ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ
Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Казахский национальный исследовательский
технический университет им. К. И. Сатпаева

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Kazakh national research technical university
named after K. I. Satpayev

SERIES
OF GEOLOGY AND TECHNICAL SCIENCES

4 (436)

JULY – AUGUST 2019

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

«ҚР ҰҒА Хабарлары. Геология мен техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).
Қазақстан республикасының Мәдениет пен ақпарат министрлігінің Ақпарат және мұрағат комитетінде 30.04.2010 ж. берілген **№10892-Ж** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Мерзімділігі: жылына 6 рет.
Тиражы: 300 дана.

Редакцияның мекенжайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., 220, тел.: 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

Редакцияның мекенжайы: Қазақстан, 050010, Алматы қ., Қабанбай батыра көш., 69а.
Қ. И. Сәтбаев атындағы геология ғылымдар институты, 334 бөлме. Тел.: 291-59-38.

Типографияның мекенжайы: «Аруна» ЖК, Алматы қ., Муратбаева көш., 75.

«Известия НАН РК. Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан (г. Алматы)
Свидетельство о постановке на учет периодического печатного издания в Комитете информации и архивов Министерства культуры и информации Республики Казахстан **№10892-Ж,** выданное 30.04.2010 г.

Периодичность: 6 раз в год
Тираж: 300 экземпляров

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, ком. 219, 220, тел.: 272-13-19, 272-13-18,
http://nauka-nanrk.kz /geology-technical.kz

Адрес редакции: Казахстан, 050010, г. Алматы, ул. Кабанбай батыра, 69а.
Институт геологических наук им. К. И. Сатпаева, комната 334. Тел.: 291-59-38.

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA "National Academy of Sciences of the Republic of Kazakhstan" (Almaty)
The certificate of registration of a periodic printed publication in the Committee of information and archives of the Ministry of culture and information of the Republic of Kazakhstan N 10892-Ж, issued 30.04.2010

Periodicity: 6 times a year
Circulation: 300 copies

Editorial address: 28, Shevchenko str., of. 219, 220, Almaty, 050010, tel. 272-13-19, 272-13-18,
http://nauka-nanrk.kz/geology-technical.kz

Editorial address: Institute of Geological Sciences named after K.I. Satpayev
69a, Kabanbai batyr str., of. 334, Almaty, 050010, Kazakhstan, tel.: 291-59-38.

Address of printing house: ST "Aruna", 75, Muratbayev str, Almaty

N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224-5278
Volume 4, Number 436 (2019), 12 – 23 **https://doi.org/10.32014/2019.2518-170X.93**

UDC 541.128, 547.261, 665.612.3, 662.767, 66.023:088.8, 66.093.673

L. R. Sassykova[1*], S. Sendilvelan[2], Y. A. Aubakirov[1], Zh. Kh. Tashmukhambetova[1], A. A. Batyrbayeva[1], R. N. Azhigulova[1], Sh. N. Kubekova[3], K. O. Sharipov[4], R. G. Ryskaliyeva[1], B. B. Tyussyupova[1], M. A. Sarybayev[1]

[1]Al-Farabi Kazakh National University, Almaty, Kazakhstan,
[2]Department of Mechanical Engineering, Dr.M.G.R. Educational and Research Institute, University, Chennai, Tamilnadu, India,
[3]Satbayev University, Kazakh National Research Technical University after K. I. Satpayev, Almaty, Kazakhstan,
[4]Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan.
E-mail: larissa.rav@mail.ru

METAL BLOCK CATALYSTS FOR COMPLEX CLEANING OF HARMFUL EMISSIONS OF TRANSPORT AND THE INDUSTRY

Abstract. The aim of the work is the synthesis and testing of catalysts on metal block carriers in the processes of complex gas cleaning of CO, C_3H_8, NO and deep oxidation of propane-butane and CO. The active phase of the catalysts was prepared on the basis of the compounds Pt, Pd, Ir, Au, Mn, Fe, Ni. The washcoat composition was based on alumina and zeolites. Catalysts prepared from colloids Pt, Pd, Ir, Au, possess high activity in the oxidation of hydrocarbons (100% in the range 573-773 K) and in the reduction reaction of nitrogen oxides - up to 67.0-69%. Among the catalysts containing manganese in the active phase, the most active was a catalyst prepared by introducing an organometallic compound based on polyethylene glycol into a washcoat suspension: the degree of CO oxidation was 93-100%, hydrocarbons - up to 82-83.2% at 623 K. While studying full-size samples of catalysts based on platinum on the stand on the basis of a diesel generator the degree of conversion of CO - 100%, hydrocarbons - above 98-99%, nitrogen oxides - 58-63% was achieved.

Keywords: motor transport, industry, harmful emissions, catalysts on metal blocks, complex gas cleaning, deep oxidation.

Introduction. The experience of last decades shows that the intensive economic development of many countries, based on extensive, irrational, and often predatory use of natural resources, leading to an unfavorable and irreversible phenomena in the environment. The poor state of water and air at the moment is one of the global problems of today. The deterioration of the state of the environment proceeds because of the uncontrolled production of performing business and thoughtless spending of natural resources [1-5]. The principal sources of air pollution are industrial plants and motor vehicle exhaust. The level of air pollution due to the development of industry and transport increases in tens of times year by year. Most industrial enterprises either do not keep records of emissions or perform it very inaccurately and tentatively. In some cases, it is not known exactly which pollutants come from one or another industrial facility. Alkanes, CO, NO_x, organic solvents, sulfur-containing compounds and many others belong to harmful toxiferous emissions of the industry and motor transport and which negatively influence on human health. Contamination of soil, vegetation, water bodies, the huge consumption of oxygen, heat radiation, the burning of associated gas contributes to the greenhouse effect, acid rain and climate change [6-8].

There are 3 main sources of air pollution by toxic substances emitted by vehicles:

- the exhaust gases which are coming out the muffler,
- the crankcase gases coming to the atmosphere from the system of ventilation of the engine,
- the evaporating fuel getting to the environment from fuel system of the engine and a fuel tank [9-12].

Constantly increasing growth in car numbers is one of the reasons for the deterioration of the ecological situation in the cities and towns. Condition of air is particularly important, because in contrast to other factors of the external environment air comes in direct and fast contact with very large physiologically active surfaces of the human body. In the absence of appropriate treatment methods also many industrial plants contaminate the air with the combustible or odorous compounds. A strong air pollution is very noticeable to cities with a bad natural ventilation, to which, in particular, belongs a number of industrial cities of Kazakhstan [7, 8]. Deep catalytic oxidation of organic compounds to carbon dioxide and water is one of the most effective methods of fighting against of the waste gases of industry and the motor transport. The catalysts-neutralizers of the exhaust (catalytic converter, an afterburner) are the mandatory option for all cars in the developed countries. Today, the monolithic metal blocks are considered as the most appropriate catalysts used for the solution of environmental problems [13-17]. High heat conductivity of metal carriers provides the good thermoregulation preventing an overheat of catalysts and interfacing constructional details. Plasticity, the characteristic of metals, allows to manufacture carriers in any idle time and a form, convenient for operation, with rather high specific geometrical surface area and gas permeability. The most typical catalysts are the three-way catalysts based on platinum, palladium and rhodium deposited on the ceramic or the metal blocks coated with alumina. However, the high cost of these metals and their low resistance to poisons stimulate carrying out of scientific research aimed at the creation of more optimal from an economic and technological point of view, the compositions and methods of preparation of the catalytic neutralizers. One of the perspective directions in this area is the partial replacement of noble metal on the oxide component [18-21]. Application of the low-percentage supported catalysts on the basis of the colloid metals with the chosen homogeneous particle size and with the low content of the active phase allows obtaining such examples of catalysts which provide necessary activity and selectivity. The use of the organometallic complexes instead nitrates and metal chlorides in the step of preparing of the active phase of the catalyst systems makes it possible to reduce the emissions of toxic substances formed during the preparation of the catalysts and reduce corrosion of the exploited equipment.

The purpose of this work was synthesis and test of the efficient and stable catalysts on metal block carriers with the reduced content of platinum metals in the active phase of catalysts for processes of neutralization of harmful emissions of the industry and combustion gases of motor transport.

Materials and methods. In this work, the catalysts on the basis of platinum and basic metals have been created by the technique earlier developed [22-26]. Catalysts on the basis of Pt, Pd colloids (particle size approx. 15-25 nm) have been produced. Metal block carriers have been made of the metallic foil (figure 1). The concentration of platinum metals was changed in the range of 0.05-0.2%. Also rare-earth metals have been added to composition of the active phase for increasing the thermal stability of the catalysts. The sols of metals have been supported on the block carriers. The samples of catalysts containing in their compositions Pt, Pd, Ir, Au with a low content (0.01-0.1%, on Pt basis) and 0.05 to 0.2% (on Pd, Ir, Au basis) have been prepared. In a stage of synthesis of a washcoat alumina with a zeolite additive

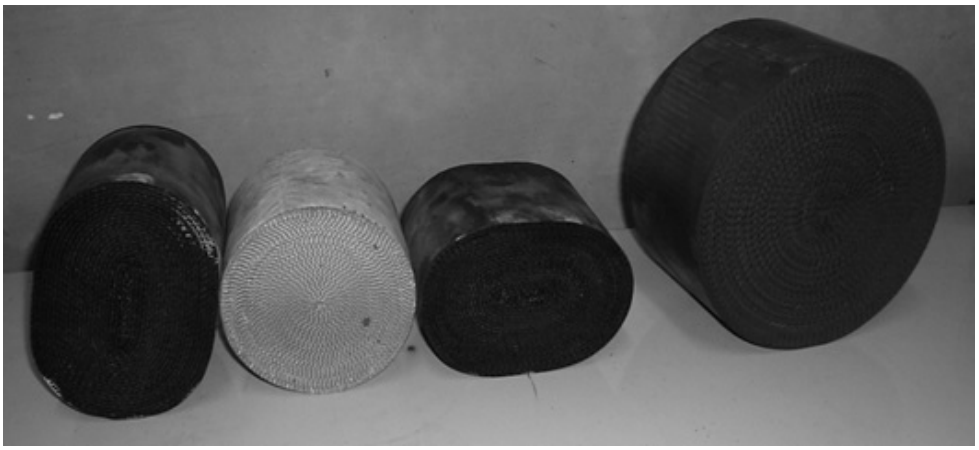


Figure 1 – Catalysts on the metallic blocks for tests at the experimental stand on the basis of a diesel generator

has been used. Different organic compounds for prevention or decreasing coagulation of the produced colloids have been chosen. Into the aqueous solutions of stabilizers (for example, polyethylene glycol, PEG) the necessary amount of salts of platinum metals dissolved in water was entered. By results of the conducted experiments the important technological parameters for preparation stable colloid particles of Pt, Pd, Ir, Au have been determined.

In the work along with the catalytic systems on the base of platinum metals, catalysts with the active phase containing of Mn, Ni, Co, Fe have been created and examined. For their preparation formates and acetates have been used. In the research one- and two-component catalytic systems on the basis of the compounds of Fe, Ni, Pt, Pd, with the different additives have been created. A wet hydrogel of aluminum hydroxide (80% humidity) was used as a binder. For preparation the such catalysts ZSM-5 zeolites with the module 30 and NaY with the module 5.1 were applied. Procedure of deposition of the active component have been carried with the use of a method of impregnation on a moisture capacity.

The prepared catalysts were tested in the reactions of oxidation of CO, a mixture of propane-butane (PB), hydrocarbons (HC) and in the reaction of nitrogen oxides reduction at temperature 423-973 K. Before testing, the catalyst sample was kept in the reactor for 30 min. in the flow of the reaction mixture at 773 K. After that, the gas temperature was reduced to given values, and the conversion of NO_x, CO and hydrocarbons was determined. The possible formation of CO in the reaction was also noticed. A characteristic activity of the catalyst is the degree of initial reagent (hydrocarbon, carbon monoxide, nitrogen oxide) conversion (α). The volumetric flow rate of the gas mixture was varied in the limits from 36, 000 to 50,000 h^{-1}.

The processes were researched in the flow catalytic installing with an integral tubular reactor type and with optimized parameters of the catalyst bed (figure 2). In the work also has been made a stand on the basis of the diesel generator for testing full-size samples of catalysts in the real exhaust gases (figure 3). The samples before and after the catalyst were selected in all operating modes of the diesel engine (idle mode-4 Kv) directly from the exhaust pipe with "OPTOGAZ-500.3" gas analyzer. Investigations have been carried out in the load range 0-4.0 Kv. The temperature in the catalyst zone has been measured with the help of a chromel-alumel thermocouple and IRT.

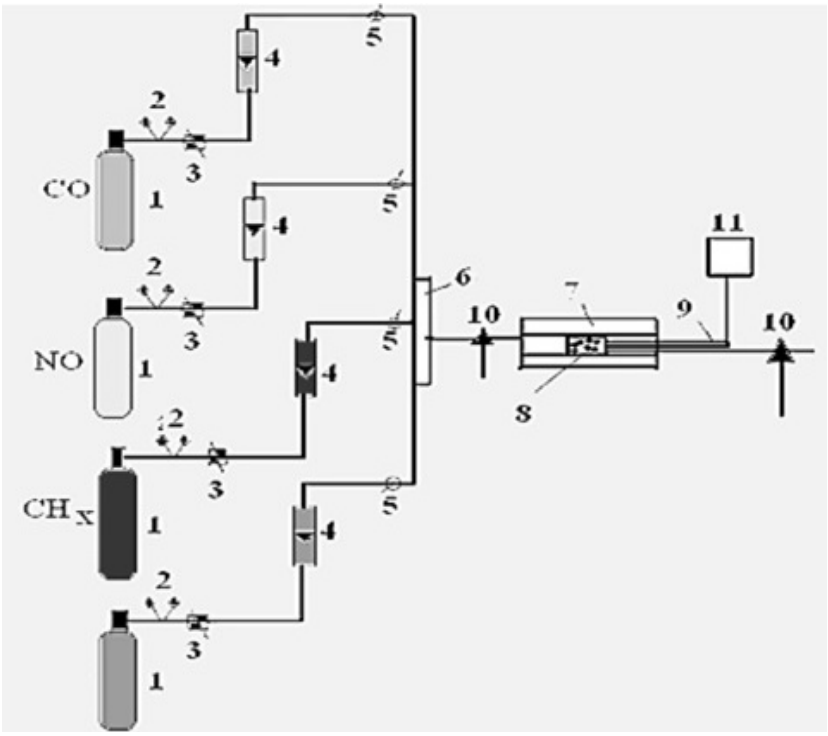
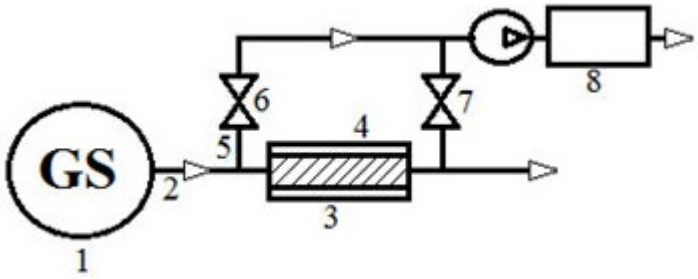
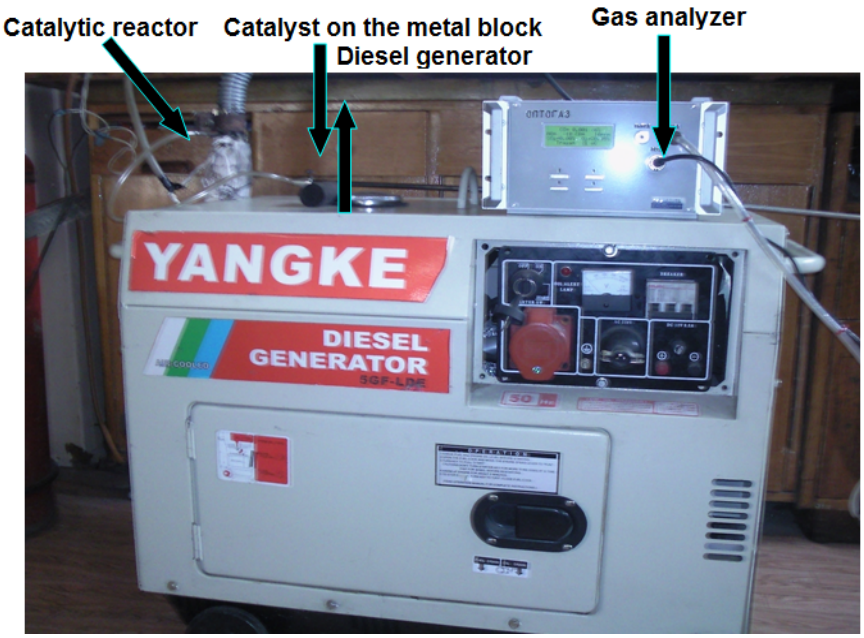


Figure 2 – Flow installation diagram:
1 - gas cylinder; 2 - pressure gauge; 3 - valve of a fine regulation; 4 - rotameter;
5 - crane; 6 - mixer; 7 - system of heating; 8 - sample of a catalyst; 9 - thermocouple; 10 - sampling; 11 - IRT



a



b

Figure 3 – Stand on the base of diesel generator:
a – schematic drawing of the experimental installation, consisting of a diesel-generator (1), pipe for exhaust gases (2), a reactor for catalysts' test (3), sample of a catalyst (4), gas operated probe (5), and 6,7 - valves for sampling; 8 - a gas analyser; *b* - general view of the experimental installation

Results and discussions. The tests show that the catalytic activity (efficiency) depends as on the content of an active metal as on the method of the active metal deposition. The complexing composition for a colloid preparation also influenced. At the identical technique of platinum introduction into a washcoat the catalyst activity is increased with increasing of the platinum content in a range 0.05%-0.1%. The activity of 0.05% platinum-containing catalyst was 18% (at 523 K) and 100% (at 773 K).

In table 1 the results of studying activity of the catalysts synthesized by introduction of colloids of platinum metals to an alumina-oxide matrix by various methods are shown. It is visible, that activity depended on the contents of active metal and a method of introduction. At an identical method of introduction of platinum to the secondary carrier of the block metal catalyst (a washcoat) with increase in the contents of platinum from 0.05 % up to 0.1 %. activity of 0.05 % of the platinum catalyst was reduced from 100 % at 773 K up to 18.0 % at 523 K while with increase in the contents of platinum in 2 times activity grown and was 89.3 % at 523 K and 100% at 623 K.

At transition to Pd catalysts their activity at the contents of a palladium equal of 0,1 %, below, then platinum (No5 and No1). At preparation of the colloid Pd catalyst with use in quality complex former No2 activity increases to 94.2-100% at temperatures 623-773 K.

In the process of the complex cleaning of gases (table 2) was also demonstrated the high activity by the catalysts on the basis of colloids of palladium (with different concentrations) deposited on alumina.

Table 1 – Influence of concentration and a method of introduction of active metal on activity of catalysts in the reaction of HC oxidation and NO_x reduction

No	Catalyst (metal+No of complex former)	The active metal concentration, %	Conversion, % at different temperatures, K			
			773	623	523	423
1	Pt+1	0.05	100	76.9	18.09	0
2	Pt+1	0.1	100	100	89.3	10.7
3	Pt+2	0.1	100	88.0	40.0	0
4	Pt+3	0.1	100	87.3	11.5	0
5	Pd+1	0.1	92.0	82.1	6.0	0
6	Pd+2	0.1	100	94.2	11.6	0
7	Pd+1	0.05	93.0	79.2	5.4	0

Table 2 – Influence of concentration of palladium on activity of catalysts in the processes of HC oxidation and NO_x reduction

Pd concentration, wt. %	The degree of conversion HC/NO_x gases (%) at different temperatures, K			
	773	623	523	473
0.2	100/40.8	98.0/42.6	31.5/30.4	18.0/15.6
0.1	100/38.0	60.0/23.0	21.6/18.3	13.0/9.2
0.05	100/24.8	58.0/21.0	19.2/16.8	8.0/9.4

The degree of HC conversion on catalysts containing Pd-0,2%, with a decrease in the temperature from 773 to 623 K is reduced slightly - from 100% (773 K) to 98.0% (623 K), for catalysts on the basis of 0.1% and 0.05% Pd conversion decrease more sharply: from 100% to 60.0% (for 0.1% of Pd-contacts) and 58.0% (0.05% of Pd). For catalysts with the content of 0.2% of Pd in the field of temperatures 623-773K conversion degree of HC was equal to 97.4-100%, and NO_x - 40.8-42.6%. With decrease of content of palladium to 0.1% an activity of catalysts is decreased, for example, at 623 K conversion degree of HC is decreased to 60.0%, nitrogen oxides - to 23.0 %. With a decrease the content of palladium in catalysts to 0.05% are required higher temperatures (773 K) for the deep oxidation of hydrocarbons, at 523 K the degree of hydrocarbon conversion is reduced to 19.0-25.0%, and the conversion degree of nitric oxide is reduced slightly (to 16. 8%).

The method of introducing and the magnitude of dispersion of colloidal metal affected the activity of the catalysts based on the colloids of Pt, Pd, Ir, Au. So, on the catalyst on the basis of Pd when using as a complexing-PEG, the catalytic activity at change of ways of introduction is ranged between 69.0% to 94.2-100% in the temperature interval 623-773K. With increasing concentration of the metal in the catalyst is increased its activity depending on the nature of the metal and a complexing. When the palladium content 0.2% in the temperature interval 623-773K the catalyst activity was equal to is 98.0-100% on a methane. With the reduction of the noble metal content up to 0.1% activity of the samples - by methane is reduced to 60.02% at 623K. With the further decrease of the palladium content up to 0.05% the total methane oxidation was carried out at a higher temperature (623-773K), and at 523K the catalyst activity was decreased to 19.0-25.0 % by hydrocarbons, for nitrogen oxides the catalyst activity was not substantially changed. Thus, by results of the performed researches it is found that the synthesized on the basis of colloids of noble metals (Pt, Pd, Ir, Au) catalysts have high activity in oxidizing reaction of hydrocarbons (100% at 573-773 K) and reduction of nitrogen oxides - to 67.0-69.0%. On the catalytic activity in reaction of the complete oxidation of the propane - butane mixture the catalysts on the basis of colloids of noble metals form a series: Pt › Pd › Ir (Au), in the reaction of complex cleaning of exhaust gases of the motor transport: on CO-conversion degree on all noble metals almost identical (98-100%, depending on the process conditions), for nitrogen oxides the most efficient catalyst – on the basis of Pt.

The effectiveness of catalysts containing manganese in the composition of the active phase was determined during the deep oxidation of CO+C_xH_y in the temperature range 373-773 K (table 3). The content of CO in the mixture with air was 1%, propane-butane (PB) - 0.5%, the volumetric rate - 50,000 h^{-1}. It

Table 3 – The oxidation reaction of CO (1%) and PB (0.5%) over the different manganese catalysts, volume flow rate –50, 000 h^{-1}

Temperature, K	Conversion degree (%) at the different catalysts					
	Manganese nitrate		Manganese acetate		PEG-manganese oxide	
	CO	PB	CO	PB	CO	PB
773	85.8	29.5	100	38.0	100	95.4
623	68.9	0	95.5	12.1	100	83.2
523	53.8	0	74.7	9.0	94.6	10.0
473	34.9	–	39.9	–	63.0	–
423	0.3	–	7.0	–	9.7	–

was established that catalytic systems, the active phase of which was prepared on the basis of manganese nitrate and acetate, showed low activity in the oxidation of CO and oxidation of the propane-butane mixture. The maximum degree of CO conversion was 85.8-100%, and the propane-butane mixture was 29.5-38.0% at 773 K. Adding the same compound of manganese with polyethylene glycol (PEG) contributed to increasing the efficiency of the catalyst. When use this catalyst the carbon monoxide and hydrocarbons begin to be oxidized with the sufficiently high activity at low temperatures. Thus, at 523 K carbon monoxide is oxidized to 94.6%, and hydrocarbons - up to 83.2% at 623 K. On this catalyst 100% CO oxidation is achieved at a temperature of 623 K, and the maximum conversion of PB (95.4%) is observed at 773 K.

The catalyst on the basis of PEG containing 5.0% of oxide of manganese was tested in oxidizing reaction of 1% CO and 0.5% of propylene in the air at the volume speed 35,000 h^{-1} (table 4). At lower volume rate of gas flow (35,000 h^{-1}) and in the presence of a propylene the catalyst begins to demonstrate activity already at 423 K, and the complete oxidation of CO is observed at 503 K. It should be noted a high activity of the catalyst in the reaction of propylene oxidation: at 503 K conversion degree is 86.7% and 100% of propylene oxidation proceeds at 573 K.

Table 4 – Activity of 5% Mn-containing catalyst in the oxidation reaction of 1% CO and 0.5% propylene in the air (the gases volumetric flow rate - 35,000 h^{-1})

The temperature of test, K	Conversion degree, %	
	CO	propylene in air
403	5.7	0
423	44.3	1.7
443	89.1	3.3
463	98.6	18.3
483	99.4	56.7
503	99.9	86.7
523	100	96.7
553	100	99.1
573	100	100

In the case of systems on the basis of Fe, Ni, Pt, Pd with additives of zeolites irrespective of the nature of introduced zeolite, the noticeable transformation of NO_x began at temperature over 473 K, gradually increased with increase of temperature and reached a maximum value at T=773 K. Among the Fe-containing catalysts the biggest activity at reduction of nitrogen oxides by propylene was revealed for the sample, modified by NaY zeolite. The catalyst with the same composition was the most effective also for C_3H_6 oxidation. At 473 K the degree of C_3H_6 conversion on this catalyst was 35.8%, and complete conversion is observed at 573 K. The degree of conversion of C_3H_6 at 573 K on the catalysts of this series decreased in the series: Fe/NaY>Fe/ZSM-5>Fe/Al_2O_3. Oxidation of propylene at the Ni-containing zeolites happened, in comparison with the Fe-containing block catalysts, with lower degrees of conversion: 100% transformation of C_3H_6 was observed on Ni/HY catalyst only at 773 K. The other samples of Ni-based catalysts are less active and the degree of C_3H_6 conversion at them was little varied depending on

the zeolites nature. Noticeable NO conversion at Ni-containing zeolites was observed at temperatures above 473 K. Depending on the nature of the modifying zeolite activity of the Ni-containing zeolites in reaction of reduction of NO at 573 K is decreased in the series: Ni/HY>Ni/NaY>Ni/ZSM-5.

Effectiveness of the Ni, Fe/zeolite catalysts was determined by heat stability at T=973 K during 50 h in the gaseous environment. It is appeared that the most stable sample at all temperatures was Ni/HY, at 673 K degree of NO_x conversion was equal to 67.0% and the conversion of propylene - 100%.

Activity of prepared catalysts has been defined at the experimental installation, consisting of the diesel-generator with 4 Kv (figure 3). Dimensions of catalysts were the following: d - 30 mm, h - 90 mm, V - 63.4 mm^3. The data of experiments in the bifunctional mode at various loadings of operation of the engine are shown in table 5. The catalyst containing 0.1% of Pt is effective already at 540 K, transformation degree of CO was 99.6 %, hydrocarbons - 80.7% and nitrogen oxides - 44.4%. When engine capacity was increased to 3-4 Kv than conversion degree of NO_x to 58-63% was reached.

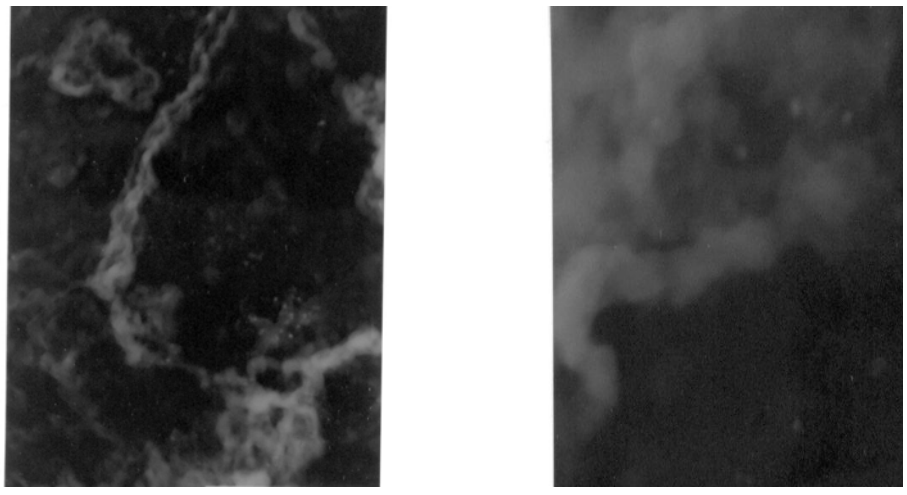
Table 5 – Results of the analysis of toxic emissions on the diesel generator on the block platinum catalyst at various loads

The consumed capacity, kV	Temperature of the exhaust gases, K	Degree of the exhaust gases cleaning, %		
		CO	CH_x	NO_x
Idle motion	293	90.6	21.5	3.0
2	540	99.6	80.7	44.4
3	581	100	95.6	61.1
4	700	100	99.3	63.0

The prepared catalysts were examined by different physical and chemical research techniques (figure 4–6).

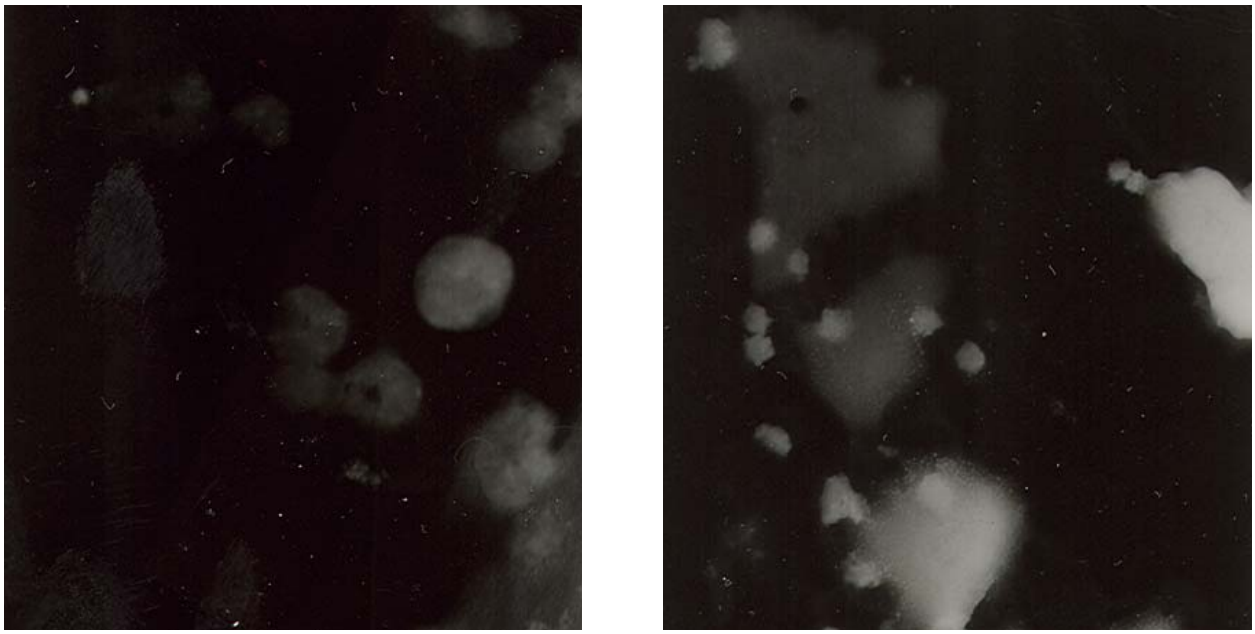
The study of Pt and Pd - containing catalysts for thermal stability was carried out by holding the chosen catalyst during 5 hours at T = 673 and 773 K in the reaction gas mixture with a content of 0.5% propane-butane with further analysis of the reaction products. Duration of the such test was 100 hours. The catalysts obtained from Pt acetates proved to be the most stable, while those based on Pd acetates were less stable.

X-ray phase analysis of tested catalysts has been performed on X-ray diffractometer DRON-4-0.7 with a copper anode. It was revealed scattering of the spectrum for Pt- and Pd-catalysts, and this fact confirmed the high dispersion of metals [26]. Catalysts have been examined on TEM on EM-125 K by the single-step replica method (figure 4, 5). At zoom 33,000 there were found semi-transparent regions of polymer bunches filled with dispersed particles 3 nm in size in the case of Pt-, Pd-catalysts. At zoom 62,000 times the small sparse clusters of denser particles 5 nm in size have been also revealed (figure 5).



a *b*

Figure 4 – TEM-images of catalysts on the base of platinum metals: *a* - Pt-containing catalyst, *b* - Pd-containing catalyst



a *b*

Figure 5 – TEM images of fragments of metal clusters:
a - Pt-particles, *b* - clusters of denser Pd particles 5 nm in size

The thermostability of the prepared catalysts was calculated by definition of activity of the initial catalyst on the diesel engine - generator working under loading in 3 Kv, with the subsequent fractional calcinations of the neutralizers at 873 K with an interval of 5 hours in the muffle furnace. During 100-hour test the high thermostability was shown.

The characteristics of some samples of catalysts on the basis of Pt and Pd obtained with use of the TPD NH_3 method are shown in table 6. The total concentration of acid sites of Pt- and Pd-promoted catalysts of nickel and manganese oxides is higher than that of the initial alumino-platinum and palladium catalysts. Pt- and Pd-containing catalysts have similar values of the total concentration of acid sites 620-660 μmol/g, but they are characterized by different ratios of centres of different force, and it apparently determines the differences in their catalytic properties. The catalysts based on $Pt/Ni\text{-}Mn/Al_2O_3$ have a greater concentration of strong acid sites (280 μmol/g) and for $Pd/Ni\text{-}Mn/Al_2O_3$ catalyst is revealed the highest concentration of weak acid sites - 250 μmol/g (figure 6).

Table 6 – TPD data of Pt- and Pd-catalysts

Catalyst sample	Pore structure of catalysts		The total concentration of the acid sites, μmol/g
	The specific surface area, m^2/g	Pore volume, cm^3/g	
Pt-containing	200	0.348	240
Pd-containing	205	0.356	110
$Pd/Ni\text{-}Mn/Al_2O_3$	350	0.274	620
$Pt/Ni\text{-}Mn/Al_2O_3$	370	0.290	660

It was found by the TPD method of ammonia that in case of catalysts on the basis of basic metals introduction to the carrier of Co and Mn oxides led to small increase in a share of the retained volume of ammonia, i.e. force of the acid centers of the catalyst is slightly increases. Possibly, activity of the oxide-coated catalyst is influenced by the structural changes arising at introduction of oxides of cobalt and manganese into the carrier. For catalysts based on the colloids of Pt, Pd, Ir, Au revealed high dispersion (25.0-30.0 nm), colloids demonstrated good stability over 1-1.5 months at room temperature. XPS and EM data showed that the platinum metals in the starting monodisperse catalysts are in an oxidized state with uniform distribution of the metal particles on the carrier and they are characterized by high thermal

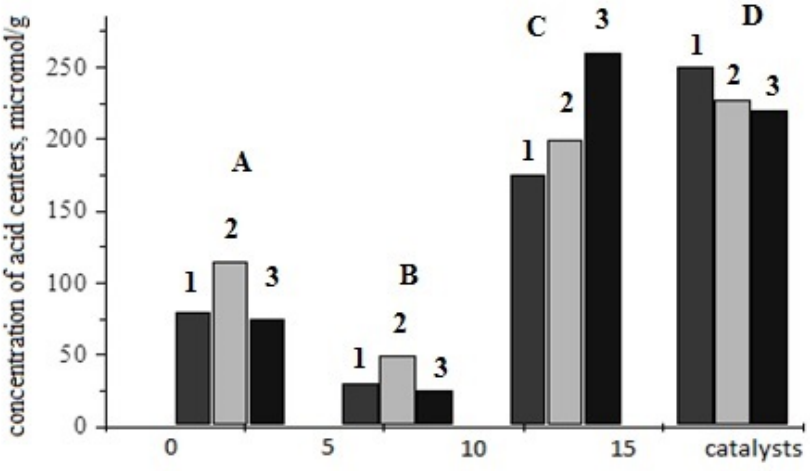


Figure 6 – Acid centres' share for different active phases of catalysts:
A - on the basis of platinum, B - on the basis of palladium, C - on the basis of platinum, nickel and manganese,
D - on the basis of palladium, nickel and manganese; 1 - weak centers, 2 - medium centers, 3 - strong centers

stability. By the EM and RFA methods it is found that in the Mn-containing catalysts on the basis of PEG are formed the particle which are finely divided, evenly distributed on a surface of the carrier. The catalysts prepared from acetate and also on the basis of manganese nitrates, had larger particles, which causes, may decrease the activity of manganese catalysts in hydrocarbon and CO oxidation.

Results of physical and chemical research of catalysts prepared confirmed literature data [6, 13, 14, 27-30].

Conclusion. Thus catalysts on the basis of colloids of noble metals and compounds of basic metals on block metal carriers were prepared. Catalytic efficiency of the prepared catalysts was tested in the reactions of complex cleaning of gases from CO, C_3H_8, NO and in the oxidizing reactions of propane-butane mixture and CO. The catalyst activity prepared with the noble metals depends on the active metal content and on the deposition method of the active metal (complexing composition for preparing of the colloid). The catalysts synthesized on the basis of colloids of noble metals (Pt, Pd, Ir, Au) catalysts have high activity in oxidizing reaction of hydrocarbons (100% at 573-773 K) and reduction of oxides of nitrogen - to 67-69%. It was found that in a series of manganese-containing catalysts the introduction of the Mn-compound with PEG increased a catalytic activity. So, at CO is oxidized to 93-100% (at 523-623 K, and hydrocarbons are oxidized to 82-83.2% at 623 K. On this catalyst the maximal transformation of propane-butane mixture (95.5%) is observed at 773 K. The full-size samples of the catalysts on the basis of platinum were tested on the stand on the basis of a diesel-generator. The degree of conversion of CO was equal to 100%, hydrocarbons – more than 98-99%, nitrogen oxides – 58-63%.

Л. Р. Сасыкова[1], С. Сендилвелан[2], Е. А. Әубәкіров[1], Ж. Х. Ташмухамбетова[1], А. А. Батырбаева[1], Р. Н. Ажигулова[1], Ш. Н. Кубекова[3], К. О. Шарипов[4], Р. Г. Рыскалиева[1], Б. Б. Тюсюпова[1], М. А. Сарыбаев[1]

[1]әл-Фараби атындағы Қазақ ұлттық университеті, Алматы, Қазақстан;
[2]Department of Mechanical Engineering, Dr. M.G.R Educational and Research Institute, University, India,
[3]Қ. И. Сәтбаев атындағы Қазақ ұлттық техникалық зерттеу университеті,
Институт химических и биологических технологий КазНИТУ им. К. И. Сатпаева, Алматы, Казахстан,
[4]С. Д. Асфендияров атындағы Қазақ ұлттық медициналық университеті, Алматы, Казахстан

КӨЛІК ЖӘНЕ ӨНДІРІСТЕН ШЫҒАРЫЛАТЫН ЗИЯНДЫ ЗАТТАРДЫ КЕШЕНДІ ТАЗАЛАУДЫҢ МЕТАЛЛ БЛОКТАҒЫ КАТАЛИЗАТОРЛАРЫ

Аннотация. Жұмыстың мақсаты металл блокты тасымалдағыштағы катализаторды синтездеу және газдың құрамындағы CO, C_3H_8, NO кешенді тазалаумен пропан-бутанды және CO терең тотықтыру процестерінде сынау. Катализатордың белсенді фазасын Pt, Pd, Ir, Au, Mn, Fe, Ni қосылыстары негізінде дайындалды.

Pt, Pd, Ir, Au коллоидтары негізіндегі катализаторлары көмірсутектерді тотықтыруда (100% ,573-773 К температура аралығында) және азот оксидінің тотықсыздану реакциясында 67,0-69 % дейін жоғары белсенділік көрсетті. Катализаторлар арасында біріншілік тасымалдағыш суспензиясына полиэтиленгликоль негізіндегі металлорганикалық қосылысты енгізу арқылы дайындалған белсенді фаза құрамында марганец бар катализатор белсенділік көрсетті: 623 К температурада СО-ның тотығу дәрежесі 93-100%, көмірсутектердің тотығу дәрежесі - 82-83,2% дейін болды. Платина негізіндегі катализатордың толық өлшемді үлгілерін қабырғалық дизель-генераторда зерттегенде СО-ның конверсия дәрежесі - 100%, көмірсутектер - 98-99% жоғары, азот оксидтері - 58-63%.

Түйін сөздер: автотранспорт, өндіріс, зиянды заттар, металл блокты катализаторлар, газды кешенді тазалау, терең тотығу.

Л. Р. Сасыкова[1], С. Сендилвелан[2], Е. А. Аубакиров[1], Ж. Х. Ташмухамбетова[1], А. А. Батырбаева[1], Р. Н. Ажигулова[1], Ш. Н. Кубекова[3], К. О. Шарипов[4], Р. Г. Рыскалиева[1], Б. Б. Тюсюпова[1], М. А. Сарыбаев[1]

[1]Казахский национальный университет им. аль-Фараби, Алматы, Казахстан,
[2]Department of Mechanical Engineering, Dr. M.G.R Educational and Research Institute, University, India,
[5]Казахский национальный исследовательский технический университет им. К. И. Сатпаева, Институт химических и биологических технологий КазНИТУ им. К. И. Алматы, Казахстан,
[4]Казахский национальный медицинский университет им. С. Д. Асфендиярова, Алматы, Казахстан

КАТАЛИЗАТОРЫ НА МЕТАЛЛИЧЕСКИХ БЛОКАХ ДЛЯ КОМПЛЕКСНОЙ ОЧИСТКИ ВРЕДНЫХ ВЫБРОСОВ ТРАНСПОРТА И ПРОМЫШЛЕННОСТИ

Аннотация. Целью работы является синтез и испытание катализаторов на металлических блочных носителях в процессах комплексной очистки газов от CO, C_3H_8, NO и глубокого окисления пропан-бутана и CO. Активную фазу катализаторов готовили на основе соединений Pt, Pd, Ir, Au, Mn, Fe, Ni. Состав первичного носителя был на основе оксида алюминия и цеолитов. Катализаторы, приготовленные из коллоидов Pt, Pd, Ir, Au, обладают высокой активностью в окислении углеводородов (100% в интервале 573-773 К) и в реакции восстановления оксидов азота - до 67,0-69 %. Среди катализаторов, содержащих в активной фазе марганец, наиболее активным был катализатор, приготовленный введением металлоорганического соединения на основе полиэтиленгликоля в суспензию первичного носителя: степень окисления CO была 93-100%, углеводородов - до 82-83,2% при 623 К. При изучении полноразмерных образцов катализаторов на основе платины на стенде на основе дизель-генератора достигнута степень конверсии CO - 100%, углеводородов - выше 98-99%, оксидов азота - 58-63%.

Ключевые слова: автотранспорт, промышленность, вредные выбросы, катализаторы на металлических блоках, комплексная очистка газа, глубокое окисление.

Information about authors:

Sassykova Larissa R., Ph.D., Prof. of the Department of Physical Chemistry, Catalysis and Petrochemistry, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU, Almaty, Kazakhstan; larissa.rav@mail.ru; https://orcid.org/0000-0003-4721-9758

Sendilvelan Subramanian, Prof., Dean, Department of Mechanical Engineering, Dr. Sc. M.G.R Educational and Research Institute, University, Chennai, India (***Hirsch index 13***); sendilvelan.mech@drmgrdu.ac.in; http://orcid.org/0000-0003-1743-4246

Aubakirov Yermek A., Prof., Head of the Department of Physical Chemistry, Catalysis and

Petrochemistry, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU, Almaty, Kazakhstan; miral.64@mail.ru; https://orcid.org/0000-0001-5405-4125

Tashmukhambetova Zheneta Kh., Ph.D., Ass. Prof. of the Department of Physical Chemistry, Catalysis and Petrochemistry, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU, Almaty, Kazakhstan; zheneta@mail.ru; https://orcid.org/0000-0003-4125-4114

Batyrbayeva Aigul A., Ph.D., Ass. Prof. of the Department of Physical Chemistry, Catalysis and Petrochemistry, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU, Almaty, Kazakhstan; batyrbaeva_aigul@mail.ru; https://orcid.org/0000-0003-2280-4846

Azhigulova Ryskul Ninilovna, Ph.D., Ass. Prof. of the Department of Physical Chemistry, Catalysis and Petrochemistry, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU, Almaty, Kazakhstan; razhigulova@gmail.com; https://orcid.org/0000-0003-4498-8439

Kubekova Sholpan N., Associated professor, Candidate (Ph.D.) of Technical sciences, Department of Chemical Technology of Inorganic Substances, Institute of Chemical and Biological Technologies, KazNTRU after K. I. Satpayev, Almaty, Kazakhstan; kubekova_10@mail.ru; https://orcid.org/0000-0001-8665-9970

Sharipov Kamalidin Orynbaevich, Professor, Doctor of Biological Sciences, Head of the Department of Biochemistry, Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan; skamalidin@mail.ru; https://orcid.org/0000-0001-5946-5521

Ryskaliyeva Roza G., Ph.D., Ass. Prof. of the Department of General and Inorganic Chemistry, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU, Almaty, Kazakhstan; roza12_11_64@mail.ru; https://orcid.org/0000-0002-9591-1477

Tyussyupova Bakyt B., Ph.D., Ass. Prof. of the Department of Analytical, Colloidal Chemistry and Technology of Rare Elements, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU, Almaty, Kazakhstan; baimuratovna78@mail.ru; https://orcid.org/ 0000-0001-6149-2326

Sarybayev Madiyar A., Ph.D., Senior Lecturer of the Department of Physical Chemistry, Catalysis and Petrochemistry, Faculty of Chemistry and Chemical Technology, al-Farabi KazNU, Almaty, Kazakhstan; sarybayev.madiyar@gmail.com; https://orcid.org/0000-0003-4488-5659

REFERENCES

[1] Verheggen B. (2012) Global Warming Debate. in: Encyclopedia of Global Warming & Climate Change. Edit. S. George Philander. doi:10.4135/9781452218564.n314 (in Eng.).

[2] Meinshausen M., Meinshausen N., Hare W., Raper S.C.B., Frieler K., Knutti R., Frame D.J., Allen M.R. (2009) Greenhouse-gas emission targets for limiting global warming to 2°C // Nature. 458:1158-1163 (in Eng.).

[3] The Global Air Pollution Crisis. http://greencleanguide.com/the-global-air-pollution-crisis/ (in Eng.).

[4] Lefeber R. (2006–2007) Non-compliance procedures and mechanisms and the effectiveness of international environmental agreements, 303. doi:10.1007/978-90-6704-557-5_18 (in Eng.).

[5] O'Neill B.C. (2002) Climate change: Dangerous Climate Impacts and the Kyoto Protocol // Science, 5575:1971. doi:http://dx.doi.org/10.1126/science.1071238 (in Eng.).

[6] Sassykova L.R. (2018) Technogenic emissions into the atmosphere: impact on the environment and neutralization by catalytic methods. Almaty: Qazaq university. ISBN: 978-601-04-3440-0 (in Eng.).

[7] Tashmukhambetova Zh., Aubakirov Y., Shomanova Zh., Burkhanbekov K., Safarov R., Sassykova L., Zhakirova N., Faizullaeva M. (2017) The effects of pretreatment methods of carbon-containing wastes in thermal catalytic recycling // Oriental Journal of Chemistry. 33(6):2884-2890 (in Eng.).

[8] Global change of climate. Kazakhstan: the steps to the Kyoto protocol. Project 70-242 TASIS. Astana, 2006 (in Eng.).

[9] Akhmedzhanov T.K., Abd Elmaksoud A.S., Baiseit D.K., Igembaev I.B. (2012) Chemical properties of reservoirs, oil and gas of Kashagan field, southern part of pre-Caspian depression, Kazakhstan // Int. J. Chem. Sci. 10:568-578 (in Eng.).

[10] Core Writing Team, Pachauri R.K., Meyer L.A., (2014) IPCC 2014 Climate Change: Synthesis Report. IPCC, Geneva, Switzerland, 151 (in Eng.).

[11] McGrath M. (2017) Four major cities move to ban diesel vehicles by 2025. http://www.bbc.com/news/science-environment-38170794 (in Eng.).

[12] Val'dberg A.Yu., Kosogorova T.O., Tsedilin A.N., Pokrovskii D.D., Yakimychev A.A. (2007) Cleaning diesel plant exhaust gases // J..Chem. and Petrol. Eng. 5-6:287-291 http://dx.doi.org/10.1007/s10556-007-0051-7 (in Eng.).

[13] Burdeinaya T.N., Matyshak V.A., Tret'yakov V.F., Glebov L.S., Zakirova A.G., Garcia Carvajal M.A., Villanueva Arias M.E. (2007) Design of catalysts for deNO_x process using synergistic phenomenon // Applied Catalysis B: Environmental. 1-4:128 (in Eng).

[14] Tungatarova S.A., Xanthopoulou G., Kaumenova G.N., Zhumabek M., Baizhumanova T.S., Grigorieva V.P., Komashko L.V., Begimova G.U. (2018) Development of composite materials by combustion synthesis method for catalytic reforming of methane to synthesis gas // News of the National academy of sciences of the Republic of Kazakhstan. Series of chemistry and technology. (6)432: 6-15 (in Eng.). https://doi.org/10.32014/2018.2518-1491.20

[15] Rauch S., Hemond H.F., Barbante C., Owari M., Morrison Gregory M., Peucker-Ehrenbrink B., Wass U. (2005) Importance of automobile exhaust catalyst emissions for the deposition of platinum, palladium, and rhodium in the northern hemisphere // Environ. Sci. Technol. 1:8156. doi: http://dx.doi.org/10.1021/es050784m

[16] Thomson J., Anstice P.C.J., Price R.D. (2003) A novel „thrifted" palladium-zinc catalyst supported on ceria stabilised zirconia for use in three way vehicle exhaust catalysis // Chapter in: Catalysis in Application, 63-69.

[17] Bhaskar K., Sassykova L.R., Prabhahar M., Sendilvelan S. (2018) Effect of dimethoxy-methane ($C_3H_8O_2$) additive on emission characteristics of a diesel engine fueled with biodiesel // International Journal of Mechanical and Production Engineering Research and Development. 8:399-406 (in Eng.).

[18] Sendilvelan S, Bhaskar K (2017) Aluminium phosphate supported copper phosphate catalytic converter to reduce nitrous oxides and particulate matter from engine emission, Oriental J Chem, 33:2111-2117 (in Eng.).

[19] Sendilvelan S., Bhaskar K. (2017) Chemical and experimental analysis of fumigation process to reduce emission without affecting the performance of an engine // Rasayan Journal of Chemistry. 10:111-116 (in Eng.).

[20] Kramer M., Schmidt T., Stowe K., Maier W.F. (2006) Structural and catalytic aspects of sol–gel derived copper manganese oxides as low-temperature CO oxidation catalyst // Applied Catalysis A: General. 302:257–263. doi: http://dx.doi.org/10.1016/j (in Eng.).

[21] Kołodziej A., Łojewska J. (2013) Engineering Aspects of Catalytic Converters Designs for Cleaning of Exhaust Gases // Chapter in: New and Future Developments in Catalysis doi:http://dx.doi.org/10.1016/b978-0-444-53870-3.00010-1 (in Eng.).

[22] Sassykova L.R., Nalibayeva A., Gil'mundinov Sh.A. (2017) Development of technology of synthesis of catalysts for neutralization of emissions of the industry and motor transport // Bulg. Chem. Comm. 49:583-588 (in Eng.).

[23] Sassykova L., Nalibayeva A. (2018) Development and testing of catalysts on metal block carriers for exhaust gases neutralization // Journal of Chemical Technology & Metallurgy. 53: 289-295 (in Eng.).

[24] Aubakirov Y.A., Sassykova L.R., Nalibayeva A.M., Dossumov K., Tashmukhambetova Z.K., Zhumakanova A.S., Zhussupova A.K., Zhakirova N.K. (2017) Synthesis and testing of catalysts for decrease of toxic emissions of vehicles // Oriental Journal of Chemistry. 33(6):3130-3137 (in Eng.).

[25] Sassykova L., Bunin V., Nalibayeva A., Nurakhmetova M. (2018) Synthesis of catalysts on the metal block carriers and testing their effectiveness in the real conditions of operation // J. Chem. Technol. Metall. 53:537-542 (in Eng.).

[26] Sassykova L., Gil'mundinov Sh., Nalibayeva A., Bogdanova I. (2017) Catalytic systems on metal block carriers for neutralization of exhaust gases of motor transport // Rev. Roum. Chim. 2:107-114 (in Eng.).

[27] Lee B.Y., Inoue Y., Yasimori I. (1981) Catalytic activity of highly dispersed palladium. II. X-ray photoelectron spectroscopic and thermal desorption studies of the effects of ZrO2 added to.ALPHA.-alumina-supported palladium // Bull. Chem. Soc. Jpn. 54:3711. doi: http://dx.doi.org/10.1246/bcsj.54.3711 (in Eng.).

[28] Wang Q.M., Shen D., Bulow M., Lau M.L., Deng Sh., Fitch F.R., Lemocoff N.O., Semanscin J. (2002) Metallo-organic molecular sieve for gas separation and purification // Microporous and Mesoporous Mater.: Zeolites, Clays, Carbons and Related Materials, 2: 217. doi: http://dx.doi.org/10.1016/s1387-1811(02)00405-5 (in Eng.).

[29] Johann Dueck J., Tatayeva R., Baymanova A., Bakeshova Z., Kapsalyamov B. (2018) Biological treatment of waste water: theoretical background and experimental research // News of the National academy of sciences of the Republic of Kazakhstan. Series of Chemistry AND Technology. 432:16-22 (in Eng.). https://doi.org/10.32014/2018.2518-1491.21

[30] Silva R., Cataluña R., Martínez-Arias A. (2009) Selective catalytic reduction of NO_x using propene and ethanol over catalysts of Ag/Al_2O_3 prepared by microemulsion and promotional effect of hydrogen // Catalysis Today. 143(3-4):242-246 (in Eng.).

Publication Ethics and Publication Malpractice
in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайте:

www:nauka-nanrk.kz

ISSN 2518-170X (Online), ISSN 2224-5278 (Print)

http://www.geolog-technical.kz/index.php/en/

Верстка *Д. Н. Калкабековой*

Подписано в печать 22.07.2019.
Формат 70x881/8. Бумага офсетная. Печать – ризограф.
15,7 п.л. Тираж 300. Заказ 4.

Национальная академия наук РК
050010, Алматы, ул. Шевченко 28, т. 272-13-19, 272-13-18