ABSTRACT AND REFERENCES

TECHNOLOGY ORGANIC AND INORGANIC SUBSTANCES. ECOLOGY

## STUDYING THE PHYSICAL AND CHEMICAL REGULARITIES OF THE INTERACTION OF CALCIUM OXIDE WITH WATER (p. 4-15)

**Valery Shaporev, Inna Pitak, Mykhailo Vasilyev, Oleg Pitak**

The paper presents an analysis of the experiment findings in the study of the processes of water hydration of CaOfree at different ratios of $CaO/H_2O$ and different activity of CaO.

The analysis of the regularities in the processes of obtaining lump CaO and hydration of the samples proved that the reactivity of CaO is predetermined by the concentration of point defects in the lattice, and the ionoicity proportion in the Ca-O compound. The highest reactivity was achieved at 1473 K, the lowest – at 1773 K.

The experimental data on the hydration of CaO of different activity at various ratios of $CaO/H_2O$ allowed confirming the fact that the mechanism of interaction between CaO and water has a series of sequential steps, such as: (1) the capillary water absorption by the sample, (2) chemisorption of water on the surface of CaO crystals, and (3) formation of end products of $CaO(OH)_2$ solid or $Ca(OH)_2$ slurry.

The proposed equation is aimed at determining the velocity of the capillary water absorption depending on the reactivity of the CaO samples and properties of the liquid phase. It is found that the rate of the specific surface of the hydrated sample is commensurate with the rate of $Ca(OH)_2$ formation.

**Keywords**: process, hydratin, calcium oxide, reaction, water, temperature, kinetics, crystals.

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## DEVELOPMENT OF TECHNOLOGY OF PORTLAND CEMENT USING GAS CONDENSATE SLUDGE RECYCLING WASTE (p. 16-21)

**Tatiana Rishenko, Konstantin Vyatkin**

The paper deals with the topical issue of increasing the energy efficiency of manufacturing construction materials, such as Portland cement, applying organic-mineral additives. Using gas industry waste – gas sludge as the organic-mineral additive is proposed. Gas sludge due to its chemical composition accelerates the rate of chemical reactions during firing the raw mix of Portland cement clinker, thereby saving energy. Energy saving is associated with a decrease in temperature of the relevant physicochemical reactions during the Portland cement clinker firing.

The paper contains the analysis of theoretical and practical aspects of the problem, proposes solutions to improve the

energy efficiency of Portland cement clinker production by applying the organic-mineral additive, in particular gas sludge, which lowers the temperature of chemical reactions, and also considers the features of chemical reactions in the process of Portland cement clinker firing using the gas sludge waste in the raw mix.

**Keywords**: gas sludge, organic-mineral additive, Portland cement clinker.

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## SIMULATION OF THE VAPOR PHASE COMPOSITION IN $HNO_3 – H_2SO_4 – H_2O$ SYSTEM WITH LOW CONTENT OF NITRIC ACID (p. 22-26)

**Sergiy Kondratov, Tet'yana Khlyakina**

Based on the analysis and processing of literature data, the mathematical model describing the vapor phase composition of the ternary system nitric acid – sulfuric acid – water from the liquid phase composition and temperature at a low mole fraction of nitric acid was developed. It was shown that even with low content of nitric acid in the system, deviations of the ideal solution and the execution of the Raoult's law to within a factor (activity coefficient), the value of which depends on the sulfuric acid concentration are observed. It was found that with an increase in the mass concentration of sulfuric acid from 60 to 80 %, the mean values of the activity coefficients increase linearly with the coefficient of determination 0, 998. The general equation of the model – dependence of the partial pressure of the nitric acid on the temperature (t, °C), the mole fraction of nitric acid (x), and the mass concentration of sulfuric acid ($C_{H_2SO_4}$, % mass) has the form of a non–linear dependence, obtained by combining the Ant o ine, Raoult's equations and the dependence of the nitric acid activity coefficient on sulfuric acid concentration.

It was found that using the equations of the model for the ternary system $HNO_3 – H_2SO_4 – H_2O$ at mole fraction of nitric acid in the solution of up to 0.02, it is possible to predict normal boiling points with the maximum error not exceeding 5 °C, and mole fractions of nitric acid in the vapor phase with a relative error no more than 10 %.

The model can be used as a subsystem in developing the mathematical model of the reactor for adiabatic nitration of aromatic compounds, as well as in calculating and designing the regeneration systems of spent sulfuric acid.

**Keywords**: mathematical modeling, $HNO_3 – H_2SO_4 – H_2O$ system, vapor phase, composition, temperature.

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## PHENOMENOLOGICAL STUDY OF VISCOSITY AND DENSITY OF ALKALI METAL HYDROXIDE SOLUTIONS (p. 27-33)

**Vladimir Nefedov, Alexander Atapin, Dmitri Golovko**

Alkaline solutions are widely used in many industries. For dilute solutions, physicochemical properties, such as solubility of gases, hydration numbers and mobility of ions are well known. A relatively new trend is using concentrated alkaline solutions to obtain ferrates. In these processes, the solution concentration of more than 8 M is used. Studying the processes of transport of matter and charge in concentrated alkaline solutions requires updating the data on the hydration numbers and radii of ions, the effect of concentration, viscosity and nature of electrolytes on them.

A method for determining the hydration numbers of alkali metal cations in hydroxide solutions, based on calculating the number of water moles per mole of cations at concentrations close to the limit was proposed. In addition, the influence of ions, strengthening and breaking the solution structure on the density and viscosity of alkali metal solutions was examined. It was shown that primary hydration of ions has the predominant impact on the solution viscosity in dilute solutions, and secondary – in concentrated.

It was found that a sharp increase in the solution viscosity with increasing concentration occurs with decreasing distance between ions up to $3{,}7\times10^{-7}$ m.

At high concentrations, the solution density is higher in hydrated cations with smaller dimensions. High density of lithium hydroxide solutions in concentrations of from 2 to 4 M can be explained by the fact that the positively hydrated cation is embedded in the structure of water without a significant increase in its volume.

**Keywords**: concentrated alkaline solution, crystallographic radius, hydration of ions, density, viscosity, structure strengthening and structure breaking ions.

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## INCREASE OF THE REACTIVITY OF A LOW-ACTIVE PART OF LIME SLURRY IN SODA PRODUCTION (p. 33-39)

**Musii Tseytlin, Oleksii Shestopalov, Valentina Rayko**

The study focuses on the reactivity of low-active parts of lime in the solid phase of lime slurry in soda production. It is determined that low-active lime, that is compounds of calcium with oxides of aluminum, iron, silicon and magnesium, is concentrated in fractions with particles over 60 microns in size. It is found that the maximum rate of decomposition of the low-active components of lime is achieved with the increase of its residence time in the reactor to 40–50 minutes at low pH – 8–8.5.

It is shown that the reactivity of lime milk increases at its dispersion in a vapor-liquid injector due to the cavitational effect. Favorable conditions for the use of low-active parts of lime are possible in recycling the solid unreacted phase in a mixer reactor through a vapor-liquid injector. It is determined that accumulation of the solid recirculating phase in the reactor promotes the removal of supersaturation of the sulfate ion that crystallizes on the surface of the slurry solid particles.

The suggested solutions allow both maximizing the use of low-active lime and reducing the reactor operation time to 10 minutes.

**Keywords**: soda production, ammonia regeneration, low-active lime, vapor-liquid injector, mixer reactor, recycling.

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## INVESTIGATION OF DIFFUSION MECHANISMS DURING PERVAPORATION OF MOLECULES OF ORGANIC SOLVENTS IN POLYMER MEMBRANES (p. 40-47)

**Inessa Burtna, Otar Gachechiladze**

With the help of the original experimental setup using a pervaporation process, parameters which allow to indirectly determine the mechanisms and models of diffusion of solvent molecules in the polymer membrane body were investigated. The time dependencies of these parameters during pervaporation were obtained for both unsaturated and saturated membranes. It was shown that the mechanism of diffusion of the solvent molecules in the polymer membrane for the unsaturated membranes consists of two components: diffusion through thermal activation of the system and diffusion occurring through the free volume. Moreover, the rate of thermally activated diffusion is much higher and is observed in the beginning of the pervaporation process, whereas the diffusion using the free-volume model begins to emerge in the middle of the process and runs more slowly, but it is a source of transfer of the majority of solvent molecules. For saturated membranes, the main transfer mechanism is diffusion through the structural voids of the polymer. These results allow to interpret diffusion models in polymer membranes.

**Keywords**: polymer, membrane, pervaporation, thermal activation, free volume, diffusion, voids, jump technology.

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## DEVELOPMENT AND RESEARCH OF THE METHOD FOR PROPANE-BUTANE GAS CONVERSION INTO METHANOL (p. 48-52)

**Alexei Tselischev, Marina Loriya, Peter Eliseev, Vladimir Nosach, Ayodezhi Adebayo Ijagbujii, Roman Fedotov**

The schematic diagram and the physicochemical study of the process of propane-butane gas conversion into methanol in the presence of hydrogen peroxide solution were proposed. In general, the process of methanol formation is described in the reaction: $(C_3H_8+C_4H_{10})+H_2O_2 \rightarrow 2CH_3OH+C_2H_4+C_3H_6+H_2$. It should be noted that other alcohols and other oxygen-containing products except methanol were not found in all presented experiments. The analysis of the liquid reaction products was carried out by chromatography in a specialized laboratory by the instruments LHM and "Tsvet 500" using the 3 m long nozzle "Polisorb". The analysis of experimental data led to the conclusion that direct conversion of propane (butane) into methanol allows to achieve the conversion level of ~ 10 % in one pass. The reactor design and the flow diagram of the laboratory setup for methanol synthesis by the cavitation method in the total absence of reaction byproducts were developed. The applied cavitation method is extremely promising for using propane-butane gas as a raw material in a fundamentally new production of methanol.

**Keywords**: hydroxyl radical, propane-butane gas, methyl radical, cavitation, methanol.

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## DEVELOPMENT OF A MATHEMATICAL MODEL OF THE PROCESS OF BIOLOGICAL TREATMENT OF GASEOUS EMISSIONS (p. 53-61)

**Anna Bakhareva, Oleksii Shestopalov, Olesya Filenko, Tetyana Tykhomyrova**

In experimental studies, the kinetic characteristics of methane oxidation by the immobilized microbial association in gaseous emissions were determined. The obtained quantitative values of specific oxidation rate of $CH_4$ indicate a technological possibility of using the fluidized-bed bioreactor as the stage of the installation, designed for treatment of gaseous emissions from methane in drainage networks. It was found that the oxidation rate of $CH_4$ varied from 60 ml/g·h in the region of minimum concentrations of $CH_4$ in the medium to a maximum value of 260 ml/g·h. The presence of dependence of the specific oxidation rate of methane on its concentration in air was revealed.

Based on experimental studies, a mathematical description of the processes occurring in the reactor due to changes in the concentration of incoming pollutants was developed. It was found that persistent cyclic changes in the concentration at the bioreactor inlet will lead to the persistent cycle of changes in the pollution concentration at the outlet. The results of checking calculations show the transformation of fairly smooth concentration variations of the methane at the bioreactor inlet into dramatic changes in its concentration at the end of the biotreatment process, consideration of which is necessary in designing gas-treatment equipment.

**Keywords**: mathematical model, biological treatment of emissions, specific oxidation rate, concentration, harmful substance, bioreactor.

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## STUDY OF WATER QUALITY IN THE DISTRIBUTION NETWORK OF THE CENTRALIZED WATER SUPPLY SYSTEM IN THE CITY OF LVIV (p. 62-70)

**Oksana Matsiyevska**

The problem of water quality change in the distribution network of the centralized water supply system in the city of Lviv is considered, and some results of our research in this area are presented. The main purpose of the research is identifying the main factors of water quality change in the distribution network of the city. During the research, collection, analysis and synthesis of data on technological parameters of the distribution network were carried out, and the data of the analysis of eight water samples taken from residents in different districts of the city of Lviv were used. The results suggest that the increase in total hardness and alkalinity of water is caused by mixing of water from different water intakes in the distribution network; water oxidability growth - by probable accidents with entry of organic pollutants into the pipeline; increase in the concentration of total iron – by corrosion of long-life and great-length sites of the distribution network; reduction of free residual chlorine – by its spending on oxidation of chemicals contained in water and elimination of pathogenic microorganisms of biofilms on the inner walls of pipes. In some water samples, an excess of requirements of physiological full value of the mineral composition of drinking water by total hardness and probable value of solids, due to their increased values in the source water was observed. However, the values of water quality indices in the studied sites do not exceed the norms applicable to drinking water. To prevent the deterioration of the drinking water quality, and, therefore, the health of residents, the introduction of modern systems of monitoring and modeling of water quality change in the distribution network is recommended.

**Keywords**: water quality, physiological full value, distribution network, centralized water supply, human health.

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## RESEARCH OF MECHANICAL TREATMENT OF STORMWATER RUNOFFS FORMED ON OBJECTS OF AUTOMOBILE AND ROAD COMPLEX (p. 71-77)

**Valentina Iurchenko, Oksana Melnikova, Anna Bakhareva, Mariia Yachnyk**

Experimental research revealed that the concentration of oil products in surface wastewater, formed in winter and summer on the objects of automobile and road complex – gas stations, car parks and roads, greatly exceeds the MPC for discharge into water bodies. In stormwater runoffs at gas stations and car parks, the concentration of oil products has higher values than in surface wastewater, formed on the roads, despite the low traffic level. In surface wastewater, formed at gas stations and car parks, conditionally heavy fractions of oil products, more efficiently removable during settling prevail. The effect of surface wastewater treatment from oil products (maximum 80 %) depends on several parameters, the most significant of which is the concentration of suspended solids.

**Keywords**: automobile and road complex, objects of road infrastructure, stormwater runoffs, mechanical treatment, oil products.

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## INFLUENCE OF REDOX POTENTIAL OF THE MEDIUM ON PHOSPHORUS MIGRATION IN SLUDGE LIQUOR (p. 78-84)

**Valentina Yurchenko, Oleksandr Smyrnov, Anna Bakhareva**

The characteristics of the influence of the redox potential of the medium on the process of biological wastewater treatment from phosphates were investigated. The research was aimed at identifying new control actions to intensify wastewater treatment from phosphorus compounds and protect natural water bodies from pollution. The quantitative relationships were determined in the laboratory simulation of aerobic and anaerobic cultivation conditions of sludge liquor, as well as when examining existing sewage treatment facilities. It was found that the lower the redox potential values in the anaerobic wastewater treat-

ment zones, the more intensive the phosphate mobilization from activated sludge into the aqueous medium and, consequently, the more phosphates will be immobilized from the aqueous medium into sludge under aerobic conditions. The obtained quantitative characteristics allow to use the redox potential of wastewater (controlled variable) to manage and intensify the deep removal of phosphorus compounds during biological wastewater treatment.

**Keywords**: wastewater, activated sludge, phosphates, redox potential, volatile fatty acids.

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