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COMPOSITE CATALYSTS BASED ON FLY ASH OF THERMAL POWER PLANTS AND NATURAL ZEOLITE FOR PURIFICATION OF GAS EMISSIONS AND CATALYTIC CRACKING OF FUEL OIL

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ABSTRACT

In this research, the hollow microspheres based on fly ash from the Ekibastuz coal deposit (Kazakhstan), produced as a result of the operation of TPP-2 (Almaty, Kazakhstan) were used for investigation of two processes. The composite on the base of cenisheres was applied in the technology of SO_2 oxidation with oxygen in aqueous solution at T=40-60°C. Conditions of selective oxidation of SO_2 (100%) to obtain sulfuric acid as a product were optimized. Specific surface of the catalyst calculated according to full isotherms of low-temperature adsorption of nitrogen by BET method makes 12.6 m^2/g. Integral volume of pores makes 0.57 ml/g. The results showed that the degree of SO_2 removal was up to 94.9%. The catalysts based on fly ash cenospheres with addition of natural zeolite from Tayzhuzgen field (Kazakhstan) were also tested in the process of catalytic cracking of fuel oil (with preliminary electromagnetic excitation of hydrocarbon molecules) to obtain light carbon fractions. On the optimal catalyst in the products of oxidative cracking of fuel oil, the fraction of light gas oil is the main part. Determination of the individual composition of the hydrocarbons included in this fraction showed that the formation of C_7-C_{12} hydrocarbons happened exclusively due to the symmetric decomposition of C_{14}-C_{24} paraffins, since the products of this reaction are the corresponding α-olefins and n-alkanes.

Keywords: fly ash, Almaty TPP-2, Ekibastuz coal, catalytic cracking, natural zeolite, water and gas purification, highly toxic organic compounds.

INTRODUCTION

More than 100 million tons of ash waste is accumulated in landfills as a result of the combustion of solid fuel at a CHP (or TPP) annually [1-6]. Obviously the problem of the utilization of ash and slag of the CHP working on solid fuel is actual. TPP fly ash contains a number of components with valuable and unique technological properties: aluminosilicate hollow microspheres (AHM, which are really the most original and perhaps the most valuable components of ash), magnetite microbeads, the unburnt carbonic particles, ferrosilicon and carbonate microspheres [7-11]. They are hollow, almost perfectly shaped silicate balls with a smooth surface and a diameter from 10 to several hundred micrometers, an average of about 100 microns. The value of AHM is determined by the fact that they can be ideal fillers. The main components of ash and slag are silicon oxide, SiO_2 (45-60%) and alumina, Al_2O_3 (15-25%). The content of iron oxides Fe_2O_3 is from 5% to 15%, of calcium oxide CaO (1.5 - 4.5%) and of potassium oxide K_2O (2.0-4.5 %) and some other oxides, the content of which usually does not exceed 1%. Its most part contains in a form of iron-organic compounds. At coal burning the thermochemical transformation of all these compounds into the mineral magnetite (Fe_3O_4) happens. It is important to note that unlike other components the hollow microspheres are relatively easy to separate from ash. Due to the low density they can float to the water surface of

hydraulic structures (ponds, sedimentation tanks, recycled water channels) and can be collected by any means including the simplest. AHM are in great demand in many countries. Ash dumps are, in fact, a technogenic deposits of valuable products [5, 6, 12, 13].

In this research the hollow microspheres based on fly ash from the Ekibastuz coal deposit (Kazakhstan), produced as a result of the operation of TPP-2 in Almaty (Kazakhstan) were selected and used for preparation of composites and testing in two processes: for purification of gas emissions and catalytic cracking of fuel oil. Ekibastuz coal basin (Kazakhstan) is one of the most significant by reserves and ranks first in the world in terms of coal density: on the area of 62 km^2 the coal reserves are estimated at 13 billion tons or 200 tons per m^2 [14-16] and is one of the most promising areas in the world by open-pit coal mining. The main consumers of coal from this basin are in the Urals (Russia) and in the Republic of Kazakhstan.

Features of the chemical and mineral-phase composition of cenospheres make it possible to synthesize microspheric fuel cracking catalysts based on them. Heavy oils and natural bitumens have a high content of aromatic hydrocarbons, resinous-asphaltene substances, a high concentration of metals and sulfur compounds, high density and viscosity, increased coking, which gives an increased production cost of such raw materials and problems during transportation and oil refining.

Traditional processes of catalytic cracking of heavy petroleum raw materials require continuous regeneration of expensive zeolite-containing catalysts and sophisticated equipment [17-21]. The improvement of heavy oil feedstock conversion processes is mainly aimed at creating highly efficient catalytic systems and equipment. Development of methods for the activation of heavy oil raw materials by such physical influences as ultrasound, magnetic treatment, microwave, infrared radiation, mechanochemistry, ultraviolet radiation can be an alternative or addition to traditional oil refining processes. The publications of the last decade on testing unconventional methods of processing heavy petroleum feedstocks convincingly indicate the effectiveness of these methods for regulating the direction of interactions of feedstock molecules in the composition of petroleum dispersed systems [22-25]. Analysis of literature and patent data shows that the most promising method for obtaining light hydrocarbon fractions is the implementation of catalytic cracking of heavy petroleum raw materials, in the presence of air additives in the reaction medium, i.e. in an oxidizing medium [26-29]. Probably, the effect of waves on oil and petroleum products using a high-frequency electromagnetic field is associated with the presence of magnetic particles in the composition of oil, as well as the action of an electromagnetic field. It consists in the destruction of aggregates of colloidal magnetic particles and activation of their surface due to heating [30-34].

Implementation of the process of catalytic cracking of fuel oil without preliminary desulfurization and demetallization of heavy oil feedstock is of considerable practical interest. Synthesis of catalysts based on composites from natural raw materials is one of the most promising ways to increase the economic efficiency of catalytic cracking to obtain target fuels.

The purpose of this work was to study the possibility of using hollow microspheres based on fly ash from the Ekibastuz coal deposit (Kazakhstan), obtained as a result of the operation of CHPP-2 in Almaty, for purification of waste gases from sulfur dioxide to produce sulfonic acid and sulfoxides as reaction products. The catalysts based on fly ash cenospheres with addition of natural zeolite were also tested in the process of catalytic cracking of fuel oil (with preliminary electromagnetic excitation of hydrocarbon molecules) to obtain light carbon fractions.

EXPERIMENTAL

The fractions of cenospheres resulting of the combustion of coal of Ekibastuz field (Kazakhstan) at the Almaty TPP-2 (Kazakhstan) with an aluminosilicate module $SiO_2/Al_2O_3 = 3.2$ and an iron content of 3.03-3.67 wt. % in Fe_2O_3 (Table-1) have been used for the research. The scheme for producing mycospheres from the Ekibastuz coal ash is based on the use of dry magnetic separation methods, particle size classification and gravity separation using liquid separating media.

Table-1. Cenospheres fractions from the combustion of coal of Ekibastuz field (Kazakhstan) at the Almaty TPP-2 (Kazakhstan).

No	Fraction, mm	Composition, wt. %			SiO_2/Al_2O_3, wt. %	Crystalline phase, wt. %			Glass phase	S_{BET}, m^2/g
		SiO_2	Al_2O_3	Fe_2O_3		Quartz	Mullite	Calcite		
1	-0.19+0.09	67.71	20.95	3.01	3.2	3.4	0.8	0.5	95.4	125
2		66.50	20.68	3.77	3.2	-*	-*	-*	-*	125

*n.d. -not determined

The kinetics of oxidation of sodium sulfite with oxygen was studied under stationary conditions in a glass non-gradient thermostatic reactor of the "duck" type with a potentiometric device. The process was carried out according to the previously developed methodology [6, 11, 20, 28]. For the classification of fly ash from coal combustion a column pulsation apparatus with pneumatic pulsators and swirling partitions (with the distance between the partitions - 80 mm) has been applied. The rate of upward flow of the water was 0.005 m/s, an amplitude of pulsation was kept within 5 mm. The pulsations frequency was varied within the relationships density/specific surface area which are inherent to the two non-magnetic products (quartz sand and γ-Al_2O_3). The efficiency of the process was defined by the results of X-ray phase analysis and by means of visual control of quality of the selected products using a microscope. A

vibration magnetometer AMH-500 Hysteresisograph (Italy) was used for magnetic measurements.

Processing of M-100 grade fuel oil from Amangeldy gas processing plant (AGPP, Kazakhstan) was studied during catalytic cracking on composite catalysts based on cenospheres of fly ash with addition of natural zeolite of Kazakhstan field. Distillations at atmospheric and reduced pressures were used to establish the fractional composition of fuel oil. Fractions of gasoline, light gas oil, vacuum gas oil and heavy residue (T boiling > 500°C) were taken. The content of each fraction (wt. %) was determined by gravimetric method. The sulfur content of the liquid fuel and vacuum gas oil was determined by high temperature oxidation of the samples followed by acid-base titration of the resulting sulfur dioxide. In the initial fuel oil, in gasoline and kerosene-gas oil fractions formed during cracking, the presence of oxygen and sulfur-containing compounds was determined by the infrared

spectral method. This method in addition, allows establishing the qualitative composition of hydrocarbons in the analyzed samples. So, it was found that more than 80 wt. % of fuel oil in the composition is vacuum distillate and heavier fractions.

The proton spectrum of fuel oil from AGPP contains ^1H signals of paraffinic, naphthenic and aromatic compounds, which are the main components of the mixture. Methyl proton signals from saturated hydrocarbons were detected as a broadened singlet at 0.90 ppm. High-intensity signal with a chemical shift of 1.28 ppm indicates a significant content of protons of methylene groups of aliphatic cyclic and acyclic hydrocarbons. The highest-frequency signals (δ = 6.97-7.76 ppm) indicate the presence of monoaromatic compounds and condensed aromatic rings in the fuel oil. Signals of methyl protons of saturated hydrocarbons (HC) are noted as a broadened singlet at 0.90 ppm. A small amount of CH_3 groups was noted in the α-position to the aromatic ring (δ = 2.30-2.63 ppm). In the range of 2.70-4.50 ppm probably the resonance of protons of the CH_2 and CH groups in the α-position of aromatic compounds [17, 35-40].

RESULTS AND DISCUSSIONS

It was found that the optimum sizes of active parts of the catalyst are 40-50 nm. Specific surface of the catalyst calculated according to full isotherms of low-temperature adsorption of nitrogen by BET method makes 12.6 m^2/g. Integral volume of pores is 0.57 ml/g. SEM images of isolated aluminosilicate microspheres extracted from fly ash of TPP are shown in the Figure-1.
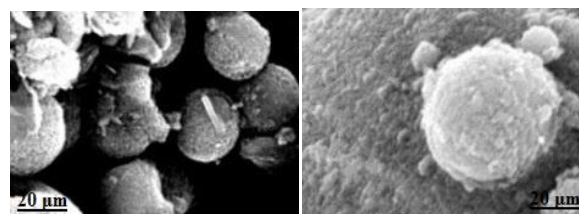

Figure-1. SEM images of aluminosilicate microspheres extracted from fly ash of TPP-2, Almaty.

The chemical composition (Table-2) is represented by oxides of aluminum, silicon, iron, calcium and titanium (ca. 95 wt. %).

Table-2. The elemental and chemical composition of aluminosilicate microspheres (cenospheres), % wt.

Sample	Al₂O₃	SiO₂	CaO	TiO₂	Fe₂O₃	Na₂O	S	P	SrO	ZrO
Initial	26.5	59.4	2.14	1.193	5.52	0.82	0.187	0.599	0.041	0.053
1	26.6	57.49	1.16	1.07	4.93	3.59	1.58	0.467	0.043	0.053
2	25.37	56.77	1.82	1.10	5.67	3.75	1.86	0.536	0.045	0.055
3	25.84	58.3	1.38	1.08	5.59	3.30	2.74	0.599	0.07	0.06
4	25.75	57.6	0.93	1.12	5.61	2.85	3.64	0.54	0.06	0.05
5	25.90	57.3	0.03	1.13	5.60	1.77	5.78	0.49	0.052	-

Purification of Gas Emissions from Sulphur Dioxide

To study the kinetics of oxidation of sulfur dioxide by oxygen in stationary conditions in the presence of modified cenospheres as a catalyst, Na_2SO_3 was used as a source of SO_2, inasmuch as under the experiment conditions at pH =10-12 in an aqueous solution SO_2 is in the form of SO_3^{2-} and the reaction (1) was actually studied:

$$2Na_2SO_3 + O_2 \rightarrow 2Na_2SO_4 \qquad (1)$$

The main results of the study of microspherical catalysts of oxidation of sodium sulfite by oxygen are summarized in the Table-3. From the data of the Table-3 it follows that the degree of conversion and the ratio of the process depend on the concentrations of components of the system Na_2SO_3-Al-O-Si-Fe-H_2SO_4-H_2O. In optimal conditions, the Na_2SO_3 rate conversion reaches 100 %, the maximum oxygen absorption rate reaches 6.8 ml/min.

Figure-2 shows the conversion curves in coordinates W_{O2}=f(Q_{O2}), where W_{O2} is the rate of oxygen absorption in mol/l·min; Q_{O2} is the amount of absorbed oxygen in mol/l, as well as potentiometric curves in coordinates φ(Q_{O2}), where φ(V) is the redox potential of the platinum electrode in relation to the calomel half-element. In most cases, the Na_2SO_3 oxidation rate dependence on the initial concentrations of the components has extreme nature. The initial redox potential of the Na_2SO_3-Al-O-Si-Fe-MX-H_2SO_4-H_2O system, where MX is a modifying component, is placed in the range 0.8-0.45 V, with $d\varphi/C_{Na2SO3} < 0$, passing through the maximum, $d\varphi/dT > 0$. These results allow to suppose that the redox-determinative pair in this case is Fe^{3+}/Fe^{2+}. Conversion curves in coordinates W_{O2}=f(Q_{O2}) (Figures-2a, c) and potentiometric curves in coordinates φ=f(Q_{O2}) (Figure-2b) show that with the Na_2SO_3 introduction into the redox system, the potential sharply shifted to the cathode region by 0.5-0.25V, and oxygen absorption starts immediately. The potential jump depends on the components correlation in the system. In the course of the experiment, the potential returns to the anode region, in optimal conditions - to the initial value, which indicates that the reaction products do not change the structure and composition of the catalyst and it works in a sustained way under these conditions. In these conditions, the potential

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remains at a certain value, without returning to the original value, and for these conditions (Figure-2a, curve 4), the

violation of the stoichiometry of the reaction (1) is observed.

Table-3. Oxidation of sodium sulfite by oxygen in the presence of a microspherical catalyst at T=40ºC.

No of a test	Ash, g	Concentration, mol/l			Na₂SO₃ conversion degree, %	W$_{O2}$, max, ml/min
		Na_2SO_3	$FeSO_4$	H_2SO_4		
1	0	0.4	-	-	100.0	0.6
2	0.1	0.4	-	-	100.0	5.4
3	0.5	0.4	-	-	100,0	4.4
4	1.0	0.4	-	-	100.0	4.0
5	2.0	0.4	-	-	-	3.4
6	0.1	0.2	-	-	100.0	4.8
7	0.1	0.1	-	-	100.0	3.6
8	0.1	0.2	$1 \cdot 10^{-4}$	-	100.0	4.0
9	0.1	0.2	$0.5 \cdot 10^{-5}$	-	100.0	4.6
10	0.1	0.2	$1 \cdot 10^{-5}$	-	100.0	6.8
11	0.1	0.2	$1 \cdot 10^{-2}$	-	79.0	3.8
12	0.1	0.2	-	-	100.0	4.8
13	0.1	0.2	-	$1.75 \cdot 10^{-2}$	100.0	5.2
14	0.1	0.2	-	$5.2 \cdot 10^{-2}$	100.0	3.8
15	0.1	0.2	-	$8.75 \cdot 10^{-2}$	100.0	3.0

The conversion curves obtained by varying in the range from 0.11 to 0.4 mol/L are presented in the Figure-2c. The correlation $C_{Na2SO3}/Q_{O2}=2$ and the correspondence of the stoichiometry of the reaction (1) are preserved throughout the studied interval. The dependence (Figure 2d) of the oxygen absorption rate (Q_{O2} at $Q_{O2} = 1/2$ from ΣQ_{O2}) is described by the equation (2):

$$W_{O2}=(k_1 \cdot \beta_1 \cdot C_{Na2SO3})/(1+ \beta_1 \cdot C_{Na2SO3}) \qquad (2)$$

where β is the constant of Na_2SO_3 adsorption on the surface of aluminosilicate microspheres. The data of the Table-3 also indicate on the Na_2SO_3 sorption.
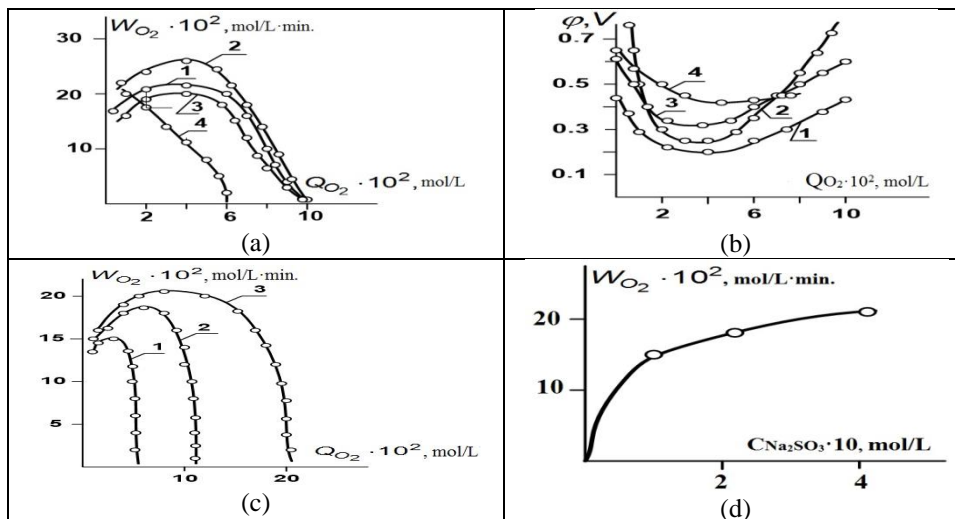

Figure-2. Oxidation of sodium sulfite by oxygen in the pre sence of microspherical aluminosilicates at T=40ºC, P$_{O2}$= 0.1 MPa; a, b: C$_{Na2SO3}$= 0.2 mol/l, C$_{H2SO4}$=10^2 mol/l: 1 - 1.75; 2 - 3.50; 3 - 5.25; 4 - 7,0; c, d: C$_{Na2SO3}$: 1 - 0.1; 2 - 0.2; 3 - 0.4 mol/L.

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So according to the aim of the study the technology of gas emissions purification from sulfur dioxide with simultaneous separation of sulfonic acid and sulfoxides as reaction products has been developed [41, 42]. After absorption of $4.7 m^3$ gaseous sulfur dioxide (concentration of SO_2 in an aqueous solution of 0.4 mol/L), the aqueous solution of SO_2 was separated from the catalyst and analyzed. The analysis showed the presence of about 70% H_2SO_4 in the solution. The ratio of adsorbed toxic oxides per adsorbent A unit (mg/g) was used as the kinetic parameter of adsorption. In order to determine the quantitative dependences characterizing the rate of adsorption of SO_2 molecules by fly ash, experiments were performed on a laboratory installation with an adsorber. The conditions of selective oxidation of SO_2 (100%) were optimized. The optimum catalyst is tested on a vortex unit. The oxidation state of SO_2 was 93.5-94.0 %.

The catalyst created has been tested in the process of gases purification from SO_2 at a pilot vortex stirrer of design capacity 2 m^3/h on model gas mixtures SO_2-Ar with the content of SO_2 up to 1 % vol. The results have demonstrated that with gas feed speed of 10,000-15,000 h^{-1} degree of removal of SO_2 reaches 86.9-94.9 %.

Catalytic Cracking of Fuel Oil of the M-100 Brand from AGPP

The analysis shows that the investigated for cracking fuel oil of M-100 brand is low-sulfur (Table-4). According to the IR spectral analysis of the fractions of the initial fuel oil, gasoline, light gas oil and heavy residue after the conversion of fuel oil from AGPP, their composition, together with alkanes of normal structure, includes a significant amount of olefin and aromatic hydrocarbons. The presence of olefins is indicated by strong absorption bands at 3,080-3,050 cm^{-1} in the spectra of gasoline and two fractions of light gas oil, as well as a band of medium intensity for a heavy residue. Aromatic hydrocarbons are also concentrated in light fractions, since the intensity of the absorption bands at 1,700; 1,640 and 1,600-1,580 cm^{-1} decreases during the transition from gasoline to light gas oil (185-340°C), and in the spectra for the 340-350° C fraction and the heavy residue of the absorption bands at 3,150; 1,700 and 1,620 cm^{-1} are absent. However, the bulk of all fractions is composed of aliphatic hydrocarbons with absorption bands characteristic of deformation vibrations of these molecules at 1, 480-1, 380 cm^{-1} and 980-700 cm^{-1} [43-46].

Table-4. Fractional composition and sulfur content in fuel oil from AGPP, grade M-100.

No	Fractional composition	Content, wt. %	
		hydrocarbon fractions	sulfur
1	initial fuel oil	100.0	0.7
2	gasoline	0.3	-
3	light gas oil	41.1	0.4
4	vacuum gas oil	18.4	1.3
5	heavy residue	39.3	0.7
6	losses	0.9	-

It has been established that the optimum in terms of the yield of light gas oil during cracking both in an inert atmosphere and in the presence of trace amounts of air is a catalyst based on fly ash from thermal power plants with the addition of the activated Tayzhuzgen zeolite.

According to X-ray diffraction analysis (Figure-3), the following components the composition of Tayzhuzgen zeolite are comprised (concentration, % intensity): Fe (49.939/739.15); Ca (1.715/9.16); Sr (0.270/1.98); Mn(0.129/1.81); Al (21.955/0.31); Si (23.114/0.98); Ti (1.903/20.87) and K (0.976/1.96).
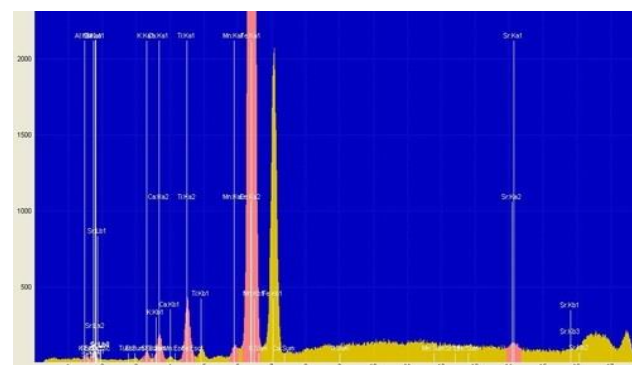

Figure-3. Image of diffraction analysis of natural zeolite from the Tayzhuzgen deposit (Kazakhstan).

On the optimal catalyst in the products of oxidative cracking of fuel oil, the fraction of light gas oil is the main part. Therefore, to elucidate the reaction mechanism, we set the task to determine the individual composition of the hydrocarbons included in this fraction. The results of gas chromatography-mass spectrometric analysis are presented in Table-5. As can be seen from the Table-5, the formation of C_7-C_{12} hydrocarbons occurs exclusively due to the symmetric decomposition of C_{14}-C_{24} paraffins, since the products of this reaction are the corresponding α-olefins and n-alkanes. Thus, as a result of cracking reactions of the M-100 fuel oil from AGPP, the resulting light gas oil contains a significant amount of α -olefins (Table-5), which are a scarce raw material for the production of synthetic additives and oils. It is known from the literature that the best synthetic oils that ensure the operation of equipment in cold climatic conditions are

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obtained on the basis of oligomers α - olefins C_8-C_{12} [46-48].

Table-5. Individual hydrocarbon composition of light gas oil from oxidative cracking of fuel oil M-100 from AGPP on a catalyst based on fly ash from thermal power plants with the addition of Tayzhuzgen zeolite activated by ion exchange (simultaneously with La^{3+} and NH_4^+ ions). Cracking conditions: $\omega_{suspension}$ = 1.0 h^{-1}, ω_{air} = 0.15 h^{-1}, 0.2 wt.% in raw material, T = 470°C.

No	Hydrocarbons	Content, %
1	heptene-1, C_7H_{14}	1.92
2	heptane, C_7H_{16}	2.82
3	octene-1, C_8H_{16}	0.69
4	octane, C_8H_{18}	1.30
5	nonene-1, C_9H_{18}	0.67
6	nonan, C_9H_{20}	1.07
7	decene-1, $C_{10}H_{20}$	0.83
8	decane, $C_{10}H_{22}$	1.37
9	undecene, $C_{11}H_{22}$	1.01
10	undecane, $C_{11}H_{24}$	1.43
11	pentylcyclohexane, $C_{11}H_{22}$	0.77
12	dodecene-1, $C_{12}H_{24}$	1.26
13	dodecane, $C_{12}H_{26}$	2.24
14	1-butyl-2-pentylcyclopropane, $C_{12}H_{24}$	0.65
15	2,6-dimethylundecane, $C_{13}H_{28}$	0.70
16	tridecene-1, $C_{13}H_{26}$	1.25
17	tridecane, $C_{13}H_{28}$	2.70
18	3-tetradecene, $C_{14}H_{28}$	1.31
19	tetradecane, $C_{14}H_{30}$	2.88
20	3-methyltetradecane, $C_{15}H_{32}$	0.63
21	2,6,1-trimethyldodecane, $C_{15}H_{32}$	0.51
22	1- pentadecene, $C_{15}H_{30}$	1.09
23	pentadecan, $C_{15}H_{32}$	3.36
24	1-hexadecene, $C_{16}H_{32}$	0.99
25	hexadecane, $C_{16}H_{34}$	3.29
26	2-methylhexadecane, $C_{17}H_{36}$	0.72
27	5-heptadecene, $C_{17}H_{34}$	0.77
28	heptadecane, $C_{17}H_{36}$	3.47
29	2,6,10,14-tetramethyltetradecane, $C_{18}H_{38}$	1.43
30	2,6,11-trimethylpentadecane, $C_{18}H_{38}$	0.70
31	2,6,10-trimethylpentadecane, $C_{18}H_{38}$	0.53
32	1-octadecene, $C_{18}H_{36}$	1.02
33	octadecane, $C_{18}H_{38}$	3.96
34	2- methyloctadecane, $C_{19}H_{40}$	2.42
35	2,4- dimethylheptadecane, $C_{19}H_{40}$	1.60
36	nonadecane, $C_{19}H_{40}$	4.88
37	6- propylheptadecane, $C_{20}H_{42}$	1.82
38	2-methylnoneadecane, $C_{20}H_{42}$	1.15
39	3-methylnoneadecane, $C_{20}H_{42}$	0.93
40	eicosan, $C_{20}H_{42}$	6.55
41	3-methyleicosane, $C_{21}H_{44}$	1.76
42	heneicosane, $C_{21}H_{44}$	6.63
43	5- propylnonadecane, $C_{22}H_{46}$	2.82
44	docosane, $C_{22}H_{46}$	5.05
45	3-butylnonadecane, $C_{23}H_{48}$	1.96
46	tetracosan, $C_{24}H_{50}$	3.13
47	pentacosane, $C_{25}H_{52}$	2.49
48	heptacosane, $C_{27}H_{56}$	1.17

CONCLUSIONS

The purpose of this work was to study the possibility of using hollow microspheres based on fly ash from the Ekibastuz coal deposit (Kazakhstan), obtained as a result of the operation of TPP-2 in Almaty, for purification of waste gases from sulfur dioxide to produce sulfonic acid and sulfoxides as reaction products. Optimum sizes of active parts of the catalyst are 40-50 nm. A catalytic method of sulfur compounds oxidation by oxygen in an aqueous solution have been developed. Multiple circulation of the aqueous solution makes it possible to obtain 60-70% solution of sulfoacids in the form of a commercial product. It has been found out that microspheres of fly ash are highly effective sorbents of SO_2 and low-temperature catalysts of oxidation of Na_2SO_3 with oxygen in water solutions. Obtained results have demonstrated that with gas feed speed of 10,000-15,000 h^{-1} degree of removal of SO_2 reaches 94.9%. The catalysts synthesized in this work based on fly ash cenospheres with addition of natural zeolite were also tested in the process of catalytic cracking of heavy oil raw materials (with preliminary electromagnetic excitation of hydrocarbon molecules) to obtain light carbon fractions. As a result of the M-100 fuel oil cracking reactions, the final light gas oil contains a significant amount of α - olefinsю A single-stage method for producing α - olefins by cracking affordable and cheap raw materials-fuel oil on catalysts from natural Kazakhstan raw materials could make it possible to master the production of synthetic oils, which is new for Kazakhstan.

ACKNOWLEDGEMENTS

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