Short Reports

THE SUBARCTIC PEAT POLYMER MATRIX STRUCTURAL ORGANIZATION (BY THE EXAMPLE OF THE ILASSKY BOG MASSIF PEAT)[1]

[1]Parfenova L.N., [1,2]Selyanina S.B., [1,2]Bogolitzyn K.G., [1]M.V. Trufanova, [1]Surso M.V., [2]Chukhchin D.G., [1]Orlov A.S.

[1]The Institute of the Ecological Problems of North YpO RAS, Arkhangelsk;
[2]The North (Arctic) Federal University after M.V. Lomonosov, Arkhangelsk

The paper has been devoted to the structural organization study of the peat polymer matrix, and its components at the different levels of the dimension hierarchy. The high-moor peat samples have been selected in the course of the field works carrying out on the Ilassky bog massif, where the experimental section of the Russia's single bog «Brusovnitza» Hydrometeostation of the North Hydrometeoservice Control is situated.

The light microscopy in the transmitted light has been used to be investigated the peat microstructure; the atomic force microscopy and the dynamic light scattering method have been used to be measured the particles size and the polydispersity at the nanoscale. The high-moor peat samples micrographs and the AFM-images of its nanoscale components of the humic nature have been analyzed. Finally, it has been found, that the supramolecular particles conformation of the humic nature biopolymers, having extracted from the peat, is characterized by the asymmetry elements.

The Introduction

At present, the organization and the self – organizations, having studied by the synergy, are being acquired the interdisciplinary character. According to the modern concepts and its presentations, the natural objects may be presented themselves, as the ordered, structured, and hierarchically organized systems. The special significance is being acquired the natural objects structure study at the different hierarchical levels, the relationships disclosure between the structure peculiarities, special features, and the properties of the fundamental and its applied nature.

The peat – is the unique natural renewable organic raw materials, its physical and mechanical properties, the chemical properties are associated with the structure's peculiarities and its specific features.

Thus, the main purpose of the present research is to be studied the peat polymer matrix structural organization study and its components at the different levels of the dimension hierarchy.

The Experimental Part

The high-moor peat samples have been selected in the course of the field works carrying out on the Ilassky bog massif, having located in the Primorsky district of the Arkhangelsk Region, where the experimental section of the Russia's single bog «Brusovnitza» Hydrometeostation of the North Hydrometeoservice Control is situated. So, from the point of the view of the fundamental researches, the Ilassky bog massif is quite interested, because there are long – termed observations data on the hydrological regime, and, moreover, the peat deposit has not been subjected to the landreclamation.

The characteristic of the high-moor peat of the Ilassky bog massif, having selected from the different depth of its bedding, have been presented in the paper [1]. The component and the elemental composition of the peat have already been studied.

So, the peat – is the polydisperse, getero-porous system, in which the macro- and the microstructures are being distinguished [2,3,4].

The temporary aqueous preparations of the peat samples have already been examined and photographed, using the «Axio Scope A1 Zeiss» laboratory microscope, which is completed with the «Canon – G10» digital camera, to be investigated the structural organization at the micro – level. The necessary images editing has been produced, using the «AxioVison Rel.4.8» licensed program.

The humus nature biopolymers particle – size study at the nanoscale has been performed, using the «ACM Multimod 8 Bruker» atomic force microscope, and, moreover, in the liquid phase, using the «Horiba-LB – 550» particle size meter, by the dynamic light scattering method:

The peat polymer matrix macrostructure is presented itself the elastic and flexible frame, having formed the fibrous plants residues interlacing – e.g. the peat – forming plants;

The peat macrostructure is depended on the peat accumulation dynamics. Thus, the eight main types of the peat structures are being distinguished, depending on their origin, the peat – forming plants type, and the decomposition degree [2]. For the high-moor sphagnous peats of the medium and low decomposition degrees, which are the most representative in the boreal low – land ecosystems (see, Figure No.1), the spongy structure is the most characteristic for the upper minor puddled layers deposit with the further transition to the goffering and puckering structure with the bedding depth increasing;

The peat macrostructure is usually studied by the light microscopy method. The images, having obtained, using the «Axio Scope A1 Zeiss»

[1] The studies have been performed with the support of the Inter-Regional, Interagency and Fundamental Researches Program, the Ural Branch RAS (The Project № 12-C-5-1017), the Russian Foundation for Basic Research (The Project RFFI № 12-03-90018-Bel_a), the Programs, having orientated the Fundamental Research, the Ural Branch RAS 12-5-3-008-ARCTICA, the Programs of the Presidium RAS № 4 (The Project № 12-П-5-1021), using the equipment TsKP NO «Arctic» (SAFU) and TsKP KT RF-Arctica, (IEPS, IFPA, the Ural Branch RAS).

laboratory microscope, for the polymer matrices of the high-moor sphagnous peat, sampled at the different bedding depths, have been presented in the Figure No.2. So, the loose structure is clearly visible, where the minor – decomposing sphagnum fragments are practically contacted with the minor amount of the humus.

The Figure No.1 – The Peat Deposit Section the Ilassky Bog Massif.

The Figure No.2 – The Photomicrographs: a) sphagnum; bedding depth peat:

b) 0 – 20 cm; c) 20 – 50 cm; d) 50 – 70 cm.

The macrostructure cells of the peat polymer matrix are being filled with the peat particles of the aggregative nature, having formed on the basis of the humic substances and the peat carbohydrate complex. Then, the microstructure is characterized the aggregates (e.g. associates) inner structure, which are usually referred to the coagulation ones, i.e. the movable highly – elastic structures. The necessary interaction between the aggregates elements is practically carried out by the molecules and the water layers, and, mainly, due to the hydrogen bonds [2].

Thus, the image, which has been obtained by the AC-microscopy, having allowed to be fixed the nano-particles sizes of the individual macro-molecules of the aromatic biopolymers and their supramolecular formations and the structures (see, the Figure No.3). So, the globular nature of the separate macro-molecules, whose dimensions are not practically exceeded 10 nm, has been already fixed, which it is comparable to the nano-particles sizes of the other biopolymers of the lingo-humic nature. Larger particles (e.g. 5 – 100 nm) with the asymmetry elements are, apparently belonged to the associative nature.

The Figure No.3 – The AFM image of the biopolymers nano-particles of the humic nature of the high-moor peat.

The dynamic light scattering is practically used for the particles sizes measures and the polydispersity in the liquid solutions of the humic substances. The final results are usually explained in the framework of the intra-molecular compaction (e.g. the contraction), or the intra-molecular aggregation models [5,6].

The particles size distribution histograms in the water solutions of the peat humates, relatively on their contribution to the light scattering have been presented in the Figure No.4. Moreover, it has also been established, that the supra-molecular particles of the micellar nature are found themselves in the dynamic equilibrium with the individual macro-molecules, and for the both particles groups are characterized by the polydispersity.

The Figure No. 4 – The Particles sizes distribution histogram in the diluted (a) and the concentrated (b) solutions of the biopolymers solutions of the humic nature, the high-moor peat allocated.

The mode, corresponding to the individual molecules with the particle sizes from 3 up to 11 nm, is being fixed only at the concentrations lower 0,1 g/l, at the concentration increasing, the inter – molecular aggregation is practically led to the particles formation, with their sizes from 60 up to 600 nm, with the polydispersity clearly expressed in the nanometer, as well as in the micrometer ranges. So, in the paper [5,6] such aggregates, which are prescribed the pseudo – micellar nature, have already been fixed and recorded in the humic substances solutions, having isolated from the soil, the lignite, and he river water. The pseudo – micellar nature particles absence in the peat humates solutions is explained their manifestation the surface and active properties. Thus, the comparative characteristic ability to be reduced the surface tension of the water by the aromatic biopolymers of the lignite and humic nature, having used, as well as the natural PAV surfactants, has been given in the earlier publications [7–9].

The Conclusions

The structural organization of the peat polymer matrix at the quite different levels of the dimension hierarchy (e.g. marco-, micro-, and nanoscale) with using the light, AC-microscopy, and the dynamic light scattering methods has already been studied.

Moreover, it has been found, that the supramolecular particles conformation of the biopolymers humic nature, having extracted just from the peat, is practically characterized by the asymmetry elements. The supra-molecular particles in the solutions are usually in the dynamic equilibrium with the individual globular macro-molecules, the sizes of which 3 – 10 nm are made up, which is comparable to the nano-particles sizes of the other biopolymers of the ligno – humic nature.

Thus, the authors of this paper are much grateful for the warm welcome and the assistance provided to the employees of the «Brusovitza» Swamp Station and also its Manager Rastorgueva N.V.; IEPS UrO RAS staff PhD in Chemistry Larionov N.S., Junior Researcher Ulyanovsky N. V., PhD in Chemistry Khviyuzov S.S., Junior Researcher Kuznetzova E.A. for the help and the assistance in the peat tests sampling during the expedition activities.

References

1. Parfenova L.N., Selyanina S.B., Trufanova M.V., Bogolitzyn K.G., Maltzeva E.V., Sokolova T.V., Kashina E.M.,"The Characteristic of Ilassky Bog Massif Peat". // «International Journal of Experimental Education», 2014, № 4;

2. Lishtvan I.I., Bazin E.T., Gamayunov I.I., Terentjev A.A.,"The Peat Physics and Chemistry". M.: «Nedra», 1989, p. 304;

3. Lishtvan I.I., Bazin E.T., Kosov V.I.,"The Peat and Peat Deposits Physical Properties". – Minsk: «Science and Technology», 1985, p. 240;

4. Kulikova M.P., Kuular L.L.,"The Study of Chemical Composition of Peat".// «The Basic Reseach». № 4. 2013, p.p. 90 – 94;

5. Palmer N.E., Wandruszka R.,"Dynamic Light Scattering Measurements of Particle Size Development in Aqueous Humic Materials". // «Fresenius J. Anal. Chem», V. 371 (7), 2001, P. P. 951 – 954;

6. Shinozuka N, Nehei Y In: Sensesi N, Miano T.M. (eds.),"Humic Substances in Global Environment and Implications on Human Health", «Elsevier Science», Amsterdam, 1994, P. P. 889 – 894;

7. S. B. Selyanina, L. N. Parfenova and M. V. Trufanova,"A Comparative Study of Surfactant Properties of Aromatic Macromolecular Compounds of Lignin and Humus Nature". «Russian Journal of Applied Chemistry». Volume 85, Number 8 (2012), p.p.1275 – 1281;

8. M.Trufanova, S.Selyanina, L.Parfenova,"Comparative Characteristic of Surfactant Properties of Aromatic Lignin and Humic Polymers". // «Proceedings of the EWLP 2012 – 12th European Workshop on Lignocellulosics and Pulp», Espoo, Finland, 2012. p.p. 544 – 547;

9. L.Parfenova, S.Selyanina, M.Trufanova, K.Bogolitzyn,"Lignin and Humic Polymers, as Natural Surfactants". // «Natural and Engineered Nanoparticles in Clean Water and Soil Technologies». The Theses of 2-nd International Conference. СГН МГО on Humic Innovative Technologies. Moscow, 2012, p. 41.