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Comparative Analysis of the Adsorption Properties of Various Carbon Adsorbents

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ABSTRACT. The article presents the results of the dependence of oxygen-containing groups (carboxyl, hydroxyl and phenolic) studies on the use of Angren carbon adsorbents, the degree of absorption of Cu^{2+} ions. It is justified during thermal pyrolysis with increasing temperatures for activated carbon adsorbents that the absorption of Cu^{2+} ions decreases.

KEYWORDS. Coal adsorbent, sorption, ions, industrial wastewater, carboxyl and hydroxyl groups.

I.INTRODUCTION

It is well known that at the moment coal adsorbents are widely used in various fields of science and technology: in chemistry, biology, pharmaceuticals and medicine, in purification, separation, and other industrial processes. A variety of areas of use of sorbents leads to different requirements for them [1, 2].

Along with the porous structure of sorbents, the composition of surface functional groups is also important, which is important in chromatographic studies and also affects the efficiency of extraction of organic impurities from the aqueous medium [3, 4].

The paper presents the results of a comparative study of the sorption characteristics of natural and modified coal sorbents depending on the origin.

II. SIGNIFICANCE OF THE SYSTEM

The article presents the results of the dependence of oxygen-containing groups (carboxyl, hydroxyl and phenolic) studies on the use of Angren carbon adsorbentsThe study of literature survey is presented in section III, methodology is explained in section IV, section V covers the experimental results of the study, and section VI discusses the future study and conclusion.

III. METHODOLOGY

Samples of coal from a hydraulic dump, rock mass, raw coal, BSSH grade, and also oxidized (weathered) (Angren) were selected as objects of study.

Coals were subjected to technical analysis: moisture content, ash, volatiles, as well as chemical analysis of the content of humic acids and the amount of acid groups (carboxyl and hydroxyl, phenolic). To determine the structure of coal adsorbents, we used: the chemisorption method, to determine the carboxyl and hydroxyl (phenolic) groups of coal using barium hydroxide ($Ba(OH)_2$) and calcium acetate ($Ca(CH_3–COO)_2$ [5]; IR spectroscopy method for determining

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oxygen-containing and other groups in carbon adsorbents on an IR-20 spectrometer in the presence of KBr [6, 7]; EPR method of electron paramagnetic resonance to determine the presence of free radicals on the surface of coal images (initial and heat-treated) and their interaction with oxygen [8]; a thermographic method for determining the heat resistance of oxygen-containing groups and the temperature ranges of their decomposition [9].

The sorption capacity of coal samples with particle sizes of 2-5 mm was determined by sorption under static conditions at room temperature. Copper cations were sorbed from a model 2,5% aqueous solution of $CuSO_4$ containing 0,53% copper. Coal was introduced into a solution of $CuSO_4$, the mixture was shaken for 30 minutes. Next, the copper content on the I-160MI ionomer was determined in the filtrate. According to the difference, the copper content in the initial solution and in the filtrate established the capacity of coal to copper ions.

IV. EXPERIMENTAL RESULTS

The technical analysis showed that the moisture content in the coals ranges from 25-30%, and the ash content on dry weight in coals of the BSSH brand and ordinary, respectively, is 30 and 14%. The ash content of the samples also varies in values: in the samples of the hydraulic dump, rock mass, and oxidized coal, they are 70, 73, and 44%, respectively. The high content of minerals in coal waste leads to a high yield of volatile substances up to 48-57%, against ordinary coal and BSH brand with a yield of 35-36%.

The content of humic acids in ordinary coal does not exceed 1.0%, and in samples of HSS, hydraulic dump, rock mass and oxidized coal, respectively, is 5, 35, 30 and 50%.

The content of the sum of acid groups (carboxyl and hydroxyl phenolic) in coals varies from 0,6 to 3,5 mg.eq/g, which indicates the oxidized form of some part of the organic mass of the coal dump and rock mass. The studied coal samples also differ in chemical composition: in the content of humic acids, as well as carboxyl and hydroxyl (phenolic) groups.

Table 1
Dependence of the sorption capacity of coals of different deposits on the content of functional groups in them

Name of coal sample	The content of acid groups, mg.ekv/g		The output of humic acids on a combustible mass, %	Ion sorption “Cu” g/kg
	COOH	OH (fenol)		
Angren, BSSH	0,3	2,7	10,0	32,0
AngrenVitren	0,5	5,2	15,0	14,0
AngrenFusen	0,2	1,7	0,0	2,0
Kzyl-Kyi natural - oxidized*	2,0	5,5	70,0	50,0
Shurabsky, BSHH *	0,2	2,5	30,0	35,0

* The brown corners of Kyrgyzstan and Tajikistan were taken for comparison.

Many other factors affect the sorbability of fossil fuels: petrographic composition, microporosity, degree of chemical maturity, pH of the medium, and others. To exclude the influence of various factors, the sorption characteristics of coal samples of the same field were studied, depending on only one indicator - the content of acid groups. For this, the coals of the Shargun deposit of varying degrees of natural oxidation with a humic acid content of up to 90% were taken. UnoxidizedShargunsky coal, unlike brown coal, does not have sorption ability for cations (Table 2). As the degree of oxidation increases and the amount of humic acids increases from 2 to 90%, the sorption of copper from aqueous solutions increases from 13 to 32%.

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Table 2
Dependence of sorption properties on the content of acid groups in the coal of the Shargun deposit

№	Coal characteristic				Sorption properties of coal, g/kg.
	COOH+OH	COOH	OH	The output of humic acids in the mountains.mass. %	Cu^{2+}
	mg·ekv/g				
1	0,06	0,04	0,02	0,0	-
2	0,30	0,10	0,20	0,3	0,0
3	0,12	0,05	0,07	0,8	0,0
4	1,20	0,25	0,95	2,0	0,0
5	3,58	1,37	2,21	20,7	13,0
6	4,60	2,41	2,19	43,2	13,6
7	5,04	2,93	2,11	64,0	27,0
8	6,60	4,00	2,60	84,3	31,6

It is well known that the content of oxygen-containing groups in coal during heat treatment decreases, and increases during oxidation. BSSH grade Angren coal was heat treated at temperatures of 120, 200, 300, 400, 500, and 600 °C. In heat-treated coal samples, the contents of carboxyl and phenolic hydroxyls were determined, as well as the sorption capacity for Cu^{+2} ions, which showed as the temperature of coal processing increases, the sum of acid groups (carboxyl and hydroxyl - phenolic) decreases and, accordingly, sorption to copper ions decreases (tab.3).

Table3
The influence of heat treatment on the sorption characteristics of Agren coal

№	Samples	pHwater solution	Contentmg.ekv/g		Sorption capacity
			COOH	OH	Cu^{2+} g/kgdry. mass
1	H-form	3,5	1,49	3,15	36,4
2	exodus.	6,2	0,52	3,10	28,6
3	Heat treated at 120˚C	6,2	0,48	3,19	28,3
4	Heat treated at 200˚C	-	0,43	3,20	25,8
5	Heat treated at 300˚C	6,5	0,02	2,52	10,1
6	Heat treated at 600˚C	6,6	0,0	0,07	0,0

In the form of Angren coal, artificially oxidized with a 6% solution of hydrogen peroxide, taken in 3 times in excess, the content of acid groups increases and, accordingly, the sorption capacity for copper ions increases from 32 to 74 g/kg (Table 4).

Table 4
The content of acid groups and the sorption capacity of artificially oxidized forms of coal

№	Name of samples	pH Coal	A^a	COOH	OH	Amount	sorptionCu^{2+}g/ kgdry. Coal
				mg·ekv/g			
	Angren (BSSH)	6,0	9,6	1,4	3,5	4,9	59,0
	Angren H-form	-	13,5	2,1	3,5	5,6	141,0
	Kzyl-Kyi	5,3	29,1	3,8	5,8	9,6	74,7

** Note: the pH of coal treated with hydrogen peroxide was brought to the original by alkalizing the solution.*

It is known that strongly acidic cation exchangers allow the sorption process to be carried out in any media in a wide pH range, and weakly acid cation exchangers in alkaline and neutral ones. As a result of the study of the effect

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of pH on the sorption capacity of Angren coal, it was found that with an increase in the pH of the solution from 1,035 to 2,81, a decrease in the filtrate content of copper from 4,5 to 1,5 g/l is observed. the process of sorption of cations by the adsorbent is accompanied by the release of acid, which will lower the pH of the solution, which will lead to the opposite process - desorption of the sorbedcation by the adsorbent.

V. CONCLUSION AND FUTURE WORK

Thus, the data obtained as a result of oxidation processes, heat treatment of coals and a change in the pH of the system environment are evidence of a relationship between the sorption capacity of coal and the presence of acidic and other functional groups in it.

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