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EDUCATION
NATIONAL UNIVERSITY OF OIL AND GAS «GUBKIN UNIVERSITY»

**SINO-RUSSIAN SYMPOSIUM ON REDUCING EMISSIONS AND
IMPROVING THE ENVIRONMENTAL COMPONENT OF THE CHEMICAL
AND PETROCHEMICAL INDUSTRY
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Objective: Develop a scientific agenda and topics for joint work of Chinese and Russian scientists to achieve carbon neutrality of chemical and petrochemical industries, as well as promote the development of scientific and educational cooperation in the field of ecology, environmental protection and carbon neutrality.

This collection of works is based on the materials of the Sino-Russian symposium on reducing emissions and improving the environmental component of the chemical and petrochemical industry held in a remote format on the basis of Gubkin University and China University of Petroleum (East China) on May 27-28, 2024.

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COMPOSITE MATERIALS BASED ON NATURAL ALUMINOSILICATES FOR SELECTIVE HYDROGENATION OF GASOLINE PRODUCED BY REFORMING

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Keywords: *halloysite, gasoline, benzene removal, Euro-5*

The demand for liquid motor fuels, in particular gasoline and diesel, is increasing every year. At the same time, the quality of the fuels themselves, as well as the quantity and composition of exhaust gases emitted by engines, are becoming more stringent. One of the main indicators regulated by modern standards is the content of aromatic compounds, especially benzene, in gasoline. From the economic point of view, the most effective method for benzene removal is selective hydrogenation. The main disadvantage of this method is a sharp decrease in the gasoline octane number due to exhaustive hydrogenation of all aromatic compounds. Application of selective catalysts allows to remove benzene from reforming gasoline without affecting other arenes.

The use of transition metals or platinum group metals as an active phase and ordered mesoporous structures such as SBA-15, HMS, MCM-41 as a carrier is a promising approach for preparation of effective catalysts for selective benzene hydrogenation [1]. Ordered mesoporous silicates are devoid of disadvantages of zeolites, whose microporous structure complicates the diffusion of branched organic substrates to the catalysts active sites. One of such silicates is MCM-41, which has a highly ordered two-dimensional hexagonal structure, homogeneous pore size distribution (2 – 4 nm), large specific surface area (~1000 m²/g), but low thermal stability (up to 700 °C) and mechanical strength (225 MPa). In order to eliminate the described disadvantages, MCM-41 can be reinforced with stronger materials, such as natural clays.

In this work we synthesized a Ru-containing catalyst based on a composite material consisting of ordered mesoporous silicon oxide of MCM-41 type reinforced with natural aluminosilicate halloysite nanotubes (HNT). The activity of the synthesized catalyst was studied in hydrogenation of gasoline fraction produced by reforming in the temperature

range of 60 – 150 °C and H₂ pressure from 1.5 to 6.0 MPa in autoclaves. The substrate/metal molar ratio was varied from 1000 to 6000 and the reaction time – from 1 to 5 h (Fig. 1).

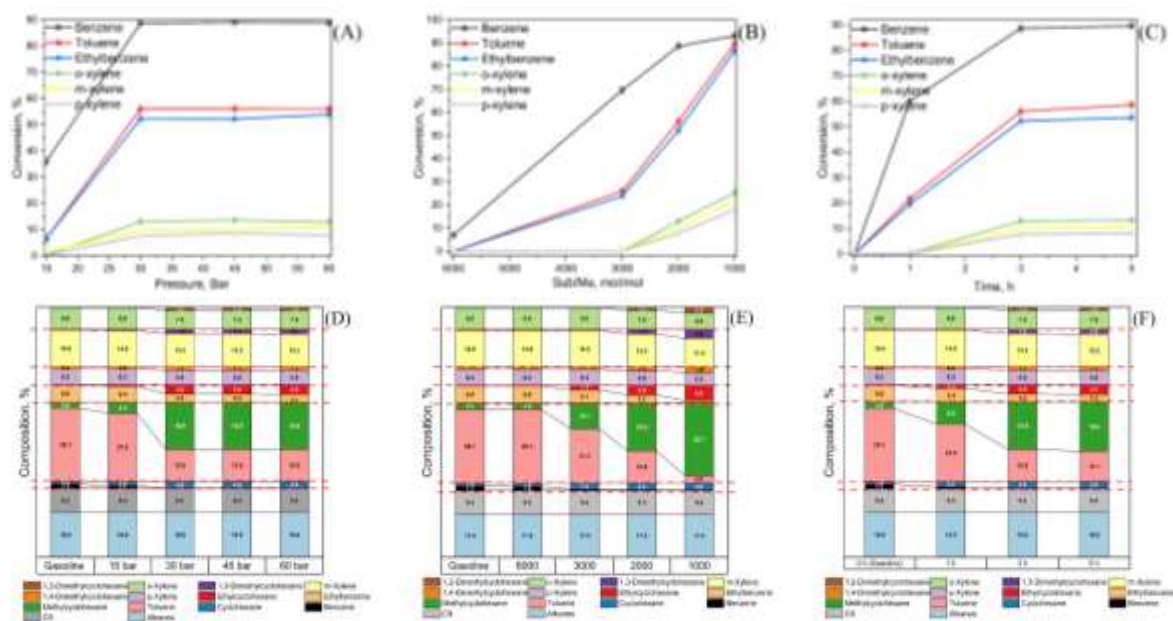


Figure 1 - Conversion of aromatic components and distribution of the reaction products as a function of pressure (A, D), substrate/metal ratio (B, E) and reaction time (C, F) over Ru/MCM-41@HNT catalyst

It was found that the pressure of 3 MPa is optimal and provides maximum benzene conversion (89 %). Further increase of pressure up to 4.5 and 6.0 MPa does not lead to significant changes in the aromatic feedstock conversion, thus confirming that the limiting factor is temperature, and the reaction proceeds in the kinetic region. Reduction of hydrogen pressure to 1.5 MPa led to a decrease in the conversion of aromatic components, with benzene content in the reaction products exceeding 1 % vol. The most optimal substrate/Me was of 3000 mol. Under these conditions, benzene content in the reaction products was 0.5 % vol. and RON achieved 93.2 points. Reducing the substrate/Me ratio to 1000 resulted in exhaustive hydrogenation of all aromatic components, indicating an excessive number of catalytic sites per unit volume of feedstock. When increasing the reaction time from 3 to 5 h, a slight increase in the conversion of arene-containing feedstock was observed, while the selectivity for benzene hydrogenation remained at the same level. Decreasing the reaction time to 1 h led to a decrease in the conversion of aromatic components, with benzene undergoing significant conversion (60 %), while conversion of toluene and ethylbenzene

was 21 % and 19 %, respectively. In terms of fuel quality parameters, hydrogenation for 1 h leads to reduction of benzene content to 0.7 % vol., while the RON remains at 94.0 points.

Acknowledgement: This work was supported by the Ministry of Science and Higher Education of the Russian Federation under the State Assignment № FSZE-2022-0002.

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GREEN SYNTHESIS OF MTT ZEOLITE AS A KEY COMPONENT OF BIFUNCTIONAL CATALYSTS FOR DIESEL FRACTION HYDROISOMERIZATION

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Keywords: *green synthesis, seed-assisted method, ZSM-23, zeolite, bifunctional catalysts, hydroisomerization*

Improving diesel fuel properties is crucial for the petrochemical industry. Hydroisomerization is a key technology used to enhance the fuel's chemical composition, meeting stricter quality requirements. Hydroisomerization catalysts are often bifunctional, containing a metal component for dehydrogenation/hydrogenation reactions and an acidic support for isomerization [1]. A major challenge in this field is developing highly efficient and selective bifunctional catalysts that minimize byproducts from hydrocracking [2].

This study focuses on synthesizing MTT (ZSM-23) zeolite using a seed-assisted method for application as a functional component of diesel fuel upgrading catalysts. We have investigated how varying the gel composition and crystallization time affects the crystal structure, textural properties, morphology, and acidity of the resulting zeolites.

All synthesized materials were characterized using various analytical techniques. These techniques included X-ray diffraction (XRD), X-ray fluorescence (XRF), transmission electron microscopy (TEM), scanning electron microscopy (SEM), low-temperature nitrogen adsorption-desorption, and temperature-programmed desorption of ammonia (TPD-NH₃). The obtained analysis data allowed to identify connections between the elemental composition, structure, morphology of the zeolites, and the synthesis conditions used.

Table 1 – Synthesized ZSM-23 samples

Sample	Si/Al, mol	Crystallization time, h	Seeds/SiO ₂ , wt%	Topology (Relative crystallinity, %)	S _{BET} , m ² /g	Total acidity, mmol NH ₃ /g
Z-23-1	50	72	4.45	ZSM-23 (55.81 %)	109	0.482
Z-23-2	50	24	3.86	ZSM-23 (40.74 %)	98	0.537
Z-23-3	50	48	3.86	ZSM-23 (48.58 %)	200	0.591
Z-23-4	50	72	2.00	ZSM-23 (62.51 %)	181	0.580
Z-23-5	40	72	2.00	ZSM-5 (100 %)	-	-
Z-23-6	30	72	2.00	ZSM-5 (100 %)	-	-

X-ray diffraction analysis results show that when Si/Al < 50, the ZSM-5 zeolite phase is formed instead of ZSM-23 (Table 1). Increasing the crystallization time from 24 to 48 h leads to an increase in the specific surface area (S_{BET}) and a slight decrease in the pore volume of the resulting materials. After 48 h, the S_{BET} decreases to 181 m²/g. As for the synthesis without NaOH, Z-23-1 showed an acceptable surface area (S_{BET} = 109 m²/g) and the largest pore volume (0.29 m³/g) among all the samples obtained. Samples Z-23-(1,2,3) have a similar particle morphology, which looks like dense clusters consisting of numerous needle-like crystals (Fig. 1– a), while Z-23-4 crystals are presented by some lamellar-shaped ones. The highest concentration of acid sites (0.591 mmol NH₃/g) was achieved at a crystallization time of 48 h (Fig. 1–b).

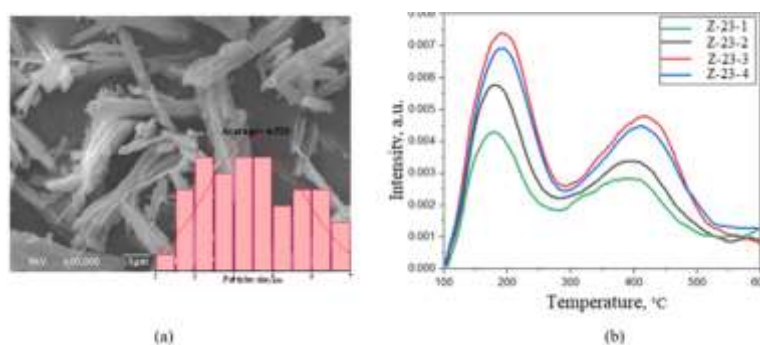


Figure 1 - (a) SEM image of Z-23-3 sample, (b) TPD-NH₃ profiles of prepared samples in the form of H-ZSM-23

Based on the overall results of the physicochemical analyses, sample ZSM-23-3 was selected due to its most favorable characteristics. Additionally, it was concluded that further post-synthesis treatment is necessary to enhance the acid-base properties of ZSM-23 zeolites, which are considered crucial characteristics for bifunctional catalysts employed in the hydroisomerization of diesel fuel fractions.

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INSTITUTIONALIZATION OF ESG STRATEGY IN ENGINEERING EDUCATION

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Keywords: *concept of sustainable development, ESG, engineering education, Federal State Educational Standard (FSES), responsibility*

The long-term global economic development, aimed only at maximizing profits and minimizing costs and having no other fundamental goals and guidelines, has led to serious degradation of the ecological, social and even spiritual environment. Environmental problems, global climate change, social and gender inequality are only part of the systemic crises and global challenges that countries, businesses and people faced at the end of the XX — beginning of the XXI century. This clash led to a revision of the global view of the world and an awareness of the importance of sustainable development. **Objective:** to analyze the level of integration of the ESG strategy and develop recommendations for its improvement in the medium-term perspective. **Research methods:** the authors use the method of logical and structural analysis, the method of deduction, the institutional method, as well as benchmarking. **Research results:** based on the analysis of the activities of oil and gas companies within the framework of ESG, the authors proposed recommendations for improving the model of engineering education.

More than 40 years ago, the United Nations (UN) report recorded a Sustainable development strategy, which assumes such a development of society in which one generation, realizing its capabilities, does not harm the development of future generations. Sustainable development was presented as the further development of mankind in three main dimensions: social, environmental and economic. To implement the sustainable development strategy, regulatory documents have been developed and adopted at the national and international levels, such as the UN Framework Convention on Climate Change (Paris Agreement), Federal Law of the Russian Federation "On Environmental Protection" dated 01/10/2002 No. 7-FZ, etc. The focus on sustainable development has become the main

one in the formation of national strategies and corporate policies, but the pace of scaling up business practices based on the principles of sustainable development was insufficient.

And twenty years ago, in 2004, UN Secretary-General Kofi Annan again attempted to draw the attention of the powerful to the problems of the environment, social development and governance transparency by formulating the ESG development strategy, which stands for "Environment, Social, Governance".

Industry, in particular the oil and gas industry, has the greatest impact on environmental issues. Given the uneven energy transition in the world, the degree of ESG integration in Russian oil and gas companies is of interest.

Table 1 - Comparative data table of selected oil and gas companies in the field of financial indicators, investments in sustainable development and the level of ESG integration [1]

	Total Energies	Shell	ENI	Rosneft	Lukoil	Tatneft
Proven hydrocarbon reserves (billion barrels of oil equivalent)	12.1	9.4	6.6	38.3	15.3	1.2
EBITDA (\$ million)	42 302	60 357	22 957	33 125	19 960	4 060
R&D expenses (\$ million)	849	815	189	427	71	18
Renewable energy/environmental costs (\$ million)	4 506	328 (40% RE)	No data available	782 (environmental protection)	300 (environmental protection) 38 (RE)	161 (environmental protection) 0,17 (RE)
The level of integration of ESG into the company's management	4 of 4 The level of strategic assessment	4 of 4 The level of strategic assessment	4 of 4 The level of strategic assessment	3 of 4 The level of integration into the operational decision-making process	3 of 4 The level of integration into the operational decision-making process	3 of 4 The level of integration into the operational decision-making process

The geographical, socio-economic and institutional features of the development of countries influence the priorities in responding to various aspects of sustainable development. For example, Russian companies have been focusing on the environmental component of sustainable development for a long time. But recently, the world has increasingly turned to the goals of sustainable urban development, education and an increase in the quality of life in the territories covered. Nevertheless, over time it becomes obvious that the decomposition of ideas of sustainable development "from top to bottom" does not provide the necessary synergetic effect, which actualizes the discourse on responsibility – humanity as a whole, states, their governments, parliaments and other institutions, individual corporations, each person. The environmental agenda, responsible environmental management, and ecosystem thinking are at the center of their conflicting interests.

In this context, engineering education needs to focus on this issue. It seems to us that this task should be prioritized in importance. However, the analysis of the Federal State Educational Standard (FSES) reveals that the development of social and professional responsibility of students is not recorded as a necessary result of their training. And this is despite the fact that in professional standards, the level of responsibility assigned to an employee, linked to authority, serves as a defining characteristic of qualifications. Nevertheless, the world experience in the formation of models of engineering education indicates the inclusion of the competence "professional responsibility" [2]. In more detail, the discrepancy between the FSES and professional standards for one of the key engineering competencies is discussed in [3].

Consequently, the creation of institutional conditions for the formation of responsibility in the professional activities of future specialists within the framework of Russian engineering education will contribute to the formation of ecosystem thinking and scaling of the ESG ideology on a national scope.

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RESEARCH OF PRODUCTS OF FOREST CHEMISTRY AND FAT-AND-OIL PRODUCTION AS VALUABLE RAW MATERIALS FOR PETROCHEMISTRY

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Keywords: *higher carboxylic acids, tallow oil fatty acids, distilled tallow oil, crude tallow oil, diesel fuel, fatty acid esters*

Currently, there is a trend towards replacing products obtained from mineral resources with products obtained in the direction of "green chemistry". Thus, higher carboxylic acids are in demand as raw materials for the synthesis of various compounds used in many areas of the national economy. In industry, higher carboxylic acids are obtained synthetically by oxidation of high molecular weight hydrocarbons with oxygen in the presence of metal-containing catalysts. However, natural "green" sources of higher carboxylic acids can be fat-and-oil waste from food production - deodorization shoulder straps, as well as by-products of sulfate cooking of cellulose - fatty acids of tallow oils (FATO).

The field of application of higher carboxylic acids and their derivatives is extremely extensive. Acid mixtures are used for the production of anti-wear additives in Euro 5 diesel fuel [1], acid amines and amides as components of dispersing additives for the production of low-hardening grades of diesel fuel [2], complex low-molecular acid esters as components of biodiesel [3], corrosion inhibitors [4,5], higher molecular acid esters – as a base base for Group 5 synthetic motor oils, PVC plasticizers, perfumery and cosmetics industries. The need for fatty acids is constantly increasing, and the range of applications is growing.

The purpose of this work is to study the composition of natural sources of higher carboxylic acids as potential raw materials for petrochemistry.

The objects of the study were selected – fat-and-oil waste from food production – deodorization shoulder straps (№ 1) and four products of sulfate cooking of cellulose - tall

oil fatty acids (№ 2), distilled tall oil (№ 3), crude tall oil (№ 4) and tall oil fatty acids (№ 5).

Table 1 shows the physico-chemical characteristics of the studied products.

Table 1 - Physico-chemical characteristics of the studied substances and acid composition

№ п/п	Acid number (AN) GOST 50457-92	carboxylic acids							Mass fraction of fatty acids,% GOST 31933- 2012
		C _{12:0}	C _{14:0}	C _{16:0}	C _{18:0}	C _{18:1}	C _{18:2}	C _{18:3}	
		GOST 30418-96							
1	92,4	0,8	1,5	50,6	8,9	31,9	5,8	0,5	49,9
2	200,4	-	-	5,0	1,3	23,4	52,2	16,6	99,8
3	192,2	-	-	4,9	2,3	24,5	51,4	15,3	96,1
4	127,7	-	-	12,0	4,0	8,4	60,2	14,8	64,8
5	189,5	-	-	6,1	2,0	25,0	47,7	16,2	93,2

The data shown in Table 1 indicate a different acid composition of fat-and-oil waste compared to forest chemistry products. Thus, in 1 product the content of higher saturated acids is about 62%, in forest chemistry products it does not exceed 16.0%. In the products of forestry chemistry, about half of the acid composition is unsaturated linoleic acid, in the product of fat-and-oil production - saturated palmitic acid. In addition, in 1 sample the content of fatty acids is about 50%, and the remaining part is triglycerides of fatty acids, in products 2-5 the mass fraction of fatty acids is above 90% (except sample 4), the remaining part is resin acids and unsaponifiable substances. This is consistent with the aggregate state of the analyzed products – 1 product is solid, products 2,3,5 are liquid, product 4 is viscous. Samples 3 and 5 are similar in composition, as they are fatty acids of tallow oils (FATO), but are produced at different enterprises.

The results obtained allow us to conclude about the value of waste from forestry chemistry and fat-and-oil production as a natural renewable "green" source of higher carboxylic acids.

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NANOSHEET-STRUCTURED ZNCO-LDH MICROSHERE FOR RECHARGEABLE ZINC BATTERIES

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Scientific adviser: Professor Bing Li

Keywords: ZnCo-LDH, Zn-ZnCo battery, hybrid Zn batteries

Zinc batteries and their hybrid counterparts are gaining significant research attention, thanks to the cost-effectiveness and environmental stability offered by zinc anodes. While high-performance zinc batteries also require advanced cathodes, the development of such cathodes lags behind, especially given the limited options available for the cathode materials [1-3].

Here, we introduce ZnCo bimetallic hydroxide (ZnCo-LDH) microspheres as the cathode material for high-performance Zn-ZnCo and hybrid Zn batteries. The Zn-ZnCo battery exhibits a remarkable cycling stability, retaining 86% capacity after 5000 cycles. Additionally, we showcase the potential of ZnCo-LDH in enabling hybrid Zn batteries to leverage the benefits of Zn-ZnCo and Zn-air batteries.

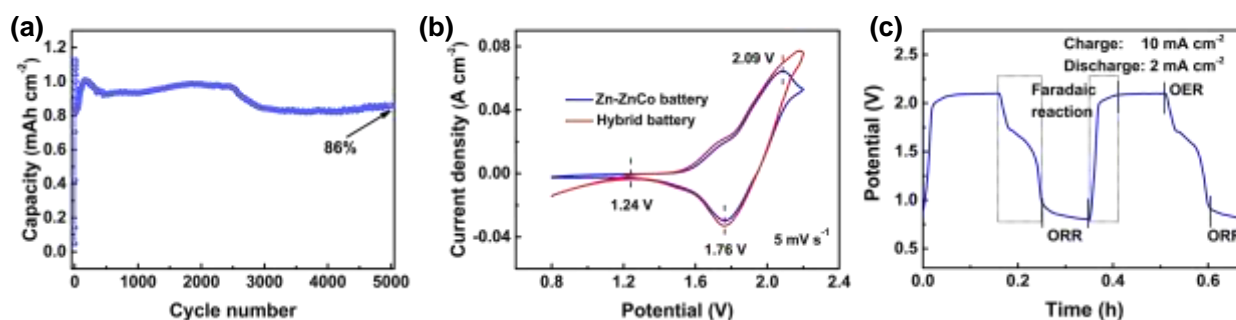


Figure 1 - (a) Cycle stability of Zn-ZnCo battery. (b) Typical CV curves and (c) charge-discharge voltage profile of the hybrid zinc battery

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DIGITAL TRANSFORMATION IN THE OIL AND GAS INDUSTRY

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Keywords: *digital transformation; oil and gas industry; ecology; carbon neutrality*

The article discusses the main advantages of implementing digital solutions for companies in the oil and gas industry. The analysis of the experience in optimizing the work of Sakhalin Energy through digital solutions has been carried out. Assumptions are made about further vectors of digital development of Russian oil and gas companies in a similar direction.

Nowadays, the problem of introducing digital technologies and solving environmental problems is one of the most controversial topics for politicians and scientists. The challenges associated with the digital world and the environment were described by UN Secretary-General Antonio Guterres as two of the "four horsemen" who "threaten our common future." Digital transformation is the process of introducing digital technologies to optimize various types of activities.

Today, the fuel and energy industry in Russia is implementing digital solutions. This is largely due to the desire to simplify business processes and improve the accuracy of reports on emissions of harmful substances. The contribution of the energy industry to greenhouse gas emissions is more than 70%. [1].

The purpose of the work is to analyze the experience of digital transformation in the oil and gas industry and determine the prospects for its development in Russia.

Scientific novelty. In this article, from the methodological point of view of a systematic retrospective analysis, the main trends and problems, directions of the transformation are considered.

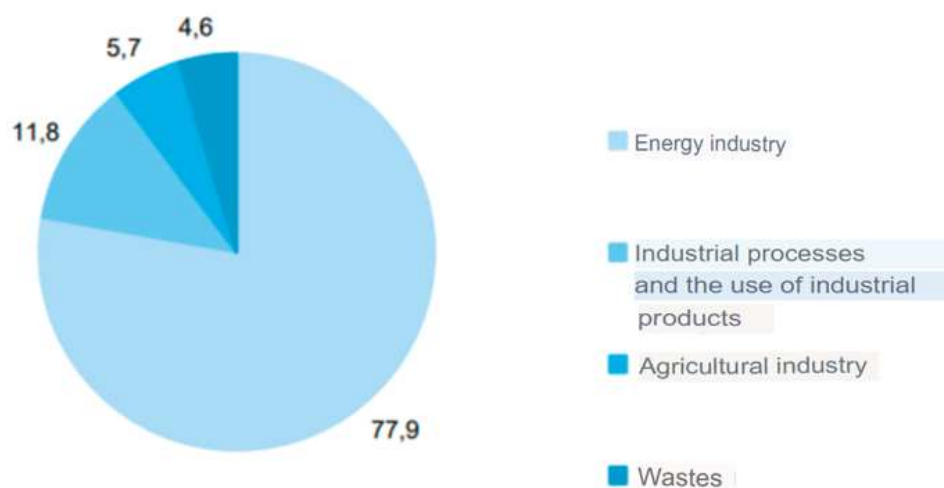


Figure 1 - Greenhouse gas emissions in Russia by sector

Moreover, the most interesting result can be shown by an analysis of oil and gas companies in Russia, since companies in this sector have a great impact on the country's economy and the ecological state of the regions.

Practical significance. The results of the work will be useful for the project analysis in the field of environmental transformation and can also be used as a foundation for the further research.

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DIGITALIZATION OF THE LABOR MARKET. MODERN STANDARDS FOR ASSESSING PERSONNEL SELECTION IN TURBULENT CONDITIONS AND ENERGY TRANSITION

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Keywords: *HR software, job sites, labor market, staff management, recruitment/selection/estimation of staff, government programs, energy companies, M&Y platform.*

In the era of current geopolitical tensions, green sources development, changes are required in various aspects of the modern Russian economy, where the labor market will not be an exception. The sanctions measures imposed on the Russian Federation affect not only its market conditions, but also the proper functioning and confidentiality of data regarding the personnel of any enterprise, especially the energy industry. With the departure of various foreign systems from Russia, such as SAP, Oracle, Jira, Trello, etc., there was a need to transition and develop domestic analogues that would have proper functionality, not inferior to Western developments, as well as not contradicting the current legislation of the Russian Federation. The main reasons for the transition: a possible security threat, a database leak, an increase in the cost of services and withdrawal from the Russian market. Thus, there is a need to create a universal product that can become a worthy replacement for foreign services, will facilitate work at enterprises of the energy complex and contribute to improving the efficiency of the following processes: selection, selection, evaluation, control, communication, etc.

The paper provides an example of replacing existing services with a more convenient and multifunctional Russian system. Its creation will open up many new opportunities and will become a single space where the entire energy industry of the Russian Federation will be able to use many tools without any restrictions. To achieve this goal, the following methods were used:

1. Identify digital tools and basic functions at various stages of work with staff;

2. reflect current and prospective government programs and measures for the development of digital technologies in relation to the labor market;
3. analyze the operated platforms using the example of the Russian energy complex, taking into account their existing shortcomings (Figure 1);
4. To present our own HR platform for employees of energy enterprises.



Figure 1 - Digital platforms used in specific energy enterprises

Describing this scheme, it can be concluded that all these energy organizations use different digital platforms in personnel management. It is worth noting that the most popular system in this branch is 1C, which is a domestic development and simplifies the work of organizations. There are also more popular systems, but with their withdrawal from the Russian market or limited functionality, they have become irrelevant, among them: SAP, MS Office, E-staff.

The introduction of digital technologies into the structures of the labor market is an extremely important process in the modern world, ensuring the greatest efficiency, increasing the quality of life of the population, transforming the employment structure, as well as opening up new horizons for the workforce through the development of new markets and forms of employment.

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SYNERGISTIC NO, CO AND CO₂ REMOVAL BY CU/CE CO-DOPED CAO DURING THE CARBONATION STAGE IN CALCIUM LOOPING PROCESS

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Keywords: calcium looping, Cu/Ce-doped CaO, CO₂ capture, NO reduction by CO

The cyclic calcination/carbonation of CaO, known as calcium looping, enables simultaneous CO₂/NO removal from coal-fired flue gas [1]. However, the formation of CaCO₃ reduces NO removal efficiency. To enhance the NO removal performance, a Cu/Ce co-modified CaO is proposed. At the optimal Cu/Ce/Ca molar ratio of 1:5:100, 99% NO and CO removal, and 80% CO₂ capture was achieved. The addition of Cu/Ce improves redox cycle activity and oxygen vacancy formation, enhancing CaO catalytic activity for NO removal and carbonation. This innovation holds promise for efficient simultaneous NO, CO, and CO₂ removal in the calcium looping process.

The cyclic calcination/carbonation of CaO (i.e. calcium looping) can realize the simultaneous CO₂/NO removal from coal-fired flue gas. In this process, CaCO₃ decompose into CaO and CO₂ in a calciner during oxy-fuel combustion. The generated CaO absorbs CO₂ in a carbonator. Simultaneously, NO is reduced by CO (generated by the oxidation of coke) in the carbonator, as shown in Fig.1. CaO is good catalyst for NO reduction by CO. However, the formation of a CaCO₃ product layer on the surface of CaO decreases the NO removal efficiency in calcium looping cycles [2]. Therefore, it is necessary to improve NO removal performance by enhancing catalytic activity of CaO in the carbonator.

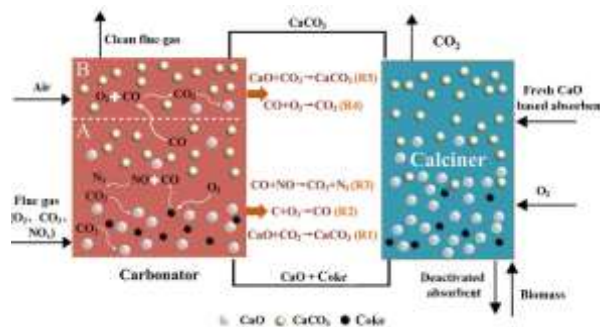


Figure 1 - The CO₂/NO synergistic removal process based on the calcium cycle

In this work a novel Cu/Ce co-modified CaO is proposed for simultaneous NO/CO₂ removal, and the impact of the molar ratio of Cu/Ce/Ca on the simultaneous NO/CO₂/CO removal performance is evaluated. The Cu/Ce co-modified CaO demonstrates high efficiency at the optimum Cu/Ce/Ca molar ratio of 1:5:100, i.e., 99% for NO and CO removal, and 80% for CO₂ capture, as illustrated in Fig.2.

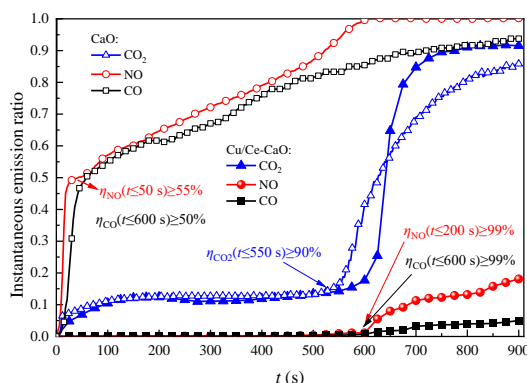


Figure 2 -Comparison of Cu/Ce-CaO and CaO in simultaneous NO/CO₂/CO removal

The promotion mechanism of Cu/Ce addition on the simultaneous removal of NO/CO₂ is determined from a microscopic perspective. The catalytic activity of Cu/Ce-CaO based on the redox cycle of Ce³⁺/Ce⁴⁺ is improved by Cu addition. Additionally, the interaction between Cu⁺ and Ce³⁺ substantially increases the oxygen vacancy on CaO, thereby reducing the diffusion resistance of O²⁻ ions. Consequently, the catalytic activity of the CaO for NO removal and the carbonation conversion of CaO are both improved. The Cu/Ce co-doped CaO shows promising potential for simultaneous NO, CO, and CO₂ removal during the carbonation stage in the calcium looping process.

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ONE-STEP CONVERSION OF CO₂ AND CH₄ TO ALCOHOL PRODUCTS BASED ON CUFE BIMETALLIC CATALYST

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Keywords: carbon dioxide conversion, alcohol, plasma

The direct conversion of CO₂ and CH₄ to liquid products in plasma systems for the control of liquid products remains a formidable challenge. We conceived a novel CuFe bimetallic-modified γ -Al₂O₃ catalyst (Cu₁₀Fe₂/ γ -Al₂O₃) tailored for the one-step conversion of CO₂ and CH₄ into alcohol-based products within a Dielectric Barrier Discharge (DBD) reactor featuring a circulating water electrode. We achieved remarkable results: CO₂ conversion reached 26.3%, CH₄ conversion stood at 25.3%, and the selectivity of liquid product formation reached an impressive 59.4%. Within the liquid product fraction, alcohol-based products accounted for 48%, representing a substantial 80% of the total liquid product yield.

Bimetallic catalysts composed of copper (Cu) and iron (Fe) combine the excellent C-C coupling ability of Cu and the OH radical enrichment ability of Fe, which can efficiently convert CO₂ into higher alcohols[1]. As a high specific surface area alumina material with abundant surface active sites and good stability, it can provide sufficient contact area and catalytic activity to improve the effect of CuFe bimetallic catalysts in plasma catalytic reactions. A series of bimetallic Cu-Fe catalysts were synthesised by an initial impregnation method. Compared with the plasma mode, the conversion of both CO₂ and CH₄ was improved after filling the DBD with Cu_xFe_y/ γ -Al₂O₃ catalysts. Among them, Cu₁₀Fe₂/ γ -Al₂O₃ showed the highest CH₄ and CO₂ conversions of 25.3% and 26.3%, respectively. Compared with CH₄, the conversion of CO₂ was substantially increased from 17.8% to 26.3%, indicating that the catalyst had a strong adsorption effect on CO₂, which promoted the conversion of CO₂ (Fig. 1a). The Cu₁₀Fe₂/ γ -Al₂O₃ catalyst effectively reduced the selectivity of CO to 23.1%, which ensured a substantial participation of CO radicals in the formation of liquid products.

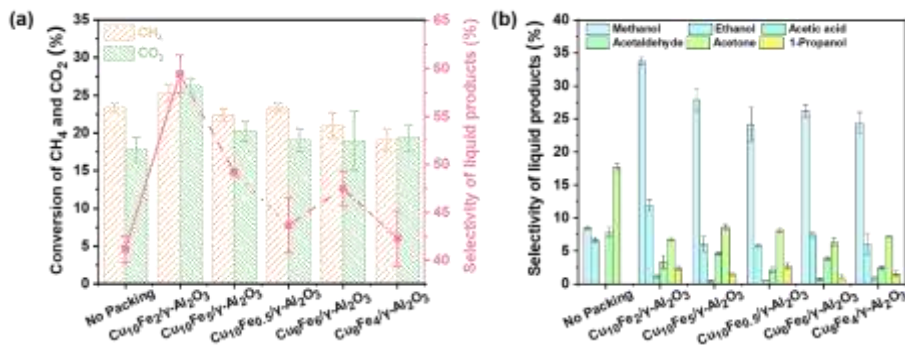


Figure 1 - The conversion and selectivity of main liquid products without packing, with Cu_xFe_y/γ-Al₂O₃ (Total flow: 30 mL·min⁻¹, Discharge power: 25 W)

Figure 1b illustrates the impact of both unfilled and filled catalysts on the selectivity of oxygenated compounds. Through liquid 1H NMR analysis, it was established that the oxygenates encompassed alcohol, acetic acid, acetone, and acetaldehyde, with alcohol being the predominant liquid product. Among these CuFe catalysts, Cu₁₀Fe₂/γ-Al₂O₃ exhibited the highest oxygenate selectivity (~ 59.4%). It was worth noting that alcohols, including methanol (33.7%), ethanol (12%) and 1-propanol (2.3%), accounted for 80% of the total product selectivity. The introduction of CuFe catalyst greatly promoted the production of alcohol products. The total liquid selectivity was 18.2% higher than that of unfilled catalyst, and the selectivity of alcohol products was about 3.1 times higher than that of unfilled catalyst. When the Cu₁₀Fe_{0.5}/γ-Al₂O₃ catalyst was filled, the propanol reached the highest value (2.7%), which proved the promotion effect of Fe on higher alcohols. In summary, we designed and prepared Cu and Fe bimetallic catalysts for the conversion of CO₂ and CH₄ into liquid products within a DBD reactor, utilizing circulating water as the grounding electrode, and operating under room temperature and pressure conditions. The regulation of liquid product formation was achieved by carefully adjusting the Cu and Fe ratios. Notably, when Cu₁₀Fe₂/γ-Al₂O₃ was employed as the catalyst, the overall liquid phase selectivity reached an impressive 59.4%, with alcohol liquid phase products constituting approximately 80% of the total liquid phase products. These alcohol products encompassed not only common methanol and ethanol but also 1-propanol. This research marks a significant breakthrough in the field of plasma catalysis for the direct conversion of CH₄/CO₂, underscoring the enticing potential for the transformation of C1 gas products into valuable alcohol-based products.

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THE APPLICATION OF 3D PRINTING TECHNOLOGY IN THE PREPARATION OF NEW DEGRADABLE POLYLACTIC ACID POLY (BUTYLENEADIPATE-CO-TEREPHTHALATE) PRODUCTS IN CHEMICAL INDUSTRY

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Keywords: 3D printing technology, FDM, PLA, plasticizing, PBA

Fused Deposition Modeling (FDM) is a 3D printing technology based on extrusion. Polylactic acid (PLA) is a commonly used printing material, but PLA has the disadvantages of high cost and brittleness, which limits the development of its 3D field. In order to improve its cost and brittleness, a self-made new plasticizer (PCL), modified shell powder (TSP) and PBAT were added. PLA/PCL/TSP/PBAT composites and printing wires were prepared by melt blending method. The standard mechanical tensile splines were printed by SolidWorks three-dimensional software modeling. The effects of different PCL contents on the thermal and mechanical properties of the composites were discussed, and the 3D printing entity work was completed.

3D printing technology [1-3] is a digital manufacturing technology that converts geometric models to entities. FDM technology has the characteristics of low cost of printing equipment, simple operation, low threshold and wide popularization. PLA 3D printing products have been widely used in biomedicine, packaging industry, food processing and environment^[4]. However, PLA materials still have problems such as high brittleness and high cost, and it is difficult to guarantee the performance requirements of some products. Therefore, PLA needs to be modified. In this experiment, PLA/PCL/TSP/PBAT composites and printing wires were prepared by melt blending with self-made modified shell powder (TSP) as filler, self-made polycaprolactone plasticizer (PCL) as plasticizer and PBAT as toughening agent. The effect of PCL on the properties of PLA/PCL/TSP/PBAT composites was investigated by DSC, mechanical and other test methods, and the corresponding parameters were selected to print the final entity.

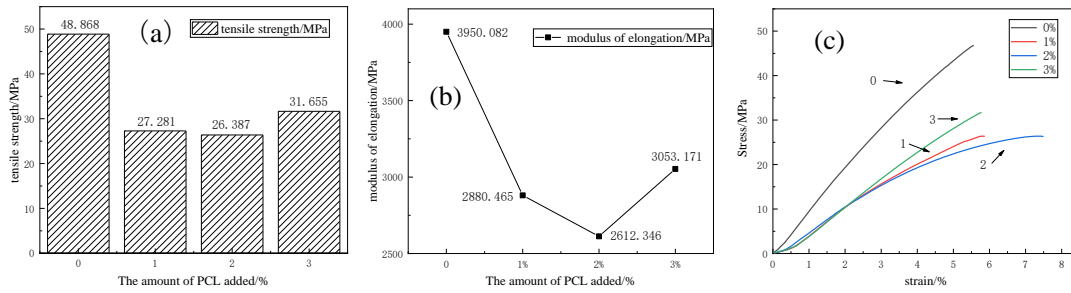


Figure 1 - The effects of different PCL content on the tensile strength(a), tensile elastic modulus(b) and stress-strain curve(c) of PLA were studied

It can be seen from Figure 1 that the tensile strength of pure PLA was 48.868 MPa. After adding PCL, the tensile strength of the composite material decreased as a whole, and the lowest decreased to 26.387 MPa. The tensile elastic modulus decreased from the initial 3950.082 MPa to 2612.346 MPa of the 2 % PCL addition, and then there was a certain increase, but the overall value was significantly lower than the pure PLA value.

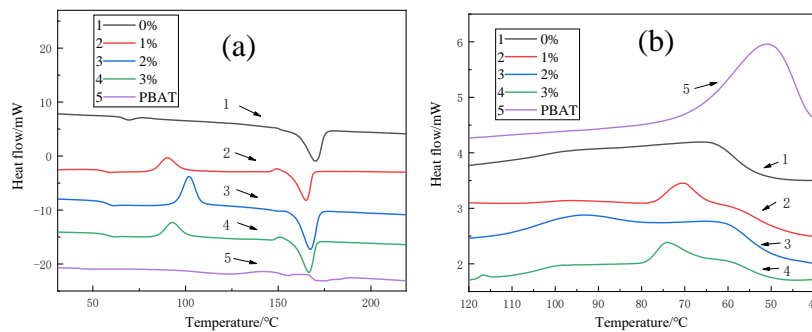


Figure 2 - The DSC curve of the melting section(a) and the DSC curve of the crystallization section(b) of PLA with different PCL additions

It can be seen from Fig.2 that the glass transition temperature is significantly reduced, and PCL reduces the intermolecular force of PLA. PLA molecular chain can move at a lower temperature, and its movement ability is enhanced, which enhances its segment activity and reduces the energy required for segment activity. The cold crystallization temperature and melting temperature decreased slightly with the addition of PCL and PBAT.

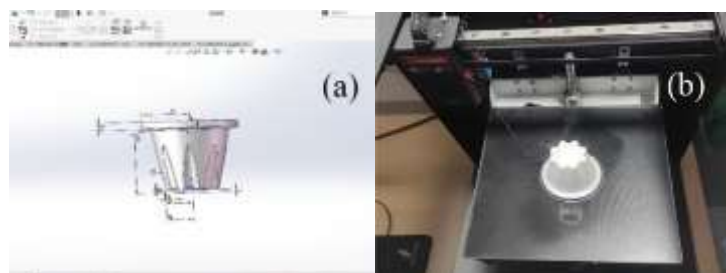


Figure 3 - Garbage bin 3D modeling(a) and printing(b)

It can be seen from Fig.3 that the surface quality of 3D printing products is good, and its mechanical strength and flexibility are guaranteed.

Although the mechanical properties of 3D printed PLA products have been optimized to a certain extent after modification, the interlayer bonding method in the FDM printing process makes the surface quality of the product still need to be improved. In the future printing work, the printing quality of the product needs to be further improved.

Thank you to all the students involved in the experiment, 3D printing work.

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THE CEILING OF THE TAX BURDEN IN THE OIL AND GAS SECTOR. THE POSSIBILITY AND PROSPECTS OF ITS SIMPLIFICATION

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Keywords: *financial obligations, payment fund, simplification of the tax system*

At the beginning of 2024, the tax obligations for LLC in the oil and gas industry are undergoing major changes that significantly affect companies. The high tax burden becomes a problem, creating difficulties for accounting due to the difficulties of dividing reporting between different instances. It also makes it difficult to maintain stable prices in the market, which leads to higher oil prices and negatively affects the population. Even subsidies from banks cannot fully cope with high interest rates, which make it more difficult to improve production and increase financial obligations, creating difficulties for companies. To reduce the financial burden on companies, the idea arises to use the payroll for VAT deduction. This step will allow companies to get rid of the need to pay contributions and 20% VAT on this amount. In this way, companies will be able to significantly ease their financial responsibilities.

The relevance of this study lies in the need to simplify the tax burden and allocate opportunities to reduce financial expenses of companies for the development of the Russian oil and gas industry and ensure the sustainability of the state economy. The results of this study can be useful for developing effective measures and mechanisms to support the oil and gas sector and stimulate its development.

The purpose of the work is to analyze the financial problems of the Russian oil and gas industry and identify opportunities to simplify the tax burden for the development prospects of the oil and gas sector.

At the beginning of 2024, there are changes in tax obligations that have a significant impact on Limited Liability Companies (LLC) related to the oil and gas industry. Companies in this industry face a high tax burden caused by a number of tax contributions, fees, reporting and penalties, including Income Tax (NP), Value Added Tax (VAT), Mineral

Extraction Tax (MET), Property Tax (NI), Land Tax (NZ), Unified social contribution (ERU), Fees for negative environmental impact, Excise taxes, Fines for non-reporting, which at the moment are also handed over to different authorities: IFNS, FIU, FSS, Statistics, military enlistment office, Rospotrebnadzor, and others, significantly complicating accounting.

Due to the difficult tax situation, it is becoming difficult for companies operating in the oil and gas industry to develop financially. They have difficulty maintaining a stable price in the market due to a variety of factors, including taxes. As a result, oil prices are rising, which does not suit the majority of the Russian population.

Even with the company's commitment to further development and the use of subsidies from banks, the high interest rate makes it difficult to improve production. Financial obligations are only getting worse, which makes it difficult for the company to improve its operations.

At the moment, the tax burden in the oil and gas industry has reached the growth ceiling. The continued increase in the tax burden may have negative consequences for the industry, as it may lead to a reduction in investments. The ceiling of the tax burden varies for each company and depends on the operating cash flow. However, the Ministry of Finance of the Russian Federation notes that in the coming years, budgetary opportunities to stimulate the production of hard-to-recover oil and gas reserves are limited, and consideration of this issue is possible no earlier than 2027.

Despite this, the State Duma adopted a law on tax increases in 2023-2025 for the oil and gas sector, according to which the income tax rate for LNG producers in the coming years will rise to 34%, with 17% deductions to the federal budget and 17% to the regional budget. Taking into account these factors, we propose simplifying the tax burden in the following way: it is necessary to take into account the wage fund and make it possible to deduct VAT. This will allow companies to significantly ease the financial burden, as they will be freed from the need to pay contributions and 20% VAT on this amount.

This proposal, taking into account current changes in tax legislation, may lead to a simplification of the tax burden for LLC in the oil and gas industry. Thus, this method will allow companies to avoid using gray schemes. Significantly reduce the financial costs of companies by exempting them from paying contributions and 20% VAT. It will enable

companies to save on taxes and implement them in development. And the Budget will receive full salary deductions, and the accounting department will be transparent.

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DECARBONIZATION OF PETROCHEMICAL PROCESSES OF THE RUSSIAN ENERGY SECTOR IN THE CONDITIONS OF SANCTIONS AND GLOBAL ENERGY TRANSITION

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Keywords: *decarbonization, petrochemical processes, global energy transition, sanctions, energy*

The problem of decarbonization is one of the most urgent and significant in the modern world. Global climate change caused by increasing greenhouse gas emissions leads to serious environmental consequences, such as global warming, more frequent natural disasters, biodiversity change and other negative phenomena.

Decarbonization – reduction of carbon dioxide emissions into the atmosphere, is becoming a necessary step to counteract climate change. Energy sectors, such as the oil and gas industry, which has traditionally been one of the largest sources of greenhouse gases, play a key role in the decarbonization process.

The objectives of the study are to investigate the current state of petrochemical processes in the Russian energy industry, taking into account greenhouse gas emissions and decarbonization opportunities, and to analyze the impact of sanctions on the development of the petrochemical industry and possible prospects for its modernization in the context of the global energy transition.

The petrochemical industry plays a crucial role in the energy and economy of Russia. It is based on the processing of hydrocarbons obtained from oil and gas into various chemical products. The energy industry is also closely related to petrochemicals. The petrochemical industry is of strategic importance in the Russian economy. It generates significant income from exports, contributes to the development of other sectors of the economy and creates jobs. In addition, the development of petrochemicals contributes to technological progress and increases the competitiveness of the Russian economy in the global market.

Decarbonization of petrochemical processes is a complex and multifactorial problem influenced by a number of key factors - energy policy and legislation, technological, use of alternative sources, investment and financing, cooperation and partnerships.

There are a number of methods and approaches to decarbonize petrochemical processes, which can include energy efficient technologies, replacement of fossil fuels, carbon offsetting, biotechnology development, innovative approaches such as the use of hydrogen and the formation of advanced catalysts.

Sanctions imposed on the Russian petrochemical industry in the context of the global energy transition may have a significant impact on decarbonization processes. First of all, such sanctions may affect access to technologies and equipment for transition to cleaner production processes. Sanctions may also affect the availability of financing for decarbonization projects and the development of alternative energy sources. Restrictions in financing may slow down the transition to clean technologies and reduce investments in projects to reduce greenhouse gas emissions.

The Russian petrochemical industry faces the challenge not only of decarbonization, but also of adapting to changing global economic conditions, including sanctions and requirements to reduce greenhouse gas emissions. Research in this area can help identify key challenges and opportunities for the development of clean technologies, solutions to reduce dependence on hydrocarbons and improve energy efficiency in the petrochemical industry.

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TECHNOLOGY OF RECLAMATION OF EVAPORATION FIELDS

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***Keywords:** soil pollution, evaporation fields, oil sludge processing, soil reclamation, objects of accumulated environmental damage*

This study addresses the urgent task of eliminating objects of accumulated environmental damage, in particular evaporation fields. In Russia, the Federal Law "On Environmental Protection" regulates actions to eliminate such facilities. This work step-by-step describes the technology of reclamation of evaporation fields, which are classified as objects of accumulated environmental damage. The main focus is on outdated oil fields in the Stavropol Territory.

The evaporation fields were formed as a result of the discharge of oil-contaminated reservoir waters during oil production. In the last century, there was no technology for handling reservoir waters, as a result, huge areas of contaminated soil have been "inherited" in our time. This, in turn, led to environmental damage: pollution of groundwater, air, loss of soil fertility and biodiversity. The Velichaevo-Kolodeznoye evaporation field with a total area of 24 hectares was chosen as the object of research. The soil of this field consists of layers of asphalt-resin-paraffin deposits (heavy oil components) and oil-contaminated soil of different hazard classes, extending to a depth of 1.5 m. The oil phase is distinguished from these layers. For an environmentally friendly approach to the disposal of oil waste, it is proposed to use the oil phase to produce petroleum products such as gas oil, motor fuel, bitumen.

The analysis of the available technological solutions for the purification of oil-contaminated soil has been carried out and an optimal technology for cleaning and reclamation of soil has been developed, which is characterized by high efficiency and absence of risks of secondary pollution. A scheme for the secondary processing of oily waste to create petroleum products has been developed.

The technology of cleaning oil-contaminated soil makes it possible to effectively remove petroleum products and other harmful substances from the soil, returning it to a state

suitable for use in the agro-industrial complex. This approach not only helps to clean the land from pollution, but also opens up opportunities for the use of land in agriculture.

Integrated remediation technologies play a key role in restoring natural ecosystems in polluted areas. They include measures to restore vegetation cover, restore soil fertility and maintain the viability of local flora and fauna. This integrated approach helps not only to restore natural balances, but also to create a favorable environment for living organisms, contributing to biodiversity and the preservation of the ecosystem as a whole.

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DECARBONIZATION OF MARINE VESSELS. OPPORTUNITIES AND CONSEQUENCES OF IMPLEMENTATION IN RUSSIA

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Keywords: *decarbonization, marine vessels, hydrogen, ammonia, methanol, LNG, green fuels, production capacity, carbon dioxide emissions, hydrocarbons*

At the current stage, the world is facing an aggravation of the environmental situation, which requires immediate and comprehensive solutions. There are many reasons that affect the deterioration of the environment, among which the most worrying is the problem of greenhouse gas emissions. The sources of such emissions are intensive agriculture, deforestation, poor waste management and the burning of fossil fuels, for example in the engines of cars and ships. The intensive growth in maritime traffic is accompanied by an increase in greenhouse gas emissions, which account for 3% of all emissions. Today, most ships in the world run on LNG, fuel oil and diesel are also used, but to a lesser extent. When switching to LNG, this fuel was considered the cleanest, unfortunately, emissions did not decrease much. Thus, it became necessary to switch to alternative environmentally friendly fuels such as methanol, ammonia and hydrogen.

The paper will present forecasts, optimistic and pessimistic views on the implementation of Russia's transition to alternative fuels. Russia has many opportunities and the future position of the country in the energy market depends on how they will be used. The following methods were used to generate these forecasts:

1. The proportions of the use of different types of environmentally friendly fuels at the moment are determined (Figure 1);
2. The advantages and disadvantages of switching to green fuel are analyzed;
3. The dynamics of growth in the production of ammonia, methanol and hydrogen has been studied;
4. The obtained data are combined in the scenario of Russia's development.

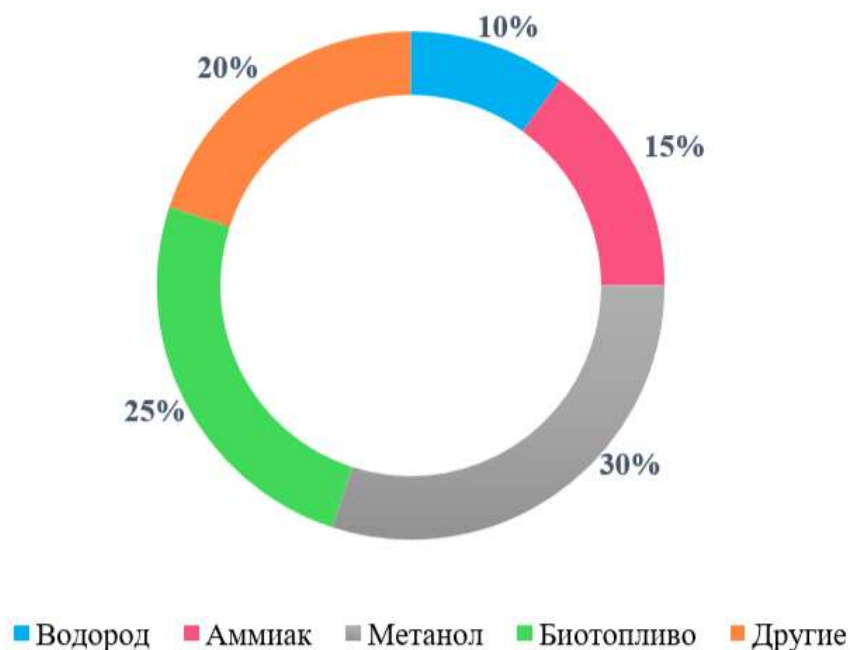


Figure 1 - Green Marine fuel market

Based on this diagram, it can be concluded that the most popular types of green fuels are methanol, ammonia, hydrogen and biofuels. As shown in the graph, methanol is the most common, as it can be mixed and gradually switched to using pure methanol. Biofuels take the second place in terms of application, as they are produced from renewable resources.

Decarbonization is one of the most important areas through which the greenhouse effect can be reduced. It helps to preserve the environment, stabilize the climate and improve the environmental situation in the world.

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MATHEMATICAL MODELLING OF SAFETY INSTRUMENTED SYSTEM FOR PIPELINE INFRASTRUCTURE PLANNING

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Keywords: *safety instrumented systems (SIS), reliability assessment, risk management, protection, avoiding accidents, multi-optimization*

The operation of many industrial processes involve inherent risks due to the presence of dangerous materials, gases and chemicals. Safety instrumented functions and systems are crucial to control the risk in many industries. That is why it is essential to identify which functions are required, as well as what requirements should be given on their performance.

Explosions and fires account for millions of dollars of losses in the chemical or oil and gas industries each year. Since a great potential for loss exists, it is common to employ Safety Instrumented Systems (SIS) to provide safe isolation of flammable or potentially toxic material in the event of a fire or accidental release of chemicals.

In land-based industry, as well as in offshore facilities, safety instrumented systems are applied in order to maintain the risk at an acceptable level. The performance of the instrumented protections is crucial for achieving the necessary risk reduction. The Safety Instrumented Systems (SIS) are the systems responsible for the operating safety and ensuring the emergency shutdown within the reasonable amount of time considered as safe, whenever the operation exceeds such limits. The main objective is to avoid accidents, such as fires, explosions, equipment damages, inside and outside plant protection of production and property, and furthermore, avoiding life-threatening situations or personal health damages and catastrophic impacts to community. It should be clear that no system is completely immune to failures and, even in case of failure; it should provide a condition as safe as possible. SIS are specifically designed to protect personnel, equipment and the environment by reducing the likelihood (frequency) or the impact severity of an identified emergency event [1].

The proposed research will contribute to the problem of infrastructure design for oil and gas industry. Many infrastructure planning projects lack comprehensive specification for safety system design, which leads to incidents and significant losses of various nature. The main objective of this research is to study the reliability assessment of SIS and implementation of optimization procedure to SIS design with respect to economic efficiency and reliability of the system. This master thesis aims to develop a framework of economically efficient safety systems design based on mathematical modelling of those system and their interaction with hazardous industrial facilities [2].

A literature study of infrastructure planning in petroleum industry was carried out in order to describe organizational structure and related activities. Before implementing any operations it is crucial to establish networks properly, where flow of materials and information will take place. Reliability theory was carried out in order to identify the main parameters of safety concept, their measuring and meaning. It is important to study different attributes of reliability concept before quantitative assessment. It is considered very significant to analyze the petroleum production infrastructure; analyze and assess risks and address the issues of mitigating those risks.

The risk management theory has become an essential part of infrastructure planning. The research project goals to develop and substantiate an approach for risk management, which can provide the company possibility to prevent hazards and eliminate expenses of accidents. The security system of the technological process becomes the most important tool for mitigating hazards and risks. Implementation of Safety Instrumented System as a layer of protection needs large amount of investment, approximately 80% of total investment. Deployment of the diagnostics and protection system for the pipeline involves investments into hardware, software and service work for installing and maintaining it, which implies a certain cost. However, this cost is not a fixed figure for a given pipeline. It highly depends on specific design of SIS is and how elaborate the diagnostics/protection system is, which is a managerial decision. Therefore, the purpose of research is to implement the procedure of selection the optimal safety system design with respect to economic criterion based on ALARP principle and achieve increases of reliability performance of pipelines together with risk reduction for the company.

Realization of safety systems model is to be described with qualitative and quantitative indices, recommended by the effective international standards. For several years, the safety systems were designed according to the German standards (DIN V VDE 0801 [3] and DIN V 19250 [4]), which were well accepted for years by the global safety community and which caused the efforts to create a global standard, IEC 61508, which now works as a basis for all operational safety regarding electric, electronic systems and programmable devices for any kind of industry. Such standard covers all safety systems with electronic nature. The modelling and optimization algorithms include the level of modelling detail and meet the requirements of IEC 61508.

The project implements design optimization of a safety-instrumented system by a multi-objective genetic algorithm. This includes optimization of safety and reliability measures along with lifecycle cost. Special attention is paid to the effect of common cause failure and the total value of dangerous detected failures rate. The requirements for safety integrity established by the standard IEC 61508 are addressed, as well as the modelling detail required for this purpose. The problem addresses reliability for a series–parallel system. The objectives to optimize are the average probability of SIS’s failure on demand, mean down time of the technological facility and lifecycle cost.

Novel contributions include implementation of modelling by Markov Analysis with flexibility for evaluation of multiple solutions; a model for quantification the reliability characteristics for each particular subsystem: average probability of failure on demand and downtime; and the integration of system modelling with optimization by multi-objective genetic algorithms with lifecycle cost assessment. Thus, this work intends to contribute to the state-of-the-art in modelling for a particular alternative of SIS specification and solution of multi-optimization of design and testing of safety systems with Genetic Algorithms based on principle of compromise between the costs of risk reduction and the achieved level of safety.

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EXTRACTION TECHNOLOGY OF HUMAN HAIR KERATIN FROM RENEWABLE RESOURCES AND ITS APPLICATION IN CHEMICAL DYE ADSORPTION

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Keywords: PVA, human hair keratin, composite film, adsorption

The membrane was prepared by alkali extraction of human hair keratin and PVA. The optimum extraction conditions and the adsorption properties of the composite membrane were explored. The extraction rate was up to 63.31 %, and the adsorption rate of the composite membrane was up to 88.34 %. It provides a reference for the application of biomass resource keratin polymer membrane materials in water pollution adsorption.

Introduction: The utilization rate of discarded hair is low, resulting in a waste of resources. However, the keratin contained in the hair has very rich amino acids. The functional groups on the surface of the amino acid molecular chain can provide adsorption sites for dyes. This structural feature makes keratin very suitable for the adsorption of pollutants^[1-2]. Due to the poor film-forming property of keratin itself, it is often mixed with other additives to prepare keratin-based composites to overcome the shortcomings of poor mechanical properties of keratin^[3,4].

Correlation: It is an innovation of green environmental protection technology to extract keratin from human hair for the adsorption of water pollution and turn waste into treasure.

Methods: Human hair keratin was extracted by NaOH, and PVA / human hair keratin composite film was prepared by casting method. The adsorption performance of the composite film to malachite green solution was tested by ultraviolet-visible spectrophotometer.

Conclusion:

(1) The dissolution rate of human hair increased with the increase of NaOH dosage, dissolution temperature and dissolution time. The extraction rate of keratin increased first and then decreased with the increase of NaOH dosage, dissolution temperature and dissolution time. In order to balance the dissolution rate and extraction rate, reduce energy consumption and improve the extraction efficiency of keratin, the final extraction conditions

for human hair keratin were as follows : NaOH : human hair ratio was 1 : 1, dissolution temperature was 60 °C, and dissolution time was 6 h. At this time, the extraction rate of human hair keratin was 63.31 %, and the dissolution rate of human hair was 91.68 %. The dissolution rate of Zhang Lin 's human hair extracted by alkali method was 90.40 %^[5].

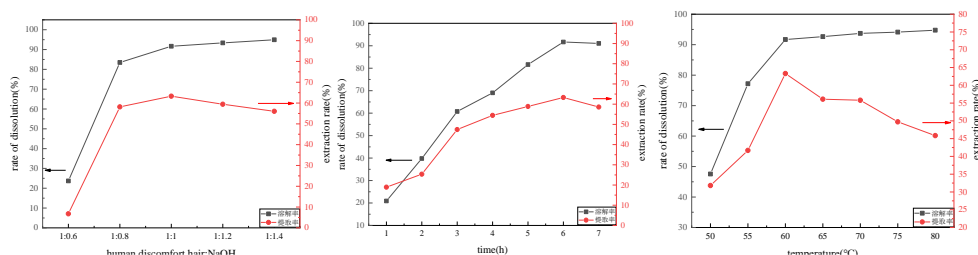


Figure 1 - The effect of keratin content on the adsorption performance of the composite membrane

It can be seen from the figure 1 that the equilibrium adsorption rate and equilibrium adsorption capacity of PVA / human hair keratin composite membrane for malachite green gradually increased steadily with the content of keratin in the composite membrane. The equilibrium adsorption rate of pure PVA membrane to 50 mL malachite green solution with a concentration of 40 mg / L was 56.09 %, and the equilibrium adsorption capacity was 22.10 mg / g.

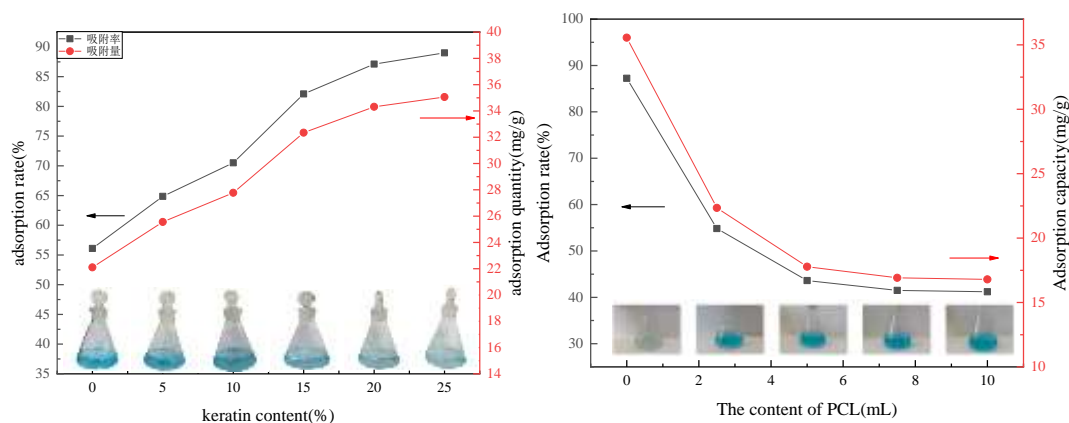


Figure 2 - The test of PCL content on adsorption performance

The test of PCL content on adsorption performance showed that the equilibrium adsorption rate and equilibrium adsorption capacity of PVA/human hair keratin composite film on malachite green showed an overall downward trend after the addition of PCL, and the decreasing speed changed from fast to slow.

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ENHANCING CO SELECTIVITY IN CO₂RR ELECTRODE THROUGH PHTHALOCYANINE SUBLIMATION

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Scientific adviser: Professor Bing Li

Keywords: CO₂RR, transition metal phthalocyanines, solvent-free, m-n/c, sublimation

Considering the dispersion uniformity and environmental pollution from solvents in the previous preparation process of phthalocyanine-based electrodes, we have successfully fabricated a series of integrated electrode materials of transition metal phthalocyanines through sublimation. This method, which does not require the use of solvents, greatly minimizes the risk of re-aggregation and is suitable for the preparation of catalysts with sublimation capabilities. Its simplicity and efficiency make it one of the ideal for the mass fabrication of electrodes.

Converting CO₂ into valuable products through CO₂ Electroreduction Reaction (CO₂RR) is a promising strategy to reach the goals of Carbon Peaking and Carbon Neutrality, and to improve the utilization of renewable energy sources [1]. Transition metal phthalocyanines (TMPcs) are efficient molecular catalysts for CO₂RR. However, the π -electron-rich TMPcs are prone to aggregate in solvents, making it challenging to achieve uniform deposition on the catalytic electrode using conventional wet-chemical methods [2-4]. This contribution introduces a solvent-free sublimation method for preparing highly efficient CO₂RR electrodes. The electrodes, with uniform TMPcs deposition, exhibit exceptional CO selectivity (> 97%, with CoPc) for CO₂RR. Theoretical calculations are also conducted to better understand the reaction mechanism.

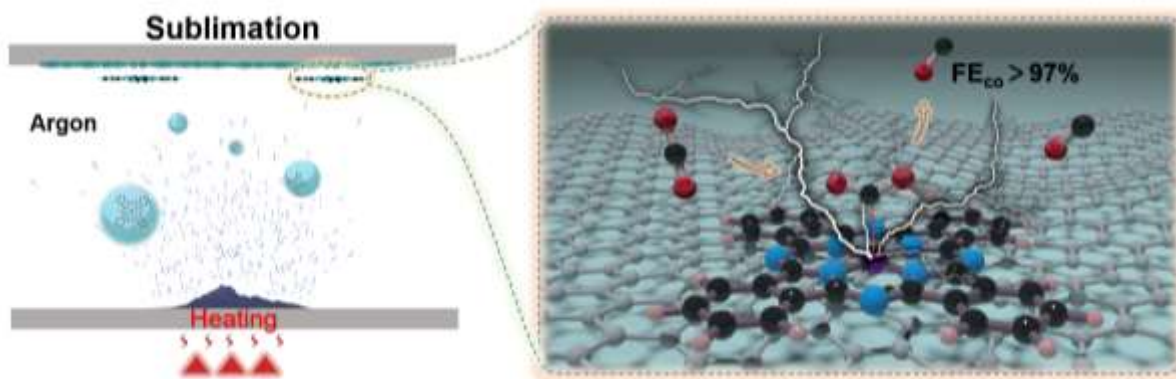


Figure 1 - The table of contents illustration in this conference

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DIGITAL GAS TRADING IN SOLVING THE PROBLEMS OF REDUCING EMISSIONS AND IMPROVING THE ENVIRONMENTAL FRIENDLINESS OF THE CHEMICAL INDUSTRY

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Keywords: digitalization, gas market, ecology, gas exchange trading, LNG

Gas digital trading is one of the drivers of the development of the global gas market. In the context of the transition to a low-carbon economy, natural gas is one of the most promising transitional energy sources. In such conditions, the development of digital technologies in the gas business contributes to its accessibility and cheapening for consumers.

Today, digital technologies are being heavily introduced into various sectors of natural gas production and consumption. This allows companies to improve technologies for production, logistics and commercial sales of the product. Thus, with the development of LNG, it becomes easier to diversify global gas supplies, which in turn stimulates the development of digital gas trading. Digitalization of trade includes: working with consumers, all stages from the emergence of interest in a trademark to the moment of making a purchase; ensuring operational efficiency, including the effectiveness of personnel, work with products, price tags, logistics and control of product deliveries; monitoring the operation of IT infrastructure and security systems [3]. Digital commerce is the exchange of goods and services that are ordered, delivered or carried out using digital means [4]. Digital trade includes not only trade in digital goods and services, but also traditional goods that are supported by digital technologies. This may include e-commerce transactions, the digital provision of services, the online sale of physical goods, and the use of digital platforms for international trading activities. Digital commerce is characterized by the use of information and communication technologies (ICTs) to ensure and improve various aspects of trade, such as marketing, sales, payment processing and logistics [5].

Currently, the gas industry is being transformed, changing traffic flows. Decarbonization policy and the development of renewable energy pose certain challenges

to the gas industry. Thus, with the development of LNG and other technologies that are changing logistics in the market, LNG contributes to the popularization of natural gas consumption worldwide, due to its accessibility to consumers. Natural gas is also used as a transitional fuel, it is an important element in the decarbonization policy [2]. In such conditions, natural gas trading platforms should be improved. In the future, this can balance the global gas market, it can become more predictable. Thus, the possibility of the gas market to become a price indication system, as well as an investment mechanism [1]. If we talk about risks, an important point may be the monopolization of the market, in terms of entry conditions for smaller companies, which in turn may discourage investment in this industry.

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ENERGY TURNAROUND IN GERMANY: GLOBAL CHALLENGES AND INNOVATIVE SOLUTIONS

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Keywords: *energy, nuclear, ecology, innovation, prospects*

In recent decades the trend of transition from hydrocarbon sources to renewable energy sources has become more and more frequent. It became especially relevant in the Federal Republic of Germany, when the policy of "energy turnaround" was introduced. It was this innovation that initiated the formation of a carbon-free economy in the European Union. This study of the transformation of the economic and energy policy of the Federal Republic of Germany will help to assess the innovativeness and feasibility of the decisions taken.

The energy transition policy in Germany started more than 60 years ago. The key point of the energy transition concept was the rejection not only of hydrocarbons, but also of nuclear energy. Thus, at the beginning of 2023. The Federal Republic of Germany had three working nuclear power units, although their closure was planned as early as 2011 (they were closed in April 2023). To reduce dependence on natural gas, a partial return to coal-fired generation was undertaken, which had a significant impact on the fuel and energy balance, the environmental situation and public opinion in the country. But how did the energy transition affect the entire economy of the country?

For a detailed analysis, it is necessary to consider many statistical indicators, such as the cost of a particular energy resource, the total market share for each proposal, and the change in the energy balance over the period of the energy transition policy.

Theoretically, energy transition creates a new basis for economic development, leads to solving environmental problems and improving the welfare of society as a whole. But in practice, things are not so clear-cut. The rejection of pipeline gas entailed multiple additional costs, which increased many times over after the sanctions pressure on the exporting countries. Geopolitical pressure has led the Federal Republic of Germany to return to the coal industry (which is much less environmentally friendly than gas), while continuing to

invest heavily in renewable energy sources. Consumption in the energy sector has fallen by 3.7% in the last 2 years, currently the lowest figure since 2012. But whether this is due to the transition from conventional hydrocarbons to renewables or whether there is another reason, this is the question we have tried to answer in our research.

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**LNG PRODUCTION PLANTS OF «SAKHALIN ENERGY» AND «YAMAL LNG»
COMPANIES COMPARISON BASED ON THE
COMPLEXITY INDEX DEVELOPED BY I.V. MESCHERIN**

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Due to the fact that the LNG production of Sakhalin Energy and Yamal LNG companies are technologically quite similar, an attempt was made to compare them based on the complexity index developed by I.V. Mescherin. The index allows you to characterize the technological complexity of an LNG production plant, considering capital investments, plant capacity and productivity losses of individual components of technological trains. Let's determine how the Mescherin index is influenced by the geographical location of plants from a climatic point of view, the composition of the natural gas feed stream, as well as the structure of the plants themselves and the technological lines of different licensors.

In recent years, an indicator similar in meaning to the Nelson index [1-2] has been developed – the Mescherin index – for another branch of the processing industry – LNG production [3]. The index characterizes the ratio of the feed gas processing capacity at the LNG plant, as well as the productivity of related systems, to the total LNG production at the plant.

The indicator considers the cost of constructing a particular unit at a gas liquefaction complex, as well as the productivity of technological trains and loss of productivity.

In the article, the author attempts to use the Mescherin index in practice, comparing the most significant Russian LNG production capacities [4]. Using the indices, we will trace the complexity of the technological structure of the Sakhalin Energy and Yamal LNG plants in terms of capital intensity. We will try to compare the efficiency of capital investments based on specific capital costs per ton of LNG. Let us evaluate how the mentioned parameters are affected by the geographical location of technological complexes.

We will calculate the complexity indices of the LNG plants of the mentioned companies, guided by the calculation methodology described in detail in the literature [3].

First, the productivity losses of each process unit within the natural gas liquefaction train of each plant are calculated [5]. This is followed by finding the productivity loss coefficients for each unit. This is followed by the calculation of cost growth ratios for the construction of each subsequent technological unit, given in table. 1. In general, there is a predominance of coefficients at the Yamal LNG plant due to the fact that in this geographical area the construction of a particular installation requires at least 30 % more investment than in more southern regions of Russia. This fact is determined by the difficult climatic conditions on the Yamal Peninsula, which is located beyond the Arctic Circle. To maintain the low temperature of permafrost Arctic soils, a different approach to the construction of ground-based facilities (pile construction) is required, as well as the use of gravitational heat pipes with circulating refrigerant. In addition, the construction of plants using the traditional method is complicated in this region, as a result of which the modular assembly method is most often used, which imposes additional costs associated with numerous requirements for the size and weight of modules and the complexity of their sea transportation [6].

The results are summed up by calculations of the complexity indices of individual technological units of the two plants, as well as the final complexity indices of the LNG production complexes of the Sakhalin Energy and Yamal LNG companies (Table 1).

Table 1 – Calculation of plant complexity indices

№	Unit	Cost, million rub.	Cost Growth Ratio	Complexity index
«SAKHALIN ENERGY»				
1	Acid Gas Removal	14 971	0,89	0,89
2	Dehydration	3580	1,02	0,99
3	Mercury Removal	1184	1,04	1,00
4	Fractionation	5288	0,40	0,40
5	Liquefaction	223 795	1,00	1,00
TOTAL:				4,28
«YAMAL LNG»				
1	Acid Gas Removal	32 937	0,90	0,89
2	Dehydration	24 501	1,06	0,99
3	Mercury Removal	6116	1,08	1,01

4	LPG extraction	24 037	1,12	1,12
5	Fractionation	11 905	0,22	0,22
6	Liquefaction	483 698	1,00	1,00
TOTAL:				5,23

The overall Mescherin complexity index for the Sakhalin Energy plant, according to calculated data, is 4.28, and for the Yamal LNG plant – 5.23.

The higher value of the Mescherin complexity index for the Yamal LNG plant indicates that the specific level of capital investment is higher than that of the competitor plant. If we calculate the values of specific capital investments, it turns out that for the Yamal LNG plant this figure is 1.36 times greater than for the Sakhalin Energy plant. This difference is explained by the complexity and high cost of constructing industrial facilities in such a harsh climatic zone.

Significant differences in the complexity index can be traced at the nodes of dividing flows into components and fractions. At the Sakhalin Energy plant, the complexity of the liquefied hydrocarbon gas fractionation unit is estimated at 0.40 points. The situation is different at the Yamal plant, where the index is 1.12 for the heavy hydrocarbon separation unit and 0.22 for their fractionation unit – a total of 1.34. This is explained by large capital investments in a separate installation for the extraction of liquefied hydrocarbon gases, which includes a number of complex and expensive equipment that is not used at the Sakhalin Energy plant: a “cold box”, a low-temperature separator, a demethanization column of complex design and an expander-recompressor high power unit. At the Sakhalin plant there is no separate installation for the extraction of heavy hydrocarbons; instead, the entire flow passes through the scrubber columns of the gas liquefaction unit, where the heavy phase is separated from the methane flow that follows the first cooling stage. The fractionation unit is fed with the C2+ fraction, which is separated into the same number of components as at the other plant.

The coefficient of growth in construction costs for each subsequent unit is growing more intensively at the Yamal LNG plant due to difficult conditions for transporting building materials and finished modules, as well as their assembly.

The lower value of the Mescherin complexity index for the Sakhalin Energy plant indicates both the lower relative cost of plant construction and the greater competitiveness of the finished LNG. The plant is located much closer to key sales markets, for example, Japan and other countries in the Asia-Pacific region, which explains the competitive advantage of Sakhalin LNG. The Yamal LNG plant also produces LNG for this region, however, it is located much further away, and in the winter season, transportation becomes significantly more expensive due to the need to use an icebreaker fleet to escort gas tankers. The key markets for the Yamal LNG plant are located at a considerable distance from the place of production of the product.

However, it is also necessary to consider that the upstream facilities not considered in the calculations of the Mescherin index. It is necessary to mention here that the competitive advantage of the Yamal LNG plant is its significant reserves of raw hydrocarbons [7], the production of which is carried out at a much lower cost than within the framework of the Sakhalin-2 project. Natural gas is extracted simultaneously from a large number of pads, and new wells are also drilled. The distances from the production pads to the plant also play into the hands of Yamal LNG, since the nearest wells are only a few kilometers from the plant. A completely different situation is observed for the Sakhalin project, where gas production is carried out on the shelf using offshore platforms [8]. It is necessary to consider that for the extraction and transportation of raw materials on Sakhalin, coastal technological structures are provided, as well as underwater and onshore pipelines, the length of which exceeds 600 km. It is clear that these facilities significantly influence the final capital investment of the project, and, perhaps, somewhat equalize the cost of LNG production at the Yamal LNG and Sakhalin Energy plants. This infrastructure is deliberately not considered when calculating the Mescherin index, since it does not directly affect the complexity of the natural gas liquefaction plant; the complexity and specific capital investments of specific technological processes for gas liquefaction of various licensors do not depend on these objects.

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APPLICATION OF RUBBER-BASED POLYMERS AS THICKENERS OF GREASES

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Keywords: *greases, thickeners, polymers*

The production and consumption of polymers is growing every year and the market for these products is improving. Polymers affect various fields from mechanical engineering to the food industry. But the use of various polymers as a component of grease thickener is an understudied area. The aim of this paper is to study the use of various polymers as a stand-alone thickener and as a component of grease thickener and to analyse the obtained samples.

During a literature search, a paper [1] was found, the authors of which claim that it is possible to develop greases with excellent tribological characteristics using polysaccharide resins such as acacia gum and guar gum as additives. Therefore, guar gum was used as a natural polymer.

Three polymers were selected as synthetic polymers. Styrene-butadiene copolymer (SBS-260) is a rubber-like material. It is one of the most advanced types of thickeners and is used to produce high-performance all-season lubricants. Ethylene-Propylene Copolymer (EPC) is an irregularly shaped transparent block in its normal state, when added to motor oils this polymer provides better shear stability and low temperature stability for passenger car oils and heavy duty oils. Polylactide is an optically active linear polyester [2]. The monomer of this polymer is lactic acid.

Industrial oil I-40A was used as a dispersion medium - general purpose, distillate oil or a mixture of distillate oil and residual oil from sulphurous and low-sulphur oils of selective purification and does not contain additives [3].

Sample №1 with guar gum thickener did not show positive results, the thickener did not dissolve. Samples №3 and №4 with polylactide and sample №6 with ethylene-propylene copolymer as a thickener also did not show positive results.

The thickener of sample № 2 was pure styrene-butadiene copolymer (SBS-260). The resulting grease has a penetration value of 474 mm s⁻¹, which means that this grease is classified as a "very fluid grease" by NLGI and can theoretically be used in closed gears. When analysing this sample to determine the tribological characteristics on a four-ball machine, the diameter of the wear spot was 0.5 mm, which is 0.15 mm less than the value of the diameter of the wear spot in the study of oil I-40A.

Sample № 5, thickened with styrene-butadiene copolymer (SBS-260) together with lithium stearate, showed positive results. According to NLGI classification, this sample was semi-solid with a penetration value of 176 mm s⁻¹. This sample showed unexpected results in the value of tensile strength - more than 2000 Pa and a fairly small percentage of evaporation - 1.14 %; the effective viscosity of this sample was 237 Pa*sec; the diameter of the wear spot of the investigated sample №4 was 0.7 mm.

Further work is planned with these samples and further research with other polymers as a thickener for greases.

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RU-CONTAINING CATALYTIC SYSTEMS BASED ON MICRO-MESOPOROUS ALUMINOSILICATES FOR LIGNOCELLULOSIC BIO-OIL REFINING

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Keywords: *bio-oil, hydrodeoxygenation, ruthenium, halloysite, zeolites*

The consumption of liquid energy carriers such as oil is increasing every year, while conventional hydrocarbons are running out of reserves. A large number of research groups all over the world are searching for renewable sources of carbon-containing raw materials, whose production will contribute to reduce emissions and improve environmental friendliness of the chemical and petrochemical industry. An effective solution is pyrolysis of lignocellulosic biomass followed by hydrodeoxygenation of the liquid product – bio-oil.

High activity in hydrodeoxygenation of phenolic components present in bio-oil (phenol, eugenol, guaiacol) is demonstrated by catalytic systems based on noble metals deposited on zeolites. The disadvantage of such catalysts is rather small pore size, which causes diffusion limitations and increased coke formation. The efficiency of zeolite catalysts can be improved by synthesizing hierarchical pore systems combining the advantages of both microporous zeolites and mesoporous materials [1].

In this work Ru-containing catalysts based on micromesoporous composite materials of MFI type were synthesized by template and non-template methods. Halloysite nanotubes having tubular structure were applied as hard co-template. The obtained corresponding catalysts were designated as Ru/MFI(HNT)-t and Ru/MFI(HNT)-nt. It was found that application of halloysite as a precursor of MFI-type composite material promotes formation of mesochannels in the resulting material. The activity of the synthesized catalysts was investigated in the hydrodeoxygenation reaction of a model guaiacol-water mixture. The process was carried out in stainless steel autoclaves equipped with a stirrer at a temperature of 120 – 180 °C and a pressure of 3 MPa.

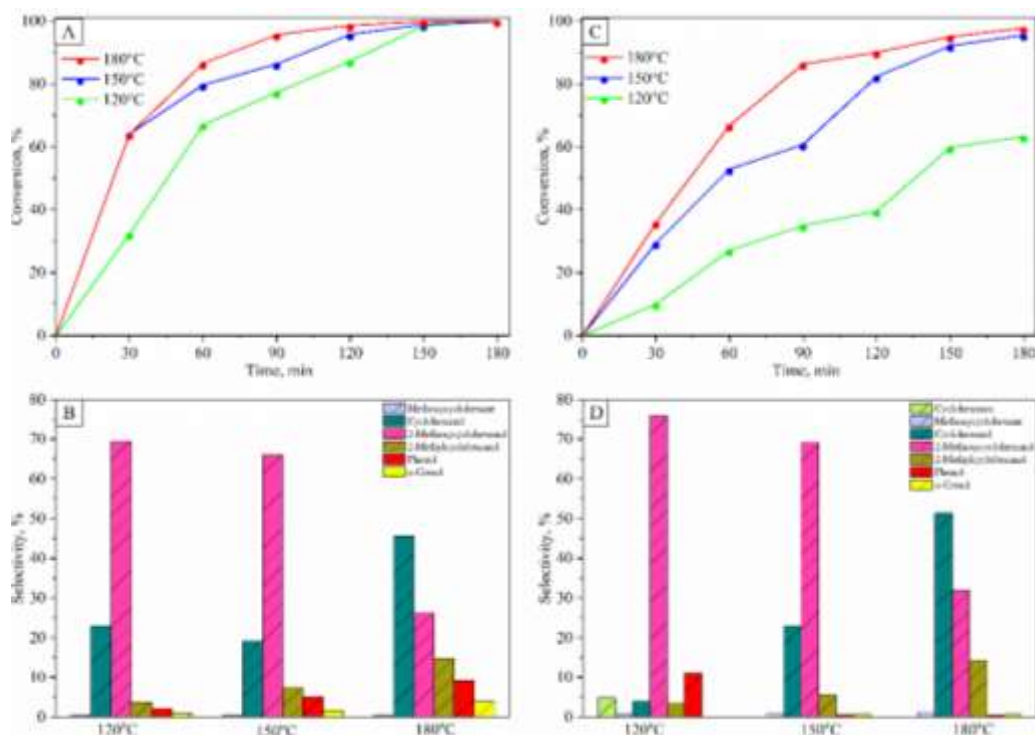


Figure 1 - Kinetics/distribution of guaiacol hydrogenation products over Ru/MFI(HNT)-t (A,B) and Ru/MFI(HNT)-nt (C,D) catalysts

In case of the Ru/MFI(HNT)-t sample, quantitative conversion of guaiacol was observed within 3 h in the whole temperature range. The main product of HDO at 120 °C was 2-methoxycyclohexanol, which indicates that the process proceeds preferentially along the route of hydrogenation of the aromatic ring with preservation of polar groups. When the temperature was increased up to 180 °C, the direction of the process shifted towards demethoxylation followed by hydrogenation of the aromatic ring, which was confirmed by the formation of significant amounts of phenol (selectivity – 9 %) and cyclohexanol (selectivity – 46 %). In addition, at elevated temperatures, the side transalkylation reaction accompanied by formation of o-cresol and 2-methylcyclohexanol was more active.

Ru/MFI(HNT)-nt sample demonstrated less activity in the low-temperature region, however, at 180 °C conversion was close to quantitative (~ 98 %). As in the case of Ru/MFI(HNT)-t catalyst, hydrogenolysis of $C_{Ar}-O$ bonds was more active with increasing temperature, and the maximum selectivity for cyclohexanol (51 %) was observed. Due to the relatively low acidity of the Ru/MFI(HNT)-nt, selectivity for transalkylation products was lower than when using Ru/MFI(HNT)-t catalytic system.

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DEVELOPMENT OF SORPTION MATERIALS BASED ON POLYLACTIDE WITH THE POSSIBILITY OF USE IN THE OIL AND GAS INDUSTRY

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Keywords: *biopolymer materials, polylactide (PLA), electrospinning, ultrafiber nonwoven material, sorbent, oleic acid ozonide triglyceride (OAOZ)*

The work examines the production of ultrafibers based on polylactide (PLA) using the method electroforming and the possibility of their use as sorbents for liquidations consequences of emergency oil and petroleum product spills.

The role of biopolymers in the development of nature-like technologies aimed at the transformation of the technological world, including the oil and gas industry, is due to the fact that the raw materials for their production belongs to the category of reproducible resources. Benefits biopolymers and materials based on them are also biodegradable, highest compatibility with other materials, thermoplasticity, effect on reducing greenhouse gas emissions during their production, in contrast to polymers from petroleum feedstock. One of the promising biopolymer candidates for the oil and gas industry is polylactide, which can be used as sorbents to clean up spills oil [1].

Biopolymer class materials polyalkanoates and composite materials based on them have now become widespread, thanks to combination of valuable properties: biocompatibility, complete biodegradation under environmental conditions, low toxicity, availability. The most promising biopolymers of the polyalkanoate class—biopolymers based on based on polylactic acid (PLA) and polyhydroxybutyrate (PHB). Materials received based on them, are widely used in medicine, military, agricultural and food industries. Modification of such biopolymers can significantly improve the properties such materials and expand the area applications. Prospects for their use in the oil industry industry are associated with a positive impact on reduction of greenhouse gas emissions during their production, as well as with the ability to decompose in water and CO₂ emissions at the end of its life cycle. Despite disadvantages such as low gas and water protection barrier, low strength, PLA is hydrophobic, which allows use it as an important component in the

composition fibrous materials - sorbents, for eliminating oil spills on the water surface [1]. Increasing sorption sorbent abilities is provided by an effective method of electroforming PLA.

The work shows that when varying technological parameters of the electrospinning process of PLA fiber, microjets of varying thickness are obtained, which ensures different specific surface area of future non-woven ultra-fiber materials.

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EXPLORING THE POTENTIAL OF THE BRICS UNIFIED PAYMENT SYSTEM

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Keywords: *BRICS payment system, CBDC, blockchain, dedollarization, digital platform*

The goal of the research work is to analyze the potential for introducing an unified payment system for the BRICS countries. Using the methods of qualitative analysis, comparison and modelling, the options for the development of a common payment system of the BRICS are studied.

While considering the transition to settlements in national currencies within the BRICS, the following disadvantages were identified: the difficulty in tracking the exchange rates of each currency against each other and the necessary to accumulate reserves for subsequent purchases. In the case of creating a single BRICS currency, the association needs to develop common rules for conducting monetary policy due to the different levels of economic development of the countries and differences in the levels of needs.

In the course of the research work, the most promising options for the development of the BRICS payment system were selected:

- creation of a settlement unit based on a basket of currencies;
- transition to CBDC settlement on the blockchain platform.

In the first case, the share of each country in the basket could be based on the share in trade turnover between countries. In this case, the exchange rate of the BRICS currency against \$ for 2023 could be around 0.1 based on the formula proposed below:

$0.168*BRL + 0.281*RUB + 0.054*INR + 0.468*CNY + 0.028*ZAR$, where BRL - Brazilian real/US dollar exchange rate; RUB - Russian rouble/US dollar exchange rate; INR - Indian rupee/US dollar exchange rate; CNY - Chinese yuan/US dollar exchange rate; ZAR - South African rand/US dollar exchange rate.

CBDC is a digital form of money issued and controlled by a central bank. The transition to CBDC settlement is characterized by the creation of a payment infrastructure with lower transfer costs, 24/7 access to liquidity for banks, leading to financial stability and faster transactions. The platform for realisation of such payments is presented in picture 1:

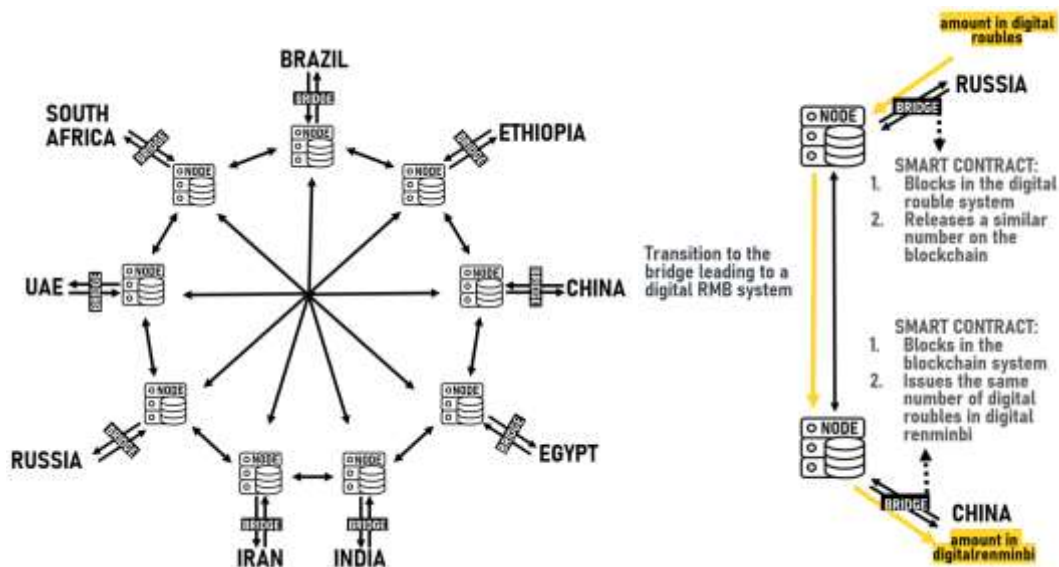


Figure 1 - An example of the CBDC settlement platform in BRICS

As a result of the research work, the following conclusions were made: the issue of developing a secure and independent international payment infrastructure from unfriendly states remains relevant to this day; it is necessary to develop and implement new international payment platforms based on digital currencies, launch their CBDCs in the BRICS countries, strengthen cooperation between the BRICS countries in the field of payment system; this requires: political support, adoption of a new regulatory legal framework for the functioning of national digital currencies and investment in the development of new international payment platforms based on digital currencies.

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INTERNATIONAL INVESTMENT COOPERATION RUSSIA DURING A PERIOD OF INSTABILITY AND RESTRICTIVE SANCTIONS

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Keywords: *investments, international, cooperation, energy sector, technology, knowledge, experience*

The oil and gas complex (NGC) is of indisputable importance for the modern economy of the country. The possible relations between the Russian Federation and friendly countries are analyzed, and favorable outcomes of joint cooperation in the fuel and energy complex (FEC) are established. In a period of global instability, the main goal is to study current trends in international investment cooperation in the Russian Federation in the energy sector.

International investment cooperation implies the interaction of friendly countries to improve and achieve greater efficiency in energy sector projects through the exchange of knowledge and experience. International investment cooperation allows us to develop profitable trade relations, in the process of implementing international projects, the positions of Russian energy sector companies in mutually beneficial markets are strengthened, as well as their competitiveness in the world is increasing.

In 2023, 2.7 trillion rubles of foreign investment in the energy sector came to Russia, and in 2024 they will increase, as the dynamics of investment growth increases every year. Despite the geopolitical instability, they continue to cooperate with Russia and create new projects. To date, relations with China have achieved good results, and the UAE and India are also partners with whom favorable relations are just being built.

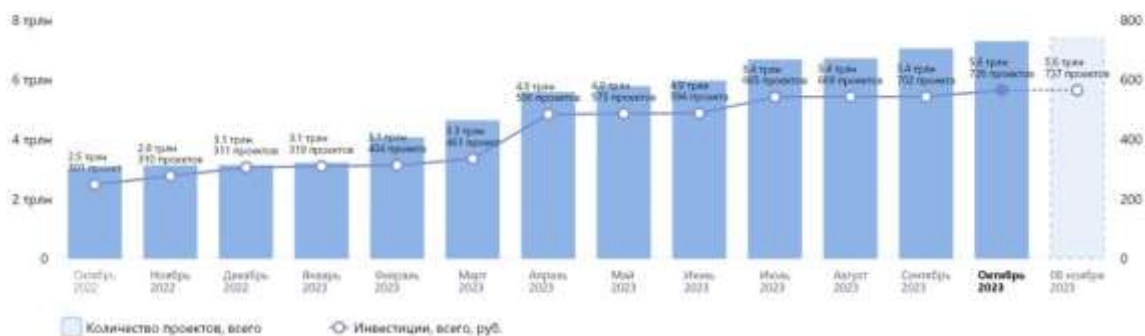


Figure 1 - The volume of investments in active projects in the energy sector

The main flow of investments comes from China, as we have long established mutually beneficial conditions with them, and the UAE invests in Russian projects, and collaborates together during a period of instability. Friendly relations between India and the Russian Federation indicate a promising partnership in the energy sector, and India is gradually joining Russia's projects.

Relations with the United Arab Emirates and India are just beginning to develop, which we need to strengthen and improve, as there is an interest of the countries in partnership with the Russian Federation and further cooperation. Joint efforts and interactions with friendly countries will contribute to the creation of advanced technologies and the introduction of the latest innovations. And also the main task is to keep the main partner of the Russian Federation – China.

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STUDY ON THE INTERACTION BETWEEN PHYCOBILISOME AND ORANGE CAROTENOID PROTEIN

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Keywords: *non-photochemical quenching, phycobilisome, orange carotenoid protein*

To address the problem of unclear interaction mode between orange carotenoid protein (OCP) and phycobilisomes (PBSs) in the non-photochemical quenching (NPQ) mechanism of cyanobacteria, OCP (wild-type and active mutants) and PBSs were prepared using gene combination expression and density gradient centrifugation, respectively, and fluorescence quenching assay was used to explore the interaction between OCP and PBSs. This study is of great significance in elucidating the photoprotective mechanism of cyanobacteria and understanding the photosynthetic evolution process of cyanobacteria, and also lays a certain foundation for the construction and practical application of “photoautotrophic cell factories” based on cyanobacterial cells as chassis organisms.

Cyanobacteria, as crucial photosynthetic organisms on Earth, possess characteristics such as rapid reproduction, nitrogen fixation, oxygen release, and hydrogen production, making them prime candidates for biofuel synthesis [1]. The PBSs within cyanobacterial cells, comprising diverse proteins and hundreds of pigment molecules, serve as light-harvesting complexes efficiently transferring energy to PS I/PS II [2]. At the same time, in order to safeguard against excessive electron transfer that could damage the light system, cyanobacteria have evolved a protection mechanism known as NPQ [3]. In this process, water-soluble OCP, containing carotenoid pigments with numerous unsaturated bonds, is activated by bright light and binds to the PBSs [2,4]. This enables the dissipation of excess excitation energy in the PBSs as heat, thus reducing energy transfer to the photoreaction centers and protecting the photosystem from damage. While studies have shown that NPQ occurs between PBSs and OCP, the specific quenching mechanisms remain unclear due to the complex structure of PBSs.

This study investigated the quenching effect of OCP on natural PBSs using fluorescence detection after heterologous expression of OCP (wild type and active mutant).

The fluorescence emission spectrum of PBSs exhibited its highest peak at 663 nm, with a shoulder peak at 676 nm stemming from the terminal emitters allophycocyanin D or allophycocyanin E (Figure 2a), which confirmed the existence of a complete energy transfer chain within the PBSs. The fluorescence spectrum of the PBSs was blue-shifted by about 6 nm after quenching (Figure 2a), and its fluorescence lifetime was reduced from 1.75 ns to 1.52 ns (Figure 2d). These alterations may be attributed to the dissociation of functionally associated phycocyanin rod. At the experimental concentrations, the quenching efficiency of OCP^R on PBSs was only 12.6%~17% at the highest, whereas OCP^{AA} exhibited a quenching efficiency of approximately 50% (Figure 2b). This discrepancy may be related to the chromophore binding rate as well as the stability of the active state of OCP. Based on the fitting results, the rate of fluorescence quenching at 663 nm was calculated as $k_1=0.814\pm 0.040 \text{ min}^{-1}$ and $k_2=0.089\pm 0.040 \text{ min}^{-1}$, suggesting that the quenching presented two processes, one was fast and the other was slow (Figure 2c). The Stern-Volmer curve illustrated that the OCP-PBSs complex retained part of the fluorescence (Figure 2e), indicating that due to the large molecular weight and complex structure of the PBSs, OCP could only quench fluorescence from specific PBS regions without forming a non-luminescent quenching complex. Moreover, a portion of energy transfer within PBSs persisted. Therefore, the interaction between OCP and PBSs was more likely to be carried out by partial energy transfer between the carotenoid pigment in OCP and phycocyanobilin in PBSs. These findings contribute to the ongoing discourse on OCP-PBSs interaction dynamics.

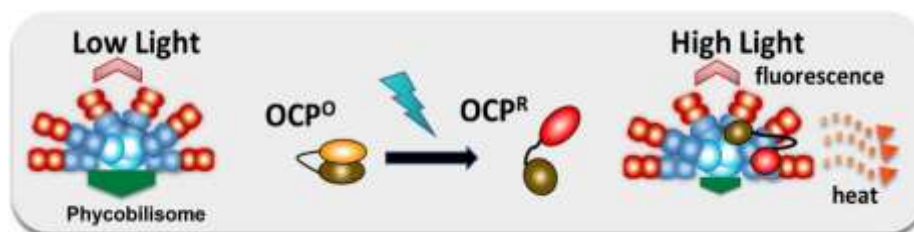


Figure 1 - Model diagram of the mechanism of non-photochemical quenching

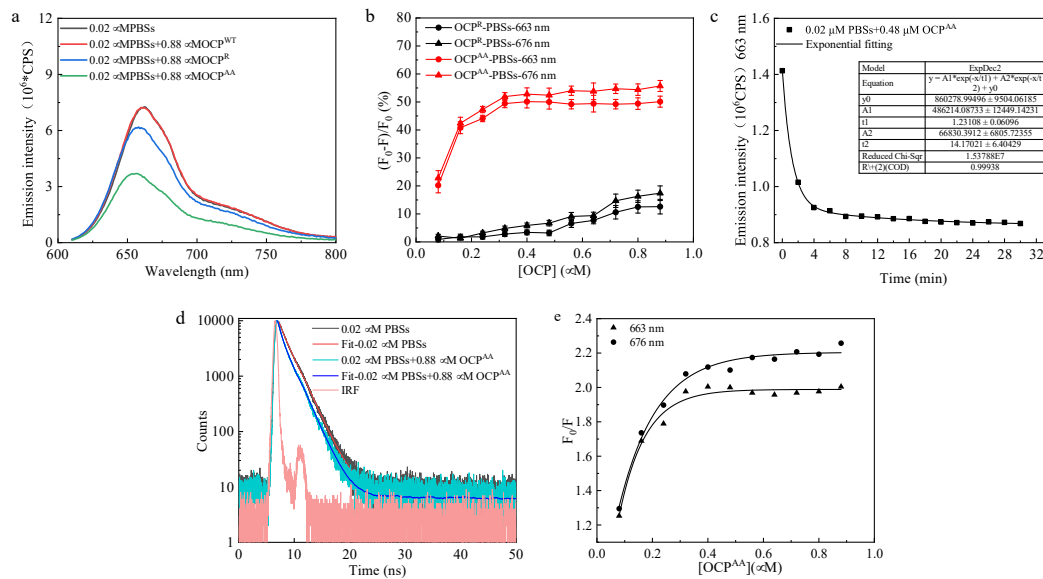


Figure 2 - The interaction between OCP and PBSs. (a) The fluorescence spectra of PBSs before and after the addition of OCP. OCP^{WT}, resting state; OCP^R, quenching active state, is obtained by OCP^{WT} illumination for 20 min; OCP^{AA}, OCP^(W288A,Y201A), stable active mutant. (b) Quenching efficiency. F_0 , the initial fluorescence value; F , fluorescence value after 20 min of OCP reaction; circle, $E_m=663$ nm, triangle, $E_m=676$ nm; (c) Fluorescence Intensity-Time. (d) Fluorescence lifetime of PBSs. (e) Stern-Volmer curve

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**WORKS OF THE DEPARTMENT OF PHYSICAL AND COLLOID CHEMISTRY
OF THE RUSSIAN STATE UNIVERSITY OF OIL AND GAS IN THE FIELD OF
“GREEN” ENERGY**

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Keywords: *greenhouse gas sequestration, enhanced oil recovery, hydrate gas production*

One of the main tasks of our time is to preserve the climate and ecology on Earth. To do this, it is necessary to reduce greenhouse gas emissions into the atmosphere and reduce its thermal pollution, for which it is necessary to reduce energy consumption, the use of harmful technologies, and the emission of harmful substances. Taking into account the oil profile of our university, specialists of the department work in the following directions using physical and physical-chemical experiment methods:

- Research and optimization of the processes of burial (sequestration) of greenhouse gases in geological traps (aquifers and depleted oil reservoirs) in order to reduce the costs of sequestration, increase the capacity of geotraps due to microencapsulation, increase the positive effect of sequestration (additional oil).

- A promising method for producing hydrated methane (inhibitor-substitution method of production). Methane is an environmentally friendly fuel, and the resources of hydrated methane are the largest on our planet (exceeding the total reserves of oil, conventional gas, coal, peat and firewood).

- Reduce energy consumption while increasing oil recovery from depleted formations by maximizing the use of reservoir residual oil, water and minimizing the use of chemical reagents.

The report will provide information on research results.

1. Physical modeling has shown that the effective capacity of a deep-lying aquifer is no more than 40% of the pore volume, regardless of the state of the injected fluid (gas, liquid, supercritical state).

2. To increase oil recovery from a hydrophobic low-permeability carbonate reservoir, the immiscible water-gas effect shows satisfactory results due to the combination of the regulating effect of the water rim and the effect of gravitational flow of oil.

3. In conditions of depleted light oil reservoirs, sequestration of greenhouse gas in the form of a water-gas mixture (microencapsulation) makes it possible to increase the efficiency of displacement of residual oil and increases the capacity of the geological trap.

4. A new inhibitor-replacement method for methane production from natural hydrates with simultaneous sequestration of carbon dioxide has been proposed and studied, consisting of sequential or simultaneous injection of a thermodynamic inhibitor (alcohols or electrolytes) and carbon dioxide into the hydrate reservoir.

5. To reduce costs when implementing a greenhouse gas sequestration project, it is proposed to gradually commission the technological chain for preparing gas for disposal through the use of flue gas in the first stages of the project, followed by a gradual increase in CO₂ concentration. A technological scheme for sequestering greenhouse gases in geological traps (aquifers and oil formations) has been proposed.

6. To reduce energy costs while increasing oil recovery from depleted formations (Ural-Volga region, high salinity of water, low reservoir temperature), compositions for water isolation and flow diversion with the formation “in situ” in the wellbore zone of reverse emulsions from residual oil, mineralized water and a minimum amount of oil-soluble Non-surfactant Neolol AF9-6. The studies were carried out on the example of terrigenous Carboniferous and Devonian strata.

Some more about the objectives of the research. In the conditions of a northern and vast country like the Russian Federation, large consumption of hydrocarbon raw materials for petrochemicals and fuel are inevitable. Energy consumption can only be reduced by reducing it's consumption, including during oil production period, for example, during greenhouse gas sequestration. Oil reservoirs are the most promising geotraps, but their capacity largely depends on the degree of oil recovery. Therefore, properly planned sequestration allows both increase the capacity of the trap and obtain energy and funds for sequestration. The authors believe that oil and gas production and greenhouse gas sequestration are not antagonists, but will increase the oil recovery factor of reservoirs and reduce energy costs for production. It takes more energy to extract and process hard to

extract oil than it does to extract and process light oil from depleted reservoirs. For now, extensive reserves of hydrated methane are not being developed due to the lack of technological and economic extraction methods. Sooner or later we will have to start extracting hydrated methane (an environmentally friendly fuel). Therefore, similar studies have been conducted all over the world for the last 10-20 years.

ENVIRONMENTAL ENERGY OF THE GAS INDUSTRY

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Keywords: *ecology of the gas industry, coalbed methane, renewable energy sources, costs, efficiency, advantages and disadvantages of energy*

The most efficient and environmentally friendly resource is gas. As environmental and economic researches show, gas has the following advantages:

- low cost of production;
- diversification in transportation (pipeline, LNG);
- minimum emissions of harmful substances into the atmosphere;
- easy to control during mining and transportation,
- few maintenance personnel are required;
- easily adjustable burning process;
- high efficiency and calorific value,
- environmentally friendly fuel, no ash and smoke are formed during combustion,
- generates less carbon dioxide than other fuels.

Gas is extracted from the reservoir much more easily than oil. During the development of gas fields, the GEC (gas extraction coefficient) is 60-80%. Gas is extracted from various fields: onshore and offshore. Large reserves of methane are contained in coal seams, which is an advantage of the development of the gas industry.

Gas is the most efficient energy resource compared to other types of resources. It is widely used in many sectors of the national economy: 48% of gas is consumed for electricity production, 19% in industry, 15% in housing and communal services, and 10% in gas chemistry. A wide range of products is produced from gas: fuels, polymers, plastics and other products.

There are many coal basins in the world. Coal reserves in Russia are 157010 million tons. The greatest gas content of coal seams is at a depth of 300-400 meters. The methane content is 40-50 cubic meters per 1 ton of coal. Taking into account the methane content, it is possible to determine the average reserves: about 83.7 trillion cubic meters, production of

52 billion cubic meters. Methane reserves in the coal seams of Russia account for about 30% of natural gas reserves. China has methane reserves of 35 trillion cubic meters, production of 12 billion cubic meters.

Coalbed methane is called sweet gas because it does not contain hydrogen sulfide. Gas composition: methane 80-98%, no heavy gases (ethane, propane), no condensate and carbon dioxide. The cost of methane production is 20-40 USD/thousand cubic meters.

Public Joint Stock Company Gazprom plans to produce liquefied natural gas from coalbed methane in 2024. The development of unconventional hydrocarbons is becoming a new important area of global energy development. Thus, according to the International Energy Agency (IEA), the production of unconventional gas in 2010 amounted to 73 billion cubic meters, or about 15% of world production, and is projected to increase to 820 billion cubic meters in 2035.

When replacing gasoline with coal methane, the release of toxic components into the surrounding atmosphere decreases: by 5-10 times carbon monoxide. The largest project was implemented in China in Shanxi Province — a 120 MW coal-fired methane power plant was commissioned at the Sihe mine in 2009. The power plant consists of 60 Caterpillar G3520 (1.8 MW each) and four G3612 (2.9 MW each) units, as well as two recovery boilers and four steam turbines/ The power plant has a capacity of 120 MW. The main fuel is coal methane. The general designer was the Chinese company Jincheng Anthracite Coal Group. This project is the largest in the world for the utilization of methane.

Utilization of mine methane will reduce greenhouse gas emissions into the atmosphere by 4.5 million tons during 20 years of operation of power equipment.

One of the promising areas is the use of coal methane in the chemical industry. It can be used to produce carbon black, hydrogen, ammonia, methanol, acetylene, nitric acid, formalin, plastics and artificial fibers.

Renewable energy sources are also environmentally friendly fuels. But on the other hand, renewable energy sources have a harmful environmental impact on the environment.

Solar cells are made from dangerous rare metals (germanium, vanadium, bismuth). The disposal of these elements requires a lot of expenses.

Wind energy has a noisy environmental impact on the nervous system of people and living organisms (plants die, fish and animals leave for other areas). Wind turbine syndrome

affects humans - tinnitus, dizziness, panic attacks, migraines, violation of the vestibular system from turbine noise. Wind turbines should be installed at a far distance from people's homes

Geothermal energy contains high mineralization of underground thermal waters, toxic compounds and harmful elements are present. Discharge of waste thermal waters into reservoirs is not possible.

Biomass energy - leads to the release of pollutants into the environment, large areas of agricultural land are not used for growing food, but are used for growing biomass.

When using renewable energy sources, large capital and operating costs are required.

When producing energy, it is necessary to use the principle of diversification. In one region to use renewable energy sources, in another to use traditional types of energy. Renewable energy is used in some industries, and oil and gas energy is used in other industries. To use hydrocarbon energy in large enterprises, to use renewable energy in small enterprises, in small and medium-sized businesses.

Conclusion. As environmental and economic researches show, gas is the most effective resource for this period of time.

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DESIGN AND SYNTHESIS OF MULTIFUNCTIONAL ALLOY CATALYTIC CLUSTERS BASED ON SHORT PEPTIDE MODIFICATION

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Keywords: *AuCdNCs, short peptide, fluorescence, enzyme-like activity*

A novel alloy-catalytic cluster (KCK-AuCdNC) with high enzyme-like activity was synthesized by designing a short peptide sequence, doping cadmium element, and using water synthesis method. The average particle size of KCK-AuCdNC is 1.46 ± 0.05 nm, and there is an absorption peak at 580 nm. It has non-blinking fluorescence properties and is suitable for fluorescence labeling imaging. KCK-AuCdNC have peroxidase activity and good antioxidant capacity. Active oxygen detection indicators and fluorescence imaging confirmed that KCK-AuCdNC can be used for efficient removal of reactive oxygen species in living cells.

Metal nanoclusters (MNCs) are characterized by their enzyme-like activity.^[1] Structurally, MNCs are hierarchical, composed of metal nuclei, sulfhydryl arms, and peripheral organic ligands, positioning them as a unique category of functional nanomaterials. Currently, MNCs with peroxidase-like activity exhibit several limitations, such as low catalytic efficiency, poor specificity, and potential cytotoxic effects, including oxidative stress, inflammation, and apoptosis.^[2]

Addressing these challenges, the modification of surface ligands and metal constituents plays a crucial role in enhancing the protective and functional attributes of composite nanoclusters.^[3] These modifications significantly influence their catalytic behavior, photoluminescence, and optical chirality, which are pivotal for designing functional alloy nanocrystals targeted at applications in sensing, catalysis, and biomedicine. Consequently, the strategic synthesis of ideal functional alloy nanoclusters through ligand regulation represents a promising direction in nanomaterial research.

We synthesis of gold nanoclusters (AuNCs) using short peptide sequences consisting of lysine and cysteine (KCK) as ligands, with HAuCl_4 as the gold precursor, performed via an aqueous synthesis method. The incorporation of Cd^{2+} at a gold-to-cadmium ratio of 24:1

altered the clusters' properties, evidenced by a broader emission spectrum, reduced excitation center, and a shift in light absorption toward 600 nm (Fig. 1a), confirming successful integration of Cd^{2+} . Transmission Electron Microscopy (TEM) analysis demonstrated a notable decrease in particle size (Fig. 1b). Compared with before doping, the cluster network structure becomes sparse and has peroxidase activity.

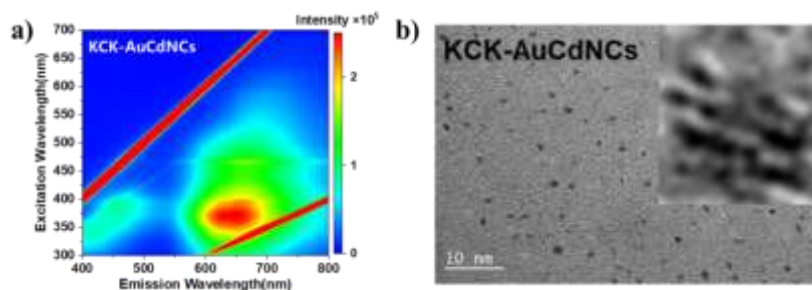


Figure 1 - Alloy catalytic clusters with (a) 3D fluorescence spectra and (b) TEM images

The peroxidase-like activity of these doped nanoclusters (KCK-AuCdNCs) was verified using both the TMB display agent method and Amplitude™ IR fluorescence technique. Additionally, antioxidant capabilities were assessed using an ABTS assay, which confirmed that KCK-AuCdNCs effectively scavenge reactive oxygen species (ROS). Cellular experiments substantiated the rapid uptake of KCK-AuCdNCs by cells, and subsequent tests employing the DCFH-DA ROS detection probe and fluorescence imaging clearly demonstrated the nanoclusters' capacity to efficiently remove ROS in living cells (Fig. 2a-d).

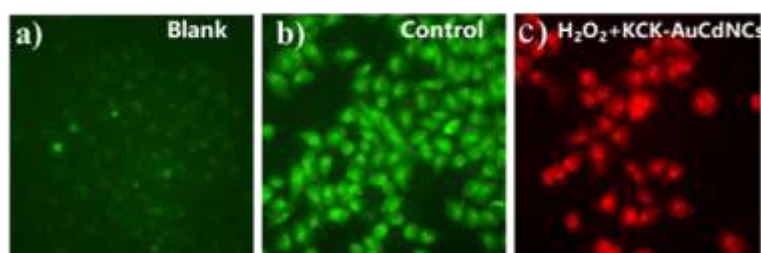


Figure 2 - Fluorescence images of alloy catalytic clusters on the level of intracellular scavenging of reactive oxygen species (a) blank group, before (b) as well as after (c) addition of alloy catalytic clusters after H_2O_2 treatment

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PLASMA TECHNOLOGIES APPLICATION IN WASTE DESTRUCTION PROCESSES

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Keywords: *plasma chemical destruction, active plasma particles, streamer corona discharge, waste treatment*

A new type of installations for solid waste treatment on the basis of non-thermal plasma has been created. The method is based on technologies of waste disposal using the low temperature atmospheric plasma initiated with streamer corona electrical impulse discharges. The study of processes occurring in the destruction camera will allow to choose optimal conditions for the waste destruction.

Waste recycling is one of the central problems of our time, since traditional storage facilities take away huge areas of land. A new approach is low-temperature plasma technology, which can be used in waste recycling processes.

The relevance of this study is due to the need to implement these technologies, study the physical and chemical processes of their implementation, and the need to analyze emissions generated during waste disposal.

Plasma chemical destruction of waste is the process of decomposition of waste through the action of particles with high chemical activity formed in a nonequilibrium plasma of atmospheric pressure. The process takes place in an industrial installation, the main element of which is the destruction chamber (destructor).

The primary process, determining the formation of corona discharge streamers, is the excitation of air and water molecules in the destructor chamber, resulting from electron impacts accelerated by an external electric field. The difference between this technology and previously known plasma waste disposal processes is that the process temperature is close to room temperature, and this eliminates the possibility of the formation of toxins and carcinogens, for example, dioxins and benzopyrenes.

The generator creates a high pulse voltage on the chamber electrodes, which causes breakdown of the discharge gap. With each pulse, a large number of streamers appear around the electrodes of the destructor chamber, which begin to multiply and spread throughout the volume of the chamber, filling the volume around its electrode.

In the plasma of a pulsed corona discharge, free radicals H and OH are formed from water molecules (the primary process of formation of active particles).

In the destructor chamber, under the influence of the discharge, other active substances, radicals, and excited particles in various quantum states are formed, for example, O₃, O₂(a¹Δ), H₂O₂, O(³p), NO, HNO₂ and HNO₃. These active species and UV radiation have a destructive effect on any organic and inorganic substances contained in the processed waste, which leads to their complete destruction with the formation of harmless gaseous reaction products - water vapor, nitrogen, oxygen and carbon dioxide. Inorganic components of waste can be destroyed by the resulting acids. The processes of oxidation of organic substances in water are chain reactions [1].

In the plasma of a pulsed corona discharge, electrons with different energies collide and activate molecules N₂, O₂ and H₂O in the air of the destructor and also with molecules NO, O(³P) and O₂(a¹Δg), formed from them.

The use of plasma-chemical technology does not require high electric energy consumption and is intended for the neutralization of solid, liquid, gaseous and paste waste. However, the processes occurring during the described disposal method have not yet been sufficiently studied due to the complex composition of the object. The purpose of further research is to study physical and chemical processes, selection of the kinetic parameters of possible reactions, studying the influence of modes on the efficiency of waste processing and minimization of the secondary impact on the environment.

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NOVEL MACROCYCLIC POLYAMINES REGULATED NANOFILTRATION MEMBRANES: TOWARDS EFFICIENT MICROPOLLUTANTS REMOVAL AND MOLECULAR SEPARATION

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Keywords: *interfacial polymerization, cyclen, loose nanofiltration membrane, organic micropollutants/salts separation, antifouling*

In this study, a free nanofiltration membrane (LNF) is fabricated by interfacial polymerization with 1, 4, 7, 10-tetraazacyclododecane (Cyclen) as a novel aqueous phase monomer to modulate the polyamide microstructure. Compared to PIP-based NF membrane, the fabricated Cyclen-TMC LNF membrane has a smoother surface, a higher density of carboxyl groups and a lower degree of crosslinking. The Cyclen-TMC membrane exhibits a significant amount of water and 92.7% for methyl blue and tetracycline (pH = 9), while maintaining low rejection for monovalent salts (e.g. 4.5% for NaCl). In addition, the LNF membrane exhibits excellent antifouling performance due to its relatively smooth, highly negatively charged surface and low operating pressure.

The discharge of wastewater containing organic micropollutants not only causes severe environmental pollution, but also exacerbates the scarcity of freshwater resources and poses a serious threat to human health^[1]. The nanofiltration (NF) membrane has unique advantages and obvious energy-saving effects in the demineralization of organic micropollutants^[2]. Poly(piperazine) amide NF membrane exhibits the poor organic micropollutants/salt selectivity and low water permeance^[3]. Therefore, developing a novel NF membrane with high water permeance and superior selectivity is of significance. In this study, a loose nanofiltration (LNF) membrane is fabricated by interfacial polymerization with 1, 4, 7, 10-tetraazacyclododecane (Cyclen) as a new aqueous phase monomer to modulate the polyamide microstructure. Compared with the PIP-based NF membrane, the fabricated Cyclen-TMC LNF membrane has a smoother surface, a higher density of carboxyl groups, and a lower degree of cross-linking. Cyclen-TMC membranes provide highly efficient organic micropollutant removal and molecular separation.

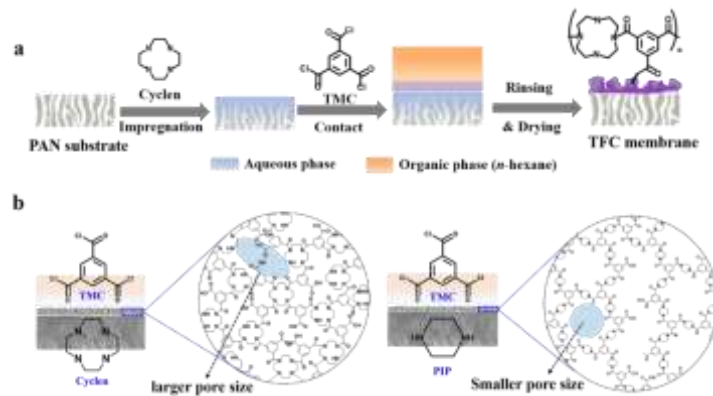


Figure 1 - Schematic diagram of the preparation process and microstructure of LNF membrane

The IP process and PA chemical structures are illustrated in Figure 1. Firstly, the PAN substrate is immersed in Cyclen or PIP aqueous solution (0.5 wt./v%) for 5 min. Next the surplus aqueous solution is poured off and drained off with an air knife. Afterwards, TMC in n-hexane (0.15 wt./v%) solution is poured onto the above surface for 90 s. Lastly, after washing with n-hexane, the membranes are heated at 60 °C for 5 min and stored in DI water for further testing. The fabricated NF membranes with Cyclen and PIP monomers are abbreviated as Cyclen-TMC and PIP-TMC, respectively.

Due to the larger spatial structure of the Cyclen monomer, the diffusion rate is slower and the reaction rate with TMC is slower, which results in the formation of a PA separator layer with a smoother, more hydrophilic surface and lower cross-linking (Figure 2). The prepared Cyclen-TMC membranes show high rejection of organic contaminants (>93%) and low rejection of salt (<19%) with good organic micropollutant/salt selectivity while ensuring excellent water permeance (Figure 3). In summary, Cyclen-TMC membrane has a broad application prospect in organic micropollutant wastewater treatment.

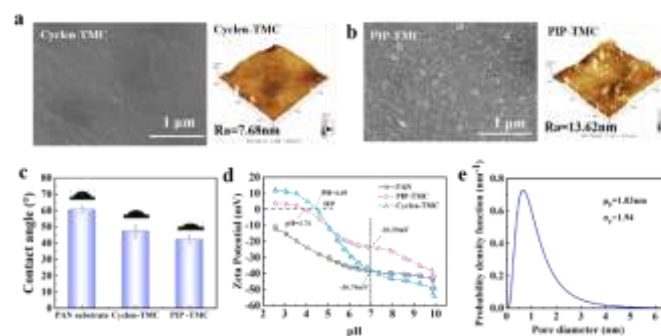


Figure 2 - Surface physical and chemical properties of the TFC membranes

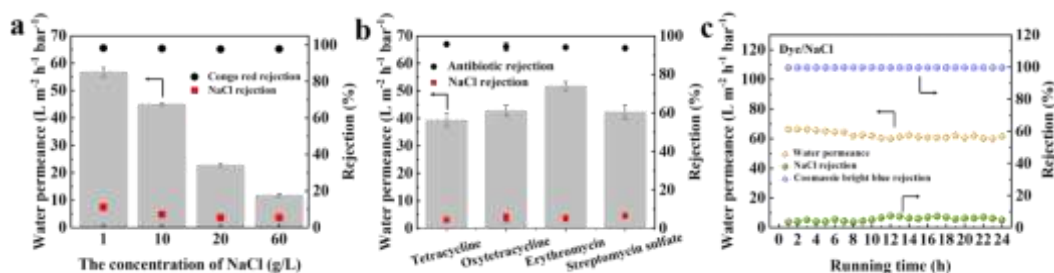


Figure 3 - Separation performance of the TFC membranes

In this study, a novel TFC membrane is fabricated for the selective separation of organic micropollutants/salts using the IP technique. The enlarged molecular structure and slow diffusion rate of the novel macrocyclic polyamine monomer Cyclen contribute to the formation of a loose PA layer with large pore size. Consequently, the Cyclen-TMC membrane can effectively separate organic micropollutants/salts ($S_{\text{NaCl/dye}} > 144$, $S_{\text{NaCl/antibiotic}} > 16$) with high water permeance (pure water permeance $> 54 \text{ L m}^{-2} \text{ h}^{-1} \text{ bar}^{-1}$).

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A SMART GREEN ENERGY-SAVING WINDOW

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Scientific adviser: Doctor of Chemical Engineering, Associate Professor Na Li

Keywords: *smart windows, electrochromic, reversible metal electrodeposition*

As the global consequences of climate change worsen, developing effective ways to minimize energy consumption has become an important subject. Smart windows, capable of dynamically modulating both light and heat flow into and out of buildings, have garnered more attention as a solution. Here, we developed a smart window using the reversible metal electrodeposition (RME) process. The incident light is absorbed or reflected because of the electrodeposition of metal onto the electrode surface. Such a smart window is promising to reduce heating and lighting, which may bring new insights into the design of the next generation of green buildings.

Using the Au/Ag alloy as stable anchoring sites, we eliminate the random self-nucleation events during the Ag deposition to achieve optimal reversibility in color switching. This strategy takes advantage of the pre-formed nanoparticles as the “seeds” to avoid the need for templates and enables instant color switching by utilizing the electrochemical process to drive the fast overgrowth and dissolution of silver atoms surrounding the seeds.

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COOPERATION IN GREEN FINANCE BETWEEN THE PRC AND RUSSIAN FEDERATION

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***Keywords:** environmental protection; green finance; green financial market; green bonds; sustainable development*

This thesis mainly starts from insighting the current status of green finance between China and Russia and introduces the current cooperation sustainable policies in both countries, which conducted and operated by China and Russia. This thesis focuses on discussing the problems and challenges encountered by the two countries during developing green financial cooperation economically and policy-wise, and giving countermeasures and suggestions on these problems and challenges. The purpose of this thesis is to provide further insights into green financial cooperation between China and Russia.

Sustainable Energy refers to non-fossil energy such as wind energy, solar energy, etc. It can be recycled and regenerated in nature and is inexhaustible. The development of sustainable energy can play a vital role in the development of green finance, energy conservation and emission reduction. A series of studies have shown that the development and implementation of sustainable energy can further stabilize national energy security and effectively develop energy diversity.

At this stage, Chinese government is vigorously promoting "Green Finance". The People's Bank of China (PBoC) defines it as "Financial Services - provided to support Economic Activities, which support Environmental Improvement, Climate Change Mitigation, and more efficient use of resources." Moreover, both China and Russia are currently in the process of transforming from a traditional industrial country to a new energy sustainable development country. On one way, there are relatively many problems faced, and the government's investment into green finance is relatively high, on the other hand, the need for green financial cooperation between China and Russia is increasing day by day, with the deepening of cooperation between the two countries, environmental issues are also

increasing. Therefore, coepeated susatanable development of green economy is crucial to the local economies of both countries.

The biggest cooperation in green finance between China and Russia is the *One Belt, One Road Initiative*. The demonstration effect of the *One Belt, One Road Initiative* cooperation between China and Russia is gradually becoming apparent. In addition, China and Russia have also carried out close cooperation under the BRICS cooperation framework and the SCO cooperation framework, which has greatly expanded the integration of the *One Belt, One Road Initiative* and deepened cooperation in both countries. In the face of increasingly severe global climate change and ecological environment problems, the *Green One Belt and One Road Initiative* has become an important feature of high-quality joint construction of the *One Belt and One Road Initiative*.

As a result, both China and Russia have proposed the goal of carbon neutrality and carried out low-carbon green cooperation under the framework of the *One Belt, One Road Initiative*. China and Russia have established an environmental cooperation subcommittee under the Prime Minister's Regular Meeting Committee to jointly coordinate cooperation between the two countries in the field of green and low-carbon environmental protection. Cooperation between the two countries in solid waste treatment, green finance, low-carbon green technology and environmental protection industries continues to make progress. In addition to that, in terms of cooperation in biodiversity, China and Russia have launched cooperation over the protection of Arctic biodiversity species and carried out cross-border biodiversity protection between China, Russia and Mongolia. With the current round of global technological, the wave of digital economy is gradually rising, and the revolution is mainly reflected in the development of digital technology. *The Digital One Belt and One Road* also constitutes an important feature of high-quality construction of the *Initiative*. China-Russia cooperation in the field of digital economy continues to deepen and has gradually become a highlight of cooperation between the two countries. [1,2]

Based on the fruitful cooperation between China and Russia on the *One Belt and One Road Initiative*, and in order to fully implement the China-Russia Comprehensive Strategic Partnership of coordination in the new era. The suggestions are listed below:

1. Persist in advocating and promoting the development of globalization, comprehensively improve the level of liberalization and facilitation of Sino-Russian

economic and trade cooperation, and promote Sino-Russian trade and investment to increase in volume and quality;

2. Comprehensively deepen cooperation in the green field, increase mutual investment in low-carbon, environmentally friendly and energy-saving projects, and focus on environmental protection, energy conservation and emission reduction in infrastructure construction;

3. Strengthen the connection between the financial systems of the two countries, expand the scope of settlement in local currencies, coordinate cross-border inter-bank payment systems of the two countries, and promote the formation of a settlement system for bulk products such as energy and grain between the two countries.

In short, the cooperation in green finance between China and Russia is a necessity and a mutual need to both countries and both countries' people.

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THERMAL REDUCTION COMBINED WITH HIGH TEMPERATURE SOLID PHASE FOR REGENERATE SPENT LITHIUM-ION BATTERY CATHODE MATERIALS

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Keywords: *petroleum coke, spent cathode materials, regeneration*

The wide application of Lithium-ion batteries (LIBs) also leads to a large number of spent LIBs. Recycling spent cathode materials is particularly important as they contain important strategic metals. However, the existing methods for recycling spent cathode materials are inefficient, costly and environmentally polluting. In this study, petroleum coke is used to reduce the spent cathode materials to Ni, Co, MnO and Li_2CO_3 . Then the reduced materials are directly regenerated to cathode materials. The results show that the regenerated cathode materials have excellent electrochemical properties. This work provides a highly effective for the regeneration of cathode materials.

LIBs are widely used in electric vehicles and energy storage power plants due to the high energy density and environmental friendliness^[1]. At the same time, this also leads to the emergence of a large number of spent LIBs. Spent LIBs have the dual attributes of environmental risk and resource value, especially the cathode materials, in which the valuable metals are not only pollution sources but also important metal resources^[2, 3]. Therefore, there is an urgent need to develop effective recycling methods for spent cathode materials to efficiently recycle and reuse valuable metals^[4]. The spent cathode materials are reduced to Ni, Co, MnO and Li_2CO_3 by petroleum coke, a petroleum by-product (Figure 1(a)). Then, the reduced materials are directly regenerated to cathode materials by high temperature solid phase method. The regenerated cathode materials show excellent electrochemical properties, with the specific charging capacity of $190 \text{ mAh}\cdot\text{g}^{-1}$ at 0.1 C (Figure 1(b)).

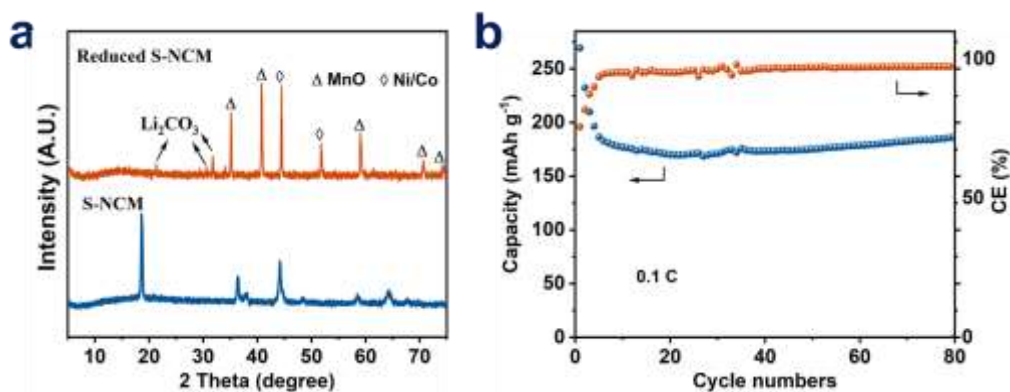


Figure 1 - (a) XRD patterns of spent cathode materials and reduced spent cathode materials. (b) The cycling performance of regenerated cathode materials at 0.1 C

The reduction of spent cathode materials:

The mixture of spent cathode materials and petroleum coke is roasted at 700 °C in nitrogen atmosphere for 1.5 h to reduce the spent cathode materials.

The regeneration of cathode materials:

The reduced spent cathode materials are first roasted at 700 °C for 2 h, and then added Li_2CO_3 and roasted at 900°C for 10 h to regenerate $\text{Li}_{1.2}(\text{Ni}_{0.23}\text{Co}_{0.08}\text{Mn}_{0.49})\text{O}_2$ cathode materials.

In summary, the spent cathode materials are firstly reduced to Ni, Co, MnO and Li_2CO_3 by thermal reduction method. Then the cathode materials with excellent electrochemical properties are successfully regenerated by high temperature solid phase method. The electrochemical test results show that the specific charging capacity of the regenerated cathode materials reach $190 \text{ mAh}\cdot\text{g}^{-1}$ at 0.1 C.

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CHALLENGES OF CHINA AND RUSSIA COOPERATION IN PETROCHEMICAL SPHERE

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Keywords: Russia-China cooperation, oil and gas companies, petrochemistry, low-carbon development, sanctions

In accordance with the Concept of the Russian Federation's Foreign Policy in 2023 [1], Russia's cooperation with China in all areas is comprehensive, equitable, trust-based, and strategic. With the closure of markets in unfriendly countries, China has indeed become a strategic partner, and cooperation in the oil and gas industry between the two countries is reaching unprecedented heights. Russia is interested in cooperating with China to develop mutual petrochemical projects, which can demonstrate more opportunities to enhance the technical potential of both countries. The purpose of this research is to delve into the challenges Russia faces when making efforts to cooperate with China in the petrochemical sphere.

Firstly, we would like to highlight the source orientation of Russian and Chinese cooperation in the energy sphere. According to the General Customs Administration of the People's Republic of China, oil supplies to China increased by 24% in 2023. Russia is the undisputed leader in terms of oil supplies, with 107 million tons of oil exported (Saudi Arabia, the second-largest oil exporter to China, exports 86 million tons). Natural gas supplies increased almost 1.5 times in 2022 [2]. However, the share of crude oil and natural gas in Russian exports to China is enormous, accounting for about 75% of the total export [3]. It means that the largest part of trade between countries is connected with low-priced resources and not with products of processing and petrochemistry.

Secondly, Russia has already made efforts to cooperate with China in petrochemistry, but the project is still not realized. Rosneft and CNPC started discussion of big joint project of constructing oil refinery and petrochemical complex in Tianjing city in China and several hundreds of gas stations [4]. The capacity of the Tianjin Refinery for primary oil refining should be 16 million tons per year, and the refining depth should be more than 95%. On

March 22, 2013 in Moscow, during the first foreign visit of the President of the People's Republic of China Xi Jinping, an «Agreement between the Government of the Russian Federation and the Government of the People's Republic of China on cooperation in the construction and operation of the Tianjin Oil Refinery and Petrochemical Plant and projects in the field of oil exploration and production» was signed. However, due to unknown reasons, the project is still on a preliminary stage of development. Reasons may be the following: transformation of Chinese oil products market conditions, environmental concerns due to potential pollution and impact on surrounding ecosystems, sanctions of western countries towards Russia, issues of unsuccessful price negotiation. These factors, among others, may have contributed to the delays in realizing the Rosneft and CNPC refinery project in Tianjin. Overcoming these hurdles will require strategic planning, effective collaboration, and continuous efforts to address the challenges faced by the project.

Thirdly, the biggest issue which lead to delaying the cooperation of Russia and China in petrochemical sphere is China's desire to purchase low-priced oil resources from Russia according to the current agreements and proceed it independently to develop petrochemical industry of China. It can be true due to the reason that China's petrochemical industry is one of the most developed in the World. China ranks second in terms of oil refining capacity in the world at 865 million tons per year, according to the Energy Institute [5], which is 16.9% of the world's oil refining volume. For comparison, in Russia this figure was 341 million tons per year and 6.7% of the world capacity, respectively. Most of contracts signed between Russia and China in energy sphere is connected with supply of hydrocarbons for Chinese refineries, which can be the evidence of Chinese policy of stimulation of country's petrochemical industry with Russian cheap resources. For instance, in 2022 CNPC and Rosneft signed an additional agreement on delivery of crude oil for its refineries in the eastern part of China [6].

Nevertheless, perspectives of China and Russia cooperation in the petrochemical sphere are multifaceted. China's growing energy demands and Russia's vast reserves of oil and natural gas make them natural partners in the field of petrochemicals. By working together, China and Russia can capitalize on each other's strengths and create a more efficient supply chain for energy resources. This can lead to cost savings, increased production capacity, and enhanced competitiveness in the global market. By collaborating

effectively in this strategic sector, both countries stand to benefit in terms of economic growth, energy security, technological advancement, and environmental sustainability. In this way, Russia will diversify cooperation with China and break the establish trend on source cooperation to increase the added cost of Russian export to China.

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HIGH-PERFORMANCE POROUS ALUMINA MATERIALS: SYNTHESIS AND APPLICATIONS

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Keywords: *alumina; synthesis; application; pore structure; catalysis*

An inorganic ion intercalation method was developed for the preparation of alumina nanofibers with both high surface and large pore volume. This material exhibits high performance in the catalytic cracking of vacuum gas oil.

Alumina is an important industrial material, widely applied in catalysis, adsorption and separation. However, the poor textural properties of the traditional alumina have limited its application in catalysis. Therefore, a considerable effort has been devoted to the preparation of mesoporous alumina with new structural properties.

Different types of alumina materials show better performance than that of traditional commercial alumina in a variety of catalytic reactions and adsorption applications, involving propane dehydrogenation, cyclohexanone condensation, heavy oil catalytic cracking, reaction adsorption desulfurization, etc. The excellent catalytic performance of the obtained alumina is mainly attributed to its superior pore structure and unique surface chemical properties.

However, most of the previous approaches involve the use of costly organic templates, which is costly and the removal of templates by calcination releases polluting emissions. What's more, as the organic templates are not able to generate intracrystalline porosity, there exists a contradiction between high surface area and large pore volume. Those materials with large pore volume commonly exhibit a low surface area. Recently, we prepared alumina nanofibers (Figure 1) with both large pore volume ($> 2.8 \text{ cm}^3/\text{g}$) and high specific surface area ($> 650 \text{ m}^2/\text{g}$) by inorganic ion intercalation method in the absence of organic templates. The alumina nanofibers exhibited a superior catalytic performance than that of commercial alumina in the fluid catalytic cracking (FCC) of vacuum gas oil (VGO). Using this alumina nanofiber as the matrix, the VGO conversion of FCC catalyst was increased by 2.21% with the yield of gasoline enhanced by 4.40%.

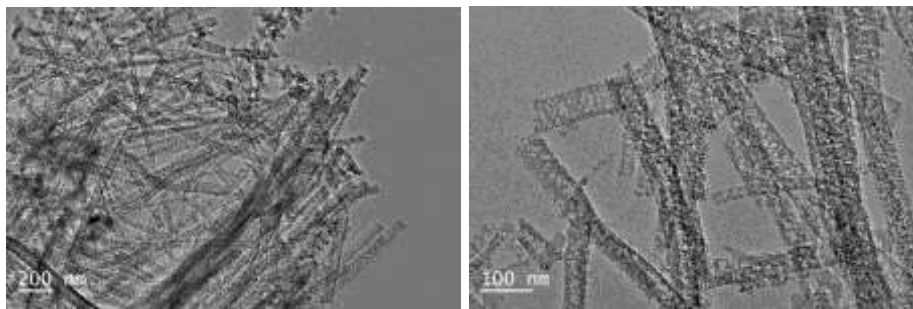


Figure 1 - TEM images of alumina nanofibers

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TECHNOLOGIES OF SOFC AND SOEC STACKS GLASS SEALANT APPLYING

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Keywords: *glass, sealant, SOFC, stack, casting method, screen-printing method*

Glass and glass-ceramic sealants are generally recognized materials for sealing solid oxide fuel cells (SOFC) and solid oxide electrolyzer cells (SOEC) on an anode and electrolyte basis.

To date, a lot of sealant compositions have been developed and tested that can be used for SOFC/SOEC construction. But there is a lack of information on techniques of glass sealer application to the single element to ensure a gas-tight connection in conditions of long-term stacks work.

According to the literature, the methods of screen printing, tape (slip) casting, as well as the applying of glass sealant using specialized dispensers with software control have become widespread. These methods are united by the fact that the glass sealant material in the form of a fine powder is mixed in certain proportions with organic compounds, including a binder, a solvent, as well as, if necessary, a dispersant and a plasticizer. The amount and type of organic compounds is directly determined by the method of applying a glass sealer.

In present paper two approaches of connection the SOFC components using the glass sealants are considered: applying glass sealants via screen printing and films obtaining via casting. For applying screen printing and molding methods aluminoborosilicate (including CaO, SrO, BaO as additional components) glass was selected. The glass composition used in this work has a temperature coefficient of linear expansion equal to $(11-11,5) \cdot 10^{-6} \text{ K}^{-1}$, glass transition temperature of (660-680) °C and softening temperature of (715-730) °C.

The ink for screen printing was prepared on the basis of a classic binder and solvent. Ethyl cellulose was used as a binder, and terpineol was used as a solvent. Ink homogenization was carried out in a planetary ball mill using a zirconium drum and corresponding grinding media. To achieve an optimal ink viscosity the content of the

organic binder varied from 40 wt.% to 60 wt.%. After applying to the SOFC single element the glass sealant was kept in a drying case at least 1 hour.

According to the results of the work, it was found that the screen-printing (Figure 1) method allows to obtain a layer of glass sealant before sintering with a thickness of up to 0.25 mm, which is not enough to obtain a tight connection between the SOFC components due to the fact that there is an additional layer of cathode material on a single element, meanwhile assembling stacks, conductive pastes to ensure electrical contact between fuel cell components are used. Applying a glass sealer in several layers does not provide a uniform layer, this can be a reason of a fuel cell gas density loss.

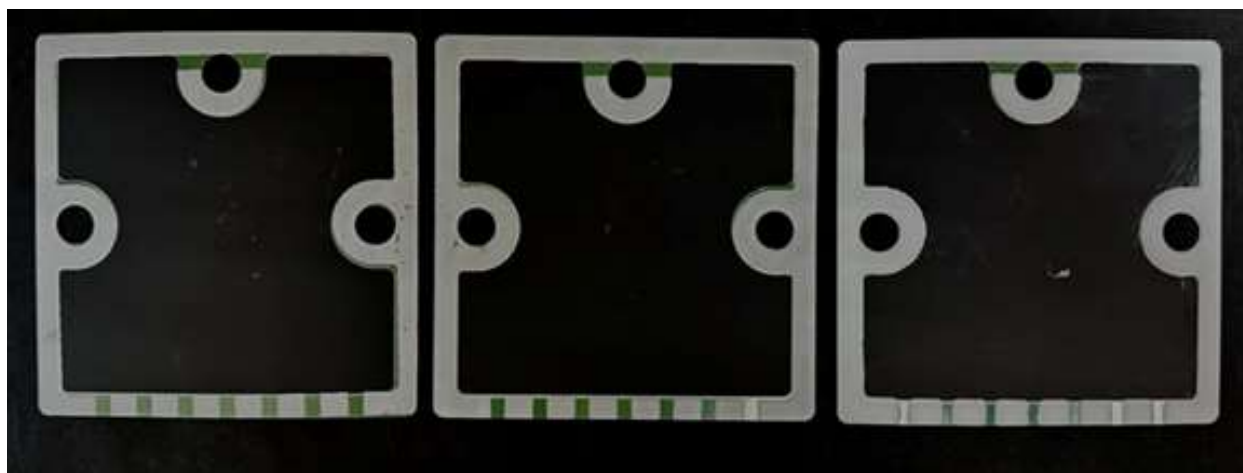


Figure 1 – Glass sealant applied by screen-printing method to SOFC single elements of the SOFCMAN company

Due to the disadvantages of the screen-printing method, the casting method was additionally considered to obtain a glass sealant of a given thickness in the form of a plastic film. As organic components, the composition of the slip included polyvinyl butyral, dibutyl phthalate and alcohol. The homogenization of the slip to produce films was carried out in a planetary ball mill. To achieve optimal viscosity of the slip, the content of organic components was also varied in the range of 40 wt.% to 60 wt.% (Figure 2). Obtained films were dried in air.

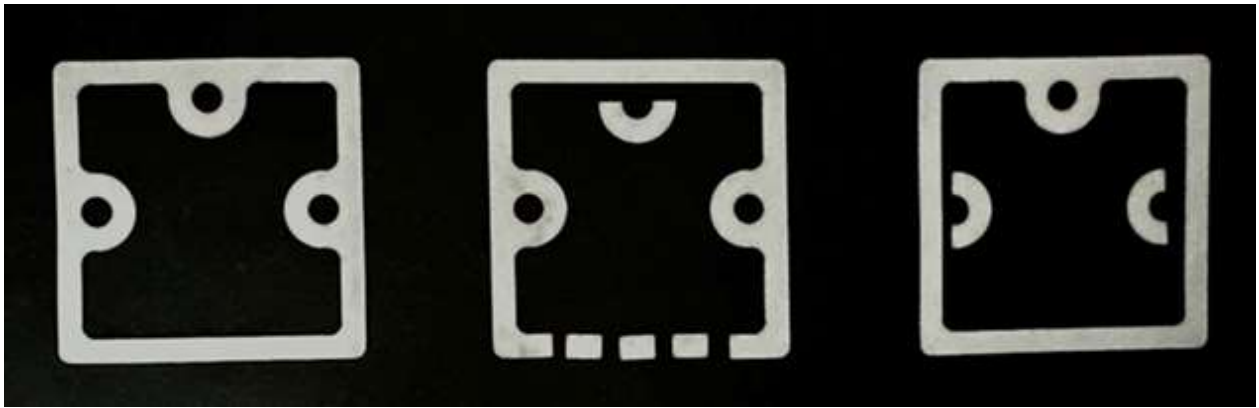


Figure 2 – Glass sealant for a pilot stack size (5 × 5) cm

It has been established that using of glass sealant films obtained by injection molding is an effective method for construction SOFC stacks with planar design. Glass films are easy to obtain, do not require long-term preparations of organic binders and the use of additional equipment, such as the screen-printing method.

APPLICATION OF ARTIFICIAL INTELLIGENCE IN OPTIMIZING PRODUCTION AND IMPROVING ENVIRONMENTAL SAFETY IN THE PETROCHEMICAL INDUSTRY

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Keywords: *artificial intelligence (AI), petrochemical industry, optimization of production processes, environmental safety, predictive maintenance*

PURPOSE: The study aims to evaluate the potential of artificial intelligence (AI) in the petrochemical industry to optimize production processes, improve environmental safety and reduce negative environmental impact.

RESEARCH METHODS: Data analysis, case study of predictive maintenance and environmental compliance monitoring in petrochemical industry, evaluation of AI effectiveness in emission reduction and logistics optimization, comparative analysis with traditional management and maintenance methods.

The application of artificial intelligence in the petrochemical industry opens new horizons for optimizing production processes and enhancing environmental safety. Active use of machine learning algorithms makes it possible to analyze production data more accurately, predict possible equipment malfunctions and minimize the risks of accidents that could lead to environmental disasters.

The main example of successful practice in this area is predictive maintenance systems. With their help, by analyzing sensor data in real time, AI can predict possible equipment failures before they occur. This not only reduces production downtime, but also reduces the likelihood of accidents that contribute to environmental pollution.

In addition, the application of AI in environmental compliance control significantly improves the efficiency of tracking air emissions. Machine learning algorithms analyze vast amounts of emission data, allowing timely adjustment of production processes in a way that minimizes the negative impact on the environment. This technology has been successfully applied at many refineries around the world.

Examples of the application of artificial intelligence in the petrochemical industry include the following specific projects:

1. "Smart Refinery" project. The project involves the use of machine learning algorithms to analyze operations data and optimize the oil refining process. AI helps to predict the most efficient operation parameters for different units, which allows not only to increase production volumes, but also to reduce resource consumption and pollutant emissions.

2. Predictive Maintenance System. This project involves the implementation of a predictive maintenance system at the production sites. The system actively monitors the condition of equipment, using sensor data and machine learning to predict possible failures and malfunctions. This significantly reduces the risks of accidents and related environmental hazards.

3. EcoVision program. The program uses AI to monitor and control air emission levels. Algorithms analyze the resulting data in real time and allow for on-the-go adjustments to production processes, contributing to cleaner and safer production.

4. "Optimized Operations" project. This project uses AI to optimize the operations of not just one plant, but the entire supply chain. Big data analysis helps to forecast raw material requirements, improve logistics and reduce the overall environmental impact.

5. AI Control Initiative. Using AI to automate the control of production processes to improve safety and reduce environmental impact. AI helps in the implementation of complex processes for monitoring and regulating equipment operation, as well as in analyzing environmental safety.

The potential for AI development in the petrochemical industry is still great. Projects related to the creation of smart energy management systems are being developed, which can significantly reduce not only the costs of enterprises, but also their carbon footprint. This allows enterprises not only to follow environmental standards, but also to actively participate in the fight against climate change.

Innovative projects include the development of intelligent systems to optimize the logistics of raw materials and finished products, which also has an impact on reducing CO₂ emissions by reducing transport movements.

And so, the possibilities of artificial intelligence in the petrochemical industry seem almost limitless, promising increased productivity while reducing environmental impact. Active adoption of these technologies will be key to sustainable development and will help to safeguard the environment for future generations.

Conclusions

1. The application of AI in predictive maintenance can reduce production downtime and decrease the likelihood of accidents contributing to environmental pollution.

2 The use of machine learning algorithms to analyze emissions significantly improves the accuracy and timeliness of process control, contributing to the reduction of harmful emissions.

3. Work on smart energy management systems promises significant reductions in the energy use and carbon footprint of businesses.

4. The development of intelligent systems for logistics optimization leads to reduced transport movements and consequently to lower CO₂ emissions.

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SYNTHESIS AND ANTIOXIDANT PROPERTIES OF NOVEL DIHYDROPYRIMIDINONES WITH PHENOLIC FRAGMENT

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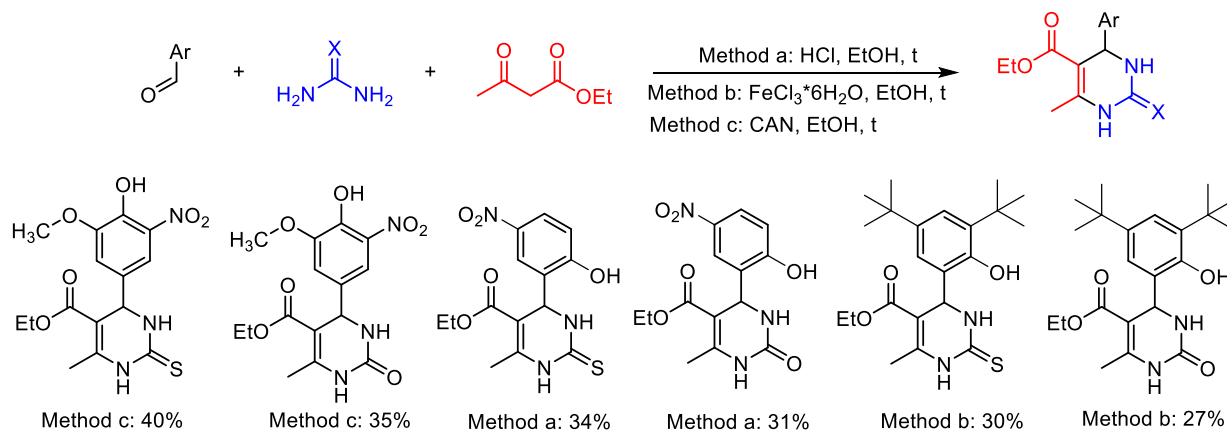
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Keywords: *synthesis, heterocycles, Biginelly reaction, phenol, antioxidant*

3,4-Dihydropyrimidones (thiones) and their derivatives are key compounds for the synthesis of various biologically active structures exhibiting antiviral, antibacterial, antitumor, and antioxidant properties [1]. The need to search for new compounds, especially antioxidants, with outstanding biological activity and therapeutic properties is increasing every year. The introduction of fragments of substituted phenols, in particular sterically hindered ones, into the structure of dihydropyrimidinones(-thiones) makes it possible to expand the pharmacological properties due to the antioxidant activity of the phenolic fragment. The most convenient way to obtain dihydropyrimidinones (-thiones) is the Biginelli reaction - three-component condensation between an aldehyde, urea or thiourea and a dicarbonyl compound [2]. The modification of Biginelli reaction conditions, the subsequent functionalization of the obtained dihydropyrimidinones (-thiones) and the study of their properties is an urgent task.

In this work, a series of dihydropyrimidinone (thione) derivatives with phenolic fragments were synthesized, using formylphenol derivatives as starting compounds. A search was carried out for optimal conditions for synthesis; the reaction was carried out by boiling the starting components in ethanol in the presence of hydrochloric acid (method a), in the presence of 10 mol% FeCl₃*6H₂O (method b) and in the presence of 10 mol% cerium ammonium nitrate (method c).



As a result, the compounds were obtained in yields of 27-40%, while for the 2,4-di-tert-butylphenol derivative the best yield was achieved when carrying out the reaction according to method b, for nitroaniline - according to method c, and for nitro-salicylic aldehyde reaction prog satisfactory yields under classical conditions - according to method a.

The ability of the obtained compounds to reduce iron ions Fe³⁺ in K₃[Fe(CN)₆] to Fe²⁺ in K₄[Fe(CN)₆], as well as the ability of the antioxidant to absorb cation-radicals by the ABTS method, was studied. It was found that all compounds prepared exhibited greater antioxidant activity than industrial antioxidant Agidol-1.

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SEEKING NEW SOLUTIONS FOR HEAVY METAL REMOVAL FROM PETROCHEMICAL WASTEWATER: APPLICATION OF CHITIN-GLUCAN COMPLEX EXTRACTED BY ULTRASONIC-ASSISTED METHOD

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Keywords: *chitin-glucan complex, ultrasonic-assisted extraction, heavy metal removal, single-factor experiment, functional biopolymers, environmental sustainability*

Background: Industrial wastewater, particularly petrochemical wastewater, poses a serious threat to ecosystems due to heavy metal contamination. Current widely used heavy metal treatment technologies, such as chemical precipitation, ion exchange, and electrochemical methods, although effective in removal efficiency, often involve complex operations, high costs, and potential secondary pollution issues[1]. In this context, the fungal-derived chitin-glucan complex (CGC) demonstrates unique advantages. Its functional groups can effectively adsorb and immobilize heavy metal ions in water through ion exchange and chelation, and its low cost and easy availability make it highly promising in environmental management. Although existing studies have shown that chelating resins and organic filters prepared from CGC perform excellently in adsorbing and filtering heavy metal ions[2, 3], their performance is influenced by factors such as polymerization degree, deacetylation degree, medium, and pH value[2]. Currently, comprehensive research on the extraction process and quality control of CGC is lacking, which limits its industrial application and large-scale production.

Objective: This study aims to develop an efficient CGC extraction technology to optimize its production process, realizing economical and scalable applications, and providing a green and economical alternative to current heavy metal treatment technologies.

Method: This study utilized ultrasonic-assisted extraction to isolate CGC from yeast by-products. To systematically optimize the extraction parameters, a single-factor experiment was conducted, examining the impact of five variables—solid-to-liquid ratio, NaOH concentration, ultrasonic power, extraction temperature, and extraction time—on

yield and monosaccharide composition. The extracted substances were then structurally characterized using Fourier-transform infrared spectroscopy and analyzed for monosaccharide content via high-performance liquid chromatography to assess their physicochemical properties and potential applications.

Results: The results of the single-factor experiment (Figure 1) indicated that the extraction time and solid-to-liquid ratio had no significant effect on the CGC yield. However, increases in ultrasonic power, temperature, and NaOH concentration led to a notable decrease in CGC yield. Analysis of the monosaccharide composition (Figure 2) revealed that the proportion of glucosamine significantly declined with longer extraction times and higher levels of ultrasonic power, temperature, and NaOH concentration. This reduction may be attributed to the greater likelihood of glucosamine degradation or transformation under conditions of prolonged extraction, elevated temperatures, ultrasonic power, and higher NaOH concentrations. Furthermore, given that NaOH is a strong base, its higher concentrations could accelerate the hydrolysis of glucosamine, resulting in its decreased proportion within the monosaccharide composition. Consequently, the optimal extraction parameters were determined as follows: a solid-to-liquid ratio of 1:10, NaOH concentration of 1M, ultrasonic power of 60W, room temperature extraction, and a duration of 1 hour, achieving a yield of 50.47%.

Conclusion: This study has effectively streamlined the extraction process of CGC from yeast by-products, using ultrasonic-assisted extraction under optimized conditions. Future work will focus on investigating the stability and adsorption performance of CGC under various environmental conditions, developing more precise quality control standards, and evaluating the material's performance in continuous flow systems to advance its industrial application. Additionally, the study will explore the differences in CGC extraction efficiency using by-products from different fungal sources, aiming to identify more cost-effective raw material sources.

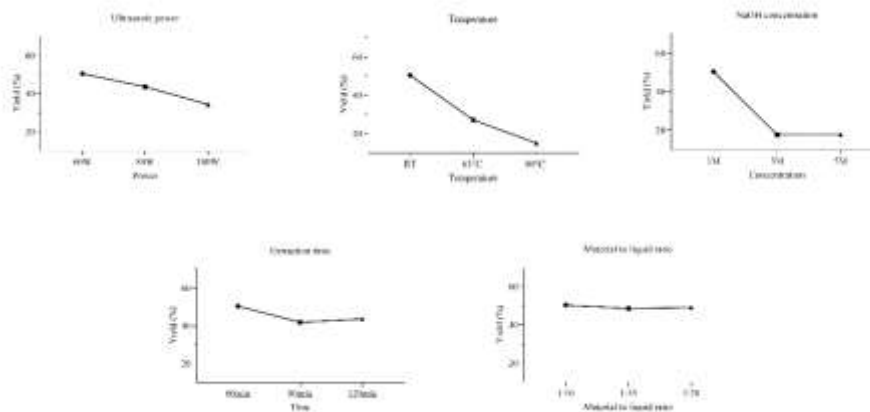


Figure 1 - Results of single-factor experiments

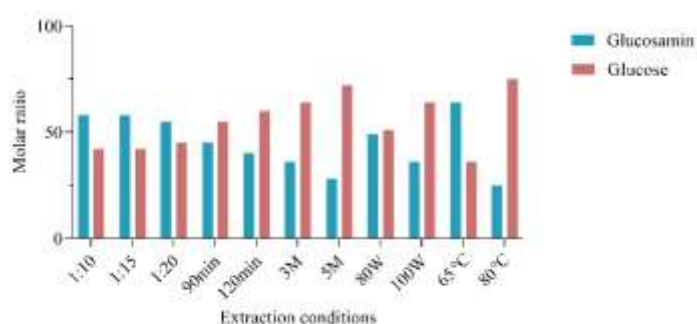


Figure 2 - Molar ratio of chitin-glucan complex under different extraction conditions

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HIGH DEHYDROGENATION PERFORMANCE OF PLATINUM COPPER ALLOY ALUMINA CATALYST IN LIQUID ORGANIC HYDROGEN CARRIERS

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Keywords: *liquid organic hydrogen carrier (LOHC), monobenzyltoluene (MBT), Pt-Cu supported alumina catalysts, dehydrogenation, Pt-Cu alloy*

Monobenzyltoluene (MBT), as one of the most promising hydrogen storage media in liquid organic hydrogen carrier (LOHC) technology, has mature hydrogenation technology and limited research on dehydrogenation process. In this study, different series of Pt-Cu supported alumina catalysts were prepared and applied to catalyze the dehydrogenation of monobenzyltoluene completely hydrogenated (12H-MBT). Among them, highly dispersed Pt-Cu based nanocatalysts anchored by calcination exhibited excellent bimetallic synergistic catalytic activity. Under the action of this Pt-Cu alloy catalyst, the conversion rate of 12H-MBT was as high as 99.97% within a reaction time of 3 hours at 260 °C and the conversion rate of MBT was higher than 90.10%. The reaction time was much shorter and the reaction temperature was also significantly reduced, all of which were better than pure Pt catalyst with equal loading capacity and previous reported catalysts.

Due to the demand for renewable and environmentally friendly clean energy, hydrogen energy is being elevated to the height of energy strategy and the direction of technological reform. The development of hydrogen sources, storage and transportation of hydrogen, and hydrogen utilization technology are the main segments of hydrogen energy systems ^[1,2], among which safe and effective storage is one of the most critical factors restricting the development of effective hydrogen utilization. The liquid organic hydrogen carrier (LOHC) technology is defined as the hydrogen storage strategy that can undergo reversible catalytic dehydrogenation reactions of organic compounds under appropriate conditions. Due to the advantages of high hydrogen storage capacity, good safety, good cycling performance, and compatibility with existing fuel storage and transportation infrastructure, it stands out among many hydrogen storage methods and is expected to become one of the main methods for international hydrogen trade and remote hydrogen storage and transportation ^[3,4].

This study prepared metal alumina nanocatalysts modified Pt-Al₂O₃ with Cu and pre-treatment of the carrier with different loading amounts and preparation methods for the catalytic dehydrogenation performance of 12HMBT.

The catalysts were prepared by equal volume impregnation hydrogen reduction method and formaldehyde reduction method. Alumina roasted in a Muffle furnace at 500 °C for 4 h was used as the carrier, and 0.265g H₂PtCl₆·6H₂O and 0.015g Cu(NO₃)₂·3H₂O were dissolved in 3.6 mL deionized water to form the precursor solution of the target product. Then, the precursor solution was added to the 4g of alumina carrier and soaked for 12h, and then the sample was placed in the air, dried and roasted again at 500 °C for 4 h. Finally, the sample was heated to 500 °C in H₂, that is, Pt_{2.5}Cu_{0.1}-Al₂O₃-H₂ (wt%) catalyst was obtained. Similarly, the metal ratio transformed could obtain different loads of Pt-Cu catalysts, which could be named accordingly. Similarly, the liquid-phase reduction method uses formaldehyde reduction. Finally, Pt_{2.5}Cu_{0.1}-Al₂O₃-MR catalyst is obtained, and other catalysts with different metal ratios could also be prepared.

20g of 12H-MBT and 2g of Pt_xCu_y/Al₂O₃-H₂/MR catalysts (x, y-different mass loadings) were added in a high-temperature stainless steel reactor of dehydrogenation reaction at 260 °C, atmospheric pressure, and 800 rpm. Hydrogen release was transcribed adopting the electronic display flow recorder.

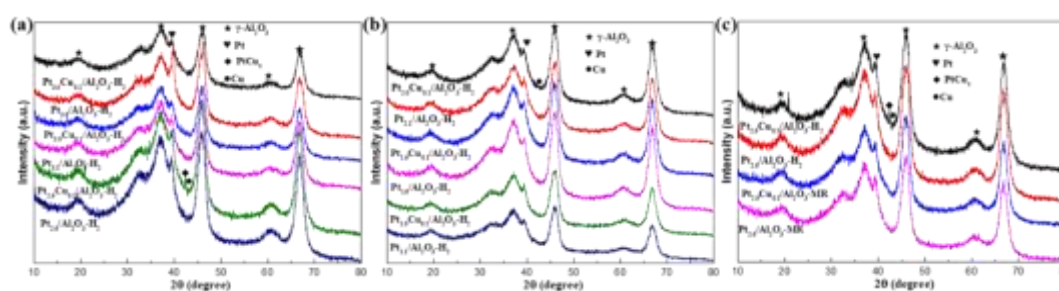


Figure 1 - Powder XRD patterns of Pt-Cu/Al₂O₃ and Pt/Al₂O₃ catalyst powders with different preparation methods and different loading loads

Figure 1 manifested that the characteristic diffraction peak of $2\theta = 42.4^\circ$ symbolized the Pt and Cu new phase in the unique Pt_{2.5}Cu_{0.1}/Al₂O₃-H₂ catalyst, explicating the successful formation of Pt-Cu bimetallic alloy and the relationship between the formation of Pt-Cu alloy and the preparation method and loading amount.

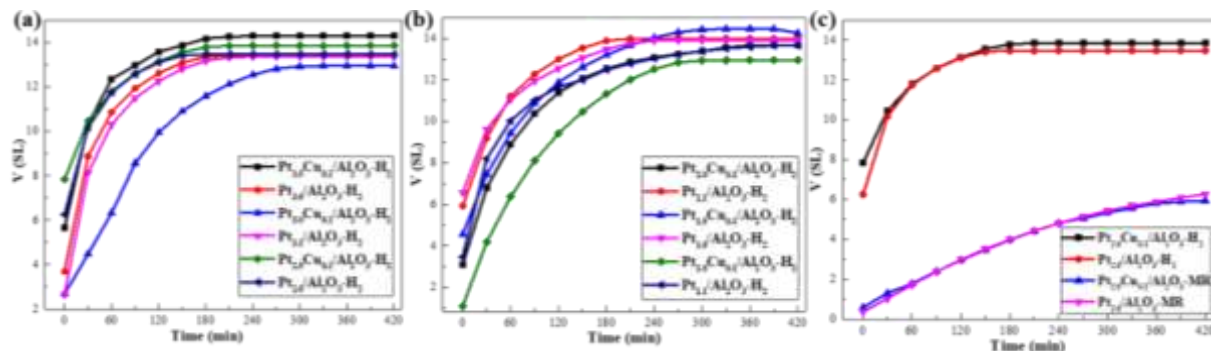


Figure 2 - Flow diagram of dehydrogenation of fully hydrogenated monobenzyltoluene with the prepared Pt-Cu/Al₂O₃ and Pt/Al₂O₃ catalyst

As shown in Figure 11, when the Pt load was below 2.5%, the addition of Cu had the reverse effect. When the loading was greater than 2.5% and Pt: Cu=10, the synergistic effect was observed, and the catalytic activity of Pt-Cu catalysts with higher loading was significantly higher than that of catalysts with lower loading, requiring less reaction time, which was related to the number of active components.

In conclusion, the 12H-MBT dehydrogenation activity was highest on the Pt_{2.5}Cu_{0.1}/Al₂O₃-H₂ catalyst. At a reaction time of 3 hours, the dehydrogenation rate was close to 100% and the complete dehydrogenation rate was also relatively high due to the unique Cu-Pt alloy structure, which were higher than Pt_{2.6}/Al₂O₃-H₂ and much higher than the Pt_{2.5}Cu_{0.1}/Al₂O₃-MR catalyst. the potential hydrogen storage medium -12HMBT dehydrogenation catalyst for synthesizing efficient of Pt-Cu alloy nanoparticles had broken the proportional relationship that limited the catalytic performance of Pt based bimetallic catalysts, providing good experimental and theoretical support for the future industrial development of LOHC technology.

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COMPOSITE FIBERS BASED ON EICOSANE AND FUNGAL MYCELIUM AS A THERMOREGULATING ADDITIVE TO GYPSUM PLASTER

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Keywords: *phase-change materials, thermal energy storage, latent heat capacity, biopolymers, natural fibrous materials*

The development of new energy-efficient materials to reduce energy losses and optimize energy consumption is one of the main directions in modern materials science. Phase-change materials (PCMs) are attractive due to their ability to store and release thermal energy in the form of latent heat of phase transitions during melting and crystallization cycles and thus can be used to solve problems of irrational use of thermal energy. Organic PCMs, such as fatty acids and paraffins, are actively used as functional additives in paint compositions or construction materials. However, their significant disadvantage is their shape instability in the liquid state, which requires their deposition on a carrier [1]. In this regard, it is important to obtain shape stable thermoregulating materials. It is promising to use natural fibrous materials as carriers for PCM, such as the mycelium of higher fungi. Mycelium is a self-growing organism composed of fibers with a diameter of microns [2], which can act as a biopolymer matrix for depositing various substances.

The objective of the work was to obtain thermoregulating composite fibers based on the mycelium of *T.hirsuta* and eicosane and to study their effect on the latent heat storage of gypsum plasters. Mycelium cultivation was carried out by liquid-state surface cultivation under static conditions for three weeks. The formed mycelium was represented by 1-1,5 - micron thick fibers with a narrow size distribution of diameters. Thermoregulating composite fibers were obtained by mycelium wetting with melt eicosane. After optimization of the eicosane/mycelium fiber ratio, the obtained thermoregulating composite fibers were mixed with gypsum plaster in the amount of 15–30 wt.%. The composition and morphology of the obtained materials were investigated by FTIR spectroscopy and scanning electron

microscopy. Functional properties of the obtained materials were investigated by thermogravimetry and differential scanning calorimetry, and the dynamics of heating and cooling of the material under simulated sunlight was also studied.

It is established that the optimum eicosane/mycelium fiber ratio at which there is no significant leakage of deposited eicosane is 30/70 wt.%, with the latent heat storage of the resulting fibers being 63.2 J/g. A study of the morphology of the modified gypsum plaster showed a uniform distribution of fibers within the hardened plaster layer. The incorporation of 15 and 30 wt.% of the thermoregulating composite fibers into the gypsum plaster significantly improved the latent heat storage properties. The latent heat capacity of the composites was 8.2 J/g and 18.2 J/g, respectively, depending on the fiber content. Experiments on the thermoregulating properties of the modified gypsum plaster under simulated sunlight showed that the addition of the thermoregulating composite fibers reduced the heating rate in the range of 37–39°C and the cooling rate in the range of 38–34°C. Thermoregulating composite fibers were also found to increase the material's thermal conductivity. Thus, the obtained fibers can find application as a thermoregulating additive considering the simplicity of composite production, the self-growing nature of mycelium, and its eco-friendly performance.

The study was funded by the Ministry of Science and Higher Education of the Russian Federation (State assignment; Project FSZE-2022-0001).

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SMART URBANISM: LOCAL NETWORK OF SOLAR PANELS BASED ON BLOCKCHAIN TECHNOLOGY

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Keywords: *local energy grid, solar panels, blockchain, alternative energy source, ecology, microeconomics of energy circulation, 3 D's concept, artificial intelligence*

The world community's concern about global environmental problems that require immediate action determines the need to transform all spheres of human activity, primarily the energy complex and urban economy. The cold winter of 2023-2024 in Russia revealed the problems of the electric power industry: in many regions of the country there were failures and short circuits in power supply systems, which left the population without electricity for up to several days. The economic crisis triggered by the COVID-19 pandemic, followed by the geopolitical crisis of 2022, also contributed to the state of the country's energy sector, emphasizing the importance of energy security.

Reliable and eco-oriented energy supply to cities and towns is possible using the concept of "3 D's": decarbonization, decentralization and digitalization (digitalization) of energy and synergy of conventional and alternative energy sources.

This study considers a model of a "smart neighborhood" whose electricity supply is based on the sale of surplus energy from one household to another. It is assumed that each of the bidders has solar panels that will provide its own energy consumption. Surplus energy is sold within the neighborhood via a blockchain platform. Pricing can be provided in two ways: by the seller's rate or by artificial intelligence.

The research includes the following steps:

1) theoretical material and foreign experience in creating local power grids are studied (Figure 1);

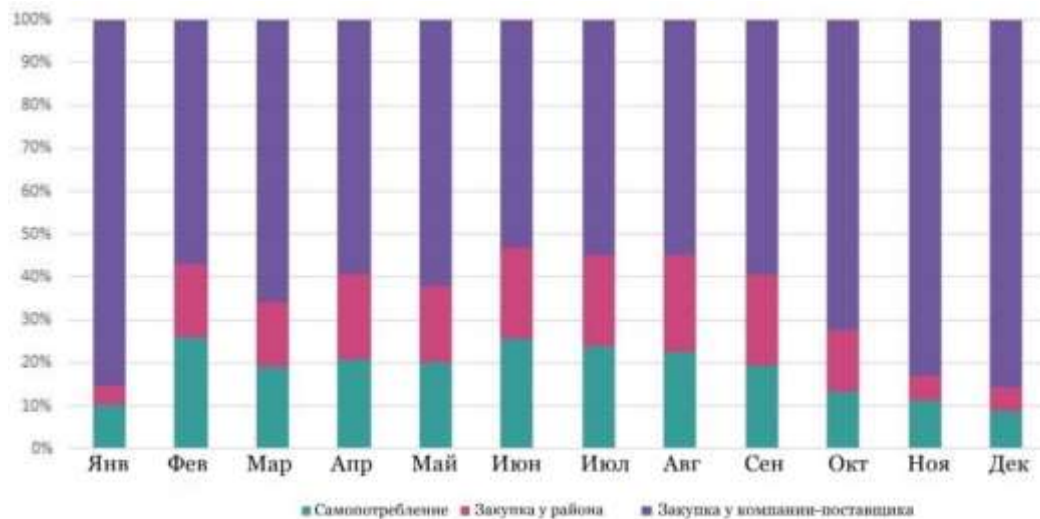


Figure 1 - Electricity supply for the district electricity community, 2019, Switzerland [1]

2) the possibility of realizing such a model in the conditions of the Russian Federation is considered;

3) a conditional economic model of the local power supply network was developed.

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ANALYSIS OF THE REALIZATION OF SUSTAINABLE DEVELOPMENT GOALS IN THE OIL AND GAS INDUSTRY: RUSSIAN AND FOREIGN EXPERIENCE

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***Keywords:** UN sustainable development goals, analysis of the implementation of the sustainable development goals, ways of implementing the sustainable development goals, negative impact on the environment*

At its core, sustainability can be distilled into one word: balance. It emerged as a result of growing concerns about the impact of human activities on the environment and society. To actually operationalize sustainability, it is often divided into three dimensions: environmental, social, and economic sustainability.

Sustainability, with its three dimensions, can be quite broad and ambiguous. Therefore, translating sustainability into workable concepts and perspectives is vital. One of the perspectives include the 17 United Nations Sustainable Development Goals or SDGs.

The SDGs are a set of 17 interlinked global objectives established in 2015 and aiming to achieve all goals by 2030 worldwide. The SDGs apply universally, calling upon every nation, regardless of their economic status, to contribute together to a sustainable future.

In September of 2015 the United Nations adopted 17 Sustainable Development Goals. Energy takes a significant place in many of these goals as it is connected to the economy, education, health and the environment. Despite its importance in the world's energy supply and lower environmental footprint than the coal industry, the significance of sustainability issues in the oil and gas industry increases every year.

Many oil and gas companies are implementing sustainable development principles to reduce their negative impact on the environment.

LUKOIL has identified 5 priority UN Sustainable Development Goals within the Company's key business areas:

1. Decent work and economic growth;
2. Industry, innovation and infrastructure;

3. Climate action;
4. Life on land;
5. Life below water.

Petrobras directly contributes to the realization of the goals set by the UN not only through its core activities, but also by supporting and participating in various projects and initiatives.

The Company's priority sustainable development goals are:

1. Industry, innovation and infrastructure;
2. Responsible consumption and production;
3. Climate action;
4. Life below water;
5. Life on land.

Analysis and reporting mechanisms are key indicators of the sustainability performance for the oil and gas companies worldwide. Such tools not only help to increase company profitability, but also raise awareness of the environment and climate change in order to act more responsibly.

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THE IMPACT OF EUROPEAN UNION CARBON BORDER ADJUSTMENT MECHANISM ON INTERNATIONAL CARBON EMISSION PERMITS AND ITS RESPONSE

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Keywords: carbon border adjustment mechanism, carbon emissions trading, international carbon emissions trading

The European Commission adopted amendments to the Carbon Border Adjustment Mechanism On June 22, 2022, which importers will be formally required to purchase import permits matching the price of emission quotas for imported products within the adjustment range to solve the carbon leakage problem in 2026. The Carbon Border Adjustment Mechanism will have an impact on the price, concept and pattern of China's outwardly connected international carbon emission trading market. At present, there are some difficulties in the legislation of carbon emissions trading at the international level. China should systematically study and judge the impact of Carbon Border Adjustment Mechanism on international carbon emissions trading. On this basis, the article analyzes the feasibility and necessity of establishing an international carbon emissions trading mechanism. Then China should improve its carbon emissions trading legislation, carefully connect the domestic market with the international market, construct and design the legal mechanism of international carbon emissions trading, and find countermeasures in the future climate change governance to help build a community with a shared future for mankind.

On June 22, 2022, the European Commission voted on the amendment of the Carbon Border Adjustment Mechanism Act (hereinafter referred to as CBAM), which aims to reduce carbon leakage and narrow the gap between domestic and foreign carbon emitting enterprises, and provides for the levy of carbon taxes on importing enterprises and tax rebates for exporting enterprises.

The legislative dilemma of international carbon emissions trading including unclear concept, conflicting interests and limited cooperation. The impact of CBAM on international carbon emission rights is mainly reflected in three aspects: concept, price and form. Therefore, in order to solve the above difficulties and the impact, it is essential to analyze

the feasibility and necessity of establishing an international carbon emissions trading mechanism.

China should find the public interest acceptable to each country under the common but differentiated responsibilities, and take this as the ultimate goal and action plan to build and design the international carbon trading legal system from the three directions of improving China's carbon trading legislation, building an international carbon emissions trading market and effectively connecting the domestic mechanism with the international mechanism.

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SYNTHESIS OF CHALCONES WITH A HINDERED CATECHOL MOIETY

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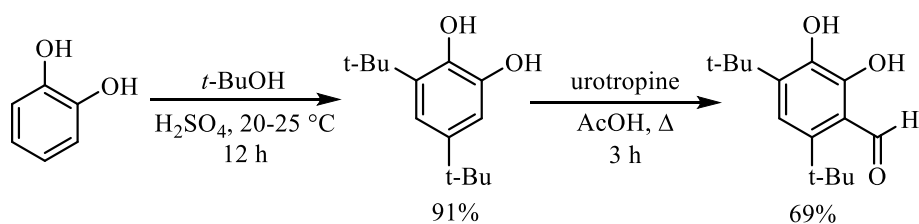
Keywords: phenol, chalcone, antioxidant activity

In light of the growing need for multifunctional molecules that can be used in various fields, new routes for their synthesis are being sought. The idea of combining heterocyclic and phenolic fragments in one molecule to acquire a combination of the antioxidant activity of phenol and the wide variety of properties inherent in heterocycles in a new structure remains relevant.

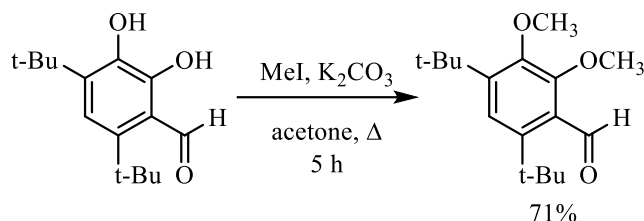
One of the interesting ways to synthesize heterocyclic compounds containing a hindered phenol moiety is to use the corresponding chalcones as starting compounds. These compounds have significant potential as starting material in the synthesis of biologically active compounds, as well as for use in other industries.

In recent years, chemists have focused on environmentally friendly synthetic organic transformations. Research into reaction media that could replace hazardous, toxic and flammable organic solvents. pose a serious threat to the environment and is progressing. Currently, many organic reactions use environmentally friendly reaction media, called “green solvents”, such as ethanol, glycerol, etc., ionic liquids, supercritical fluids and fluorine phases. Each green solvent has its own specific advantages depending on lipophilicity, viscosity and other factors, both internal and external.

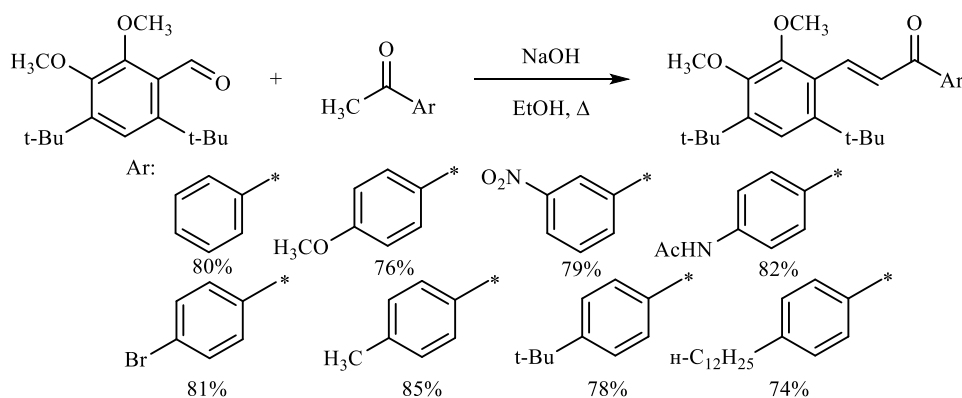
In this study, at the first stage, 3,5-di-*tert*-butylcatechol was obtained by reacting catechol with *tert*-butanol in the presence of sulfuric acid [1]. The yield was 91%. In the second stage, 4,6-di-*tert*-butyl-2,3-dihydroxybenzaldehyde was obtained by reacting 3,5-di-*tert*-butylpyrocatechol with hexamine in acetic acid with a yield of 69% [2].



Then, 4,6-di-*tert*-butyl-2,3-dihydroxybenzaldehyde was obtained from 4,6-di-*tert*-butyl-2,3-dihydroxybenzaldehyde by reacting with methyl iodide in acetone in the basic condition, the yield of the product was 71% [3].



By reacting the resulting 4,6-di-*tert*-butyl-2,3-dimethoxybenzaldehyde with various acetophenones in ethanol in the presence of sodium hydroxide, the following compounds were obtained according to a known procedure [4]. The yields of chalcones obtained from acetophenone, *p*-methoxyacetophenone, *m*-nitroacetophenone, *N*-(4-acetylphenyl)acetamide, *p*-bromoacetophenone, *p*-methylacetophenone, *p*-*tert*-butylacetophenone and *p*-dodecylacetophenone were 76-85%, respectively.



All obtained compounds were characterized by ^1H NMR, ^{13}C NMR, and IR spectroscopy.

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BIG DATA TECHNOLOGY AS A TOOL FOR OPTIMIZING PROCESSES IN POWER GENERATION

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Keywords: *digital technologies, big data, electricity production, efficiency parameters*

Relevance

The adoption of digital technologies in everyday life would not have been so rapid without the increased interest from industry. Because of investments in the development of digital technologies we can observe an increased competitiveness of large companies. First of all, this applies to the energy sector. However, this field of activity is extremely wide and has specific regional features. Therefore, in this study, the authors focus on ways to optimize power generation through gas turbine units (GTUs). The relevance of this topic is predetermined by the global trend towards the optimization of electricity production, the driver of which is the widespread digitalization of production processes.

State of scientific elaboration

The founder of the term Big Data was Clifford Lynch, who published an article of the same name in the journal Nature in 2008. Also in this article, the classification and parameters of the described technology were given. From an economic point of view, the term Big Data is defined in the book "Big Data in Simple Language" by Alexei Blagirev, where it is noted that this technology reflects a new model of business maturity. As applied to the oil and gas industry, big data technology is analyzed by Y. S. Petrova, A. D. Lobanova, and E. E. Kharlamova in their article "Problems and Prospects for the Application of Big Data Technology in the Oil and Gas Industry" published in Novainfo No. 130. It notes and discusses practical examples of the use of Big Data in oil and gas companies of the Russian Federation.

Goals

The main purpose of the analysis of the implementation of Big Data technology in this article is to reduce the cost of repairing a gas turbine unit while maintaining the same level of electricity production.

Research Base

Gas turbine units used in gas turbine power plants in the Russian Federation.

Theses

In this article, optimization refers to the process of introducing digital technologies that allow you to generate the same amount of electricity at a lower cost for equipment repairs.

The main impulse for the introduction of digital technologies was the Energy Transition Plan 2030 adopted by the European Union in 2022, which outlines how new technologies can help improve the efficient use of energy resources, facilitate the integration of renewables into the grid and save costs for EU consumers and energy companies.

Big Data is structured or unstructured arrays of large amounts of data. They are processed with the help of special automated tools or computer algorithms for subsequent analysis, forecasting, as well as decision-making.

As an example, a power plant based on the combustion of natural gas (GTPP) was taken. The main unit in the operation of power plants of this type is a gas turbine unit. Stopping such a system for repairs will bring the company not only losses associated with repairs, but also lost profits.

Results of the study

In this article, the Big Data technology was considered, as well as the possibility of its application to companies that produce electricity by burning gas in gas turbines. The prerequisites for the introduction of this technology describe the global trend towards digitalization.

In this context, optimization is the ability to produce the same amount of electricity with the lowest costs for the repair of gas turbines.

The paper also describes general approaches to ensuring an optimal balance between the reliability and efficiency of the GTU operation using Big Data technology.

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ASPECTS OF NEUTRALIZATION AND UTILIZATION OF ACID TAR IN RUSSIA

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Keywords: *acid tar, neutralization, utilization, bituminous materials*

In the authors' opinion, hazardous waste management is the most important aspect of the policy of sustainable environmental development of petrochemical enterprises. Such wastes include sour tar - multi-component mixtures formed in the processes of sulfuric acid treatment of hydrocarbon raw materials (II class of hazard). Due to the low spread of technologies for their neutralization and utilization, acid tar was stored in open-type storage ponds. This method of waste disposal led to a number of environmental problems causing public concern [1, 2]. On the territory of Russia acid tar is located in Nizhny Novgorod and Yaroslavl regions, as well as in a number of other regions. The total amount of this type of waste in Russia may exceed 1500 thousand tons [2].

Based on the above, the objectives of this paper are:

1. Consideration of measures aimed at elimination of acid tar storage ponds in Russia.
2. Consideration and evaluation of already implemented technologies in this direction.
3. Justification of the most promising technologies.

The research methodology is based on the consideration of the situation on acid tar handling in the Yaroslavl and Nizhny Novgorod regions. This is justified by the largest technogenic reserves of waste in these regions - 295 and 320 thousand tons, respectively [2]. The measures aimed at liquidation of storage ponds in the period from 1987 to 2023 have been considered [2, 3].

For example, in the Yaroslavl region about 215 thousand tons of waste were neutralized. The method of reagent encapsulation of waste was used [3]. The advantages and disadvantages of this approach are identified and substantiated. As an alternative, the solutions planned for implementation in the period up to 2027 within the framework of

utilization of residual quantities of waste are considered. The planned technology consists in fractionation of sour tar with preliminary magnetic-pulse activation. The pilot plant is currently at the assembly stage [4].

In addition to the above, the European experience in handling acid tar is briefly reviewed [2].

In addition to the above, state support measures were also highlighted. Within the framework of the national project "Ecology" there are federal programs aimed, among others, at the elimination of accumulated harm: "Volga Recovery", "Clean Country", "General Cleanup". One of the conditions for participation is to enter information about the facility planned for elimination into GRONVOS. Yaroslavl and Nizhny Novgorod Oblasts and Khabarovsk Krai have already undergone this procedure.

In connection with the above, the authors hope to make some practical decisions on the utilization of acid tar. As promising, the authors consider methods of obtaining bituminous materials with the involvement of acid tar. The advantages of the group of methods are: the possibility of obtaining products with a long service life, a wide range of applications of bituminous materials, the possibility of implementation on site, relative simplicity of hardware design, minimizing the amount of secondary waste, wastewater and emissions, relative to other methods, minimizing the risk of possible secondary pollution of the environment, logistical feasibility.

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with slopes and reclamation of lands disturbed by the construction and operation of the pond

THE LOC-FREE SURFACTANTS COMPOSITION AS A GELLING AGENT FOR FRACTURING FLUIDS

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Keywords: *light organochlorine compounds (LOC), surfactants composition, amine oxide, sulfonol, synthesis, fracturing fluids*

At the present stage of global development, surfactants have found their application in almost the entire oil and gas complex. Surfactants play a significant role in oil and gas production processes, during transportation and storage of extracted resources, as well as in a wide range of petrochemical and refining processes.

Nowadays it is hard to imagine without surfactants the implementation of one of the most widespread enhanced oil recovery methods – hydraulic fracturing [1]. Zwitterionic surfactants, which are used as gelling agents of water-based fracturing fluids, are of particular interest within the framework of this technology. The main drawback of these compounds is the presence of light organochlorine compounds at the production stage. This circumstance entails failures in the operation of technological equipment and catalytic compositions during oil and gas processing, and also leads to the disruption of ecological balance when organochlorine compounds enter the environment [2].

To solve this problem, it is proposed to use zwitterionic surfactants such as amine oxides. Despite the high environmental friendliness and the absence of LOC at the stages of their production, amine oxides have not yet been widely used as oilfield reagents. The reason for this is mainly due to the supply shortage of compounds of this type by Russian companies. As for those amine oxides, which are presented on the Russian surfactants market, they are not able to thicken aqueous solutions at economically advantageous low concentrations.

As part of this work, laboratory synthesis of amine oxide was carried out. Furthermore, the rheological properties of aqueous solutions thickened with a composition of synthesized surfactant (amine oxide) and sodium alkylbenzenesulfonate (sulfonol) were studied. The addition of an anionic surfactant to a zwitterionic one, according to a number

of scientific articles, leads to the manifestation of a synergetic effect [3]. This point will subsequently have a positive impact on the economic performance of fracking technology. It was decided to call the mixture of amine oxide and sulfonol as the LOC-free surfactants composition, since both of these substances are produced without the use of organochlorine compounds.

The end-products were analyzed by null-current potentiometric titration and Fourier transform infrared spectroscopy (FITR) [4]. As a result, the presence of N→O bond in the final product was confirmed and the quantitative content of amine oxide was determined.

The results of the study of rheological properties of aqueous solutions of the LOC-free surfactants composition when changing the content of sulfonol in the total surfactants mixture are presented in Figure 1. The total mass concentration of surfactants was maintained at 2%.

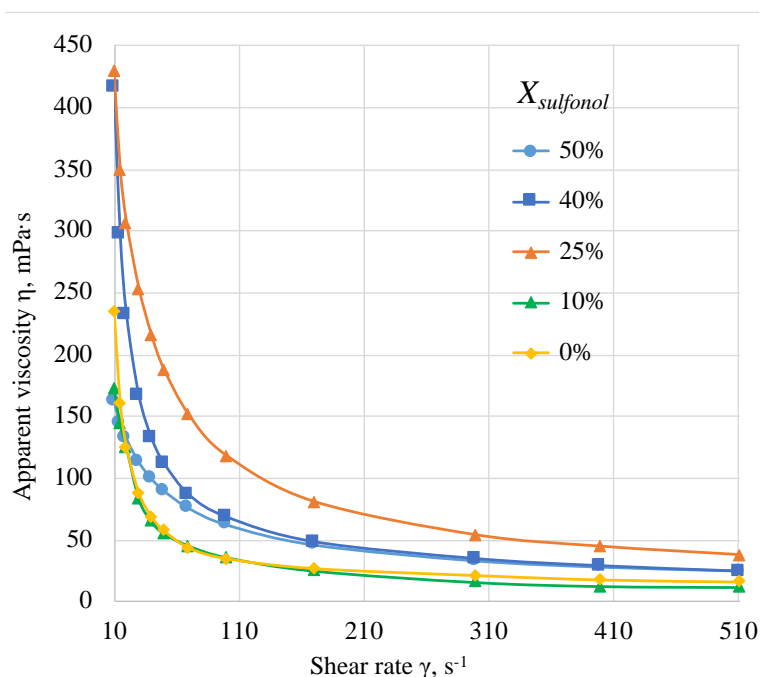


Figure 1 – Dependence of the apparent viscosity η (mPa·s) of aqueous solutions of the LOC-free surfactants composition on the shear rate γ (s^{-1})

Based on the results obtained, it is evident that there is a synergetic effect from the joint presence of zwitterionic and anionic surfactants in aqueous solutions. This effect is observed to the greatest extent at mass content of sulfonol in the LOC-free surfactants composition equal to 25%.

Further research will focus on the influence of the total concentration of surfactants on the rheological properties of the aqueous system. In addition, it is planned to study the technological properties of aqueous solutions of the LOC-free surfactants composition. This mixture will be successfully used as a gelling agent of water-based fracturing fluids and will be a serious competitor to the polymer compositions already used in this technology, if the proper level of service properties and economic performance is achieved.

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STUDY OF THE CURRENT STATE OF THE MARKET AND TECHNOLOGIES FOR PRODUCTION OF DETERGENTS BASED ON CALCIUM ALKYLSALICYLATE

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Keywords: calcium alkylsalicylate, detergents, production technology, additives

Nowadays, alkylsalicylates are among the most effective ash detergent additives characterised by stability and high detergent characteristics. The paper considers the main requirements for modern detergent-dispersing additives. The basic technologies of alkylsalicylates production in industry are defined. The assortment of alkylsalicylate additives produced both in Russia and abroad has been studied.

Alkylsalicylate additives are often used in modern high quality motor oils, heavy machinery oils, transmission fluids and other specialised lubricants. The choice of a specific type of alkylsalicylate additive and its concentration in the oil depend on the required characteristics of the final product, but most often calcium salts are used at a concentration not exceeding 5% [1].

Two main methods of alkylsalicylates production are known in the industry. The first method is based on the Kolbe-Schmidt reaction and consists of 4 stages: alkylation of phenol with α -olefins with 14 - 18 carbon atoms in the molecule, neutralisation of the obtained phenol with sodium or potassium hydroxide to obtain phenolate, interaction of phenolate with carbon dioxide (carboxylation reaction) to obtain the corresponding metal alkylsalicylate and, finally, optional treatment of the product with magnesium or calcium chloride, which is then supersaturated with alkali to obtain highly alkaline products that can effectively neutralise the acidic products formed during oil operation (Fig. 1) [2].

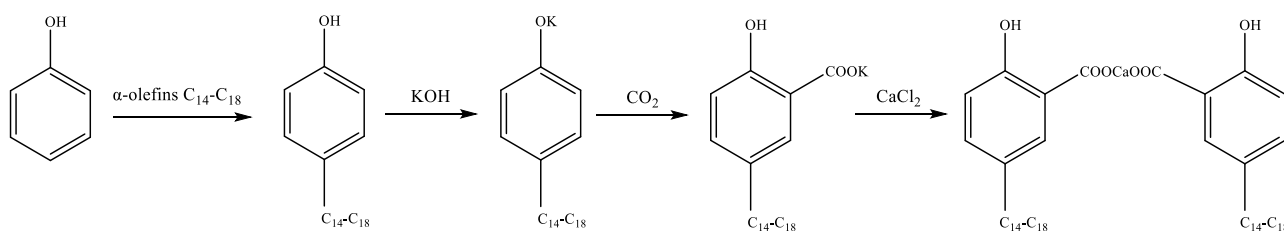


Figure 1 - Scheme of calcium alkylsalicylate production by the first method

The second method consists of neutralising alkylsalicylic acids with sodium hydroxide or sodium oxide and treating the resulting product with carbon dioxide and alkaline earth metal (calcium or magnesium) hydroxide (Fig. 2). This method allows to significantly increase the alkalinity of the obtained products [2].

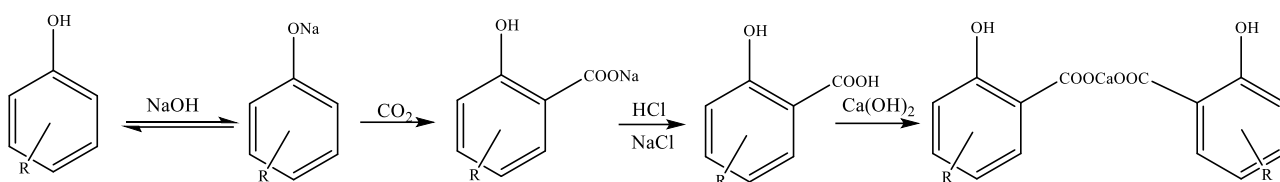


Figure 2 - Scheme of alkyl salicylate production by the second method

It is worth noting that the technology for producing alkylsalicylate additives is expensive and multi-stage, so despite its good cleaning properties, this type of compounds accounts for only 3% of the global production of detergent additives.

Modern alkylsalicylate additives must not only ensure engine cleanliness, but also meet high environmental standards by minimising harmful emissions. They are required to have high thermal and chemical stability, anti-corrosion properties and compatibility with various lubricants. The requirements depend mainly on the grade of the additives themselves. For example, for the 3 largest domestic additives, one of the main parameters determining its ability to neutralise acidic decomposition products, the alkaline number, varies widely. For Detersol-140 it is not less than 135-170 mg KOH/g, for Detersol-300 - not less than 280-320 mg KOH/g, and for Kompleksal-100 - 100-135 mg KOH/g. Abroad, the flagship in the production of alkyl salicylates is the Shell company. They have successfully mastered the production of super alkaline additives SAP 007, reaching an alkaline number of 345 mg KOH/g. Their range also includes SAP 001, SAP 002 and SAP 005, which have alkaline numbers of at least 168, 70 and 280 mg KOH/g, respectively [3].

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«GREEN AGENDA» AS A CATALYST FOR DIGITALIZATION OF ENERGY

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Keywords: digital transformation, digitalization, automation, ecology, digital technologies in energy, artificial intelligence, environment, environmental problems

In recent years, the trend of the world's transition to a new technological paradigm has been manifested, in connection with which countries and economic entities are beginning to compete for leadership positions by developing the innovative structure of the economy and digitalization of business processes.

In addition, the COVID-19 pandemic and the ensuing geopolitical crisis of the global economy since 2022 was a major shock, causing a sharp decline in foreign economic activity and disruption of established global economic ties. But it was the crisis that catalyzed a massive acceleration of development and implementation of digital technologies in the socio-economic sphere.

Naturally, the energy sector, being one of the most important sectors of the national economy, could not stay away from the universal digital trend. In addition, the many environmental constraints faced by the industry force enterprises to look for new ways of doing business.

One way to not only optimize but also to make traditional energy processes more environmentally friendly is to adopt digital technologies. Shell, for example, uses well location optimization technology (Figure 1), which allows engineers to more effectively incorporate reservoir uncertainty into their studies.

Digitalization performs such important functions as control and monitoring of plant operations, analytical processes in drilling and well operation, etc. This makes it possible to reduce the risk of oil spills and other environmental disasters that, one way or another, the energy industry faces.

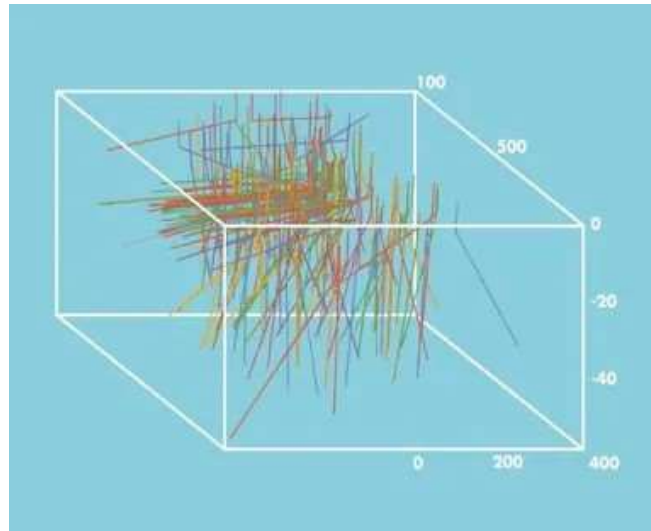


Figure 1 - Shell Well Location Optimization Technology [1]

In this paper.

- 1) Digital technologies in the traditional energy industry and their impact on the environmental friendliness of business processes are studied;
- 2) identified the main functions that ensure the environmental safety of the energy sector;
- 3) the correlation between the "green agenda" and the acceleration of digitalization in the energy sector is analyzed.

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DIGITAL ENERGY OF THE ASIA-PACIFIC REGION THE EXPERIENCE OF LEADING COUNTRIES

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Keywords: *digitalization of energy, energy transition, Asia-Pacific region, energy efficiency*

The topic of digitalization of energy in the Asia-Pacific region (APR) is extremely relevant. Japan, South Korea and China are among the leading countries in this field. They are actively developing digital technologies in the energy sector, striving to increase the energy efficiency and sustainability of their energy systems. This is an extremely relevant topic, since the digitalization of energy allows not only to improve energy efficiency, but also to make energy systems more flexible and resistant to variable conditions and challenges.

In recent years, digital technologies have taken over energy systems, making them ever friendlier, smarter, more efficient and more sustainable. Advances in areas such as data analytics, artificial intelligence and technology have supported the energy sector. Digital energy systems will play a key role in delivering efficiency and a secure energy outlook.

According to Bloomberg New Energy Finance, estimated global annual revenue from energy digitalization could reach US\$54 billion today. In the future, this figure could increase by almost 19 percent to US\$64 billion by 2025. Already, sales growth in the economic energy management market reached US\$22 billion in 2017 and is projected to grow to US\$36 billion in 2025.

The Southeast Asia region is one of the fastest growing regions in the world. In line with this, the International Energy Agency (IEA) projects that electricity demand in Southeast Asia will grow by 60 percent by 2040 based on today's figures, with power generation being one of the main sectors leading this growth. Consequently, the countries of the region must ensure their energy reserves. Many of these countries are prioritizing renewable energy sources, although coal and oil will still play a large role in the future. This is only half the story. The other half is to ensure efficient energy management and

distribution. This is an incredible opportunity for Southeast Asian countries to join the digitalization of energy – and for good reason. With new energy technologies emerging, governments must ensure reliable and efficient access to energy to keep industry running.

The digital energy system will help solve many problems associated with electricity production. Countries such as the Philippines, Myanmar and Cambodia often face power outages and skyrocketing utility bills due to inefficient power systems.

New technologies such as machine learning, electrical computing and cloud computing can be used to design power systems to improve demand management. A digital energy system also helps balance backup systems and harness energy from self-generators such as rooftop solar systems. There are already smart grid applications that place grid sensors along power transmission lines to identify locations with additional electricity demand and regulate power load accordingly. This, in turn, helps maintain network stability and reliability.

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ANALYSIS OF METHODS FOR DEODORATION OF OIL-CONTAINING WASTEWATER AT BIOLOGICAL TREATMENT FACILITIES

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Keywords: *biological treatment, wastewater, deodorization*

At atmospheric air pollution there is a problem of presence of odourants in emissions. The problem of odour occurrence in the process of wastewater transportation and treatment is very actual. Maximum concentrations of pollutants in the atmospheric air at wastewater treatment facilities are fixed in receiving chambers and their concentrations are reduced at subsequent stages of treatment. Treatment of oily wastewater is accompanied by emissions of sulphur compounds and volatile organic compounds into the air. The presence of hydrocarbons of various structures in emissions is associated with the processes of evaporation of oil and oil products from the open surface of the aeration tank. Characteristics of emissions from biological treatment facilities for oily wastewater are presented in Table 1 [1].

Table 1 - Characteristics of emissions from biological treatment facilities for oily wastewater [1]

Substance	Equilibrium concentration above aeration tank, mg/m ³
Ammonia	Not more than 0,11
Nitrogen oxide	Not more than 0,038
Hydrogen sulphide	Not more than 0,012
Carbon oxide	Not more than 0,6
Mercaptans	Not more than 0,000038
Ultimate and unsaturated hydrocarbons	2,73 – 12,62
Ultimate cyclic hydrocarbons	0,36 – 1,25
Monocyclic aromatic hydrocarbons (benzene, xylene, toluene)	2,13 – 3,32
Phenols	0,0016 – 0,0053
Alcohols, aldehydes, fatty acids and others	0,02 – 0,05

Pollutants from biological treatment plants are contained in concentrations that are not capable of producing toxic effects, but are odourants - substances capable of producing odour at concentrations well below the toxicity threshold.

Odours can be eliminated by implementing the following measures [2]:

- blocking of open surfaces of treatment facilities, collection of the resulting vapours and their purification;
- elimination of odourants from wastewater before it enters the treatment plant;
- elimination of odorants during biological treatment of wastewater;
- masking of odorous substances, isolation of the odour source and the object of exposure.

Deodorisation methods can be divided into two groups: minimisation of odorant formation by upgrading the wastewater treatment technology and diversion with further treatment of gas emissions from the facilities [2]. Methods of further treatment of gas emissions from odorants can also be conditionally divided into two groups (Table 2): Physico-chemical and biological. The most significant parameters determining the boundaries of methods application are concentration of pollutants and gas flow velocity [2].

Table 2 - Methods of purification of gas emissions from wastewater treatment [2-4]

Plants (methods)	Principle of operation	Purification efficiency
Physico-chemical methods		
Scrubber (absorption)	Absorption of pollutants by aqueous solution of reagents (acid and alkaline solutions)	For hydrogen sulphide, ammonia - 90-99%
Filtration plants (adsorption)	Absorption of pollutants by solid sorbents with high specific surface area	For hydrogen sulphide and sulphur dioxide - 99,5%, odour - 99%, ammonia - 73%, nitrogen dioxide - 79%, methane - 77%, toluene - 80%, benzene - 50%
Regenerative thermal oxidiser (thermal oxidation)	Oxidation of pollutants under the action of high temperatures	For ammonia, hydrogen sulphide, phenol - 99,9%

Catalytic units (catalytic oxidation)	Chemical transformation of pollutants under the action of special catalysts	Nitrogen oxides, hydrocarbons - up to 95%, carbon oxide - up to 97%
Biological methods		
Biofilters (adsorption)	Passage of polluted air through a filtering layer covered with a biological film	Odour and ammonia - 80%, phenol - 93%, hydrogen sulphide - up to 92%, organic pollutants - 90%
Bioscrubbers (absorption)	Absorption of pollutants by circulating liquid represented by aqueous suspension of activated sludge in the absorption column	For hard-to-solve and insoluble organic compounds does not exceed 30%
Bioreactors	Barbotage of polluted air through liquid containing free-floating microflora	For ammonia - more than 95%, phenol - 93%, hydrogen sulphide - up to 95%

The analysis of the presented data has shown that physical-chemical and biological methods of purification of generated gases from oily wastewater treatment facilities are quite effective. The choice of method in each case is determined by the type of odorant, its concentration and emission regimes, indicators of economic efficiency.

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DIVERSIFICATION OF NATURAL GAS USE: PRODUCTION OF BIOPROTEIN FROM METHANE

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Keywords: natural gas diversification, bioprotein, feed protein from natural gas methane, food security

Diversification of natural gas use in Russia can be considered as an anti-crisis strategy in the current economic and geopolitical conditions. The paper analyzes the directions of diversification of the gas industry in the context of the transformation of global energy markets: production of liquefied natural gas, hydrogen production, gas extraction from gas hydrates, development of gas chemical production, production of bioprotein from methane, etc. The aim of the work is to study and analyze the production of a bioprotein from methane, which, in addition to expanding the scope of gas applicability, will ensure food security in Russia, will contribute to the development of regions and improve the quality of life of the population.

The following methods were used in the study: analysis, synthesis, induction, deduction, study and generalization.

The possibility and effectiveness of diversification are considered from three points of view: access to sales markets; financial security and investment attractiveness; availability of domestic technologies and equipment. In all these three directions, a positive response was received from the point of view of the prospects for obtaining a bioprotein from methane.

A bioprotein is a biomass of bacterial origin produced using nature-like technologies from methane. Sources of methane can be natural gas; associated petroleum gas; coal mine methane from coal seams and mines, biogas during waste processing.

Bioprotein from methane is an environmentally safe product - it is non-toxic, does not have carcinogenic and cumulative effects. These technologies can also be used to solve environmental problems, such as reducing greenhouse gas emissions, preserving the fertile layer of the earth and recycling industrial waste.

The methane bioprotein has successfully passed comprehensive tests on all types of animals: cattle and pig breeding, poultry, fish and fur-bearing animals. The tests were carried out on all age groups and on several generations of farm animals and poultry.

Meat products obtained using bioprotein in animal feed are harmless to humans – this has been proven by the long-term use of bioprotein in animal feed in the West, in particular in Europe. This technology was also used in the USSR, back in the period from 1985 to 1994. 5 industrial plants for the production of protein and vitamin concentrate (BVK) were built, with a total capacity of about 250,000 tons per year.

As a result of the research, it is possible to identify the prospects of this project. An increase in gas consumption within Russia, an increase in the life of depleted gas fields, the creation of a Russian bioprotein market, an increase in the feed base and an increase in livestock and poultry, a reduction in production costs and retail prices for food, and an increase in the sustainability of the Russian economy.

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DESIGN AND TRAINING OF NEURAL NETWORK MODELS FOR CALCULATING CARBON DIOXIDE STEAM GAS EMISSIONS FROM A PETROCHEMICAL PLANT

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Keywords: *petrochemical industry, greenhouse gases, emissions, concentration calculation, neural networks*

The main components of gross emissions of the petrochemical enterprise of Kazan public joint stock company "Kazanorgsintez" are ethane (39.37%), a mixture of marginal hydrocarbons (21, 35%), carbon monoxide (14.58%), nitrogen dioxide (6.2%). The content of carbon dioxide is not possible to take into account since the statistical reporting of the enterprise needs to contain information on the sources of emissions of this greenhouse gas. We used the program "Ecolog-Gorod" developed by Integral Company, St. Petersburg (version 4.70) to calculate the dispersion of pollutants in the atmospheric air. With the help of the program complex at the points of the residential area, the maximum single concentrations of impurities corresponding to the set of emissions from the plant sources were calculated. The composition of waste gases generated by the combustion of any type of fuel, including fossil carbon raw materials, in natural conditions also includes several pollutants, including nitrogen oxides and carbon monoxide CO - carbon monoxide. Carbon monoxide is formed due to incomplete combustion of fuel carbon. Thus, these substances are invariable "companions" of carbon dioxide in actual industrial combustion processes, which entails some relationship between the concentrations of these gases. Therefore, the concentration of carbon monoxide was used as a predictor of the neural network model to calculate the concentration of carbon dioxide coming with emissions from a petrochemical enterprise.

Using the software package "Ecolog-Gorod" the maximum single concentrations of this emission component from the plant sources were calculated at points in the residential zone. The maximum concentration amounted to 0.61 mg/m³, and the average annual concentration was 0.0045 mg/m³. In previous works [1-2], we described different variants of neural network models for calculating emission components in the surface layer of atmospheric air. When determining the carbon dioxide content by the carbon monoxide content, the required predictors of neural network models to be considered are the parameters characterizing secondary chemical reactions that ensure the transformation of carbon monoxide into carbon dioxide. Secondary chemical reactions mainly proceed by a radical mechanism. A constant source of radicals in the atmosphere is external ionizing radiation, a constantly present radiation background, the fluctuations of which are associated with cosmogenic factors and anthropogenic impact [3].

Therefore, to account for the intensity of secondary chemical reactions in the atmosphere, it is reasonable to use the values of the transformation coefficient determined based on the ratio of the air content of nitrogen oxide and dioxide, ozone, and gamma background concentrations measured at automated air pollution monitoring stations. Ozone and gamma background concentrations in the atmospheric air were obtained experimentally based on several measurements from the automatic air pollution control station AAPCS-1 in Kazan. Experimental values of transformation coefficient and meteorological parameters for training neural network models were obtained by direct measurements at automatic atmospheric pollution control stations AAPCS-1, 3, 4 in Kazan for 2016-2022.

We set a stepwise research task to study the influence of atmospheric carbon dioxide concentrations on calculation accuracy. The task's list included parameters such as transformation coefficient, gamma background, and ozone concentrations.

A multilayer neural network of MLP type with a single hidden layer was selected as an intelligent prediction model. The number of input neurons is determined by the number of model predictors, and the model output is single—the value of carbon dioxide concentration in the atmospheric air. A neural network model was built for each variant of predictor accounting. The final model of neural network calculation of carbon dioxide concentrations with the sequence of computational processes is shown in Fig. 1.

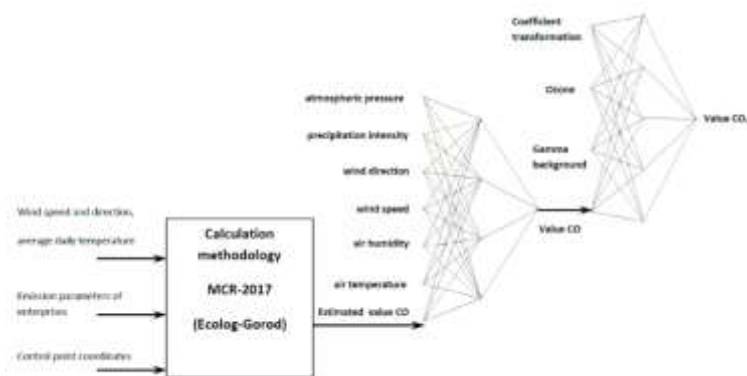


Figure 1 - Algorithm of neural network calculation of carbon dioxide concentrations

It has been proved that using only one transformation coefficient does not allow for a stable increase in carbon dioxide concentration modeling accuracy. The same applies to using the gamma background as the only predictor reflecting secondary chemical reactions. Considering two parameters directly affecting secondary chemical reactions in the atmosphere, the transformation coefficient and gamma background give the most accurate calculation results. The average model error over the entire data set was less than one percent, 0.9%.

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GREEN SYNTHESIS OF NOVEL LACTAM-CONTAINING PHENOLS DERIVATIVES

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Keywords: *alkylphenols, organic synthesis, QSAR, quantum-chemical calculations, antioxidant activity*

Phenols, the widespread compounds in nature, are important bioactive substances, possessing various effects: antiseptic [1], analgesic [2], antitumor [3-5] and others. One of the most important classes of phenolic compounds is alkylphenols, the well-known antioxidants [6]. Alkyl substituents decrease the toxicity of the phenols and increase their antioxidant effect in comparison to unsubstituted compounds. Introduction of lactamomethyl group can not only help to reach these goals but also induce some new biological effects. In paper [7] we describe the synthesis of lactamomethyl derivatives of several alkylphenols (thymol and 2,4-di-*t*-butyl-phenol) with butyrolactam, valerolactam, caprolactam and 4-phenylpyrrolidone fragments by Tscherniak-Einhorn reaction with moderate yields.

This synthetic routine, though being effective, required chloroform as a solvent and trifluoroacetic acid as a catalyst. It does not satisfy the rules of green chemistry because of large amounts of wastes and usage of toxic solvents. In order to improve this method, we started our investigation for more appropriate conditions for the lactamomethylation reaction. We haven't succeeded in this search in case of alkylphenols, but, finally, we found that polyphenols react with hydroxymethyl lactams in water with catalytic amounts of acetic acid [8]. All the starting compounds soluble in water well, while the products are almost insoluble. Thus, they can be obtained in high yields by filtration. This method is much more eco-friendly, though it produces organic-containing water wastes. The purity of obtained compounds was proved by elemental analysis and NMR-spectroscopy, and it was revealed, that these compounds need no further purification.

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LEGAL RISKS AND COMPLIANCE PATHWAYS IN CARBON EMISSION RIGHTS TRADING FOR CHINESE PETROCHEMICAL ENTERPRISES

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Keywords: petrochemical enterprises, carbon emission rights trading, compliance, risk response

Large petrochemical enterprises with their own power plants are important participants in China's carbon emissions trading market. This article analyzes the compliance key points of China's major emitters in carbon emission rights trading and, combined with typical cases since the pilot of carbon emission rights trading, discusses the normative requirements and practical operational needs of petrochemical companies in compliance management. Furthermore, this article aims to identify potential compliance risks in carbon emission rights trading and to explore the establishment of a comprehensive legal framework for compliance review and supervision to ensure the compliance of enterprises and the healthy development of the market.

“Carbon emissions trading is an effective market mechanism for addressing climate change and reducing carbon dioxide emissions. Carbon emission rights are legal entitlements created by the state for the purpose of macroeconomic regulation to achieve a low-carbon transformation, based on relevant national economic management laws, administrative regulations, or normative documents issued by economic management departments. Tradable carbon emission rights and nationally certified voluntary emission reductions (CCER) have economic value and legally constitute intangible assets measured in carbon dioxide equivalent. Enterprises participating in carbon emissions trading and engaging in trading activities must comply with a series of compliance rules such as national carbon market systems at various levels and corporate carbon asset management systems.”

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MECHANISM INSIGHT INTO CALCIUM-LOOPING DRY REFORMING OF METHANE FOR IN-SITU CO₂ CONVERSION

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Keywords: *in-situ CO₂ utilization; calcium looping; dry reforming of methane; Ni/CaCO₃; density functional theory*

The reaction mechanism of calcium-looping dry reforming of methane (CaL-DRM) process as well as the role of CH₄ during the process was revealed in this work. The method is based on density functional theory (DFT). CH* assisted CaCO₃ dissociation pathway is more prone to happen during CaL-DRM process. CH₄ reduces the energy barrier for CaCO₃ dissociation, saving energy penalties in CaO regeneration process. C-O bond in the carbonate is effectively activated when C or CH exist, promoting the decomposition of CaCO₃.

The calcium-looping dry reforming of methane (CaL-DRM) process couples CO₂ capture and dry reforming of methane process using Ni/CaO bifunctional material [1]. This process in-situ converts CO₂ captured by CaO through reacting with CH₄, catalyzed by Ni, to produce syngas [2]. However, researches on reaction mechanism for CaL-DRM are rare. In this work, the fundamental reaction mechanism of calcium-looping dry reforming of methane is elucidated by density functional theory (DFT) analysis. The energy barriers for elementary reactions involved in various potential pathways were investigated to determine the primary reaction pathway. The DFT analysis shows two possible reaction pathways for the CaL-DRM, with the CH* assisted CaCO₃ dissociation pathway being the more favorable one as shown in Fig.1. Along this pathway, CH₄ undergoes three dehydrogenation steps to form CH*. Then, CH* reacts with the CaCO₃* to produce CHO* and CaCO₂*, accompanying the cleavage of one C-O bond in the carbonate. Afterwards, CHO* dissociates into CO* and H*. Finally, another C-O bond in CaCO₂* breaks, generating CO* and CaO. Notably, CH₄ reduces the energy barrier for CaCO₃ dissociation from 3.47 to 2.733 eV. Moreover, the perturbation of electron clouds around O in CaCO₃* in the presence of CH or C, as evidenced in electron density differential results, highlights the effective

activation of C-O bond by CH or C, thereby promoting CaCO_3 decomposition. This work provides further support for the potential mechanism for in-situ CO_2 utilization achieved through CaL-DRM.

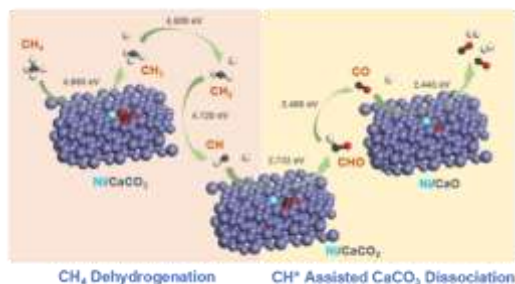


Figure 1 - Reaction mechanism of CaL-DRM process employing Ni/ CaCO_3

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THE UTILIZATION AND ADAPTATION OF NITRATE, NITRITE AND AMMONIUM NITROGEN BY SPIRULINA PLATENSIS

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Scientific adviser: Doctor of Marine Biology, Professor Baosheng Ge

Keywords: *spirulina platensis, nitrogen, growth, protein*

In the context of carbon neutrality, the treatment of nitrogen-rich flue gas using microalgae aligns with the strategic objective of sustainable development. As a kind of microalgae that have achieved industrial production, *Spirulina platensis* has great development potential in the treatment of nitrogen-containing flue gas. The adaptation of concentration range of *S. platensis* to nitrate nitrogen is the widest, followed by nitrite nitrogen, and ammonium nitrogen is the narrowest but its assimilation and absorption rate is the fastest. The soluble protein content in *S. platensis* has remained greater than 200 mg·g⁻¹. It indicated that *S. platensis* can ensure a certain accumulation of high-value products under nitrogen-containing flue gas.

The emission of nitrogen-containing compounds in flue gas has threaten to the environment and human health[1]. The traditional physical and chemical treatment methods can cause secondary pollution to the environment, but bioremediation using microalgae is an ideal method to remove nitrogen compounds in flue gas[2]. Nitrogen is an important nutrient source for microalgae growth, and its content can reach to 10% of the dry weight of algae biomass[3]. *S. platensis* has the widest adaptation range to the concentration of nitrate nitrogen and can maintain a good growth rate (Figure 1). Ammonium nitrogen has the most significant effect on promoting *S. platensis* growth at lower concentration because this nitrogen source form can be utilized directly[4], but inhibit the growth under higher concentration. The promotion effect of nitrite nitrogen on the growth of *S. platensis* was not obvious at low nitrogen concentration. The inorganic nitrogen can be transformed to organic nitrogen and participated in protein synthesis by microalgae[5, 6]. The accumulation of soluble protein was basically consistent with the *S. platensis* growth under the treatment of different nitrogen sources (Figure 2). The above results have lay a reference basis for realizing large-scale emission reduction of nitrogen containing flue gas coupling of

microalgae to produce high value-added products, so as to improve the environment, reduce the cost of microalgae culture and obtain benefits, which has great scientific significance and application prospects.

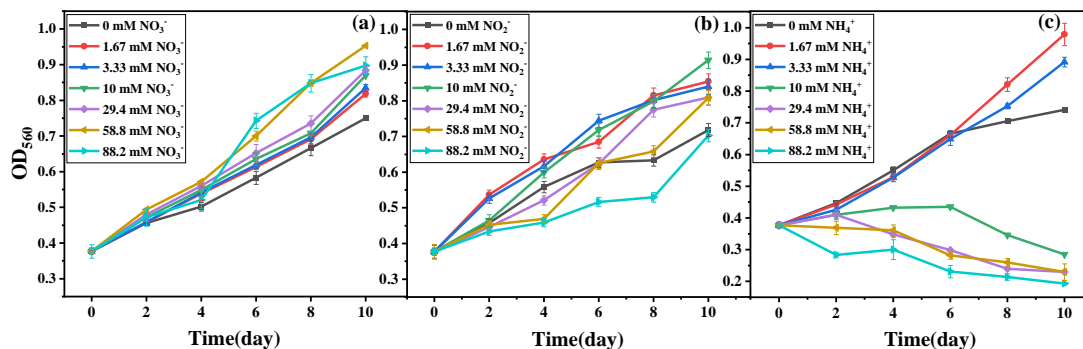


Figure 1 - Growth trend of *Spirulina platensis* under different nitrogen sources. The culture system was (a) NO_3^- ; (b) NO_2^- ; (c) NH_4^+ . Error bar shows standard deviation (n=3)

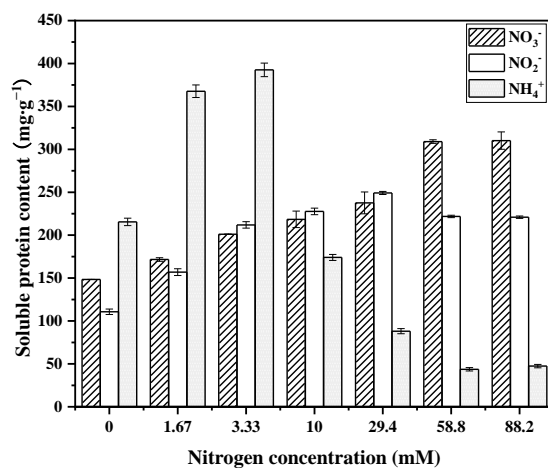


Figure 2 - Accumulation of soluble protein content in *Spirulina platensis* under different nitrogen sources. Error bar shows standard deviation (n=3)

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SYNTHESIS OF AMINO-FUNCTIONALIZED MESOPOROUS SILICA HOLLOW SPHERES USING CO₂ BUBBLES AS TEMPLATES

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Keywords: *hollow, mesoporous silica, amino-functionalized, CO₂ bubble template, CO₂ capture, controlled release of the drug, catalytic reaction*

Since the discovery of mesoporous materials, they have been known for their special structural properties such as high specific surface area, large pore volume, and continuously adjustable mesoporous channels, which makes them widely used and popularized in the fields of optics, biomedicine ^[1], catalytic ^[2], and separation. Herein, amino functionalized mesoporous silica hollow spheres were synthesized with a relatively economical and environmentally friendly bubble generated by CO₂ bubble as a template. The hollow sphere had a thin spherical shell, relatively concentrated particle size, good dispersity, and uniform amino groups on the surface. Based on the structure and functional characteristics of the synthesized materials, it was applied to the efficient adsorption of CO₂, the rapid release of drugs, and the efficient catalysis of Knoevenagel polycondensation reaction.

Experimental part

1. Synthesis of Amino functionalized mesoporous silica hollow spheres

In a typical synthesis, 1 mmol of Sar-Na was completely dissolved in 30 mL of deionized water at room temperature. Next, 1.5 ml of ethyl orthosilicate (TEOS) and 0.12 mL of 3-aminopropyltriethoxysilane (APES) were added under vigorous stirring. The entire solution was transferred. Next, high-pressure CO₂ gas was introduced to 1 MPa and stirred for 24 hours. The resulting product was extracted with 10 wt.% hydrochloric acid in acetonitrile and then washed with 1 wt.% ammonia water. The final product was filtered, washed, and dried overnight at 80 °C.

2. CO₂ adsorption experiment

The CO₂ performance test is carried out in a thermogravimetric analyzer. In the pretreatment stage, 5 mg of adsorbent was weighed into a small crucible and heated from room temperature to 150 °C in a nitrogen atmosphere for 30 min; In the adsorption stage,

when the adsorbent naturally cools to 30 °C, pure CO₂ is introduced for 60 min. The change data of the adsorbent mass is recorded and analyzed throughout the adsorption process to draw the carbon dioxide adsorption curve.

3. Metoprolol tartrate (MPT) loaded for drug release

Typically, 5 mg of MPT was fully dissolved in 2 mL of ethanol. Next, 50 mg hollow silica spheres were added and dispersed under sonication and then it was placed in a 50 °C oven for 24 h. Subsequently, 2 mL of ethanol was added to the dried sample to centrifuge and wash the unadsorbed drug on the surface of the hollow sphere. The resulting precipitate was thoroughly dried in an oven at 50 °C. Next, drug-loaded mesoporous silica hollow spheres were used for drug release experiments.

4. Knoevenagel polycondensation reaction

Specifically, 50 mg of the catalyst was placed in a reaction vessel and then 1.4 mL of toluene, 0.02 g of naphthalene (internal standard), 133 μL of benzaldehyde, and 136 μL of ethyl cyanoacetate were added, heated at 30 °C in an oil bath, and stirred. The conversion rate was measured in real time with a gas chromatograph, and the reaction kinetic curve was drawn based on the yields at different time nodes.

Results and discussion

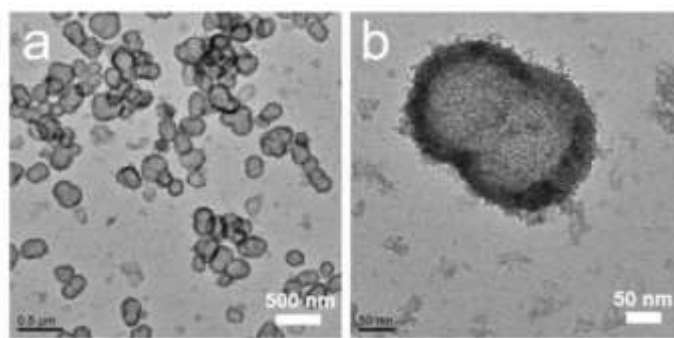


Figure 1 - TEM image of mesoporous silica nanoparticles

As shown in TEM images (Fig. 1ab), the synthesized sample has a thin spherical shell, good dispersibility, and small relatively concentrated particle size about 100 nm. The nitrogen adsorption-desorption isotherm shows a large hysteresis loop at a relative pressure of 0.45-0.95, which is attributed to the hollow structure of the synthesized sample. In addition, the synthesized samples showed a large specific surface area and pore volume of 361 m²/g and 0.95 cm³/g, respectively.

Based on the structure and functional characteristics of the synthesized material, it is applied to the following applications: (1) CO₂ adsorption. Its adsorption capacity reached 0.69 mmol/g, showing a good utilization rate of amino groups; (2) drug release. With its large hollow structure, it can not only load and deliver drugs in a large amount but also quickly release drugs in a short time. At 1 h, the accumulated release has reached 50%, indicating that it has important application value in drug stimulation response release and targeted treatment, and can achieve rapid drug delivery to the target area. (3) Knoevenagel polycondensation reaction. The conversion rate is nearly 80% at 1 h, confirming that it can efficiently catalyze the Knoevenagel polycondensation reaction.

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PROBLEMS AND PROSPECTS OF HYDROGEN ENERGY IN CONDITIONS OF DECARBONIZATION

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Hydrogen has several properties that make it potentially significant in the field of energy. The field of application of hydrogen is extensive, including its use in the transportation, industrial, chemical and utility sectors. In addition, hydrogen has high energy efficiency, does not generate carbon dioxide (CO₂) emissions during operation and can function as a backup fuel, compensating for the need for electricity during periods of low energy production from renewable sources.

Nevertheless, a number of disadvantages should be noted in the use of hydrogen, such as its high flammability, production costs and lack of appropriate infrastructure. It is especially important to take into account that the environmental impact of hydrogen may be more significant than in the case of traditional fuel sources. Hydrogen leaks during transportation and operation, as well as the formation of water vapor, are significant aspects that must be considered when assessing the stability of hydrogen as an alternative fuel. Thus, the transition to the use of hydrogen, despite its significant environmental benefits, implies the need for a more in-depth analysis and assessment of possible environmental consequences.

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THE ACCUMULATION AND INHIBITION MECHANISM OF EXTRACELLULAR POLYMERIC SUBSTANCES (EPS) DURING THE MICROALGAL WASTEWATER RECYCLING UNDER DIFFERENT LIGHT QUALITIES

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Keywords: *Chlorella vulgaris*; wastewater recycling; growth inhibition; light quality; transcriptomics; metabolomics

This work aimed to explore the molecular mechanism of different light quality and EPS accumulation to regulate the growth and metabolism of *Chlorella vulgaris* in recycled wastewater. The EPS consisted of polysaccharides, protein, and humic acid-like compounds, which decreased algal growth under different light qualities. Up-regulation of metabolic pathways linked to glycolysis/gluconeogenesis, TCA cycle, lipid synthesis, and ABC transporters promoted the EPS accumulation, which ultimately inhibited microalgae growth under green light. This study has important practical and theoretical significance for the light quality regulation and cyclic cultivation of microalgae, as well as the conservation and efficient utilization of water resources.

C. vulgaris is highly valued renewable resources for its fast growth, high photosynthetic efficiency, adaptability, and nutrient contents (protein, polysaccharides, lipids, vitamins, chlorophyll, etc.) [1,2]. It is extensively utilized across various sectors, including foods, feeds, cosmetics, pharmaceuticals, and biodiesel production [3]. There has been a lot of interest in large-scale *C. vulgaris* production in conjunction with CO₂ fixation and wastewater treatment.

In this research, a comprehensive study was conducted to explore the accumulation and inhibition mechanism of EPS on microalgal growth during the microalgal wastewater recycling under different light qualities. The microalgal growth, photosynthesis, and metabolites, including proteins, carbohydrates, lipids, fatty acid profiles, and oxidative stress response, were investigated under either white, red, blue, or green lights. The differences in composition of EPS regulated by different light quality were investigated. The

molecular mechanisms of the secretion of potential inhibitors by *C. vulgaris* in response to different light quality were elucidated through the integration of transcriptomics and metabolomics.

As shown in Fig. 1, the EPS accumulation in the recycled wastewater, significantly inhibited cell growth, protein, and polysaccharide biosynthesis, and increased the lipid accumulation in *C. vulgaris* under different light qualities. The EPS exhibited characteristics of polysaccharides, proteins, and humic acid-like compounds. Green light significantly down-regulated the photosynthesis of microalgae and inhibited microalgal growth. Additionally, the up-regulated expression of glycolysis/gluconeogenesis, TCA cycle, lipid synthesis, and ABC transporter metabolic pathways promoted the EPS accumulation. It is necessary to further study how to effectively remove EPS and increase the recycling times of microalgal wastewater, and promote the green and sustainable development of microalgae industry.

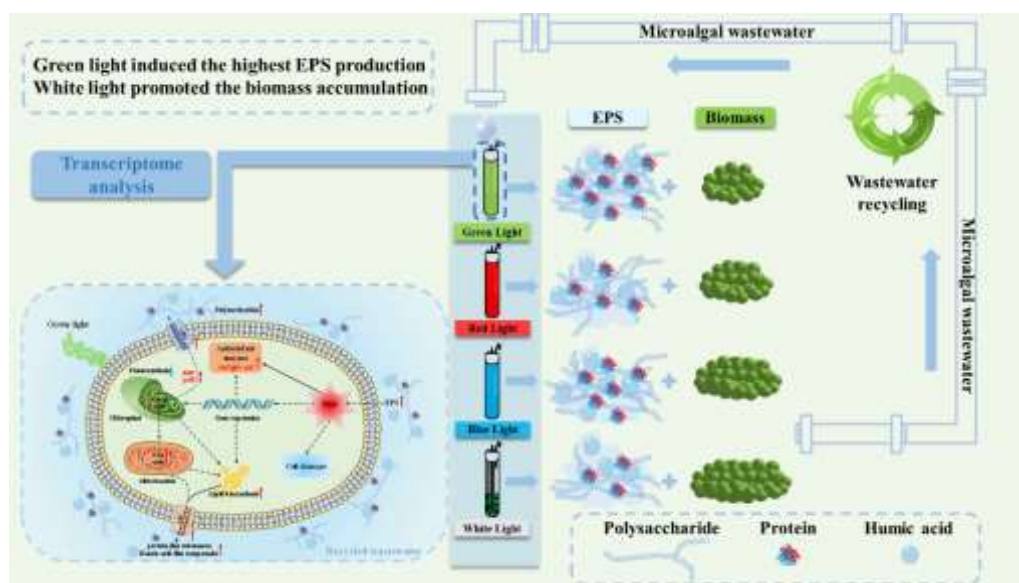


Figure 1 - The physiological and molecular regulatory mechanism model of *C. vulgaris* in response to green light for EPS production in recycled wastewater. Dashed lines represent multiple steps or potential results

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THE ROLE OF BRICS IN THE TRANSFORMATION OF GLOBAL ENERGY

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Keywords: *BRICS, SDGs, climate crisis, challenges, climate change*

The end of the 20th and beginning of the 21st centuries are characterized by the fact that the world economy gradually began to move into a new phase of economic and energy development. Western countries, led by the United States of America, in order to avoid the emergence of new competitors in the markets, began to restrict developing countries, denying them access to innovative technologies and concluding trade and economic deals with them. Against the backdrop of these measures, governments in developing countries felt the need to join forces to create healthy competition. Under these conditions, the BRICS integration association was born. Geopolitical instability, shifting the vector towards the global south, has increased the importance of the integration association.

The scale and dynamics of integration of renewable energy sources (RES) in the energy balance of the BRICS countries largely depend on socio-economic parameters (investment, level of development of science and industrial production, population and economic dynamics, volume of consumption of primary energy sources, ecology), assessment of the impact of which will allow us to draw a more detailed picture of the prospects for the development of renewable energy sources, as well as identify influencing factors. Using the methods of correlation and regression analysis, implemented using the MS Excel program, the author compiled equations that best show the existing relationships between the analyzed characteristics.

The purpose of this work is to study the role of BRICS in resolving the climate crisis, to consider BRICS mechanisms on the way to resolving the crisis.

Achieving the research goal is carried out through the integrated use of such general scientific and special methods as:

- historical and logical;
- descriptive;
- methods of analysis and synthesis.

Research results. In the future, energy and climate issues will undoubtedly remain an important factor for the BRICS, determining their domestic politics and international relations. The desire to obtain oil and gas (China, India, South Africa) to support economic development and the search for stable oil markets (Brazil and Russia) determined BRICS relations with other countries and regions. Conversely, along with increasingly scarce oil resources, the incentives and rhetoric of international climate negotiations and their consequences are pushing the BRICS to consider alternative energy sources.

According to the results of the analysis, in Russia, China, South Africa and India, the determining factor in the dynamics of green energy consumption is the level of introduction of energy generating capacities based on renewable energy sources into the electricity production structure, while the efficiency of using “green” power plants in China, India and South Africa is higher than in Russia. The author believes that the main reasons lie both in the differences in natural and climatic potential and in the characteristics of the electricity production sector. In Brazil, where green energy consumption comes in two forms—electricity and motor fuel—the rate of deployment of power generation capacity is not decisive. The population indicator comes first - not only the number of electricity consumers is growing, but also the number of car owners, which has a direct impact on the volume of biofuel consumption (bioethanol and biodiesel).

GREEN HYDROGEN PRODUCTION FROM METHANE CRACKING VIA MECHANICAL CATALYSIS APPROACH

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Keywords: *green hydrogen production, natural gas, methane pyrolysis, mechanical catalysis, single atom alloy*

A potential pathway to produce green hydrogen in large-scale without carbon emission is direct thermal decomposition of methane into hydrogen and carbon. Here we report a strategy through mechanical decomposition of methane into hydrogen through single atom alloy ball milling, achieving hydrogen generation as low as 533 K.^[1-3] The single atom alloy ball was synthesized by impregnation method on Nickel metallic balls and CH₄ decomposition performance in presence of mechanical vibration was greatly improved on Pt/Ni single atom alloy. The hydrogen generation rate could maintain 2.7 mol·g⁻¹·h⁻¹ at 723 K after 350 hrs reaction in Fig. 1. The XRD, AFM, EXAFS and XPS were conducted to examine the Pt/Ni single atom alloy structure and Pt/Ni valence. Density function theory calculations presented that the lattice deformation induced by milling ball collision and stress release could enhance electron transfer between Ni support and Pt atoms, further leading to the reduce of dehydrogenation reaction barrier. Generally speaking, this work opens a direction for large scale production of green hydrogen with low energy consumption.

This work opens a direction for large scale production of green hydrogen from methane cracking with a new mechanical catalysis approach.

The pure Ni ball was purchased from the Aladdin with 333 g and diameter of 6-12 mm. Prior to the metal loading, the Ni balls were sonicated in DMF for 30 min and washed by deionized water. After the drying of Ni balls, they were impregnated into the chloroplatinic acid solution (0.0127 M) for 10 hours, and followed by filtration, drying in air for 30 min, calcination at 850 °C and reduction at 700 °C for 2 hours in the 20 mL 10%H₂/Ar. CH₄ decomposition was performed on a home-made mechanical facility with electro-motor to control the vibration frequency of reactor, which could study the

mechanical catalysis under 450 °C and vibration frequency from 0-1500 RPM (motor speed). Typically 333 g Ni balls was sealed in the reactor and the temperature was controlled by a type K thermocouple inserted inside the reactor.

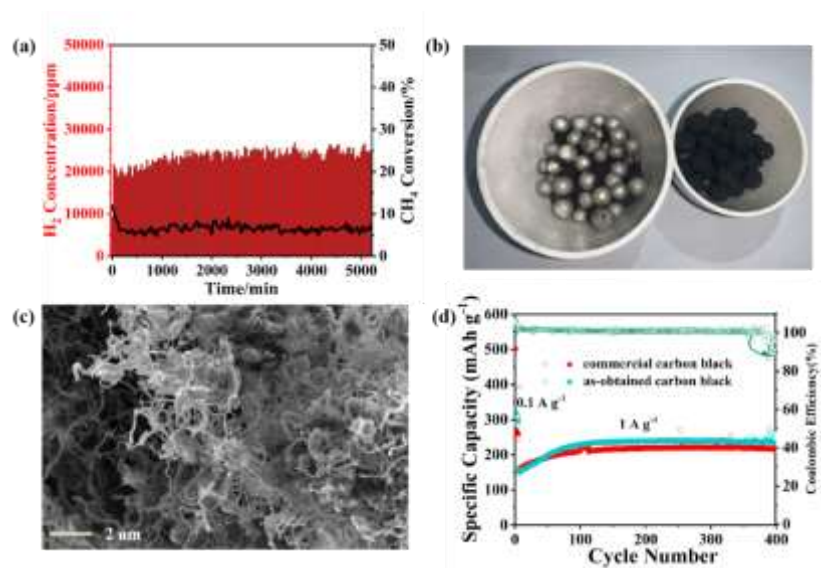


Figure 1 - (a) the life time study of CH₄ decomposition over Pt/Ni SAA with/without 500 RPM vibration frequency and 450 °C. (b) The used Pt/Ni SAA after the life time evaluation. (c) The SEM images of obtained carbon products. (d) The cycling stability of as-synthesized carbon black and commercial carbon black electrodes from 0.1 to 1 A g⁻¹

Fig. 1a presented the life-time profiles over Pt/Ni SAA, and the TOF of H₂ maintained at 2.7 mol·g⁻¹·h⁻¹ (5000 min) from CH₄ decomposition coupling with mechanical vibration, which exhibited a superior catalytic stability compared with previous studies. For the initial 1000 min, the CH₄ conversion declined from 12% to 6%, which was induced by the existence of side reaction. The mechanical vibration greatly lengthened the CH₄ decomposition stability. In addition, the calculation of carbon slip process over metal surface was conducted through CI-NEB method. The slip energy barrier was 0.68 eV and was easily removed by mechanical vibration on the grinder. Thus, the vibration could eliminate the influence of carbon deposition on the catalyst surface and prolong the catalyst life. Meanwhile, compared with the clear metal balls after mechanical vibration mode in Fig. 1b, the used metal balls under static condition were surrounded and packaged with carbon deposition, illustrating the deactivation was dominated by carbon deposition while vibration could remove the deposited carbon timely.

In order to further improve the economic benefits of this technology, the produced carbon products were also collected and reused. The BET result presented its meso-porous structure with surface area of 57.6 m²/g, and the SEM image in Fig. 1c showed the nanorod shape of the carbon products. Moreover, it exhibited good cycling stability from Fig 1d, a reversible capacity of 232.9 mA·h·g⁻¹ after 400 cycle at 1A·g⁻¹. Compared to commercial carbon black, it delivered superior cycling performance.

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Fig. 2 shows a fragment of a complex column with one of the stripping sections C-3, C-4 and C-5. Part of liquid flow L_{FR} is diverted from the complex column C-2 to the stripping column.

Superheated steam (SS) is supplied to the bottom of the stripping columns to remove the lighter components in order to improve the quality of the selected fractions. The lighter fraction along with the steam is returned to the main column above the side stream withdrawal points.

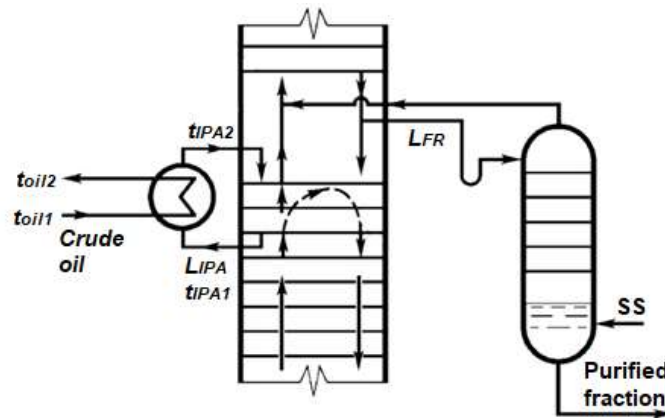


Figure 2 - Fragment of a complex column with a stripping section on the right and an intermediate pumparound (IPA) on the left

When part of the liquid (reflux) is removed from the complex column, the reflux ratio on the downstream trays decreases. To equalize the reflux flow over the height of the complex column, an intermediate pumparound (IPA) is organized at the point of liquid withdrawal to the stripping column. The flow of intermediate pumparound L_{IPA} at temperature t_{IPA1} is cooled in the heat exchanger by crude oil up to temperature t_{IPA2} and returns to the main column. At the same time crude oil is heated from t_{oil1} to t_{oil2} (Fig. 2). The return of the cooled IPA stream to the main column creates partial condensation of the vapor flow. The condensed flow part is joined to the reflux flow (arrows on the dashed line in Fig. 2) and thus compensates for the partial liquid withdrawal from the main column C-2.

The intermediate pump around heuristically found by petroleum technologists is fully consistent with the internal energy saving theory in distillation processes. Its application can provide a great effect.

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STUDY OF HYDROGEN PRODUCTION BY STEAM REFORMING OF METHANOL IN A MEMBRANE REACTOR

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Keywords: *hydrogen production, methanol, steam reforming, membrane reactor, hydrogen permeability, Pd-Cu membranes*

Development of environmentally safe and efficient methods of hydrogen production is an urgent topic of today's time. Steam reforming of methanol, which is a fast and highly efficient process for hydrogen production, is considered as one of the promising approaches. However, conventional reactor systems have their limitations related to mass transfer and reaction selectivity. In this context, membrane reactors have attracted considerable attention in academic and research circles as they have the potential to improve the efficiency and selectivity of methanol reforming [1].

Methanol was chosen as a raw material for hydrogen production due to a number of technological advantages, including: liquid state of alcohol under normal conditions, which greatly facilitates transport and storage, high reactivity, relative low temperature of methanol steam reforming process in the range from 200 to 350° C, in addition, methyl alcohol is easily biodegradable by environmental organisms and, unlike bioalcohols, usually does not contain sulphur impurities that poison catalysts [2].

The process of hydrogen production by steam conversion of methanol was carried out at atmospheric pressure at a flow-type unit in the temperature range of 200-400 °C. Systems based on copper alloys with carriers of different nature were used as catalysts of the process. The surface morphology of the catalysts was determined by transmission electron microscopy (figure 1). During the research, it was found that the process is carried out with better performance in the presence of active material on a carrier made of detonation nanodiamonds. Pd-Cu alloy metal systems with modified surface were chosen as membrane materials, and studies were carried out on membranes of different thicknesses.

It is shown that the process of methanol vapour conversion is intensified with increasing temperature from 200 to 400 °C. It is also revealed that hydrogen yield in the process of methanol steam reforming increases with transition to membrane materials of smaller thickness. It was found that when the process is carried out in a membrane reactor, the hydrogen yield per 1 mole of feedstock increases by 20% compared to the process in a conventional reactor (figure 2).

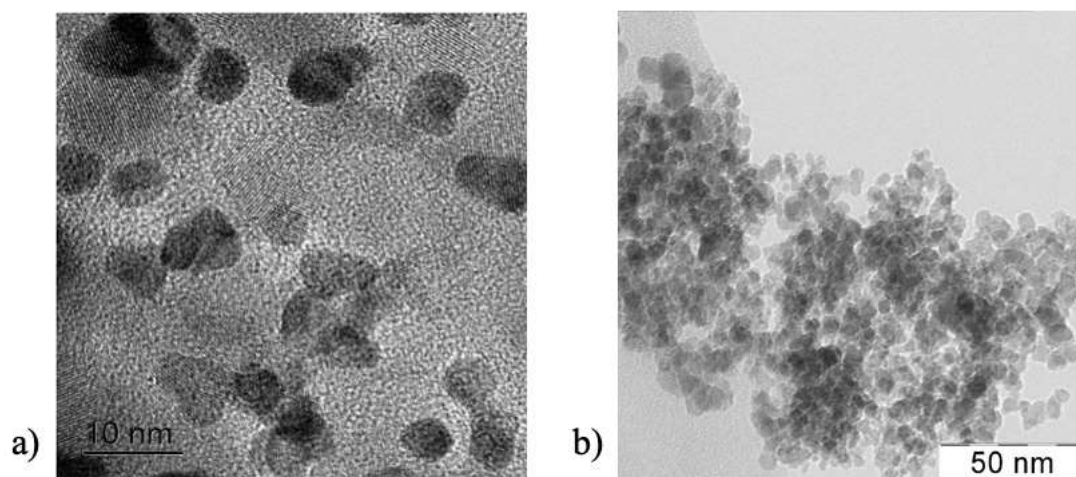


Figure 1 – Transmission electron microscopy images of catalysts:

a) Cu-Ni/TiO₂-In₂O₃; b) Cu-Ni/DND

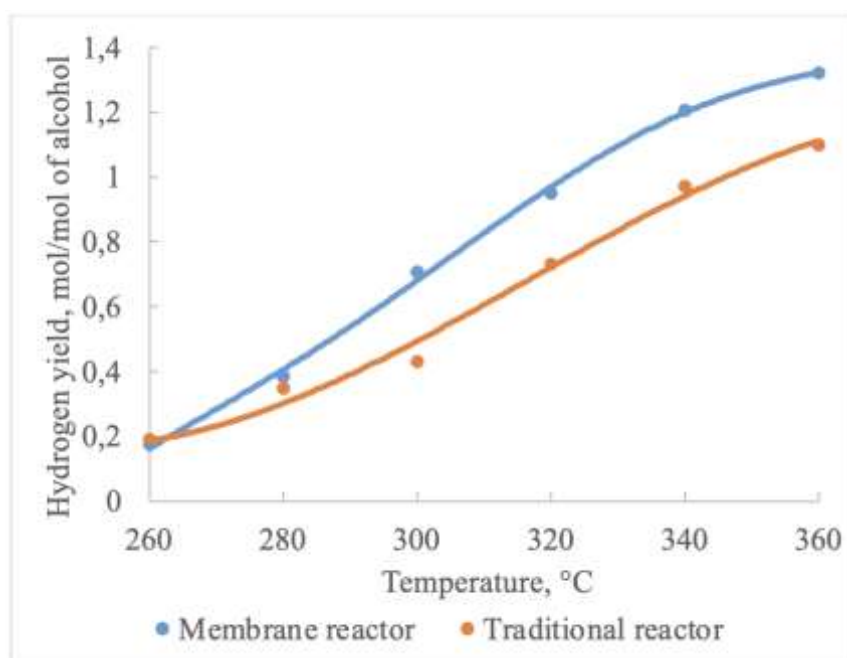


Figure 2 – Temperature dependence of hydrogen yield in different reactors

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ENCAPSULATION OF PARAFFINS FOR SUSTAINABLE ENERGY APPLICATIONS

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Keywords: *phase-change materials; latent heat storage; surfactant-free emulsions; interfacial polymerization; polyurethane shell*

Phase-change materials (PCMs) are actively studied regarding their capability to store and release thermal energy as latent heat of reversible phase transitions. Currently, paraffines (n-alkanes) are of particular interest as organic PCMs for sustainable energy development due to their high latent heat storage capacity, durability of thermal properties, and possibility of being derived from renewable raw materials [1]. However, the applicability of bare paraffins is limited, as they are prone to leakages during the solid–liquid transition [2]. The confinement of paraffins in polymeric containers by emulsion interfacial polymerization was shown to be an efficient and versatile approach to deal with the leakage issue [3]. Generally, encapsulation of paraffins by interfacial polymerization requires the preparation of an oil-in-water emulsion stabilized with surfactant or polymer, which contains the paraffin and oil-soluble monomer in the oil phase and a water-soluble monomer in the aqueous phase [4].

In this way, the polyurethane (PU) capsules with various loadings of octadecane (OD) were prepared via polymerization of commercially available polymethylene polyphenylene isocyanate (PAPI) and PEG 1000 at the oil/water interface of the PVA-stabilized emulsion. The latent heat storage properties and capsule structure were studied with respect to octadecane feeding to the emulsion oil phase. According to differential scanning calorimetry (DSC), the prepared capsules had a tunable latent heat capacity (51–133 J/g) defined by OD feeding, which remained stable through numerous iterative melting and crystallization cycles. The actual content of encapsulated OD was found to gradually increase along with the mass of the paraffin added to the oil phase until it reached 66 wt%. The further increase

in OD feeding did not result in a significant improvement in the actual content and latent heat capacity of the capsules. In turn, scanning electron microscopy (SEM) revealed that the thickness of the resulting PU shell reduced from 460 to 220 nm with the step-wise growth of the OD feeding to the oil phase at the same quantity of solvent. This can be related to the reduction in PAPI solubility, leading to its segregation from the oil phase. Nevertheless, transmitting electron microscopy (TEM) confirmed the paraffin is reliably encapsulated by the PU shell and free to undergo the phase transition in the capsule interior.

Alternatively, paraffins can be encapsulated by the preparation of surfactant-free emulsions with improved sustainability and functionality compared with conventional emulsions [5]. In this respect, nanocellulose attracts much attention as a stabilizer in the preparation of Pickering emulsions due to its intrinsic amphiphilic nature and ease of surface modification [6, 7]. There are two common types of nanocellulose that can be isolated from the waste base of renewable sources, which are cellulose nanocrystals (NCC) and cellulose nanofibrils (NFC). This approach does not need the surfactant and additional monomer, as nanocellulose acts simultaneously as a stabilizer and a source of hydroxyl groups for shell cross-linking through the formation of urethane linkages in reaction with isocyanate groups of PAPI dissolved in the oil phase. In the case of NCC-stabilized emulsions, NCC behaves as a branched oligo-polyol with high functionality. This gave rise to a rigid and highly cross-linked PU structure due to the high density of urethane groups. The resulting shell effectively prevented the OD leakage but was quite fragile due to the dense packing of NCC at the oil-water interface and the lack of soft urethane domains in the shell structure. The NCC/PU capsules had a latent heat storage capacity of 79 J/g, corresponding to 40 wt% of the actual content of the encapsulated paraffin. The average capsule shell thickness was 450 nm.

Alternatively, the oil droplets can be stabilized with NFC [6]. Unlike NCC, NFC additionally has amorphous regions in its structure, which provides a more flexible shell. Furthermore, the assembly of surface-modified NFC at the oil-water interface can be controlled by altering the ionic strength. In an aqueous medium, NFC assembles at the interface as single fibers owing to electrostatic repulsion or jams into a solid-like thin film of NFC clusters as salt is added to the NFC suspension [8]. The addition of 0.1 M NaCl resulted in an increase in the average thickness of capsule shells from 210 to 390 nm, and

no ruptured shells were detected. This led to improved thermal stability due to the shift of the onset decomposition temperature from 114°C to 224°C and a more efficient protection of the encapsulated OD from elution in the organic solvent. The latent heat storage capacity was 142 J/g for NFC@NaCl/PU capsules and 133 J/g for NFC/PU capsules, corresponding to the actual content of the encapsulated OD of 71 wt% and 66 wt%, respectively.

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COKE RELOCATION AND MO IMMOBILIZATION IN DONUT-SHAPED MO/HZSM-5 CATALYSTS FOR METHANE DEHYDROAROMATIZATION

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Keywords: *methane dehydroaromatization, Mo/HZSM-5 catalyst, defects, coke relocation, Mo immobilization*

Molybdenum-modified HZSM-5 catalysts are widely used for methane dehydroaromatization (MDA) but suffer from rapid deactivation due to coke formation. In this study, we modify Mo/HZSM-5 catalysts by removing the crystal core to enhance methane dehydroaromatization (MDA) performance. Two treatments, fluorine (Z_F) and alkaline (Z_{OH}), dissolve the silicon-rich core, creating central macropores, resulting in donut-shaped catalysts. Alkaline treatment generates additional mesopores and silanols, limiting coke deposition and molybdenum carbide sintering. This strategy relocates coke from micropores to macropores, effectively mitigating deactivation. The approach improves Mo/HZSM-5 catalyst stability and performance in MDA reactions.

Methane dehydroaromatization under non-oxidative conditions (MDA) over bifunctional Mo/HZSM-5 catalysts has raised the hope of the scientific community over the last decades as a new potential energy source.¹ However, the industrial development of MDA is still impeded by (i) a relatively low benzene yield, limited by thermodynamics at about 12.5% (700 °C), and (ii) a rapid catalyst deactivation due to coke formation. Catalyst development is one of the strategies identified to address such challenges.² Different ways of catalysts improvement have been reported, such as Mo/Al balance tuning, variation of molybdenum loading approach, pretreatment, metallic promoter addition, or crystal engineering. This study reports how reducing diffusion pathways by removing the crystal core (Figure 1) affects catalysts behavior during methane dehydroaromatization (MDA).³

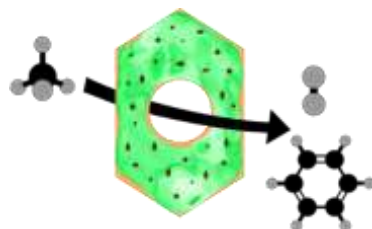


Figure 1 - The schematic diagram of the synthesis of Donut-Shaped Mo/HZSM-5 Catalysts for Methane Dehydroaromatization

A novel synthesis strategy was developed to create coreless Mo/HZSM-5, named donut-shaped catalysts. Firstly, a parent zeolite comprising a defect-rich silicalite-1 core encased by an HZSM-5 crystal was synthesized in fluoride medium. Then, fluorine and alkaline post-treatments were applied to the silicalite-1-Core/HZSM-5-Shell material to selectively dissolve its core. The textural and chemical properties of the fresh catalysts were characterized and their catalytic performance in MDA was evaluated. Furthermore, catalyst deactivation and coking mechanisms were explored through post-reaction characterization. This comprehensive approach provides insights into the role of the crystal core in the MDA process and its impact on catalyst performance.

The parent zeolite (Z_P) with a silicalite-1 core surrounded by ZSM-5 crystal was synthesized through the seed-assisted method in F^- medium. Then, Z_P was subjected to NH_4F etching (Z_F) and alkaline leaching (Z_{OH}). Both treated materials exhibit a hierarchical “donut”-like structure with mesopores connected to a central hole. The NH_4F treatment led to an almost silanols-free material and alkaline leaching to the creation of additional small intracrystalline mesopores and external silanols (Figure 2A, B). Finally, 3.5 wt.% of molybdenum was loaded by impregnation on Z_P (Mo- Z_P), Z_F (Mo- Z_F) and Z_{OH} (Mo- Z_{OH}) materials.

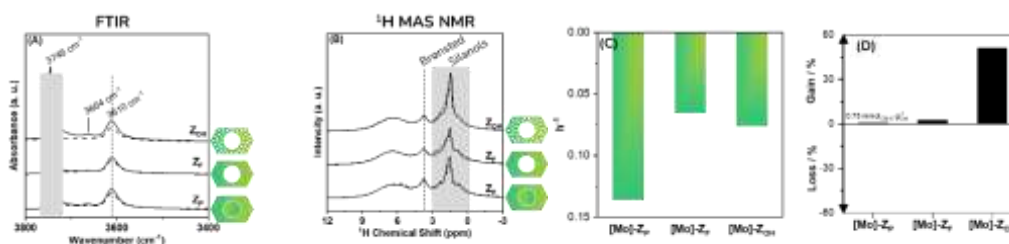


Figure 2 - (A, B) Spectroscopic characterization of ZSM-5 (solid lines) and Mo-ZSM-5 zeolites (dotted lines). The comparison of deactivation rate (C) and benzene formation (D) on the parent and both “donut” catalysts

MDA reaction was carried out at 700 °C and atmospheric pressure on molybdenum-containing materials. The diffusion path reduction through “donuts”-shaping mitigates the catalyst deactivation while improving the benzene production (Figure 2C, D). Furthermore, introducing mesopores network on Z_F and Z_{OH} modifies the coke nature and shifts its location from the microporosity towards the mesoporosity. The coke retention in Mo- Z_{OH} mesoporosity is enhanced by the silanols defects, acting as coke traps, with no impact on the activity and deactivation. Thus, only the coke in the microporosity deactivates the catalyst, while the coke deposited in the mesoporosity is a spectator of the MDA reaction.

The donut-shaped catalysts showed a relocation of coke from micropores to macropores that significantly mitigate catalyst deactivation caused by coke formation. Furthermore, the alkaline-treated catalyst contributed to limiting the sintering of molybdenum carbides and enhanced the catalyst's stability during the MDA reaction.

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DESIGN AND OPTIMIZATION OF FLUID CATALYTIC CRACKING GASOLINE FRACTIONATOR

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Scientific adviser: Doctor of Engineering, Professor Sun L

Keywords: *fluid catalytic cracking gasoline fractionator, dividing wall column, process optimization, energy saving and emission reduction*

The gasoline fractionation scheme used in catalytic cracking has a significant impact on the blended gasoline's octane number. In this study, an improved fractionation scheme was proposed for a fluid catalytic cracking (FCC) gasoline fractionation unit, and the process was optimized based on total annual cost (TAC), light gasoline recovery, and carbon dioxide emission (ECO₂) evaluation metrics, and the process was intensified using a diving wall column (DWC). In comparison to the traditional cascaded binary column (CBC) process, the DWC process improved the medium gasolines recovery by 1.96%, reduced the TAC by 22.15%, and reduced the ECO₂ by 26.18%.

The primary objective of gasoline blending is to reduce the sulfur and olefin content while increasing the octane. Fluidized Catalytic Cracking (FCC) gasoline represents a significant component of the gasoline blending pool, accounting for approximately 30-40% of the total blend ^[1]. FCC gasoline is classified into three categories: light, medium, and heavy. Light and medium gasoline are particularly effective in improving the octane rating. Given the energy-intensive nature of petroleum distillation, improving economic efficiency and reducing carbon emissions are widely recognized as key objectives ^[2]. In this paper, the FCC gasoline fractionation process is simulated using the CBC process and the DWC process for the fractionation of FCC gasoline. The TAC, ECO₂, and medium gasoline yield were optimized by a genetic algorithm to identify the optimal process operating parameters.

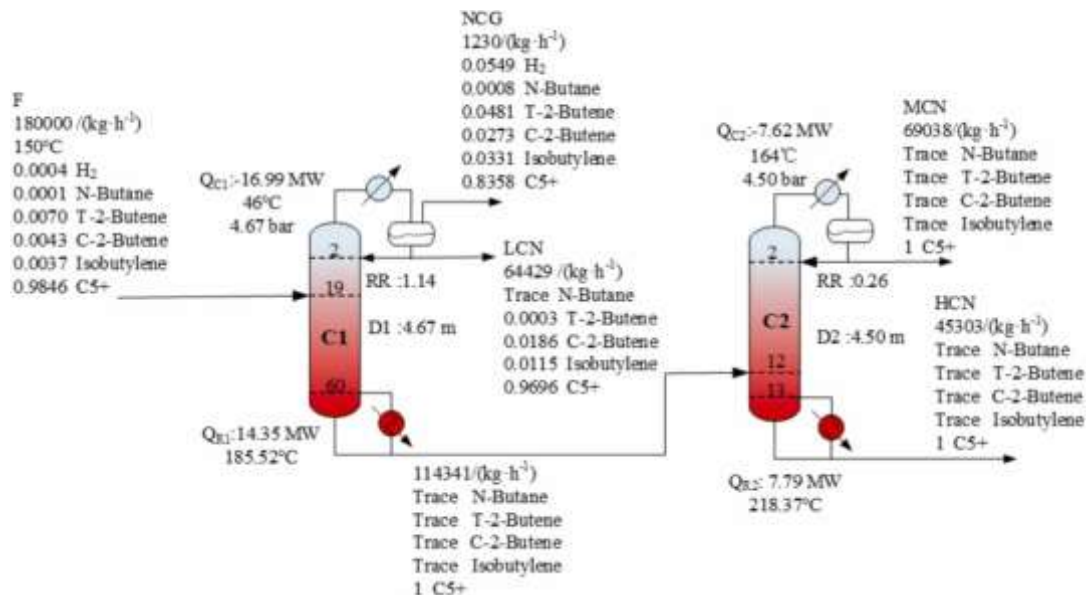


Figure 1 - CBC process flow chart after multi-objective optimization

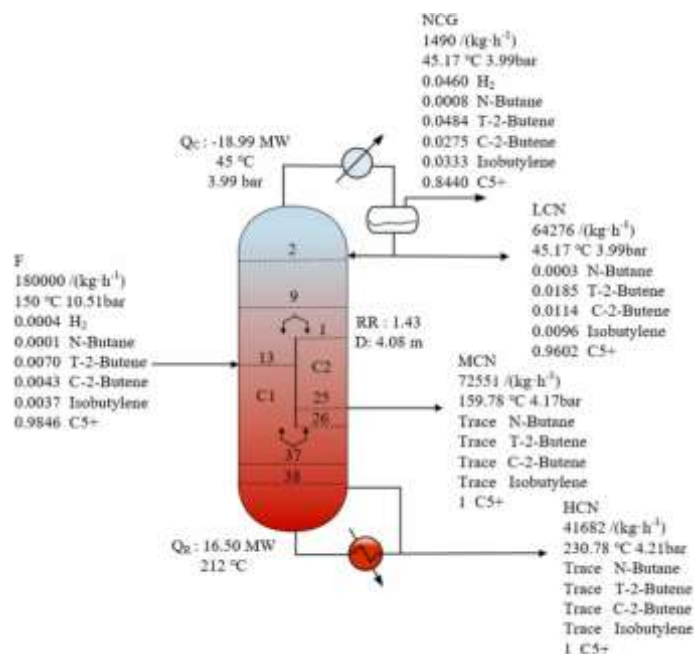


Figure 2 - DWC process flow chart after multi-objective optimization

This study employs a multi-objective genetic algorithm to optimize the CBC process and the DWC process for lower TAC, less CO₂, and higher gasoline yields. The flow rate and composition of the feed were actual data from a refinery in Zhejiang Province, China. Figure 1 depicts the optimized CDC flow with the lowest TAC. It is observed that the theoretical number of trays is higher in the C1 column and lower in the C2 column, indicating that the separation of light gasoline and medium gasoline is more challenging than the separation of medium gasoline and heavy gasoline. Figure 2 depicts the optimized DWC flow with the lowest TAC. The theoretical number of trays and total energy

consumption of the DWC process are lower than those of the CDC process. This is because the DWC for separating multi-components is an ideal structure with higher thermodynamic efficiency. Table 1 presents a comparison of the metrics for the CDC process and the DWC process.

Table 1 - Comparison of metrics for the two processes

Process \ Metrics	TAC, \$	ECO ₂ , kg/h	Medium gasolines recovery, %
Cascade binary column	7.8×10 ⁶	9795.9	38.4
Dividing wall column	6.1×10 ⁶	7231.2	40.3

This paper presents an optimization scheme for FCC gasoline fractionator, which was investigated separately for CBC process and DWC process. The results show that the DWC process has lower TAC and ECO₂ and higher yield of medium gasoline.

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THE ENHANCEMENT OF ENERGY STORAGE PERFORMANCE FOR MGO/MG(OH)₂ CYCLES WITH COMPOSITE ADDITIVE

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Keywords: *MgO/Mg(OH)₂ thermochemical energy storage, Fe/LiNO₃/TiN co-modified MgO, optical absorption capability, density functional theory calculation*

Fe/LiNO₃/TiN co-modified MgO/Mg(OH)₂ was synthesized to enhance the energy storage performance and optical absorption capability. The Fe and LiNO₃ not only increases the hydration conversion of MgO, but also lowers the dehydration temperature and activation energy of Mg(OH)₂ significantly. TiN overcomes aggregation of MgO and sustains the excellent porous structure. Fe and TiN significantly strengthen the optical absorption performance of Mg(OH)₂. And the functional mechanism of each component in composite additives revealed by density functional theory (DFT) investigation.

The energy storage can address the issue that energy supply does not always synchronize with actual demand [1]. In mid-temperature, MgO/Mg(OH)₂ thermochemical energy storage (TCES) system shows a promising research prospect due to high density of energy storage (1389 kJ/kg), minimal energy loss, affordability, easily accessible and environmental friendliness [2]. In this work, Fe/LiNO₃/TiN co-modified MgO was synthesized by wet-mixing method and its energy storage performance and dehydration kinetics was examined in a dual fixed-bed reactor and a simultaneous thermal analyzer. Fe and LiNO₃ not only increases the hydration conversion of MgO by 6.3 times, but also lowers the temperature and activation energy of Mg(OH)₂ in dehydration stage by 99.4 °C and 64 %, respectively. And TiN as a support structure maintains the energy released density in MgOFeLi₅Ti₁₀-C above 900 kJ/kg in 15 energy storage cycles, as shown in Fig. 1. Furthermore, Fe and TiN boost the optical absorption capability of hydrated MgOFeLi₅Ti₁₀-C to 71.23 %, which is 43 times higher than that of Mg(OH)₂. Concurrently, density functional theory calculation reveals that Fe and Li enhance the adsorption of H₂O on MgO model and reduce energy barrier for hydration reactions by 62.76 %, while TiN effectively inhibits MgO clusters migration within the material and enhances the optical absorption coefficient. Therefore, Fe/LiNO₃/TiN co-modified MgO/Mg(OH)₂ is a promising

thermochemical energy storage material.

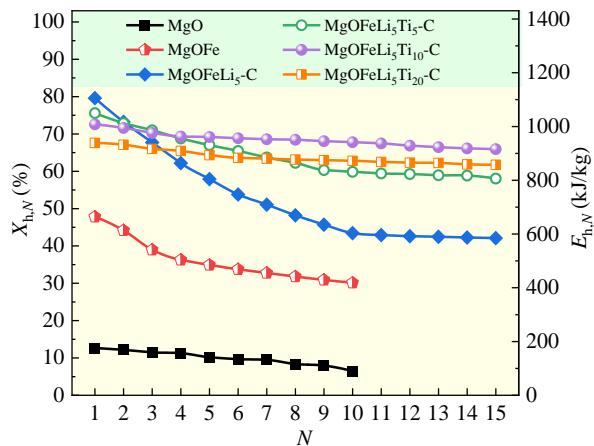


Figure 1 - The energy storage performance of Fe/LiNO₃/TiN co-modified MgO in 15 cycles

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