OBTAINING MELIORANTS BASED ON OXIDIZED COAL WITH YDROGEN PEROXIDE AND SUNNESSED LIME

Akhmedova Iroda
Institute of General and Inorganic Chemistry, Academy of Sciences of the Republic of Uzbekistan
Usanbaev Najimuddin
Institute of General and Inorganic Chemistry, Academy of Sciences of the Republic of Uzbekistan
Namazov Shafaat
Institute of General and Inorganic Chemistry, Academy of Sciences of the Republic of Uzbekistan
Orakbayev Azamat
Institute of General and Inorganic Chemistry, Academy of Sciences of the Republic of Uzbekistan
Ganiev Pirnazar.
Tashkent State Medical University. Chirchik Branch

Annotatsiya. Maqolada vodorod peroksid bilan oksidlangan ko‘mir asosida olingan, tarkibida gumin kislotalari va so‘ndirilmagan ohak miqdori yuqori bo‘lgan, tuproq strukturasini yaxshilovchi va namlikni yutuvchi guminli meliorantlar olish natijalari bayon etilgan. Bir gektarga 5 tonna hisobidan qo‘llanilgan meliorant to‘liq nam sig‘imidan eng kam nam sig‘imigacha bo‘lgan oraliqda suv saqlash qobiliyatining yaxshi ko‘rsatkichlarini namoyon etishi aniqlangan. Xususan, meliorantsiz tuproq to‘liq namlikda 25,48% gacha, kapillyar namlikda 20,34% gacha va eng kam nam sig‘imida 14,97% namlikni ushlab turadi. 5 t/ga meliorant qo‘llanilganda esa bu ko‘rsatkichlar mos ravishda 36,38%, 23,74% va 17,36% gacha, 10 t/ga qo‘llanilganda esa 47,18%, 28,34% va 21,36% gacha yetadi.

Kalit so‘zlar: meliorant, qo‘ng‘ir ko‘mir, gumin kislotalari, kalsiy oksidi, tuproq, to‘liq nam sig‘imi, tuproqning kapillyar nam sig‘imi, tuproqning eng kam nam sig‘imi.

Аннотация. В статье описаны результаты получения влаги поглощающих и улучшающих структуру почв гуминовых мелиорантов на основе окисленного угля пероксидом водорода с высоким содержанием гуминовых кислот и негашёной извести. Показано, что при применении мелиоранта полученного из расчета 5 тонны на один гектар характеризуются хорошими показателяими водоудерживающей способности в интервале от полной до наименьшей ввлагоёмкости. Так, почва без пробы удерживает при полной до 25,48 %, при капиллярной 20,34 %, а при наименьшей влагоёмкости 14,97 %. С мелиорантом 5 т/га при полной до 36,38 %, при капиллярной 23,74 %, при

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наименьшей до 17,36 %, при использовании 10 т/га при полной до 47,18 %, при капиллярной 28,34 %, при наименьшей до 21,36 %.

Ключевые слова: мелиорант, бурый уголь, гуминовые кислоты, оксид кальция, почва, полная влагоёмкость, капиллярная влагоёмкость почвы, наименьшая влагоёмкость почвы.

Annotation: The article describes the results of obtaining moisture-absorbing and soil structure-improving humic ameliorants based on oxidized coal with hydrogen peroxide with high humic acid content and unslaked lime. It has been shown that when applying the meliorant obtained at a rate of 5 tons per hectare, it is characterized by good indicators of water retention capacity in the range from full to lowest moisture capacity. For example, soil without a sample retains up to 25.48% of its total moisture content, 20.34% of its capillary moisture content, and 14.97% of its minimum moisture content. With 5 t/ha of meliorant at a full rate of 36.38%, at a capillary rate of 23.74%, at a low rate of 17.36%, at a rate of 10 t/ha at a full rate of 47.18%, at a capillary rate of 28.34%, at a low rate of 21.36%,.

Keywords: meliorant, brown coal, humic acids, calcium oxide, soil, total moisture capacity, capillary moisture capacity of soil, lowest moisture capacity of soil.

Introduction.

Agricultural production is one of the leading sectors of the economy of the Republic of Uzbekistan. To increase the efficiency of crop production, it is necessary to introduce the latest technologies for soil cultivation, use high-yielding varieties, and comprehensively apply mineral and organomineral fertilizers and soil ameliorants. Agricultural practice and numerous agrochemical tests show that one of the main factors determining the yield of high and quality crops and the preservation of soil fertility is the use of mineral fertilizers in combination with organic fertilizers containing humic substances, as well as soil ameliorants that improve the chemical, physical, and biological state of the soil.

The depletion of soil fertility is the main problem of agricultural production in many countries of the world. Using only mineral or organic fertilizers has both positive and negative effects on plant growth in the soil. Organic fertilizers improve the physical and biological activity of the soil, but they have a relatively low content of nutrients, therefore, for plant growth, it is necessary to apply them in larger quantities. Mineral fertilizers contain nutrients of higher concentration that are directly available to plants. However, the use of only mineral fertilizers leads to the degradation of soil humus substances and a decrease in soil fertility. Only an integrated nutrient management system is an alternative system for sustainable and cost-effective soil fertility management through the combined application of mineral, organic fertilizers, and soil ameliorants [1].

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One of the problems of world agriculture in the context of intensive farming is the reproduction of soil fertility, the creation of a balance of nutrients in the soil. The main indicator of soil fertility is the HS content. Increasing soil fertility and plant productivity can be achieved by applying organic and mineral fertilizers in combination and in the required amounts, depending on the soil condition [2].

In work 3, the effectiveness of using a peat-based humic preparation in potato cultivation was demonstrated. This preparation had a positive effect on the growth processes and quality indicators of potatoes. In addition, the manifestation of phytofluorous and alternarious infections was noted later, compared to the control. Its application allowed for obtaining the highest yield of 24.5 t/ha, exceeding the control by 11.13%.

In the 4th work, the influence of the source and doses of HA, i.e., compost, manure, and coal, as well as six doses of HA: 0, 0,5, 1,0, 15, 2,0, and 2.5 g/kg, on changes in soil salinity, pH, electrical conductivity, cation exchange, aggregate state, and plant growth was studied. The experimental results showed that HAs from peat increase plant mass, plant roots, grain quantity, and chlorophyll content more than others. HA also effectively increased rice yields by 10-20% due to soil pH compliance, nutrient availability, and reduced soil salinity.

In the 5th work, the results of research on humic preparations for various agricultural crops are presented, and it is shown that maximum yield increases can be achieved when mineral fertilizers and HA-based preparations are used together. Calculations also showed that in both wheat varieties, potassium-sodium humate with microelements increased the return on fertilizers by 2.6-2.8 times.

In the CAC countries, there is also interest in researching the processes of obtaining humic fertilizers and their production, as well as their application in agriculture. The work [6] presents the results of research on the elemental composition and HA content in six brown and hard coal deposits in Tajikistan. According to atomic emission spectrographic analysis data, the main components of the studied coal ash are Fe, Al, Si, while the total content of micro- and macroelements in them reaches up to 27 units. Analysis of brown and hard coal samples showed that the HA content varies from 9.54-22.33%. Based on the conducted chemical and physicochemical studies, it has been shown that the HA complex has several levels of quasi-structures consisting of high-molecular-weight particles complementary to low-molecular-weight compounds, forming an irregular structure connected by donor-acceptor and dispersion interactions, as well as hydrogen and Van der Waals bonds, contributing to the transition to a more ordered crystalline form.

In the work [7], the results of obtaining organomineral sodium humate based on Karatau phosphorites are presented, and it is shown that the introduction of

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sodium humate into the acid decomposition process of phosphate raw materials contributes not only to an increase in the coefficients of assimilable and water-soluble forms of phosphorus but also to the neutralization of acidic forms of phosphates without phosphorus retrogradation, improves the quality of the obtained fertilizers, and enhances their commercial properties.

In the work [8] a method for obtaining liquid humic acid is described. OMF from brown coal from the Maykuben deposit. The method consists of preliminary extraction of the hydrocarbon raw material with an aqueous solution of potassium hydroxide, followed by supplying air and ultrasonic radiation to the resulting suspension. The yield of free HAs (to analytical state) was 87%. It has been shown that with additional air exposure to the suspension, its oxidation state increases, and accordingly, the yield of HA increases.

In the work [9] based on the conducted research, a methodology for calculating the chemical composition of long-acting nitrogen-phosphorus-potassium based on peat and the carbonyl cellulose modifier is presented, which allows for regulating the ratio between nutrient components in the form of the ratio of nitrogen to phosphorus and potassium, taking into account the proportionality coefficients dependent on the size of the granules and the consumption of mineral streams of the components of chemical substances. A technological scheme for obtaining complex granulated fertilizer is considered, the main units of which are a dense-layer convective dryer and a granulator - extruder.

Uzbekistan has large coal reserves, with explored reserves of 1 billion 900 million tons, and projected resources are significantly higher - over 15 billion tons. Regular brown coal from the Angren deposit contains very little HA, only 3.5-4.1%. To increase the HA content and obtain humic fertilizers based on oxidized coal, the oxidation process of Angren brown coal with nitric acid was studied, depending on various parameters, acid concentration, temperature, duration, and coal:acid weight ratio. Based on the conducted research, the possibility of increasing the content of humic acids from 4.1% to 57.2% was shown if the oxidation of 40% HNO_3 was carried out at 40°C for 2 hours at a weight ratio of the organic part of coal to nitric acid monohydrate equal to 1:2 [10].

The initial raw material resources for obtaining humic fertilizers and various humates are peat, brown coal, and other organic substances with high HA content. In Uzbekistan, the explored reserves of brown coal amount to about 2 billion tons. The projected resources are significantly higher - just over 15 billion tons. The annual coal production volume is over 3 million tons, and in the future, it is planned to increase it to 11 million tons [11].

However, ordinary brown coal from the Angren deposit contains only 3.5-4.5% humic acids, which is very insufficient for obtaining humic products. It

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should be noted that fossil fuels are not only fuel used to obtain thermal and electrical energy, but also a source of organic raw materials necessary for the production of various products. To obtain target products from coals, various methods of coal destruction are used. One of the promising directions of coal destruction is oxidation, which allows for an increase in the yield of HA from coal. Oxidation is also used to establish the chemical structure of coals, to obtain valuable oxygen-containing compounds such as polycarbons, and to enhance the reactivity of coals in various processing processes. Oxidation does not require high pressures and temperatures and is primarily aimed at utilizing low-quality weathered brown coals and coal waste. Of the several oxidizers used, the following are most commonly used in the oxidation of coals: atmospheric oxygen, ozone, hydrogen peroxide, nitric acid, oleum, potassium permanganate, hydrochloric acid, copper oxide, acetic anhydride in a mixture with nitric acid [12].

The work [13] presents the results of studies on the oxidation of brown coal from the Kharanor deposit using various oxidizing agents (HCl, H_3PO_4, CH_3COOH, H_2O_2, $KMnO_4$, H_2SO_4, HNO_3, O_3) to determine the effectiveness of their processing into humic substances. Practically in all selected oxidizing reagents, an increase in HA yield, a decrease in ash content, and a decrease in the heat-generating capacity of the brown coals of the Kharanor deposit were noted. The studied reagents have an oxidizing effect on the organic mass of brown coal to a certain extent and lead to an increased yield of H_2O. The greatest effect was obtained when using hydrogen peroxide and hydrochloric acid. According to the authors of this work, it is preferable to use hydrogen peroxide for safety reasons. In the case of using hydrochloric acid or nitrogen washing of coal to a neutral reaction, it takes considerable time and requires a large amount of water. And for H_2O_2, washing is not required, moreover, this reagent decomposes when heated above 70-75°C, which is an undisputed advantage.

Based on the foregoing, and for the purpose of using oxidized coal to obtain humic simple superphosphate and carbamide, as well as to obtain complex humates, research was conducted on the oxidation of Angren brown coal using hydrogen peroxide in an alkaline environment. A large-scale hydrogen peroxide production facility is planned to be established at Navoiazot JSC, and sodium and potassium hydroxide will be produced at the same enterprise.

0,25 мм In the experiments, a representative sample of coal fineness from the Angren deposit was used, which after drying to air-dry state and grinding in a ball mill to the following size content (wt.%): moisture 15.66; ash 14.90; organic matter 69.44; GK 3.82 and fulvic acid 0.91 per organic mass. The oxidation process was carried out at a hydrogen peroxide concentration of 10 to 30%, a sodium or potassium hydroxide solution of 20 to 40%, and a weight ratio of carbon (organic

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part): H_2O_2: NaOH (KOH) from 1: 0.1: 0.005 to 1: 1: 0.01. The experiments were conducted as follows: first, coal was treated in a mechanical mortar with grated sodium or potassium hydroxide or their solution at a ratio of coal (organic part): NaOH of 1: 0.05 for 30 minutes. Then, the resulting mass was added to the tubular reactor, where a hydrogen peroxide solution was pre-filled, while stirring, and processed for 2 hours. When coal was oxidized with hydrogen peroxide, the temperature of the reaction mass rose to 45-90°C depending on the norm and concentration of hydrogen peroxide. In all experiments, at the end of the process, the reaction mass was dried to an air-dry state, and its ash content, moisture content, organic matter, and the yield of humic and fulvic acids were determined. After the extraction of alkali-soluble organic substances from oxidized coal, insoluble residual coal remains. It was washed with distilled water, then dried to a constant weight, and the content of insoluble organic substances was determined. The difference between the amounts of alkali-soluble organic substances, humic acids, and insoluble organic substances gives us the fulvic acid content in oxidized carbon. Ash content was determined according to GOST 11022-75, moisture content - according to GOST 11014-70, organic content - by the difference between 100 and the sum of the percentage of ash and moisture content, HA yield - according to GOST 9517-76. The experimental results are presented in Tables 2.1-2.5. Table 2.1 and 2.2 show how the composition of oxidized coal changes depending on the norm and concentration of hydrogen peroxide and sodium or potassium hydroxide.

Table 1

Output of coal oxidation products depending on the norm and concentration hydrogen peroxide and NaOH

Ratio Carbon: H_2O_2: NaOH	Oxidation product yield, %	Determined components in % of the organic part of oxidized coal			
		Alkali-soluble substances	Huminous acids	Fulvo-acids	Residual coal
Hydrogen peroxide concentration is 10%					
1: 0.1: 0.05	101.63	22.10	19.89	2.21	77.9
1: 0.2: 0.05	103.46	29.49	26.98	2.51.	70.51
1: 0.4: 0.05	105.31	40.37	37.32	3.05	59.63
1: 0.5: 0.05	105.69	43.09	39.95	3.14.	56.91
1: 0.6: 0.05	106.01	45.41	42.19	3.22.	54.59
Hydrogen peroxide concentration is 20%					
1: 0.1: 0.05	102.49	26.78	24.35	2.43	73.22
1: 0.2: 0.05	104.01	35.77	32.86	2.91	64.23

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1: 0.4: 0.05	106.35	47.51	44.05	3.46.	52.49
1: 0.5: 0.05	107.01	50.54	46.95	3.59	49.46
1: 0.6: 0.05	107.41	51.81	48.19	3.62	48.19
Hydrogen peroxide concentration is 30%					
1: 0.1: 0.05	103.22	31.32	28.64	2.68	68.68
1: 0.2: 0.05	105.49	40.97	37.65	3.32.	59.03
1: 0.4: 0.05	108.25	52.72	48.64	4.08	47.28
1: 0.5: 0.05	109.01	55.2	50.95	4.25.	44.8
1: 0.6: 0.05	109.41	55.51	51.19	4.32.	44.49

Table 2

Output of coal oxidation products depending on the norm and concentration hydrogen peroxide and KOH

Coal: H2O2: KOH ratio	Oxidation product yield, %	Determined components in % of the organic part of oxidized coal			
		Alkali-soluble substances	Huminous Acids	Fulvo-Acids	Residual coal
Hydrogen peroxide concentration is 10%					
1: 0.1: 0.05	102.36	26.27	23.86	2.41	73.73
1: 0.2: 0.05	104.64	31.62	28.91	2.71	68.38
1: 0.4: 0.05	106.13	35.60	32.35	3.25.	64.40
1: 0.5: 0.05	107.57	41.50	37.96	3.54.	58.50
Hydrogen peroxide concentration is 20%					
1: 0.1: 0.05	103.59	30.86	28.33	2.53	69.14
1: 0.2: 0.05	105.10	36.65	33.84	2.81	63.35
1: 0.4: 0.05	107.53	44.20	41.04	3.16	55.80
1: 0.5: 0.05	108.54	52.41	48.92	3.49.	47.59
Hydrogen peroxide concentration is 30%					
1: 0.1: 0.05	104.34	38.52	35.64	2.88	61.48
1: 0.2: 0.05	106.94	45.06	41.64	3.42.	54.94
1: 0.4: 0.05	109.52	52.79	48.61	4.18.	47.21
1: 0.5: 0.05	110.15	57.37	52.92	4.45.	42.63

Table 3.

Output of coal oxidation products depending on the concentration of sodium and potassium hydroxide

Coal:H2O2 Ratio		Determined components in % of the organic part of oxidized coal

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: NaOH	Oxidation product yield, %	Alkali-soluble substances	Huminous Acids	Fulvo-Acids	Residual Coal
Hydrogen peroxide concentration 10% (NaOH 20%)					
1: 0.1: 0.005	105.28	51.66	48.75	2.91	48.34
1: 0.2: 0.005	110.43	55.67	52.38	3.29.	44.33
1: 0.4: 0.005	115.58	60.26	56.74	3.52	39.74
1: 0.6: 0.005	120.13	63.67	59.81	3.86	36.33
Hydrogen peroxide concentration 10% (NaOH 40%)					
1: 0.1: 0.005	106.64	52.29	49.16	3.13	50.36
1: 0.4: 0.005	121.72	61.86	58.24	3.62	35.16
1: 0.6: 0.005	125.82	67.73	63.75	3.98	33.52
Hydrogen peroxide concentration is 10% (KOH 20%).					
1: 0.1: 0.005	103.46	50.29	47.06	3.13	49.71
1: 0.4: 0.005	112.27	58.56	55.04	3.52	41.44
1: 0.6: 0.005	117.28	61.95	58.07	3.88	38.05
Hydrogen peroxide concentration 10% (KOH 40%)					
1: 0.1: 0.005	104.47	51.40	48.17	3.23.	48.60
1: 0.2: 0.005	110.58	57.09	53.64	3.45.	42.91
1: 0.4: 0.005	116.27	61.06	57.44	3.62	38.94
1: 0.6: 0.005	120.28	65.05	61.07	3.98	34.95

Table 4.

Output of oxidation products of coal depending on the process temperature oxidation

Process rate	Determined components in % of the organic part				
	Oxidized coal	Alkali-soluble substances	Huminic acids	Fulvo-acids	Residual Coal
Conc. H_2O_2 = 10%, (KOH 40%) respectively. carbon: H_2O_2: KOH = 1: 0.1: 0.005, **τ** - 120 minutes					
50.	91.6	42.34	41.25	1.09	57.66
60.	96.14	47.76	45.58	2.18	52.24
70.	104.47	51.40	48.17	3.23.	48.60
80.	98.66	47.40	43.26	4.14.	52.60
Conc. H_2O_2 = 10%, (KOH 40%) respectively. carbon: H_2O_2: KOH = 1: 0.2: 0.005, **τ** - 120 minutes					

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50.	97.87	43.98	41.41	2.57	56.02
60.	103.27	51.99	48.97	3.02	48.01
70.	110.58	57.09	53.64	3.45.	42.91
80.	97.68	53.55	49.32	4.23.	46.45

The highest amount of HA 63.75% is found in oxidized carbon obtained using 10% hydrogen peroxide, 40% sodium hydroxide, and a mass ratio of carbon: H_2O_2: NaOH = 1: 0.6: 0.005. Almost the same amount of HA 61.02% is found in carbon oxidized with 10% hydrogen peroxide and 40% potassium hydroxide at a mass ratio of carbon: H_2O_2: NaOH = 1: 0.6: 0.005. That is, the oxidation of Angren brown coal by hydrogen peroxide in the presence of sodium and potassium hydroxide allows for an increase in the HA content in the coal from 4.36% to 63.75% and 61.07%, respectively.

In Table. Figure 2.4 shows the change in the composition of oxidized coal at a concentration of H_2O_2 10% and a mass ratio of coal: H_2O_2: KOH = 1: 0.1: 0.005 and 1: 0.2: 0.005 depending on the temperature. Optimal oxidation parameters are observed at 70°C. At this temperature, we have the maximum amount of oxidized carbon (110.58%) and humic acids (53.64%). Under optimal conditions, the change in pH before and after oxidation was also determined, and it was found that before coal oxidation, i.e., before adding an oxidizer, the coal pH was raised to pH 7.5 due to the addition of a minimal amount of KOH, and during the oxidation process, this indicator decreased to pH 4.2

We also determined the content of functional groups in the initial, oxidized, residual coals, and in the HA of the initial and oxidized coals. As oxidized coal, coal obtained using 10% H_2O_2, 40% KOH, and a mass ratio of coal: H_2O_2: KOH = 1: 0.2: 0.005 was taken. Functional groups were identified by the sorption method, based on the ability of the active acid groups present in the organic mass to react with caustic barite and calcium acetate in aqueous medium [14]. The results are presented in Table 2.5.

Table 5.

Content of functional groups in coal and products, its oxidation by hydrogen peroxide in an alkaline environment

Substance	Moisture, %	Ash, %	Functional groups		
			COOH+OH, mg-eq/g	COOH, mg-eq/g	OH, mg-eq/g
Initial coal	4.2	14.21	2.198	0.56	1,638
Oxidized coal	7.19	9.12.	6.56	4.24.	2.32
HA of initial coal	1.91	7.18	7.79	3.37.	4.42
GK of oxidized coal	4.22.	4.25.	8.38	4.17	4.21.

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Residual coal of the initial coal	5.61	16.42	3.53.	0.34	3.19
Oxidized coal residue	3.92	20.32	2.21	1.42	0.79

As can be seen from this table, the oxidation of carbon by hydrogen peroxide in an alkaline environment increases the content of active functional groups, both in the oxidized carbon itself and its HC. If the carboxyl group content in the initial carbon was 0.56 mg-eq/g, and the phenolic hydroxyl content was 1.638 mg-eq/g, then in the oxidized carbon these figures increased to 4.24 mg-eq/g and 2.32 mg-eq/g, respectively, and in the HA of the oxidized carbon to 4.17 mg-eq/g and 4.21 mg-eq/g. It should be noted that to determine the presence of various functional groups of properties of coal and organic substances, mainly IR analysis is used [15-17].

An additional search for the functional groups of oxidized brown coal and its HA from the initial coal was conducted using IR spectroscopy. **The IR spectra of the studied compounds in tablets with KBr were recorded (area 4000-400 cm^{-1}) on the Fourier System 2000 IR spectrometer of the Perkin-Elmer company. The obtained results are presented in Figures 1-3.**

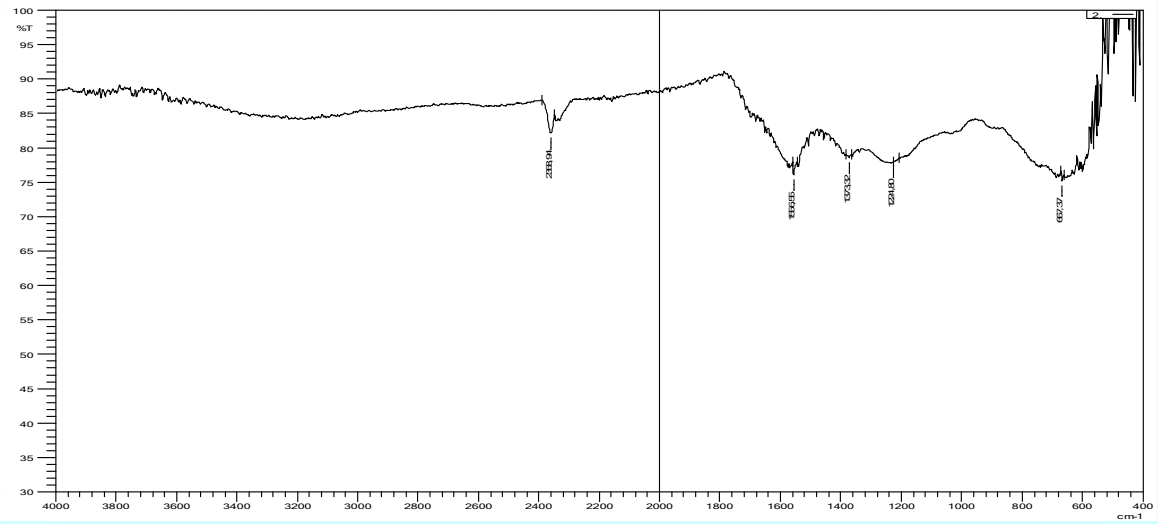


Fig. 1. IR spectrum of the initial brown coal of the Angren deposit

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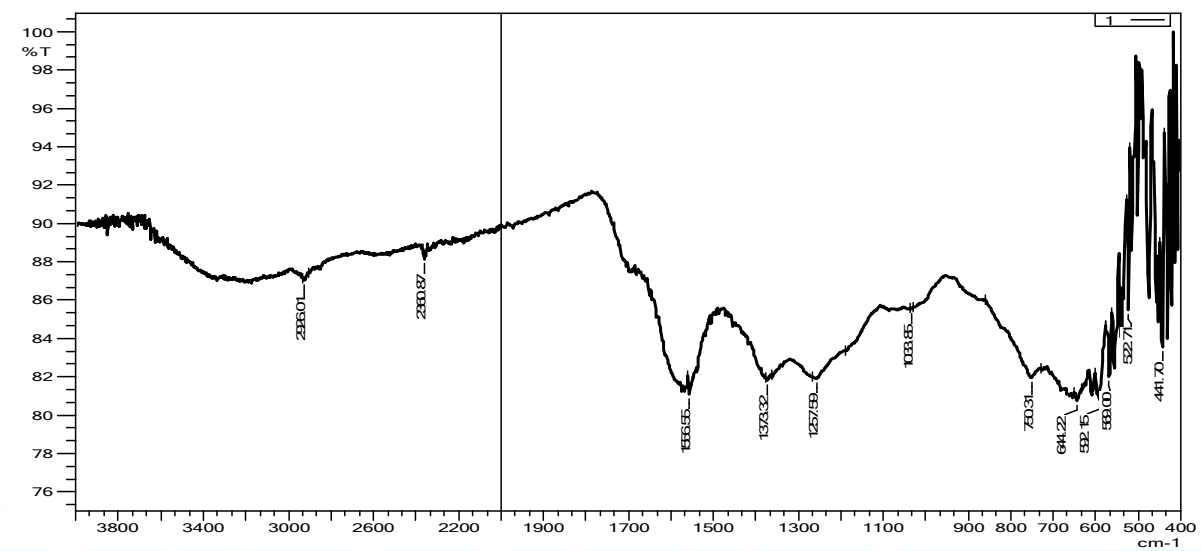


Fig. 2. IR spectrum of carbon oxidized by hydrogen peroxide in an alkaline medium

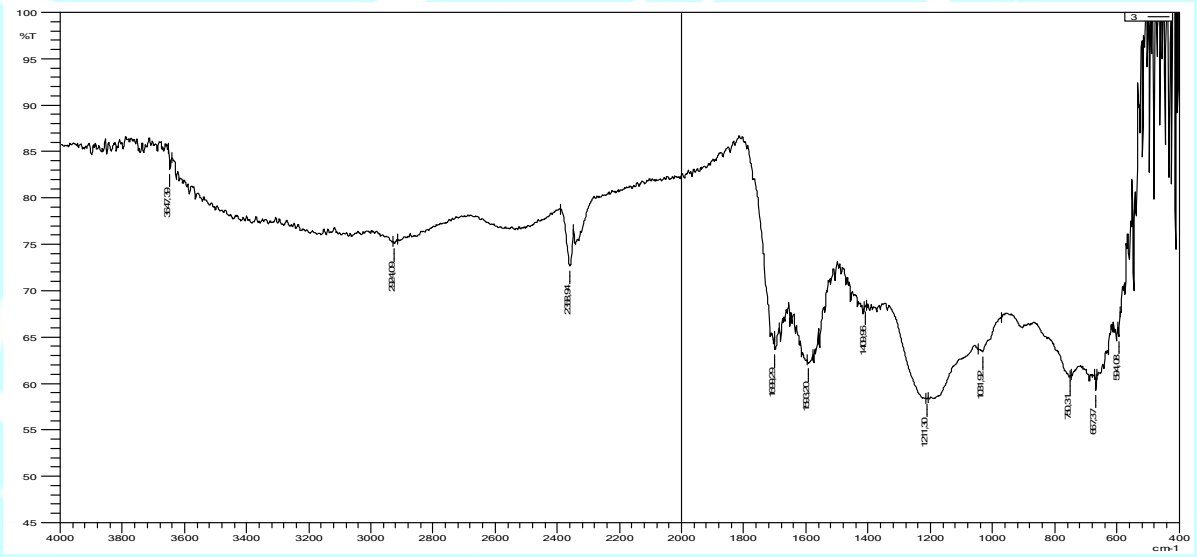


Fig. 3. IR spectrum of humic acid isolated from oxidized coal by hydrogen peroxide in an alkaline medium

Analysis of the spectra of the initial, oxidized, and HA **isolated from oxidized carbon by hydrogen peroxide in an alkaline medium showed that all samples have absorption bands characterizing the presence of OH- (3600 sm-1), primary and secondary amines, as well as** absorption bands associated with the valence vibrations of aliphatic hydrocarbon compounds CH, CH_2, CH_3, which are manifested in the region of 2960 sm-1 and 2855-2840 sm-1. In addition, bands of valence vibrations of the -CH_{group3} in the side chains at 1110-1120sm-1 are detected. Different types of deformation vibrations associated with the presence of methylene and methyl groups manifest with approximately the same intensity in all the studied samples. They can be observed in IR spectra at frequencies of 1400-1380 sm-1, 860-740 sm-1 (CH– + –OH def.), 960 sm-1 are more clearly expressed in HA preparations from oxidized carbon. Valence vibrations C=C (1600 cm) and C=C

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characteristic of aromatic structures (valence vibrations 1500 ^{sm,} deformation vibrations 910 $^{sm)}$ also manifest in all spectra, but they are more intense in the initial carbon. For HA, the appearance of a band of valence vibrations of the carbonyl groups in the C=O-OH group at 1760-1735 $^{cm-1}$ is characteristic. This band is most intense in oxidized carbon humic acids. There are also other types of C=O (1630-1610 $^{sm-1)}$ valence vibrations in HC and oxidized carbon. It is necessary to pay attention to the absorption band of the -C-O-C- group, which forms transverse bonds between condensed aromatic structures. This band manifests at ≈ 1240-1230 $^{sm-1}$ it is present only at the initial angle. Among the other absorption bands observed in the studied samples, the C-O band (valent) at 1030-1040 $^{sm-1,}$ and the C-C, C-OH, and CH deformation vibration bands at 860-680 $^{sm-1}$ with low intensity should be noted. Based on the conducted IR spectroscopic studies, certain conclusions can be drawn about the processes occurring during the oxidation of brown coal with hydrogen peroxide. During the oxidation process, a significant number of carboxyl COOH groups are formed, as evidenced by the appearance of sufficiently intense absorption bands of carboxyl and carbonyl in the HA from oxidized carbon. This conclusion is confirmed by chemical analysis data, which indicate a noticeable increase in the content of functional groups, indicating a sharp increase in the amount of COOH+OH in HAs from oxidized carbon. During hydrogen peroxide oxidation, the C-O-C bonds break between the condensed aromatic structures. Thus, the conducted research showed that the oxidation of brown coal from the Angren deposit with hydrogen peroxide in an alkaline environment significantly increases the content of HC and active functional groups compared to oxidation only with hydrogen peroxide or other oxidizing agents [18].</40

It should be noted that currently, soil cover degradation processes are intensifying worldwide. Agricultural soil contamination occurs both as a result of the manifestation of global processes and by applying excessive doses of mineral fertilizers and plant protection products, using wastewater and its sediments for irrigation, using waste as unconventional fertilizers, all of which cause chemical degradation of soils, i.e., deterioration of agronomic properties.

The structure of the soil has a great influence on its agronomic properties and fertility. Structured soils create more favorable conditions for water, air, heat, and nutrient regimes. Calcium humate is a highly effective artificial soil structure-forming agent. When calcium humate is applied, the capillary and field moisture capacity and water permeability of the soil increase, the structure and water resistance of soil aggregates improve, and the water retention capacity and air exchange in the root zone of the soil increase.

Therefore, to obtain a meliorant, finely ground (0.25 mm) quicklime was added to the oxidized coal under optimal conditions, constantly stirring to a pH

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value of 5.5-6. After adding lime, the mixing process continued for 30 minutes. Then, they were dried at a temperature of 75-80C for 60 min. The resulting product is a grain of irregular shape from dark brown to black color , having the following composition, (wt. %): organic matter 65.6; humic acids liber. 3.69; calcium humate 45.5. The obtained ameliorants were tested under laboratory conditions, i.e., the soil's water-holding capacity under the influence of the ameliorant was determined. It is known that the amount of moisture that the soil is able to retain is called moisture capacity. Depending on the form of the retained water, maximum adsorption, limiting field, capillary, and total moisture capacity are distinguished. Maximum adsorption moisture capacity is the largest amount of strongly bound water held by sorption forces. Limiting field (minimum) moisture capacity, the maximum amount of capillary suspended water retained by capillary forces after all gravitational water has flowed out. The lowest moisture capacity depends mainly on the granulometric composition of the soils, their structural composition, and soil density. In soils with a heavy granulometric composition, the well-structured (lowest) moisture capacity of the soil is 30-35, and in sandy soils, it does not exceed 10-15%. Capillary moisture capacity is the maximum amount of capillary water that can be contained in the soil. Additionally, it depends on how far the saturated moisture layer is from groundwater. The greater this distance, the smaller the capillary moisture capacity. Total moisture capacity is the maximum amount of water that the soil can hold and retain when all pores are flooded with water. It, like the lowest moisture capacity, depends not only on the granulometric composition but also on the soil structure and porosity. Total moisture capacity fluctuates within 40-50%, in some cases it can increase to 80 or decrease to 30%.

The capillary moisture capacity under laboratory conditions was determined as follows: a circle of filter paper was placed in a metal cylinder with a mesh bottom and weighed. Soil was poured into the cylinder, compacting it as it was poured, by gently tapping the bottom of the cylinder with the palm. Simultaneously, the soil moisture was determined. The height of the soil layer, the diameter of the cylinder, and the soil volume were measured. Then it was placed in a special bath with water so that the mesh bottom of the cylinder rested on a filter paper, the ends of which were immersed in water. Water is transferred to the soil through paper pores and its capillary saturation occurs. After each day, the cylinder was weighed until its mass became constant. This indicates that the soil has reached full capillary saturation. Based on weighing and soil density determination data, the capillary moisture capacity was calculated as a percentage using the formula:

$$K = \frac{(V - E) \cdot 100}{E}$$

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where K - capillary moisture capacity, (%); V - mass of soil in the cylinder after saturation, (g); E - mass of dry soil in the cylinder, (g).

The total moisture capacity of the soil was determined as follows: a soil sample in a metal cylinder, after determining the capillary moisture capacity, was placed in a bath on a piece of glass sticks, water was poured 1-2 cm above the soil in the cylinder, and left for 24 hours. Then, without removing it from the water, the cylinder was tightly closed on top with a lid and turned over. Then they took it out of the water, covered it with a lid, and weighed it. The total moisture capacity was calculated using the formula:

The total moisture capacity of the soil was determined as follows: a soil sample in a metal cylinder, after determining the capillary moisture capacity, was placed in a bath on a glass slice of sticks, water was poured 1-2 cm above the soil in the cylinder, and left for 24 hours. Then, without removing it from the water, the cylinder was tightly closed on top with a lid and turned over. Then they took it out of the water, covered it with a lid, and weighed it. The total moisture capacity was calculated using the formula:

$$P = \frac{(a - v) \cdot 100}{v}$$

where a - mass of soil in the cylinder after filling with water (v);
v - mass of dry soil in the cylinder, (v).

The test results are presented in Table 4.4. The data indicate that when mixed with a meliorant based on oxidized coal at a rate of 10 tons per hectare, the soil is characterized by good indicators of water retention capacity in the range from full to lowest moisture capacity. Thus, soil without a sample retains up to 25.48% at full moisture content, 20.34% at capillary moisture content, and 14.97% at lowest moisture content, with 10 t/ha of meliorant up to 47.18% at full moisture content, 28.34% at capillary moisture content, and 21.36% at lowest moisture content.

Table 6

Soil water retention capacity under the influence of the ameliorant, %

No. p/p	Sample number	Place sampling	Moisture capacity, % by weight		
			Complete	Capillary	The smallest
1.	1.	Control (soil without additives)	25.91	19.54	15.76
2.			25.22	20.65	15.62
3.			24.56	19.85	15.45
4.			24.88	19.96	15.31
5.			25.12	20.18	15.13.
mid			25.48	20.34	14.97

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6.	2.	Soil with 5 t/ha of meliorant	34.86	22.03	18.41
7.			35.14	22.42	18.26
8.			35.42	22.86	18.03
9.			35.79	23.25	17.82
10.			36.14	23.67	17.59
mid			36.38	23.74	17.36
11.	3.	Soil with meliorant 7.5 t/ha	39.64	23.63	19.91
12.			39.81	23.82	19.76
13.			40.02	24.06	19.63
14.			40.19	24.29	19.48
15.			40.34	24.47	19.29
mid			40.58	24.64	19.04
16.	4.	Soil with meliorant 10 t/ha	47.65	28.13	21.41
17.			47.04	28.62	21.26
18.			47.82	28.16	20.03
19.			47.29	28.28	21.82
20.			47.74	28.79	21.59
mid			47.18	28.34	21.36

The data presented in the table indicate that when soil is mixed with a meliorant based on oxidized coal and calcium oxide , it is characterized by good indicators of water retention capacity in the range from full to lowest moisture capacity. The results of the conducted research convincingly demonstrate the possibility of obtaining moisture-absorbing and soil structure-improving meliorants based on oxidized brown coal with hydrogen peroxide and calcium oxide for the polymerization of humic acids containing oxidized carbon**.**

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