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THE SPECIFIC SURFACE AREA OF THE SORBENTS BASED ON SOLID PRODUCTS OF INCOMPLETE COMBUSTION OF KARA-KECHE BROWN COAL

Удельная площадь поверхности сорбентов на основетвердых продуктов неполного сгорания бурого угля Кара-Кече

Толук эмес куйген Кара-Кече курец комурунун катуу продуктуларынын негизиндеги сорбенттердин салыштырмалуу беттик аянты

Abstract: *adsorption of methylene blue, methyl orange from aqueous solutions on solid products of incomplete combustion of Kara-Keche brown coal was studied. It is shown that in the series of studied sorbents, the dispersed product of incomplete combustion of fuel in the ascending air flow has the largest specific surface area.*

Аннотация: *исследована адсорбция метиленового голубого, метилового оранжевого из водных растворов на твердых продуктах неполного сгорания бурого угля Кара-Кече. Показано, что в ряду исследованных сорбентов диспергированный продукт неполного сгорания топлива в восходящем потоке воздуха обладает наибольшей удельной площадью поверхности.*

Аннотация: *толук эмес куйген Кара-Кече курвц комурунун катуу продуктуларында метилен кок менен метилен сары кызьшдын суудагы эритмелеринен адсорбцияланышы изилденген. Каралган сорбенттердин катарында, абанын агымында толук эмес куйген, майдаланган продукт эц чвц салыштырмалуу беттик аянтка ээ боло тургандыгы кврсвтулгвн.*

Keywords: *adsorption; sorbent; dye; surface; brown coal.*
Ключевые слова: *адсорбция; сорбент; краситель; поверхность; бурый уголь.*
Негизги свздвр: *адсорбция; сорбент; боёк; уступку катмар; курвц квмур.*

Introduction. The search for new sorbents on the basis of the secondary sources of carbon and mineral raw materials is among the priorities of rational nature management. In this regard, the study of the adsorption properties of solid products of incomplete combustion of coal is one of the topical problems in the physical chemistry of disperse systems. The present work is devoted to the comparative characterization of the

specific surface area of solid sorbents based on products of incomplete combustion of Kara-Keche brown coal.

Experiment. Brown coal of Kara-Keche deposit was used in the work; its physicochemical characteristics are described in [1]. The fuel was burned in a steel reactor. Schematic diagram and general view of the experimental stand are presented in [2]. The combustion process was carried out by feeding oxygen (air) into the combustion chamber at a flow rate of 3 liters per minute. The front of the combustion spread to meet the flow of oxygen (air), with the flame spreading over the entire section of the pipe, filled with 1 kg of coal. The temperature in the burning zone of coal under the counterflow of oxygen reached 800°C, and in the burning zone of coal under the counterflow of air - 700°C. The time of fuel burning was 30 minutes. The mass of unburned residues was not more than 500 g.

Four samples of sorbents on the basis of solid products of incomplete combustion of Kara-Keche coal were considered:

Zug(B) - a sample of the sorbent obtained in the incomplete combustion of Kara-Keche coal in a reactor with an ascending air flow. The particles of the sorbent are granules of black color, their size not exceeding 3 mm.

Zugd(B)- a sample of the sorbent obtained by dispersing the Zug (B) sample on a ball mill for 1 minute. The powder is black in color with particle sizes not exceeding 0.5 mm.

Zug(O) - a sample of the sorbent obtained with incomplete combustion of Kara-Keche coal in the reactor with an ascending flow of oxygen. The particles of the sorbent are granules of black color, their size not exceeding 3 mm.

Zugd(O) - a sample of the sorbent obtained by dispersing the Zug (O) sample on a ball mill for 1 minute. The powder is black in color with particle sizes not exceeding 0.5 mm.

The determination of the surface area of the studied sorbents was carried out by the adsorption method. As organic markers, methylene blue and methyl orange were used. The procedure for adsorption of dyes from aqueous solutions on the surface of solid adsorbents is described in [3]. The adsorption values were calculated from the following equation:

$$a = \frac{(c_0 - c_p) \cdot V}{m} 1000 \quad (1),$$

where C_0 and C_p are the initial and equilibrium concentrations of the adsorbate, (M); V - volume of the solution from which adsorption takes place, (l); m - mass of adsorbent, (g); 1000 - the conversion factor used for the adsorption values to be expressed in mmole/g. Adsorption isotherms are shown in Fig.1 and 2.

Fig.1 Adsorption isotherms of methylene blue on solid products of incomplete combustion of Kara-Keche coal at 298^0K

Fig.2 Isotherms of adsorption of methyl orange on solid products of incomplete combustion of Kara-Keche coal at 298^0K

Results and discussion. It can be seen from the Fig. 1 and2 that the adsorption of methylene blue from aqueous solutions on solid Zug (B), Zugd (B), Zug (O), Zugd (O) sorbents is always greater than that of methyl orange. The nature of the dependencies of adsorption values from the dyes equilibrium concentrations are close to the Langmuir type. At the same time, the following series is performed:

$$a^{MS}_{Zugd(B)} > a^{MO}_{Zugd(B)} > a^{MS}_{Zugd(O)} > a^{MO}_{Zugd(O)} > a^{MS}_{Zug(B)} > a^{MO}_{Zug(B)} > a^{MS}_{Zug(O)} > a^{MO}_{Zug(O)} \quad (I)$$

According to this series, the adsorption of dyes is greatest on the dispersed product of incomplete combustion of Kara-Keche coal -Zugd (B)

nd the smallest on the product of incomplete combustion of Kara-Keche coal-Zug (O). Preferential adsorption of the cationic dye, compared with an anionic, indicates a prevalence of negative charged adsorption centers in the researched samples of sorbents. At the same time, significant changes in the pH of aqueous solutions of methylene blue and methyl orange after adsorption on slightly alkaline solid products of incomplete combustion of Kara-Keche coal were not detected (Tables 1 and 2).

The obtained results indicate a small effect of the ion exchange mechanism of cationic and anionic dyes adsorption on the studied sorbents, although it is not completely excluded.

Thus, the experimental data allows us to assume that in the studied systems, in general, selective adsorption of methylene blue chloride and the sodium salt of methyl orange occurs on the suitable adsorption centers of solid products of incomplete combustion of Kara-Keche coal.

Table 1

pH of aqueous solutions of methylene blue after adsorption on solid products of incomplete combustion of Kara-Keche coal

№	C_o (mole/l)	Methylene blue				
		pH0	$P^HZug(B)$	$P^HZugd(B)$	$P^HZug(0)$	$P^HZugd(0)$
0	H_2O	5,75	7,10	7,32	7,10	7,20
1	0,00000167	5,59	6,95	7,25	6,92	6,97
2	0,00000335	5,64	6,98	7,20	7,11	7,02
3	0,00000502	5,66	7,15	7,33	7,05	7,25
4	0,00000837	5,68	7,07	7,43	7,15	7,21
5	0,00001000	5,72	7,14	7,55	7,13	7,26
6	0,00001170	5,76	7,25	7,62	7,16	7,39
7	0,00001340	5,79	7,27	7,64	7,20	7,37
8	0,00001510	5,83	7,30	7,76	7,23	7,45

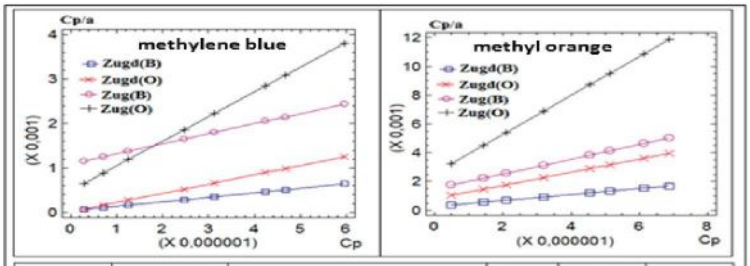
Table 2

pH of aqueous solutions of methyl orange after adsorption on solid products of incomplete combustion of Kara-Keche coal

№	C_o (mole/l)	Methyl orange				
		pH^0	$P^HZ_Ug(B)$	pHLgd(B	$P^HZ_Ug(0)$	pHLgd($_0$
0	H_2O	5,74	6,90	7,41	6,90	6,56
1	0,00000167	5,85	7,39	7,19	6,88	6,86
2	0,00000335	5,95	7,32	7,38	6,95	7,30
3	0,00000502	6,03	7,13	7,36	6,98	7,18
4	0,00000837	6,09	7,16	7,48	7,00	7,12
5	0,00001000	6,14	7,20	7,50	7,15	7,20
6	0,00001170	6,24	7,38	8,28	7,06	7,38
7	0,00001340	6,63	7,22	8,70	7,25	7,48
8	0,00001510	6,35	7,34	8,37	7,36	8,09

To complete the characterization of the adsorption of charged probe particles from aqueous solutions on the studied samples of sorbents, the data from Fig. 1 and 2 is considered in the coordinates of the Langmuir equation. Note that the linearization of the corresponding dependencies was carried out though the linear regression method using the demo version of the statistical software application package Statgraphics Centurion. The results are shown in Fig. 3.

It is seen from Fig. 3 that linear dependences with high correlation coefficients are observed. This allows us to assume that selective adsorption of dyes is realized, mainly, on the surface adsorption centers of solid products of incomplete combustion of Kara-Keche coal.



adsorbent	dye	linear regression equation	k_{corr}	a_{∞} mmole/g	K
Zugd(B)	MS	Cp/a = 0,00003 + 102,8 · Cp	0,99	0,0097	$3,4 \cdot 10^6$
	MO	Cp/a = 0,00027 + 206,6 · Cp	0,99	0,0048	$7,7 \cdot 10^5$
Zugd(O)	MS	Cp/a = 0,00001 + 208,3 · Cp	1,00	0,0048	$2,1 \cdot 10^7$
	MO	Cp/a = 0,00083 + 456,6 · Cp	0,98	0,0022	$5,5 \cdot 10^5$
Zug(B)	MS	Cp/a = 0,00109 + 226,3 · Cp	0,96	0,0044	$2,1 \cdot 10^5$
	MO	Cp/a = 0,00150 + 511,0 · Cp	0,98	0,0020	$3,4 \cdot 10^5$
Zug(O)	MS	Cp/a = 0,00049 + 556,1 · Cp	0,99	0,0018	$1,1 \cdot 10^6$
	MO	Cp/a = 0,00258 + 1352,1 · Cp	0,97	0,0007	$5,2 \cdot 10^5$

Fig.3 Adsorption of methylene blue and methyl orange on solid products of incomplete combustion of Kara-Keche coal in the coordinates of the Langmuir equation

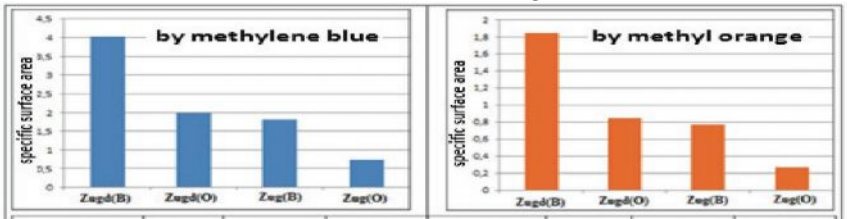
Large values of the adsorption equilibrium constants in the studied systems (Fig. 3) do not exclude the possibility of chemisorption of cationic and anionic dyes on the corresponding adsorption centers of the studied sorbents.

The linear regression equations presented in Fig.3 were used to calculate the limit adsorption values of methylene blue and methyl orange from aqueous solutions on solid adsorbents. The corresponding values are given in the table in Fig. 4. Calculation of the limiting values of the specific areas of the sorbents surfaces [4] was carried out using the following equation: $S^{\wedge} = N_A \blacksquare a_m \blacksquare a)$ (2),

where N_A - Avogadro's number; $\mathbf{a_{i0}}$- limit adsorption; **oo** - a site occupied by one dye molecule [5].

The results of the calculations are shown in Fig. 4. It can be seen from Fig. 4 that the specific surface areas of the samples of solid products of incomplete combustion of Kara-Keche coal regularly change in the series (II).

Thus, it can be concluded that the sample Zugd (B), which is a dispersed product of incomplete combustion of Kara-Keche coal in the ascending airflow at 700^0 C, has the largest specific surface area.



sorbent adsorbate	ω (nm^2)	a_{∞} ($\frac{mmole}{g}$)	$S_{\infty}^{yд}$ (m^2/g)	sorbent adsorbate	ω (nm^2)	a_{∞} ($\frac{mmole}{g}$)	$S_{\infty}^{yд}$ (m^2/g)
Zugd(B)-MS	0,69	0,0097	4,03	Zugd(B)-MO	0,64	0,0048	1,85
Zugd(O)-MS	0,69	0,0048	1,99	Zugd(O)-MO	0,64	0,0022	0,85
Zug(B)-MS	0,69	0,0044	1,82	Zug(B)-MO	0,64	0,0020	0,77
Zug(O)-MS	0,69	0,0018	0,75	Zug(O)-MO	0,64	0,0007	0,27

$$S^{\infty}_{Zugd\,(B)} > S^{\infty}_{Zugd\,(O)} > S^{\infty}_{Zug\,(B)} > S^{\infty}_{Zug\,(O)} \quad \textbf{(II)}$$

Fig.4 Histograms of the specific areas of surface of the solid products of incomplete

combustion of Kara-Keche coal

At the same time, the sample Zug (O), which is the initial product of incomplete combustion of Kara-Keche coal in the ascending flow of oxygen at 800^0C, has the lowest specific surface area in the series of the studied sorbents.

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