## CHEMICAL AND TECHNOLOGICAL SYSTEMS

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### DEVELOPMENT OF WHITE ORGANIC LIGHT EMITTING DIODES BASED ON CARBAZOLE-DERIVED COMPOUNDS

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The object of research is the thermal, photophysical, and electrophysical properties of newly synthesized carbazole-derived compounds and organic light-emitting structures based on them. The problem consists in the comprehensive solution of scientific and technical problems of improving the characteristics of white organic light-emitting diodes (OLED), expanding their emission spectrum, improving color and energy characteristics.

The results of the thermal, electrophysical and photophysical properties of the investigated carbazole compounds were obtained. They demonstrated good thermal stability. Absorption spectra in solid films were recorded in the range of 300–350 nm. Photoluminescence spectra were observed at a wavelength of 407 nm for the first and second compounds and 430 nm for the third. The quantum yield of photoluminescence in films for compounds 1, 2, and 3 was 16 %, 7 %, and 7 %, respectively.

Organic light-emitting structures of white emission color with color coordinates (0.31, 0.35), (0.32, 0.34) and (0.38, 0.34) close to natural white light (0.33, 0.33) were formed using the thermo-vacuum sputtering method. The turn-on voltage of the white OLED is 6 V, the maximum brightness of the light-emitting structures was 10,000 cd/m$^2$. The devices demonstrated a sufficiently high external quantum efficiency of 5 % to 7 %.

The obtained results are explained by the mixing of different types of electroluminescence, namely excitonic and electromeric. Electromeric radiation is obtained due to transport layers. This approach improves such an important parameter of white light as its quality, which includes color coordinates and color rendering index.

Due to their color characteristics, white light-emitting diodes based on carbazole-derived compounds are promising candidates for use in modern lighting systems. A separate advantage of these light-emitting structures is the dependence of the color gamut of their radiation on the applied voltage. In addition, organic LEDs based on carbazole-derived compounds have low energy consumption and are environmentally friendly due to the absence of toxic substances in their design, which creates prerequisites for both global energy savings and a reduction of the industrial burden on the environment.

**Keywords:** organic light emitting diodes, OLED, electroplex, carbazole-derived compounds, thermogravimetry, differential scanning calorimetry, electroluminescence.

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## ANALYSIS OF COMBINED PROCESSING METHOD OF PHOSPHATE MINERALS FROM THE KEF ESSENOUN DEPOSIT

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Currently, the processing of beige and black phosphates only concerns the main sub-layers, while the other sub-layers (lower and upper for beige phosphate and the upper for black phosphate) are considered waste rock and stored near the complex. Therefore, the object of this research is the use of mixtures of three beige phosphate sub-layers and two black phosphate sub-layers as a feed fraction for the calcination and reverses flotation processes. This research work aims to characterise and treat two types of phosphate: one beige with the sub-layers (main, lower and upper) and the other black with the sub-layers (main and upper) in order to have better recovery of $P_2O_5$.

The working methodology consists of a series of sample preparation operations and characterization of the two types of beige and black phosphate. This characterization includes a petrographic study, a granulochemical analysis, an X-ray diffraction (XRD), a scanning electron microscopy/energy dispersive spectroscopy (SEM/EDS), and an atomic adsorption spectrophotometry (SAA), an auto analyzer (AA), a Bernard calcimeter. These analyzes allow on the one hand to identify the mineral phases in quantitative and qualitative manner, and on the other hand to choose the process for treating phosphates from the Kef-Essenoun-Tebessa deposit.

The combined method of treatment by calcination followed by reverse flotation gave satisfactory results. The $P_2O_5$ content reaches 33.88 % for beige phosphate and 33.13 % for black phosphate.

The stored waste rock represents a problem for the company; this waste rock contains fairly high levels of phosphate. The treatment of the mixture of the main sub-layers with these waste rocks makes it possible to obtain a better recovery of $P_2O_5$, a better economic profitability of the Djebel Onk mining complex and an environmental impact in the region.

**Keywords:** Beige phosphate, Black phosphate, phosphate characteristic, flotation method, calcination method, Tebessa, Algeria.

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## STUDY OF THE FEASIBILITY OF VALORIZING PHOSPHATE ORE BY ELECTROSTATIC SEPARATION

pages 20–26

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The object of this research is the phosphate serves, as a fundamental and crucial raw material with diverse applications, primarily utilized in producing phosphoric acid and fertilizers. However, dolomitic impurities within the ore can greatly impede its effectiveness. Therefore, it is essential to minimize these impurities to the lowest feasible levels to mitigate their adverse effects. This ensures optimal performance and quality in various industries reliant on phosphate, promoting efficiency and sustainability in the production process. Through a comprehensive assessment, it becomes feasible to gauge the enrichment potential and propose viable methods to realize it. Among these methods, flotation stands out as one of the most effective for enhancing phosphate ore, despite its inherent drawbacks of costliness and environmental impact stemming from chemical reagents.

This study endeavors to investigate the feasibility of employing electrostatic separation as an alternative method for enriching phosphate ore sourced from the Tebessa region in Algeria. Such exploration aims to offer insights into potentially more sustainable and economically viable approaches to ore enrichment in the region of Bir Elater Wilaya of Tebessa. Tests were carried out using different types of electrostatic separators at the Angouleme site of the PPRIME Institute: a multifunctional metal-belt-type separator, a free-fall plate-electrodes-type separator and an electrostatic separator with coaxial wire – cylinder electrode system. The experimental findings demonstrate significant promise, indicating that electrostatic separation enhanced the $P_2O_5$ content from 25 % to 29 % in an untreated phosphate ore sample. Simultaneously, it efficiently eliminated 82.80 % of MgO, achieving a $P_2O_5$ recovery rate more than 80 % and a yield of 70 %. Consequently, employing this method proves effective in reducing the MgO content of the ore to below than 1 %, aligning with industrial standards for commercial phosphate products. This underscores the viability of electrostatic separation as a viable and efficient technique in phosphate ore processing, offering substantial improvements in both quality and yield.

**Keywords:** electrostatic separation, triboelectric charge, phosphate ore, valorization, enrichment, magnesium carbonate.

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## DETERMINATION OF THE LIMITS OF OPERATIONAL LOADS OF RUBBER SHOCK ABSORBERS DURING COMPRESSION

pages 27–30

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Determining the limits of operational loads of rubber shock absorbers is an urgent task in the development of methods of non-destructive control of their condition. Therefore, the object of research is the influence of the limit values of the parameters of rubber shock absorbers during their static compression under harsh operating conditions. One of the most problematic issues is cylindrical shock absorbers with a form factor of less than 1.0.

In the work, rubber shock absorbers of different hardness were used, which are model samples for tests of cylindrical shock absorbers with a form factor of 0.42, which were carried out on a laboratory stand. The study of compression process of rubber shock absorbers is an urgent task in modelling the conditions of their operation. The obtained results make it possible to simulate the most effective diagnostic parameter of rubber shock absorbers during compression and to establish its limit and permissible values. It has been established that different rubber hardnesses provide different compression rates, which can be used to study non-destructive testing of shock absorbers, especially under which conditions they can be used in practice. According to the indicators of relative deformation during compression, the use of rubber shock absorbers from the group of high hardness is recommended for more severe load conditions during exploitation. Soft and medium-hard rubbers are characterized by an increased relative deformation of the shock absorber's geometric size (height) during compression, which can lead to their destruction under increased loads.

The obtained results on model samples can be checked on rubber shock absorbers manufactured in industrial conditions. The conducted research allows to create methods of choosing rubber shock absorbers for certain operating conditions depending on the coefficient of its shape. Limits of indicators simulating operating loads for different types of rubber shock absorbers have been established, which can be used when choosing a type of rubber for certain load conditions, and choosing a reinforcing material for the rubber array of the shock absorber and its shape.

**Keywords:** rubber shock absorber, vibration insulator, operational loads, static compression, rubber hardness, shock absorber bending.

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## APPLICATION OF CARBAZOLE DERIVATIVES AS A MULTIFUNCTIONAL MATERIAL FOR ORGANIC LIGHT-EMITTING DEVICES

pages 31–36

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The object of research is newly synthesized carbazole-derived compounds and organic light-emitting structures based on them. The problem lies in the complex solution of scientific and technical problems of improving the characteristics and stability of organic light-emitting diodes (OLEDs), namely improving the brightness and energy-efficient parameters.

Organic light-emitting structures of blue, blue, and green radiation with color coordinates were formed by the thermovacuum sputtering method and the solution deposition method. The turn-on voltage of the white OLED is 6 V, the maximum brightness of the light-emitting structures was 10,000 cd/m$^2$. The devices demonstrated a sufficiently high external quantum efficiency of 5 % to 7 %.

This paper reports the multifunctional application of a simple donor-acceptor organic compound, as active and host material in the emission layer of organic light emitting devices. Em1 has been used as active components in OLEDs, where Em1 is the guest emitter (Device A), the acceptor part of the excited emitter (Device B) and the host matrix of the CdSeS/ZnS alloy quantum dot. At least four different OLEDs have been designed and characterized where Em1 plays the role of the guest emitter (Device C). The external quantum efficiencies of devices A–C are characterized by values common to pure fluorescent OLEDs (up to 5 % of the theoretical limit), but these devices sustain low-efficiency roll-off of electroluminescence over a wide range of current densities.

Organic light-emitting diodes based on carbazole-derived compounds, due to their color characteristics, are promising candidates for use in the latest lighting systems. A separate advantage of the data light-emitting structures is a multifunctional application of one compound for different types of light-emitting structures. In addid tion, organic LEDs on based on carbazole-derived compounds have low energy consumption and are environmentally friendly due to the absence of toxic substances in their architecture, which creates prerequisites for saving energy resources and reducing the industrial burden on the environment.

**Keywords:** OLED, exciplex, carbazole-derived compounds, thermally activated delayed fluorescence, CdSeS/ZnS core-shell quantum dots.

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# ECOLOGY AND ENVIRONMENTAL TECHNOLOGY

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## COMPONENT ANALYSIS FOR ENERGY-EFFICIENT MULTIMEDIA NETWORKS UTILIZING 5G RADIO ACCESS TECHNOLOGIES

pages 37–41

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The object of the research is the energy-efficient multimedia networks based on 5G wireless access technologies.

The research is aimed at developing energy-efficient multimedia networks based on 5G wireless access technologies, considering the increasing importance of information and communication technologies (ICT) in modern society. With the proliferation of wireless access networks and the advancement of fifth-generation mobile networks (5G), there is a need to assess and reduce the environmental impact of ICT. The article specifically focuses on the challenges related to energy consumption and $CO_2$ emissions in radio access networks, highlighting the responsibility to balance technological advancements with environmental concerns.

The paper examines various components and technologies necessary for enhancing energy efficiency in multimedia networks. It discusses the concept of multimedia, including digital storage, data processing, and interactive elements. Statistical data is provided to underscore the significant energy consumption and carbon footprint of the ICT industry, with an emphasis on radio access networks. Heterogeneous networks, non-orthogonal multiple access (NOMA) technologies, and multiple-input multiple-output (MIMO) technologies are identified as key components for achieving energy efficiency. The importance of reducing the distance between transmitters and receivers in heterogeneous networks is emphasized, as well as the use of energy-saving strategies such as putting small base stations into sleep mode during low network loads. Special attention is given to the role of green data centers in reducing $CO_2$ emissions and optimizing the use of green energy in high-performance networks. Proposed methods include leveraging renewable energy sources, improving hardware energy efficiency, and implementing energy-efficient routing.

The findings offer valuable insights for the development and implementation of energy-efficient multimedia networks, particularly in the context of 5G networks. The interdisciplinary approach advocated in the conclusion emphasizes the collective efforts needed to address environmental challenges in the field of information and communication technologies. The combination of these technologies ensures efficient resource utilization and reduced environmental impact compared to similar known approaches.

**Keywords:** multimedia technologies, energy-efficient multimedia networks, 5G radio access technologies, heterogeneous networks.

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## OPTIMIZATION OF COAGULATION WASTEWATER TREATMENT OF LEATHER INDUSTRY

pages 42–47

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The object of the study was the process of coagulation treatment of wastewater of leather industry enterprises. The treatment of samples of real wastewater from a leather production was investigated. Such wastewater is characterized by high concentrations of pollutants of varying degrees of dispersion, which is due to the use of a large number of various chemicals in the leather production process. During technological operations related to the skinning and processing of skins, these substances enter the wastewater, which is discharged into the sewer. A peculiarity of leather production wastewater is large fluctuations in composition and volume, high concentrations of pollutants, and an increased content of suspended solids. Such waters have certain toxicity. The existing methods of wastewater treatment of leather industry enterprises do not provide the necessary treatment efficiency, do not allow to create a closed circulation of water at enterprises, to use or regenerate valuable components of wastewater, and to ensure their economically feasible disposal. Therefore, the research is aimed at improving the process of coagulation wastewater treatment of leather factories using mathematical modeling and optimization methods. This will make it possible to modernize existing wastewater treatment schemes. The experiments were carried out on the Niva Jar-test laboratory unit, which allows simultaneous examination of 6 samples. Samples of wastewater from leather production after the fattening-filling and dyeing stages were studied. The effectiveness of the coagulation process was determined by the degree of wastewater treatment. The factors were analyzed and the intervals of variation of factors that have a significant impact on the process of coagulation treatment of wastewater from leather factories were established. An experiment plan was drawn up and implemented in order to study the effect of coagulants based on aluminum and ferrum, as well as flocculants on the quality of wastewater treatment. The choice of quality indicators of the coagulation process is substantiated. A statistical analysis of the results of experimental studies was performed, a correlational analysis of the interdependence of parameters and indicators of the quality of the coagulation process was performed. Aluminum-based coagulant has been found to be more effective than iron-based coagulant. The results of mathematical modeling were used to determine the optimal parameters of the coagulation process: pH 10, coagulant dose – 2.5 g/dm$^3$, flocculant dose – 100 mg/dm$^3$.

**Keywords:** wastewater from leather factories, coagulation, degree of treatment, optimal parameters of the coagulation process.

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## ANALYSIS OF THE EFFICIENCY OF THE APPLICATION OF NATURAL COAGULANTS

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The object of the study is the process of purifying natural waters using coagulants of natural and industrial origin. The subject of the study is the analysis of the effectiveness of coagulants of natural and industrial origin.

Today, there is great interest in finding alternative methods of water purification that would be more economical and environmentally friendly. The availability of clean and safe water is especially important during times of martial law. Coagulants of natural origin can be an affordable and effective means of water purification and disinfection. One of the important advantages is availability, which indicates the possibility of becoming an alternative to chemical coagulants. Thus, there is a need to study the possibility of using natural coagulants both on an industrial scale and in emergency conditions.

This study presents a characterization of existing coagulants of natural origin, an analysis of the effectiveness of their use, comparison with chemical analogues, as well as an analysis of the effectiveness of using Moringa oleifera as a natural coagulant.

During the work, two coagulants were synthesized from red mud from aluminium production. A comparative analysis of coagulants synthesized from red mud, Moringa oleifera, aquatone and aluminium sulphate was carried out. All reagents were used to remove ture bidity and other impurities. The studies were carried out 3 times in different seasons of the year. All results were compared to determine the most effective coagulant and its dose.

As a result, it was found that all of these coagulants can be used and reduce water treatment costs at local water treatment plants. The natural coagulant can be used in areas where there is no access to a central water supply, especially in war zones.

**Keywords:** coagulation, natural coagulant, Moringa oleifera, water treatment, turbidity, synthesized coagulants.

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