

The Adsorption Capacity of Peat Humic Acids of the Middle OB Region

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Abstract

Objectives: In this article adsorption of nitrogen in peat humic acids of Middle Ob Region of Western Siberia is being researched for the first time. **Methods:** Unit area of the adsorption surface defined by methods of Langmuir and Brunauer, Emmett and Teller (BET). **Finding:** It is established that the size of the adsorption surface of humic acids has a close connection to the extent of primary sources decomposition of humification. And changes in the following decreasing sequence (humic acids of sedge and grass peat, with a degree of decay of 55%>; humic acids of wood, sedge, and the sphagnum peat with the extent of decomposition of 30-35%>. Humic acids of sphagnum and wood peat with the extent of decay of 20-25%) and is characterized by the highest manifestation of peat humic acids with the extent of decomposition of 55%. **Conclusion:** The best adsorption properties distinguish exemplars with a greater degree of decomposition and mean value of the effective diameter of adsorption time 247-272 Å.

Keywords: Adsorption, Adsorption Isotherms of Langmuir and Bet, Botanical Structure and Extent of Decomposition, Humic Acids, Middle OB Region, Peat, Sorption

1. Introduction

Need for studying the structure and properties of humic acids providing restoration of the polluted soils and waters grows along with an increase in variety and stability of currently applied in agriculture biocides (herbicides, pesticides, fungicides, etc.). As a result of anthropogenic factor, the regular application of biocides in the agricultural sector has toxic effect on environment objects¹.

Also, threat of soil pollution and pollution of soil ground waters (especially in oil-extracting regions of Middle Ob Region) by aliphatic, acyclic and monoaromatic oil hydrocarbons and their halogen derivatives is created². It is known that intensity of sorption depends on structure of soils³. The work of Cabbar is dedicated to sorption properties of humic and clay complexes⁴.

The possibility of humic acids and initial peat use as sorbents at re-cultivation of the polluted environments demands to study of their adsorption capacity and capacity of absorption.

2. Objectives and Research Methods

For research objects, we used exemplars of the humic acids emitted from the physical and transitional sur-

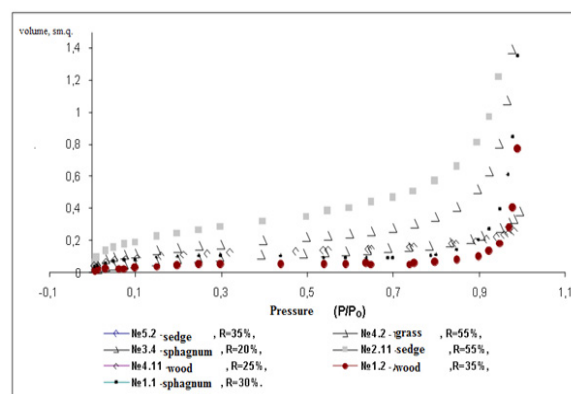


Figure 1. Adsorption isotherms of nitrogen on peat humic acids of middle OB region in coordinates of the Lyungmer equation.

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face layers and peat of Middle Ob Region. The areas of Khanty-Mansi Autonomous Area - Yugra.

They created in various hydrothermal conditions, and it is naturally possible to assume that distinctions of humification of organic weight have to find reflection in their adsorption capacity. Extraction was carried out by earlier described technique⁵. Identification of exemplars purity was carried out on IK – ranges and element structure⁶. Adsorption isotherms of nitrogen measured on the Autosorb p-6B device in the Catalysis Institute of the Siberian Branch of Russian Academy of Science (Novosibirsk).

3. Results and Discussion

Adsorption isotherms of nitrogen on peat humic acids of Middle Ob Region are studied, their distinctions which allowed diagnosing features of the molecular structure of exemplars depending on the intensity of the humification processes caused by peculiar ecological conditions of the territory, biological structure and extent of starting organic material decomposition Table 1 are revealed.

Table 1. Types of the studied peat

Code	The main peat vegetation	%	R, %	Types and categories of peat
1.1	Sphagnum narrow-leaved	25	30	Sphagnum, terrestrial
3.4	Sphagnum brown	75	20	Sphagnum fuskum-peat, terrestrial
1.2	Pine	70	35	Wood, transition
4.11	White birch	65	25	Wood, transition
2.11	Beaked sedge	45	55	Sedge, transitional
5.2	Sedge tussock Cotton grass	55 20	35	Sedge, transitional
4.2	Cotton grass	85	55	Cotton grass, terrestrial

Note: % – the plants prevailing in peat, R – extent of peat decomposition in %

Results of studying nitrogen sorption in exemplars of humic acids of Middle Ob Region various peats are reflected in Table 2 to Table 4.

From tables, we can see that if one of the indexes of the adsorption properties of humic acids increases, all other indicators also increase, and vice versa, except extent of decomposition of the used peat Table 2, Table 3.

For humic acids with effective diameter of adsorption pores from 247 to 272 Å, an example 2.11 sedge transitional (beaked sedge) and 4.2 terrestrial cotton grass (push its) peat, the greatest values of the total adsorption surface specific area in sq.m/g are observed. With a pore diameter from 17.0000 AND up to 3000.0000 Å sq.m/g, the max volume of the filled pores, with the maximal pressure of cm³/g (0.004457-0.003027). These exemplars also have the maximal extent of decomposition (R=55%).

Effective diameter of humic acid adsorption pores of all exemplars ranges from 116 to 497 Å Table 4.

For exemplars of humic acids with the least values of adsorption pores effective diameter (116-125 Å) 3.4 sphagnum frustum-peat terrestrial (sphagnum brown) and 4.11 wood transitional (birch) usually, have the least volume of the filled pores with the maximal pressure of 0,000599 - 0,000403 cm³/g. These exemplars have the smaller extent of decomposition (R=20-25%).

The exemplars of humic acids with the average extent of peat decomposition (R = 30-35%) having the greatest effective diameter of adsorption pores (330-497Å) 1.1 are sphagnum terrestrial (sphagnum narrow-leaved), 1.2 wood transitional (pine). 5.2 sedge transitional (hummocky sedge); they have mean values of the filled pores maximal volume with the maximal pressure (0,001191-0,002091 cm³/g).

Should we accept that primary adsorption centers possess the identical nature,, adsorption can be described by Lounger's model. Thus, on one center only one molecule is adsorbed, and interaction of the adsorbed molecules happens only with the centers of adsorption, but not among themselves, that means lateral interactions are absent.

In Figure 1 humic acid forms of isotherms adsorption of nitrogen by Lounger's equation are presented, which clearly confirms results of table data:

It should be noted that Lyungmer's model corresponds to process of absorption and transfer of gases quite precisely⁷.

Humic acids with a larger extent of decomposition (55%) have the greatest adsorption capacity; an average adsorption capacity has humic acids with the average extent of decomposition (30-35%), and the least belongs to humic acids with the least extent of decomposition (20-25%).

The mechanism of a polar absorption of nitrogen differs from the mechanism of many polar substances

Table 2. The volume and diameter of adsorption pores and desorption of humic acids under maximal pressure

Peat		Humic acids				
Types	Decomposition extent, %	max pore diameter under maximal filling, Å	max the volume of the filled pores under maximal pressure, cm ³ /g	The total amount of pores of adsorption with pore diameter from 17.0000 AND to 3000.0000 Å, cm ³ /g	The total amount of pores of desorption with a pore diameter from 17.0000 AND up to 3000.0000 Å, cm ³ /g	Total amount of micropores (under 2 nanometers), cm ³ /g
Sphagnum peat	30	1727.7461	0.002091	0.002082	0.002092	0.000021
Sphagnum peat	20	2986.4631	0.000599	0.000506	0.000536	-0.000105
Wood peat	35	1881.0468	0.001191	0.001173	0.001193	-0.000061
Wood peat	25	998.1876	0.000403	0.000237	0.000285	0.000019
Sedge peat	55	1401.3834	0.004457	0.004308	0.004332	-0.000159
Sedge peat	35	1685.3229	0.001916	0.001922	0.001920	-0.000163
Grass peat	55	1547.7163	0.003027	0.002936	0.002977	-0.000071

Table 3. The adsorption area and stripping surface of middle OB region peat humic acids

Peat		Humic acids		
Types	Decomposition extent, %	Total specific area of the adsorption surface, m ² /g	The area of the adsorption surface with pore diameter from 17.0000 AND to 3000.0000 Å, m ² /g	The area of stripping surface with pore diameter from 17.0000 AND up to 3000.0000 Å, m ² /g
Sphagnum peat	30	0.3868	0.1885	0.2603
Sphagnum peat	20	0.3428	0.1618	0.1920
Wood peat	35	0.1978	0.0942	0.1749
Wood peat	25	0.4257	0.0814	0.1300
Sedge peat	55	0.9545	0.6975	0.7459
Sedge peat	35	0.2994	0.2329	0.2998
Grass peat	55	0.5996	0.4308	0.4844

adsorption. So nitrogen is adsorbed in all adsorption centers which are available on an adsorbent surface, and not just on the active sites of various functional groups, but also in structural defects of humic acid molecules.

Also, we considered the theory of polymolecular adsorption of Brunauer, Emmett, Teller (BET) Figure 2.

The BET chart defines indicators of adsorption fuller. Apparently, in Figure 2, where good straight lines are received through the surface of all these adsorbents, we can see they are not uniform.

Generally, adsorption isotherms have an identical form in which with an increase in pressure the volume of

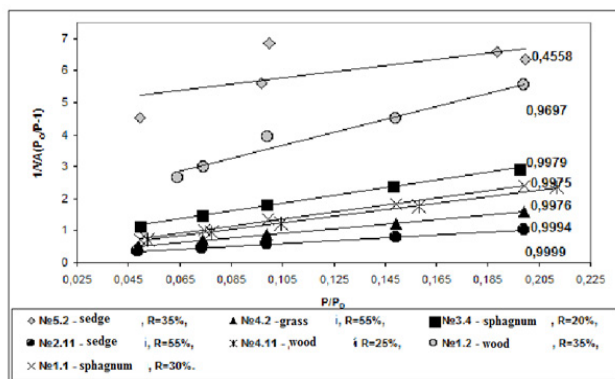
the filled pores increases, and in intervals of the relative pressure from 0, 7 to 1, 0 more intensive filling of pores is observed. It supplements the adsorption theory of Loungers, adsorption takes place exclusively on the empty surface and allows the possibility of physical adsorption in the next and the subsequent layers. Exemplars of the studied peat humic acids have five levels of energy absorption.

BET charts specify that adsorption takes place more efficiently, with smaller efforts, with smaller energy consumptions of adsorption in sedge humic acids (beaked sedge) and grass (push its) peat with extent of decomposition of 55% with coefficient of correlation almost equal to

Table 4. Effective diameter of humic acid adsorption pores

Peat		Humic acids			
Types	Decomposition extent, %	Effective diameter of pores, Å	Average diameter of adsorption, Å	Average diameter of desorption, Å	Area of micropores, m ² /g
Sphagnum peat	30	216.2752	441.7376	321.5437	0.0743
Sphagnum peat	20	69.9288	125.0714	111.7103	-0.2122
Wood peat	35	240.8540	497.8875	272.7118	-0.1059
Wood peat	25	37.8809	116.1555	87.6521	0.0594
Sedge peat	55	186.7721	247.0872	232.3063	-0.3308
Sedge peat	35	255.9555	330.0888	256.2554	-0.2321
Grass peat	55	201.9447	272.5811	245.8141	-0.1397

1 (to $R^2=0, 9999$; 0, 9994). Then in humic acids with the extent of decomposition of 20-35% with a slightly smaller coefficient. Especially low correlative dependence is shown in humic acids of an exemplar No. 5.2, sedge peat, with a dominance of hummocky sedge ($R^2=0, 4558$). The pore filling by nitrogen in an exemplar No. 5.2 occurs under larger pressure than in other exemplars.

**Figure 2.** Adsorption isotherms of nitrogen in BET equation coordinate, for middle OB region peat humic acids.

Other assumptions of Langmuir theory – uniformity of surface and lack of interaction of the adsorption molecules along the surface are upheld. However, the role of perpendicular interactions, undoubtedly, is higher. In a collision of vapor phase molecules with the adsorbed layer, they come into immediate contact with it. On the surface probability of adsorbed molecules coming in contact with each other is much lower, especially at small and average degrees of covering. Only at the high level of fill-

ing the contribution of longitudinal interactions becomes commensurable with the contribution perpendicular that is why the BET theory describes the experimental data at high relative pressure worse. The description of adsorption would become powerfully complicated if to consider both interactions. Therefore, in the BET chart, we, as well as other researchers, considered perpendicular interactions and neglected longitudinal. But considering of all sets of perpendicular interactions cannot take place in the prime theory. The phenomenon of physical adsorption is similar to evaporation, only the molecule interacts not with liquid molecules, but with particles of the solid body surface, and the energy won thus is more, than condensation heat. That is why the heat of absorption in the first layer is greater than in the second, in the second it is greater, than in the third, etc. Heats of absorption pass a continuous number of values, from the heat of absorption on the first layer of Q1 to warmth on an external layer of Qn. And Qn has to be close to Q condensations⁷.

4. Summary

By the above, it is possible to draw a conclusion that the best adsorption properties characterize exemplars of humic acids with the extent of decomposition of 55% and mean value 247-272 of Å adsorption pore diameter.

5. Conclusion

Thus, data on adsorption of nitrogen on humic acids surface are bound to the extent of initial peat decomposi-

tion. The adsorption capacity of various peat humic acids of Middle Ob Region changes in the following decreasing sequence. HA from sedge and grass peat, with the extent of decomposition of 55% > HA from wood, sedge and sphagnum peat with a degree of decomposition of 30-35% > HA from the sphagnum and wood peat with the extent of decay of 20-25%. Diameter of adsorption pores corresponds to diameter of humic acids macromolecules determined earlier by method of X-ray diffractometry⁸.

6. Conflict of Interest

The author confirms that data presented does not contain conflict of interests.

7. Credits

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