S_4$ and $PbGa_2Se_4$–$SmGa_2Se_4$ systems were investigated using physicochemical analysis methods (DTA, XRD, measurements of microhardness and density), and their phase diagrams were constructed.

Conclusions: It has been established that the specified systems are quasi-binary and are characterized by the formation of continuous substitution-type solid-solution areas. The solid solutions $Pb_{1-x}Sm_xGa_2S_4$ and $Pb_{1-x}Sm_xGa_2Se_4$ crystallize in the orthorhombic crystal system and belong to the $EuGa_2S_4$ structural type. Their unit-cell parameters vary within the following ranges: $Pb_{1-x}Sm_xGa_2S_4$ *a* = 20.745–20.706 Å; *b* = 20.464–20.380 Å; *c* = 12.236–12.156 Å; $Pb_{1-x}Sm_xGa_2Se_4$ *a* = 21.722–21.782 Å; *b* = 21.202–21.350 Å; *c* = 12.3047–12.390 Å; Space group: *Fddd*, *Z* = 32. Several physicochemical properties of the $Pb_{1-x}Sm_xGa_2S_4$ and $Pb_{1-x}Sm_xGa_2Se_4$ solid solutions have been investigated.

Keywords: System, Solid solution, Unit cell, Lattice parameter, Phase diagram

For citation: Aliev O. M., Azhdarova D. S., Agayeva R. M., Ragimova V. M. Phase equilibria and some properties of solid solutions of $PbGa_2S_4$–$SmGa_2S_4$ and $PbGa_2Se_4$–$SmGa_2Se_4$ systems. *Condensed Matter and Interphases*. 2025;27(4): 565–572. https://doi.org/10.17308/kcmf.2025.27/13293

Research article
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Study of the influence of the nature and concentration of the solubilizer on the process of formation of solid dispersions of chloronitrophenol

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Abstract

Objectives: The aim of the work was to study the influence of surfactants on the release and solubility of chloronitrophenol (CNP) from solid dispersions in water. The object of study was a solid dispersion of chloronitrophenol with PEG 1500.

Experimental: The concentration of the pharmaceutical substance in solutions was determined spectrophotometrically at a wavelength of 410 nm. The study of the solubility and dissolution rate of pharmaceutical substances (PS) in the form of powder and in the composition of solid dispersed systems (SDS) was carried out according to the method proposed by I. I. Krasnyuk. The study of the optical properties of solutions of the initial compounds and solid dispersions was carried out using the method described in the study of V. V. Grikh. IR spectroscopy, differential scanning calorimetry, and electron microscopy were used for investigation of SDS.

Conclusions: The influence of solubilizers on the process of formation of solid dispersions of chloronitrophenol was studied. It has been shown that the presence of solubilizers allows the use of lower concentrations for the carrier when obtaining solid dispersed systems of chloronitrophenol. The conducted complex of physicochemical methods of analysis allows us to more accurately explain the phenomenon of increasing the solubility and dissolution rate of PS from solid dispersions in the presence of a solubilizer. Based on the conducted studies, it can be concluded that the production of solid dispersions based on a carrier polymer in the presence of a solubilizer allows to reduce or completely eliminate the crystallinity of the pharmaceutical substance, converting it into an amorphous state. The presence of the phenomenon of light scattering and the opalescent Faraday-Tyndall cone in solutions containing solid dispersions of CNP confirmed the assumption about a colloidal-dispersed state of the pharmaceutical substance in water when dissolving CNP from solid dispersions.

Keywords: Chloronitrophenol, Solid dispersions, Solubility, Crystallinity

Funding: The study was supported by the Russian Science Foundation grant No. 24-25-20015, https://rscf.ru/project/24-25-20015/

Acknowledgements: IR spectroscopy studies were conducted at the Voronezh State University Center for Collective Use of Scientific Equipment of Voronezh State University. Differential scanning calorimetry were obtained using the equipment of the Centre for Collective Use “Experiential Center” of Voronezh State University of Engineering Technologies.

For citation: Belenova A. S., Polkovnikova Yu. A., Slivkin A. I., Semenov V. N., Vasilieva S. I., Golovina A. A., Saranov I. A. Study of the influence of the nature and concentration of the solubilizer on the process of formation of solid dispersions of chloronitrophenol. *Condensed Matter and Interphases*. 2025;27(4): 573–580. https://doi.org/10.17308/kcmf.2025.27/13294

Research article
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Redox sorption of oxygen by Pd- and Cu-containing nanocomposites in the over-limiting current mode of electrochemical polarization

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Abstract

Objectives: Palladium- and copper-containing nanocomposites have been synthesized with different capacities for a metal component chemically deposited in a macroporous sulfocation exchange matrix.

Experimental: It has been revealed that in the over-limiting mode of electrochemical polarization, the reduction of oxygen dissolved in water on a palladium-containing nanocomposite proceeds by a catalytic mechanism. In addition to the targeted O_2 cathodic reduction process, adsorbed hydrogen is formed, which reacts catalytically with oxygen, which contributes to an additional decrease in O_2 concentration. It was found that in the over-limiting polarization mode of the Pd-containing nanocomposite, the oxygen concentration decreases significantly compared to the limiting mode.

Conclusions: The specific amount of absorbed oxygen increases with a decrease in the content of the deposited metal, which is associated with the high adsorption capacity of atomic hydrogen by weakly associated palladium nanoparticles. When using copper instead of palladium, the effectiveness of water deoxygenation decreases.

Keywords: Nanocomposite metal-ion exchange materials, Redox sorption, Deoxygenation of water

Funding: The study received financial support from the Ministry of Science and Higher Education of the Russian Federation within the framework of State Contract with universities regarding scientific research in 2025–2027, project No. FZGU-2025-0001.

For citation: Vakhnin D. D., Fertikova T. E., Zheltouhova N. A., Kravchenko T. A., Kozaderov O. A. Redox sorption of oxygen by Pd- and Cu-containing nanocomposites in the over-limiting current mode of electrochemical polarization. *Condensed Matter and Interphases*. 2025;27(4): 581–591. https://doi.org/10.17308/kcmf.2025.27/13296

Research article
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Simulation of a non-stationary electrochemical process on rough electrodes under mixed kinetic-diffusion control

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Abstract

Objectives: In this work, the effect of electrode surface roughness on the rate of a transient electrochemical process under mixed transport-kinetic control is established. A mathematical model of the electrochemical process occurring on an electrode with a rough surface and characterized by a different ratio of the rate constant of the charge transfer stage and the coefficient of non-stationary bulk diffusion is constructed.

Experimental: Using the numerical method of finite element modeling, chronoamperograms of a transient electrochemical process were obtained under conditions of mixed transport and kinetic control on electrodes with different surface profiles defined by harmonic and fractal functions. The transient “roughness function - time” curves are calculated and the boundaries of the transition region are determined, within which it varies from the roughness factor to unity. It is found that the shape of the chronoamperogram depends in a complex way both on the geometric characteristics of the rough surface and on the ratio of the diffusion-kinetic parameters of the process. With relatively short durations, the gross process rate is equal to the charge transfer rate at a given potential and is proportional to the roughness factor. With relatively long durations, the chronoamperogram transforms into a current decay curve of the diffusion-controlled process, while the effect of roughness is nonlinear in this case and manifests itself only with relatively short process durations. Under these conditions, the thickness of the diffusion layer is much smaller than the size of the irregularities, and the rate of the process on the rough electrode is proportional to the true surface area and roughness factor.

Conclusions: The position of the transition region depends on the value of the rate constant of the charge transfer: in the case of a slow kinetic stage, the transition manifests itself over increasingly long periods and gradually widens, while depending on the geometric shape of the irregularity.

Keywords: Electrode process, Mixed kinetics, Roughness factor, Chronoamperogram, Finite element method, Roughness function, Harmonic profile, Fractal function

Funding: The study received financial support from the Ministry of Science and Higher Education of the Russian Federation within the framework of State Contract with universities regarding scientific research in 2025–2027, project No. FZGU-2025-0001.

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Research article
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Experimental study of phase equilibria in the Cu_2SnSe_3-Cu_3SbSe_4-Se ternary system

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Abstract

Objectives: Copper-tin and copper-antimony chalcogenides are highly desirable for the creation of novel, affordable, and ecologically friendly thermoelectric materials. Due to the potential for improving their thermoelectric performance through different cationic and anionic substitutions, these compounds have recently attracted increased attention. The aim of the work was to establish the nature of the physicochemical interaction in the Cu_2SnSe_3-Cu_3SbSe_4-Se compositions region of the Cu-Sn-Sb-Se quaternary system by experimentally studying phase equilibria.

Experimental: Elemental components of high purity (⩾ 99.999 %) from EVOCHEM Advanced Materials GmbH (Germany) were used for the synthesis of the ternary compounds. The synthesis was carried out in evacuated (~10^{-2} Pa) quartz ampoules at temperatures 50 °C above the melting points of the ternary compounds. Phase equilibria in the Cu_2SnSe_3*Cu_3SbSe_4-Se system were experimentally studied using differential thermal analysis (NETZSCH 404 F1 Pegasus system) and X-ray diffraction (diffractometer Bruker D2 PHASER). This paper presents the *T-x* diagram of the Cu_2SnSe_3-Cu_3SbSe_4 boundary system, the isothermal section at 300 K, the liquidus surface projection, as well as three polythermal sections of the phase diagram. The primary crystallization fields of the phases and the types and coordinates of non- and monovariant equilibria are also determined.

Conclusions: The Cu_2SnSe_3-Cu_3SbSe_4 system has been established to be a quasi-binary eutectic system. Eutectic equilibrium is established at 68 mol % Cu_3SbSe_4 and 727 K. The liquidus surface of the studied system consists of two wide regions of primary crystallization of the Cu_2SnSe_3 and Cu_3SbSe_4 phases and one degenerate region near the selenium corner of the concentration triangle. A wide immiscibility area of two liquid phases is observed in the system, which has the form of a continuous solid solutions between the corresponding regions of the Cu_2SnSe_3-Se and Cu_3SbSe_4-Se boundary systems.

Keywords: Copper-antimony-tin selenides, Phase diagram, Immiscibility region, Solid solutions

For citation: Ismayilova E. N., Mashadiyeva L. F., Bakhtiyarly I. B., Gasymov V. A., Huseynova I. F., Jafarov Y. I. Experimental study of phase equilibria in the Cu_2SnSe_3-Cu_3SbSe_4-Se ternary system. *Condensed Matter and Interphases*. 2025;25(4): 606–614. https://doi.org/10.17308/kcmf.2025.27/13298

Research article
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Hydration properties of heterogeneous ion exchange membranes after their long-term use in the electrodialysis treatment of wastewater from the production of mineral fertilizers

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Abstract

Objectives: In this paper, the evolution of the hydration characteristics of heterogeneous cation- and anion-exchange membranes during the electrodialysis treatment of multicomponent salt solutions is studied.

Experimental: The objects of research are heterogeneous RalexCMH-Pes (sulfocation exchange) and RalexAMH-Pes (anion exchange with quaternary ammonium groups) membranes, which have been used with different durations in an industrial electrodialyzer for the concentration/desalination of liquid waste from the production of complex mineral fertilizers. The hydration characteristics of the membranes were determined using synchronous thermal analysis. The morphology of the surface of the studied membranes was investigated by scanning electron microscopy. X-ray phase analysis of the ash residue after annealing of the membranes was carried out using the diffractometric method.

Conclusions: The moisture content and specific heat of dehydration of the studied membranes increase during long-term electrodialysis processing of liquid waste from the production of complex mineral fertilizers. For cation-exchange and anion-exchange membranes, the moisture content increases by 74 and 68 %, respectively. The predominant type of kinetically unequal water in membranes is weakly and moderately bound water. Strongly bound water molecules involved in ion-dipole interactions with active functional groups are least represented in membranes, and during operation in an electrodialyzer, their proportion increases by 1.35 times in the case of cation-exchange membranes and decreases by 1.3 times in anion-exchange membranes. The increase in moisture content and the redistribution of water fractions of different degrees of binding can be explained by the degradation of membranes caused by their morphological changes (an increase in the number of defects and the size of macropores filled with solution or water), as well as the stretching of the membrane matrix due to the presence of large and highly hydrated ions in the processed liquid waste. In addition, hydrophilic inorganic precipitates accumulate in the nanopores of anion-exchange membranes.

Keywords: Heterogeneous ion exchange membranes, Degradation, Electrodialysis, Hydration characteristics, Synchronous thermal analysis

Funding: The study was supported by the Russian Science Foundation (RSF), project No. 25-29-00557, https://rscf.ru/en/project/25-29-00557/

Acknowledgements: Synchronous thermal analysis was performed on the equipment of the Test Center of the Voronezh State University of Engineering Technologies. The studies using scanning electron microscopy and X-ray diffractometry were performed on the equipment of the Center for Collective Use of Scientific Equipment of the Voronezh State University

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Research article
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Synthesis and anticorrosive properties of 2-alkyl-5-methyl-4,5,6,7-tetrahydro-[1,2,4]triazolo[1,5-a]pyrimidin-7-ols

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Abstract

Objectives: The aim of the study is to synthesize a series of 2-alkyl-5-methyl-4,5,6,7-tetrahydro-[1,2,4]triazolo[1,5-a]pyrimidin-7-ols, to investigate their inhibitory properties and the regularities of their interaction with a steel surface, in order to create a new generation of efficient and environmentally friendly acid corrosion inhibitors.

Experimental: The paper presents the results of synthesis and investigation of the anticorrosion properties of new 2-alkyl-5-methyl-4,5,6,7-tetrahydro-[1,2,4]triazolo[1,5-a]pyrimidin-7-ol derivatives obtained from individual fatty acids and vegetable oils. The reaction of aminotriazoles with crotonaldehyde in an amphoteric surfactant medium made it possible to develop a method for producing the target compounds with high yield and purity. The anticorrosion properties of the synthesized triazolopyrimidinol derivatives were studied with respect to St3 steel in 24% HCl using both direct methods (GOST 9.905-82, 9.907-83) and electrochemical techniques (potentiodynamic polarization and polarization resistance method according to Mansfeld). Electrochemical tests by potentiodynamic polarization and direct corrosion measurements in 24% HCl showed that all investigated compounds exhibited a pronounced inhibiting effect on St3 steel.

Conclusions: It has been established that all investigated compounds act as mixed-type inhibitors. The most effective ones were the derivatives obtained from coconut oil, providing protection efficiencies up to 98.5% at concentrations of 1–2 g/L. Comparison of gravimetric and polarization data revealed that the high instantaneous protection efficiencies determined by electrochemical methods correspond to intensive physical adsorption of inhibitor molecules immediately after their introduction. However, during prolonged exposure in direct gravimetric tests, a decrease in protection efficiency was observed for compounds with alkyl substituents of C13 and longer, which is attributed to the partial instability and desorption of the protective films under extended acid exposure. This leads to localized corrosion on certain surface areas and a reduction in the overall protection efficiency. The results confirm the promise of synthesizing 4,5,6,7-tetrahydro-[1,2,4]triazolo[1,5-a]pyrimidin-7-ols from renewable plant-based feedstocks for the development of biodegradable acid corrosion inhibitors.

Keywords: Corrosion, Steel, Hydrochloric acid, Corrosion inhibitors, Heterocyclic compounds, Vegetable oils, Aminotriazoles, Tetrahydrotriazolopyrimidinols, Physicochemical research methods

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Research article
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Phase equilibria in the GeTe-Sb_2Te_3-Te system

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Abstract

Objectives: Germanium-antimony tellurides are of considerable practical interest as thermoelectrics with low thermal conductivity, topological insulators and phase memory materials. In this paper, the results of a study of phase equilibria in the region of GeTe-Sb_2Te_3-Te compositions of the Ge-Sb-Te system using the DTA, X-ray diffraction and SEM methods are we presents.

Experimental: The studied samples were synthesized using a special technique that allows them to be obtained in a state as close to equilibrium as possible.

Conclusions: A diagram of solid-phase equilibria at 300 K, a projection of the liquidus surface and some polythermal sections of the phase diagram are constructed. The fields of primary crystallization of phases are outlined, non- and monovariant equilibria are determined. According to the obtained picture of phase equilibria, the curves of monovariant equilibria originating from the peritectic and eutectic points of the boundary system GeTe-Sb_2Te_3 undergo transformations at certain transition points. In the region of compositions rich in tellurium, a number of invariant transition reactions occur, corresponding to the joint crystallization of two-phase mixtures of telluride phases and elemental tellurium.

Keywords: Layered germanium-antimony tellurides, Phase memory materials, Topological insulator, Phase diagram

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Research article
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Study of the influence of the microstructure of Pt/C materials on the electrochemical characteristics of PtCo/C electrocatalysts based on them

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Abstract

Objectives: The paper studies the effect of the uniformity of spatial distribution of Pt nanoparticles over the support surface in Pt/C materials on the microstructure and electrochemical behavior of PtCo/C catalysts obtained on their basis. PtCo/C catalysts are synthesized by the impregnation of Pt/C followed by heat treatment in an Ar/H_2 atmosphere. The use of a Pt/C material with a platinum mass fraction of about 20% and a uniform distribution of Pt nanoparticles over the surface of the carbon support makes it possible to obtain a PtCo/C catalyst, the activity of which in the oxygen reduction reaction at 0.90 V is 1215 A/g (Pt), which is 4.8 times higher than a similar figure for a commercial Pt/C catalyst. In this case, the use of a Pt/C material with an ununiform distribution of nanoparticles leads to the production of a PtCo/C catalyst with large particle size and low active surface area, which significantly worsens its activity in oxygen reduction reactions. The purpose of this article is to study the effect of the uniformity of the spatial distribution of Pt nanoparticles over the support surface in Pt/C materials on the microstructure and electrochemical behavior of the PtCo/C catalysts obtained from them.

Experimental: PtCo/C catalysts were synthesized by impregnation with Pt/C followed by heat treatment in an Ar/H_2 atmosphere.

Conclusions: The use of a Pt/C material with a platinum content of approximately 20% and a uniform distribution of Pt nanoparticles over the carbon support surface allows the production of a PtCo/C catalyst with an oxygen reduction reaction (ORR) activity of 1215 A/g (Pt) at 0.90 V, which is 4.8 times higher than that of a commercial Pt/C catalyst. The use of a Pt/C material with a non-uniform distribution of nanoparticles results in a PtCo/C catalyst with a large particle size and a low active surface area, which significantly reduces its ORR activity.

Keywords: Platinum-based electrocatalysts, Bimetallic nanoparticles, High-temperature synthesis, Heat treatment, Oxygen electroreduction reaction

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Research article
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Formation of oxide films on manganese silicide-germanides of various compositions during anodic polarization in an aqueous sodium sulfate solution

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Abstract

Objectives: Manganese silicide-germanides, with the general formula composition $Mn_5(Si,Ge)_3$, different in the quantitative ratio of silicon and germanium with the formula $Mn_5Si_{2.40}Ge_{0.60}$, $Mn_5Si_{0.60}Ge_{2.40}$, and $Mn_5Si_{0.15}Ge_{2.85}$, were subjected to anodic polarization in an aqueous sodium sulfate solution. The main objective of the study was the determination of the products of their anodic transformation in a non-oxidizing neutral medium and the identification of regularities of the formation of oxide films on their surface.

Experimental: The cyclic voltammetry method showed that the anodic oxidation process is not reversible. Polarization measurements were accompanied by subsequent monitoring of changes in the surface state using electron microscopy. The micro-X-ray spectral analysis was used for the determination of the ratio of elements on the surface before polarization of the sample and in the corrosion products.

Conclusions: The results of the study demonstrated that during the anodic transformation process for all materials, the fraction of manganese in the samples decreased, the fraction of germanium increased, and the fraction of silicon changed insignificantly. It was concluded that the dissolution of the material components occurs selectively: manganese was predominantly ionized from the solid phase of manganese germanide into the solution, and its content on the surface was reduced to insignificant amounts. Silicon and germanium formed loose oxide layers without good adhesion to a hard, manganese-depleted surface and did not provide a serious protective effect. Germanium (II) oxide and partially hydrated germanium (IV) oxide GeO_2 x H_2O were the main products of anodic oxidation that remained on the surface. Silicon oxide was also present in anodic oxidation products, but in lower quantities, and was not sufficient for the provision of the protective effect of the material.

Keywords: Silicide-germanide, Manganese, Germanium, Oxide films, Anodic oxidation, Sodium sulfate

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Phase composition and texture of palladium (II) oxide thin films on SiO_2/Si

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Abstract

The objects of the study are nanostructures based on palladium (II) oxide of various elemental compositions and morphological organization. *The aim of the work* is to establish the influence of synthesis conditions on the phase composition and texture of thin films of palladium (II) oxide synthesized by oxidation in an oxygen atmosphere of initial ultrafine layers of metallic palladium of various thicknesses on SiO_2/Si(100) substrates.

Conclusions: It has been established that the oxidation of the initial ultrafine layers of metallic palladium with thicknesses of ~ 95, ~ 190, and ~ 290 nm in an oxygen atmosphere in the temperature range T_{ox} = 873 - 1123 K leads to the formation of homogeneous polycrystalline films of palladium (II) oxide on SiO_2/Si (100) substrates. It is shown that the surface layers of PdO/SiO_2/Si (100) films have a pronounced texture (001), the degree of which increases with increasing oxidation temperature.

Keywords: Palladium (II) oxide, Phase composition, X-ray phase analysis, High-energy electron diffraction, Gas sensors

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Composition, structure, and electrophysical properties of natural zeolite clinoptilolites subjected to mechanical activation with potassium hydrosulfate

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Abstract

Objectives: The mechanochemical modification of zeolites with the addition of acidic salts causes an increase in the defectiveness of their structure, a change in the dispersion of the powder, and the conductivity of tableted samples. The aim of the study was to obtain mineral samples with improved conductivity using a mechanochemical method from air-dry mixtures of clinoptilolite-stilbite and clinoptilolite rocks and potassium hydrosulfate in different ratios.

Experimental: The shape and size of particles, chemical and phase composition of powders, and their physical properties were studied using electron microscopy, energy-dispersive X-ray spectrometry, X-ray phase analysis, differential scanning calorimetry, infrared spectroscopy, sieve analysis, gravimetry, and air permeability. The electrical conductivity of the tableted samples was measured using a three-electrode circuit in the temperature range from 25 to 100 °C.

Conclusions: The results of the study demonstrated that mechanical treatment of mixtures of zeolites with an acidic salt leads to the amorphization of stilbite and feldspar, polymorphic transformations of quartz into cristobalite and tridymite, and an increase in structural defects. The interaction of components occurs via silanol groups of clinoptilolite and the hydrosulfate groups through formation of hydrogen bonds and occurs with the involvement of water molecules. It was also established that the electrical conductivity of a mineral tablet sample based on clinoptilolite rock and potassium hydrosulfate in an equimass ratio, subjected to shock-shear action with a mechanical energy dose of 2.16 kJ/g, comprises $4.26 \cdot 10^{-4}$ $S \cdot m^{-1}$ at 100 °C. Electrical conductivity values of the same order were obtained earlier for the mechanochemical activation of natural zeolites with potassium hydrophosphates. Consequently, the hydrosulfate anion does not make a significant contribution to the conductivity of zeolite samples compared to the hydrophosphate anion.

Keywords: Natural zeolites, Clinoptilolite, Stilbite, Mechanochemical activation, Electrical conductivity, Potassium hydrosulfate

Funding: The study was carried out within the framework of the state assignment of the Ministry of Science and Higher Education of the Russian Federation – topic No. 123102000012-2. The electrical properties of the samples were determined in accordance with the state assignment at the branch of the National Research Center "Kurchatov Institute" - B.P. Konstantinov St. Petersburg Nuclear Physics Institute - I. V. Grebenshchikov Institute of Silicate Chemistry of the Russian Academy of Sciences 1023033000122-7-1.4.3.

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Biotemplate synthesis of In_2O_3-Pd for room temperature sensor of hydrogen

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Abstract

Objective: The solution to the urgent task of creating compact gas analyzers capable of long-term autonomous operation in hard-to-reach places is related to the development of sensors with reduced energy consumption. The aim of this work was to create a room temperature hydrogen sensor, as it is the sensor's heating that contributes significantly to the energy consumption of the entire device.

Experimental: To solve this problem, a new method for the synthesis of a nanomaterial based on In_2O_3 with a 3 % palladium additive was developed, which differs significantly from the common methods of sol-gel synthesis and hydrothermal synthesis. This was due to the fact that at low sensor temperatures, minimizing the effect of humidity is crucial. Performing the synthesis in an aqueous environment leads to the formation of a large number of hydroxyl groups on the surface, which attract water. In our work, the nanomaterial was prepared by sintering a cellulose fiber pre-impregnated with a solution of indium nitrate (+3) and tetraammine palladium nitrate (+2). According to X-ray phase analysis, the powder sintered at a temperature of 500 °C consists mainly of the triclinic phase of indium oxide (+3). According to scanning electron microscopy, the samples largely retained the reproducible characteristic macrostructure of the cellulose template. The electrophysical characteristics of the nanomaterial obtained at room temperature showed the possibility of determining hydrogen in the air. The detection limit is less than 10 ppm.

Conclusions: The sensitivity of our hydrogen sensor at room temperature is higher than that of sensors described in other publications. The effect of humidity on sensor readings is minimized.

Keywords: Metal oxide sensors, Biotemplated synthesis, Hydrogen, Room temperature, Indium oxide, Palladium

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Anniversaries

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Congratulations to Professor A. G. Syrkov

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Abstract

On the eve of the 250th anniversary of the first graduating class of engineers at the St. Petersburg Mining Institute of Empress Catherine II, the 165th anniversary of the birth of academician N. S. Kurnakov and the 120th anniversary of the discovery of Weimarn's law it is important to remember those who continue to preserve the memory of these significant events. Professor A.G. Syrkov, celebrating his seventieth birthday, and his research team have been following their own unique path. By arranging international seminars and symposiums on relevant scientific topic "Nanophysics and Nanomaterials" (N&N), the event planners always dedicate a portion of the presentations to the work of outstanding scientists who stood at the origins of Russian schools in the fields of materials science, nanotechnology and metallurgy.

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