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MODELING THE RHEOLOGY OF COMMERCIAL REACTIVE FIRE-RETARDANT COATING MATERIALS FOR STEEL

pages 6–11

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Fire protection of steel load-bearing building structures by surface-treating them with reactive fire-retardant coating materials is a crucial factor in ensuring fire safety on national scale. Both, the quality and operational characteristics of such materials, which are the subject of this study, require continuous improvement to reduce the cost of fire protection, as it can constitute a large portion of the overall construction expenditure. The aim of this study was to determine optimal rheological parameters for commercial reactive fire-retardant coating materials that ensure that the material can be applied with the maximum wet coating thickness.

To achieve this aim, the dynamic viscosity (η) was measured using Brookfield viscometer for a set of commercial reactive fire-retardant coating materials that provide fire resistance of at least R120 for steel load-bearing structures. The dependence of viscosity on shear rate (γ) in the range of (2.09–52.25) s^{-1} was modeled using the Casson equation. This allowed for the determination of the main rheological parameters of the studied materials – shear stress (τ, Pa), yield stress (τ_0, Pa), and viscosity at high shear rates (η_∞, Pa · s), which contribute to material's applicability.

With the use of the empirical and calculational data, the approximate viscosity of water-based intumescent coating materials necessary to produce defect-free layer of wet coating on studied surfaces was determined. It was measured by Brookfield viscometer with No. 7 spindle at rotational speeds (30–50) rpm at 20°C, and should preferably be: (30–15) Pa · s, (at 1 mm wet coating thickness); (50–25) Pa · s, (at 1.5 mm wet coating thickness), (80–50) Pa · s, (at 2.0 mm wet coating thickness). These levels of viscosity prevent sedimentation and sagging of the coating during material's application and can serve as reference markers for optimization of industrially manufactured intumescent fire-retardant products.

The obtained results can serve as practical recommendations for manufacturers seeking to improve the rheology of reactive fire-retardant materials in order to increase the wet coating thickness per layer.

Keywords: fire protection of steel, fire-retardant coating, dynamic viscosity of paint, rheological profile, coating thickness.

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OPTIMIZATION OF THE COMPOSITION OF ALUMINUM PHOSPHATE AND WALNUT SHELL-BASED COMPOSITION TO INCREASE THE CORROSION RESISTANCE OF PAINT COATINGS

pages 12–17

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The object of the study is anti-corrosion properties of walnut shell powder and aluminum phosphate mixtures. The existing problem is that the most effective chromate-containing pigments, which were traditionally used for the manufacture of paint and varnish coatings, are toxic. Given this fact, the research of scientists aims at finding alternative low-toxic compounds, which are phosphate pigments. Since they are inferior in efficiency, modern research is aimed either at the synthesis of new modifications and complex forms of pigments, or at the development of effective mixtures of pigments that would provide the necessary level of anti-corrosion protection of steel. Along with this, an urgent direction is to increase the level of environmental friendliness of paint and varnish coatings using annually renewable plant waste, which, due to the content of tannins, have proven themselves well for surface preparation before painting. The work investigated the effect of a mixture of non-toxic aluminum phosphate and finely ground walnut shell powder on the corrosion behavior of steel. An adequate mathematical model "composition – mass corrosion index" was proposed. The mathematical model allowed to establish the relationship between the composition and corrosion rate and find the optimal composition of the studied mixture. The calculations showed that at a ratio of aluminum phosphate and walnut shell powder of about 8:1, the mass corrosion rate of steel in the obtained extract is 0.020 g / ($m^2 \cdot h$). By experimentally verifying the optimal composition of the study, a mass corrosion index of 0.018 g / ($m^2 \cdot h$) was achieved, which confirms the theoretical calculations and ensures the practical applicability of the results obtained.

The results of the study will be useful for specialists working in the field of developing water-based anti-corrosion paints and coatings, with an emphasis on studying the influence of pigments and fillers on the corrosion behavior of steel.

Keywords: aluminum phosphate, walnut shell, pigment, corrosion, mathematical model of corrosion rate.

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PHYSICAL AND CHEMICAL PROPERTIES OF IRON(II) SULFATE HEPTAHYDRATE AS FACTORS FOR SELECTING THE DRYING PROCESS MODE IN A FLUIDIZED BED APPARATUS

pages 18–25

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The object of the study is iron(II) sulfate heptahydrate – the main solid waste product of titanium dioxide sulfate production, the accumulation of which poses a significant environmental threat. The problematic stage of its processing is the technological stage of dehydration in a fluidized bed to a monohydrate form, for which it is important to select an acceptable hydrodynamic regime and drying regime.

Experimental studies included microscopic, sieve, pycnometric and titrimetric methods of analysis. The average equivalent particle diameter was found to be 0.50 mm, with a shape factor of 0.75. The bulk density of the material is 911 kg/m^3, and the true density is 1888 kg/m^3. The free moisture content was found to be 2.2%, and the crystallisation moisture content was 38.7%, which corresponds to the heptahydrate form of $FeSO_4 \cdot 7H_2O$. Chemical analysis showed that the mass fraction of $FeSO_4$ in the samples ranges from 48.8% to 51.7%, and the Fe^{2+} content is 18%. Free sulphuric acid is present in an amount of 0.3–1.3%.

Granulometric analysis revealed significant polydispersity of the material, in particular the presence of agglomerates and fine fractions in samples No. 1–3 of the closed storage composition of iron(II) sulfate heptahydrate. For sample No. 4, which was characterised by the most uniform particle distribution, the minimum fluidization velocity of the largest particle fraction (0.7 m/s) and the fluidization velocity (0.97 m/s) for the equivalent particle diameter of the material were calculated. It was found that particles with a diameter of less than 0.207 mm will be carried out of the boiling layer, which requires additional measures to reduce material losses. The heat transfer coefficient for particles of intermediate fractions (0.315–1.6 mm) is 77.79–349.17 W/(m$^2 \cdot$ K), which ensures efficient heat exchange during the drying process.

Based on the data obtained, the choice of a horizontal sectioned fluidized bed apparatus is justified. The proposed design provides for the division of the process into independent zones with individual control and regulation of the drying agent parameters (temperature and flow rate). This makes it possible to obtain a stable hydrodynamic regime for polydisperse materials and reduce the influence of mixing on the driving force of the process.

The results obtained allow predicting the behaviour of the material in the fluidized bed apparatus and calculating the fluidization and drying regimes.

Keywords: iron(II) sulfate heptahydrate, particle size distribution, free and crystallization moisture, impurities.

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DEVELOPMENT OF POLYMER COMPOSITE MATERIALS FOR FRICTION ELEMENTS OF CONVEYOR EQUIPMENT

pages 26–31

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The object of the study is materials with enhanced tribological properties intended for the friction components of conveyor equipment. One of the most critical issues is ensuring the wear resistance of friction units in conveyor systems, particularly under dry friction conditions. A promising solution involves the use of tribotechnical polymer composite materials (PCMs) based on aromatic polyamide.

The research involved the use of modified graphite-containing systems based on aromatic polyamides filled with graphites of various dispersities and at different mass concentrations.

Polymer composites were obtained based on aromatic polyamide modified with organosilicon fluid and filled with graphites differing in nature and morphology. A correlation was established between the antifriction properties of the polymer compositions and both the filler content and graphite grade.

Under dry friction conditions, the enhancement of antifriction properties is achieved by incorporating graphite into the aromatic polyamide in an effective concentration of 15–20%, at which a stable antifriction film forms on the counterbody surface, acting as a solid lubricant. In this case, the coefficient of friction and the linear wear rate of the material remain low, 0.1 to 0.15 and 0.5 to 1 × 10^{-9} m/m, respectively. A notable observation is that during friction, the graphite material wears away while the metal remains virtually unaffected. It was found that an excessive filler content (> 20%) leads to brittleness of the composite, which is a critical design limitation.

As a result, the developed material can be effectively used for friction components operating under dry, lubrication-free conditions. This justifies its high utility and environmental benefits, as it eliminates the need for lubricants and their disposal. Compared to traditional materials such as bronze, the proposed composites offer distinct advantages.

Keywords: screw conveyor, dry friction, composite, graphite-filled polyamide, antifriction film, wear.

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CHARACTERIZATION AND DEVELOPMENT OF BENEFICIATION PROSPECTS OF SEDIMENTARY PHOSPHATE ORE FROM THE KEF ESSENOUN DEPOSIT (ALGERIA) BY REVERSE FLOTATION

pages 32–38

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Phosphate is one of the most important natural resources because it is so crucial to the production of fertilizers and phosphoric acid. However, many undesirable elements are present in raw phosphate ores, which need to be refined in some way to boost their market value is the objective of this work. The most efficient technique for upgrading phosphate ores by the selective removal of gangue minerals is reverse flotation. This study aims to determine the physicochemical properties and the flotation behavior of sedimentary phosphate ore from the Kef Essenoun deposit (Tebessa, Algeria), with the intention of developing an effective beneficiation process. To develop the processing parameters for the medium grade phosphate ore, a thorough investigation was conducted to ascertain its mineralogical composition, particle size distribution, and degree of impurity elimination. Particle size distribution measurements, XRF, XRD, SEM/EDS analysis, and petrographical evaluation were used to describe these phosphates. 69.64% of the total mass of the phosphate raw ore sample fell between the –0.5 and +0.1 mm range, which also showed a reasonably acceptable particle size distribution. In addition to the related impurities of MgO and SiO_2, chemical analysis revealed that the phosphates had P_2O_5 values ranging from 24% to 26%. According to mineralogical analysis, dolomite, calcite, and quartz were the related gangue minerals, whereas hydroxyapatite and fluorapatite were the predominant phosphate minerals. The traditional coprolitic and bioclastic characteristics of sedimentary phosphates were observed when examining the details on a smaller scale. Reverse flotation studies revealed that the produced concentrate reached 30% P_2O_5, confirm the effectiveness of this method for the perspective of valorization of sedimentary ore from the Kef Essnoun at Djebel Onk deposit and that this technique can increase the value of the ore. These findings support the idea that Algerian phosphate ore processing could benefit economically and environmentally from reverse flotation.

Keywords: particle size analysis, characterization, X-ray diffraction, beneficiation, phosphate, Djebel Onk, flotation.

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DEVELOPMENT OF A STRATEGY FOR USING THE BISPECTRUM OF DANGEROUS PARAMETERS TO DETERMINE AN INFORMATIVE SIGNS OF DETECTION OF MATERIALS INFLAMMATION

pages 39–44

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The object of the study is an informative sign of detecting ignition of materials in premises based on the assessment of the bispectrum of a dangerous parameter of the gas environment. The problem is to develop a strategy for using the bispectrum to determine an informative sign of detecting ignition of materials based on the observation of an arbitrary dangerous parameter of the gas environment in the premises. It is proposed to determine a new informative sign by a measure of the average degree of "order" for each frequency in the spectrum of dynamics of an arbitrary dangerous parameter of the gas environment at a fixed observation interval. The proposed informative sign was experimentally verified by studying the spectra of the average degree of "order" of the dynamics of the main dangerous parameters of the gas environment during the ignition of materials in a laboratory chamber. It was established that during the ignition of materials, the values of the average degree of "order" of the dynamics of temperature and carbon monoxide concentration for all studied frequencies of the spectrum are significantly reduced and do not exceed the value of 0.1. This indicates a loss of the average degree of "order" for all studied frequencies of the spectrum of dynamics of temperature and carbon monoxide concentration. At the same time, the value of the average degree of "order" of the dynamics of the specific optical density of smoke with respect to the studied frequencies does not change significantly. The obtained results are useful from a theoretical point of view by using the bispectrum for an informative sign of ignition and a measure of the average degree of "order" for an arbitrary dangerous parameter of the gas environment. The practical significance lies in the possibility of further improvement of existing fire protection of objects in order to prevent fires.

Keywords: informative sign, ignition detection, bispectrum, dangerous parameters of the gas environment, premises.

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ENCAPSULATION OF POLYPHENOLS IN BAKED GOODS: A STRATEGY FOR ENHANCING STABILITY AND ANTIOXIDANT ACTIVITY

pages 45–51

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The object of this study was polyphenol-rich extracts obtained from black tea, grape seeds, green tea, and blueberries, incorporated into bakery matrices in both encapsulated and non-encapsulated forms. The research addressed the critical problem of thermal degradation of polyphenolic compounds during baking, which drastically reduces their antioxidant capacity and limits their application as functional ingredients in food systems. Experimental results demonstrated that microencapsulation using food-grade biopolymeric carriers – especially sodium alginate – significantly enhanced the thermal stability and retention of polyphenols during high-temperature processing. Non-encapsulated samples retained only 42–60% of their initial polyphenol content post-baking, while encapsulated forms preserved up to 90%, showing a clear technological advantage. Antioxidant activity, assessed via DPPH and FRAP assays, decreased by up to 45% in non-encapsulated products, whereas encapsulated variants maintained 75–90% of their original activity. HPLC analysis confirmed that encapsulation reduced the thermal degradation of individual compounds such as catechins, flavanones, and anthocyanins. These protective effects are attributed to the formation of a stabilizing polymeric matrix that shields bioactives from oxidation, limits interactions with gluten and starch, and ensures more uniform retention within the food matrix. Sensory analysis further demonstrated that the addition of encapsulated polyphenols enhanced aroma, texture, crumb softness, and color, especially in samples enriched with grape seed and green tea extracts. These findings confirm the practical feasibility of polyphenol encapsulation in commercial bakery workflows for producing clean-label, antioxidant-enriched functional baked goods with improved nutritional and technological properties and extended shelf life.

Keywords: encapsulation, polyphenols, thermal stability, oxidative stress, biopolymer carriers, sodium alginate.

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BIOCHEMICAL VARIABILITY OF VEGETABLE JUICE POWDERS: A KEY FACTOR IN MODULATING THE PHYSICOCHEMICAL PROPERTIES AND SAFETY PROFILE OF VEGAN FERMENTED SAUSAGES

pages 52–59

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This research focuses on developing Thai mushroom vegan sausages (Naem Het) with improved quality and safety profiles by incorporating pumpkin seed protein isolate (PSMPI) and vegetable juice powders (yellow beet, celeriac, yellow carrot, radish) as functional ingredients. Their effects on sensory and microbiological parameters, nutritional value, and stability were evaluated. The growing demand for plant-based meat analogues necessitates the development of high-quality fermented products. A key challenge remains the achievement of desirable characteristics without synthetic additives; therefore, the use of vegetable juices as natural nitrite precursors in mushroom-based systems is a promising but under-researched area. Five formulations (A0 and 4 experimental ones) were analyzed for their chemical composition, microbiological parameters (aerobic mesophilic bacteria, lactic acid bacteria, coliforms, pH, NO_3^-/NO_2^-), and sensory properties during fermentation and 14 days of storage. It was found that PSMPI significantly increased the protein content (from 8.50% in A0 to 10.75% in A1) and improved the texture. The vegetable powders effectively served as sources of NO_3^-, modulating microbial activity. Based on a comprehensive evaluation, the samples with beetroot (A1) and carrot (A3) were identified as the best. They exhibited superior sensory profiles compared to the control A0 (7.87), receiving the highest overall scores on a 9-point scale – 8.22 (A1) and

8.12 (A3) – and demonstrated optimal microbiological stability (pH 4.49–4.51, LAB ≈ 8.3–8.5 $\log_{10}$ CFU/g). This comprehensive positive effect was attributed to the high content of pigments with antioxidant properties in these vegetables, which facilitated a controlled fermentation. In contrast, in the samples with celery and radish, a significantly lower pigment content impaired the bacterial reduction of their extremely high initial NO_3^- content (270–290 mg/kg), leading to a unique dynamic and maximal accumulation of NO_2^-. Thus, this research confirms that the judicious selection of vegetable juice powder is an effective tool for creating high-quality, safe, and sensorially appealing vegan fermented products.

Keywords: meat analogues, natural curing, ethnic cuisine, organic ingredients, future foods.

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COMPARISON OF CERTAIN SAFETY AND QUALITY INDICATORS OF DEVELOPED CHOCOLATE PASTE WITH ORGANIC AND INORGANIC RAW MATERIALS

pages 60–66

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The object of the research is the developed chocolate spreads from organic raw materials. The problem to be solved is to compare the quality and safety indicators of organic and inorganic food products. The composition of the "Sea Buckthorn" chocolate paste includes almonds, natural cocoa powder, cocoa butter, cane sugar, sea buckthorn oil, powdered milk, and flax bran. The "Hemp" chocolate paste differs in that instead of sea buckthorn oil, it contains hemp oil. The organoleptic evaluation of the pastes was carried out using a 35-point scale developed. The mass fraction of moisture was determined by drying to constant mass. The fatty acid composition was determined by gas chromatography. The content of heavy metal salts was determined by the colorimetric method and the flameless atomic absorption method. Biological, chemical, and physical hazardous factors were analyzed at each stage of the production of chocolate pastes. The results of the organoleptic evaluation indicate that all samples meet the "excellent" quality level. No significant differences were found between organic and inorganic chocolate spreads made according to the same recipes. The mass fraction of moisture in the developed products was within the normal range and did not exceed 3%. More fats were found in organic chocolate spreads than in inorganic ones. In the "Sea Buckthorn Organic" chocolate spread – by 1.48 g/100 g; in the "Hemp Organic" chocolate spread – by 1.86 g/100 g. The results of the study show that the content of polyunsaturated fatty acids in chocolate spreads made from organic raw materials significantly exceeds the content of similar acids in inorganic chocolate spreads. The content of linolenic acid is higher by 0.58 g/100 g in "Organic Sea Buckthorn Organic" paste and by 1 g/100 g in "Organic Hemp" chocolate paste compared to similar pastes made from inorganic raw materials.

The lead content is 2.77 times lower in "Organic Sea Buckthorn" oil; 2.45 times lower in "Organic Hemp" oil than in similar inorganic chocolate spreads. A very significant difference is noted in the cadmium content: 3 and 4.5 times lower, respectively. The critical control points of production are sterilization of containers and heat treatment of chocolate spreads.

Keywords: organic food products, chocolate spreads, food safety, sea buckthorn oil, hemp oil.

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EVALUATION OF PHYSICO-CHEMICAL PROPERTIES AND BIOACTIVITY OF DERIVATIVES OF BLACK CHOKEBERRY PRODUCTS OBTAINED DURING OSMOTIC DEHYDRATION

pages 67–72

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The object of the study was black chokeberry derivatives, namely syrup and powder obtained by osmotic dehydration. The problem solved in the study is the lack of a comprehensive definition of the physicochemical properties and bioactivity of Aronia melanocarpa derivatives obtained by osmotic dehydration. The described problem limits the effective use of black chokeberry syrup and powder in the production of food products with increased biological value. During the study, an assessment of the complex of physicochemical characteristics (acidity, moisture, dry matter content) of black chokeberry derivatives obtained by osmotic dehydration was carried out. The content of bioactive compounds, such as anthocyanins, flavonoids, polyphenolic and hydroxycinnamic acids, was studied. As a result of the studies, it was found that they contain a high level of anthocyanins, flavonoids, polyphenolic compounds and tannins. The moisture content of the raw material was 7.6 ± 0.5%, and soluble solids – 58.9 ± 0.2%. In addition, a significant concentration of coloring substances (10.07 ± 0.05 g/dm^3 in syrup and 82.7 ± 0.05 g/kg in powder) and bioactive components was found, which determines the high antioxidant activity of the product. The results obtained are explained by the high natural bioactivity of black chokeberry in combination with the use of the osmotic dehydration process for its processing. The results obtained during the study allowed us to assess the potential of using osmotic dehydration for black chokeberry processing. In practice, the results of the study can be used to develop new technologies for processing and storing black chokeberry-based products, in particular for the production of natural dyes and additives to functional foods or beverages. Such additives can be used in the food industry to create products with increased antioxidant properties, as well as to improve taste and preserve the beneficial properties of the product during storage.

Keywords: black chokeberry, osmotic dehydration, syrup, powder, derivatives, biologically active substances, antioxidant properties.

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IMPROVEMENT TECHNOLOGY FOR PREPARING BALSAM-TYPE DRINKS BASED ON PLANT RAW MATERIALS

pages 73–80

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The object of the study is the preparation of balsam-type drinks. The problem of creating balsam-type drinks capable of satisfying the population's need for biologically active substances and increasing the overall tone of the body, while maintaining the availability and technological effectiveness of production, was solved. The work developed a technology for the preparation of general tonic non-alcoholic and alcoholic balsam-type drinks enriched with vitamins, essential oils and phenolic compounds, intended for mass consumption. For this purpose, the most popular aromatic and spicy plants of Azerbaijan were used. A recipe composition for 11 plant names was selected in order to obtain bitter sugar-containing non-alcoholic and alcoholic tinctures. During the study,

watermelon juice and coriander (wild cilantro) were used as a preservative for this purpose. In 3 versions, a recipe composition of plants for the basis of extracts of a new range of alcohol-containing and non-alcoholic balsams was developed and proposed. Using heat treatment in a gentle mode, a blend of plants was obtained for the extraction of biologically active valuable components. Organoleptic and physicochemical indicators of the balsams were determined after their storage in normal and refrigerated conditions. The results of the studies showed that the content of dry substances in them fluctuates within 41.3–57.2%. Active acidity (pH), total amount of macro- and microelements (%) and specific gravity (g/cm^3), respectively, amounted to 5.53 ÷ 7.74, 1.136 ÷ 1.253 and 1.647 ÷ 1.2609. The nitrite content was also determined (16–18 mg/kg), since the recipe includes watermelon juice. Studies have shown that the samples stored at room and refrigerated conditions differed slightly in the main indicators and retained the corresponding color without change. However, the balsam prepared using watermelon juice, unlike the others, had a light orange color. The analyses were carried out using chromatograph mass spectrometry. The results showed that the essential oil base of the prepared drinks in all three variants of balsams is 5-hydroxymethylfurfural (13.73 ÷ 34.65%); *n*-hexadecanoic acid (11.12 ÷ 34.96%); heptadecanoic acid (12.67 ÷ 18.16%). Together with other chemical indicators, they characterize the bouquet and taste of the developed balsam "Ganja".

Keywords: plant extract, balsam, recipe, organoleptic assessment, essential oil base, aromatic and spicy plants.

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