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CONTENTS

Humic substances as complex systems

Piccolo A. Humus and carbon sequestration technologies in soil.....	10
Chaplygin D.K., Kopnov A.Yu., Alyavdin D.D., Bolshakova A.V., Arzhakova O.V. New mesoporous polymer materials: synthesis, structure, and properties.....	11
Chebykina E.Yu., Abakumov E.V. Humic acids isolated from postpyrogenic soils of forest-steppe region: elemental and molecular composition by ¹³ C-NMR spectroscopy.....	12
Chimitdorzhieva E.O., Chimitdorzhieva G.D. Elemental composition of lignin preparations.....	13
Chimitdorzhieva E.O., Korsunova Ts.D-Ts., Baldanov N.D., Chimitdorzhieva G.D. Elemental composition of zonal and intrazonal soils in Transbaikalia.....	14
Danilin I.V., Izosimova Yu.G., Tolpeshta I.I. Thermal and microbiological stability of humic acid adsorbed on various clay minerals.....	15
Davydova I.Yu., Zavarzina A.G. Extraction in alkali without nitrogen significantly alters physico-chemical properties of humic acids from compost.....	16
Gadzhibagomedov R.A., Novikova V.A., Zhirkova A.M., Sobolev N.A., Mryasova D.S., Makarov M.S., Volkov D.S., Perminova I.V. Synthesis of magnetic sorbents on the base of peat for purification of polluted waters from heavy metals.....	17
Giniyatullin K.G., Sahabiev I.A., Smirnova E.V. Possibilities of using different approaches to assessing the resistance of organic matter of fallow soils to mineralization.....	18
Golubina O.A., Veretennikova E.E. Humic acids. Age is not important.....	19
Kopnov A.Yu., Solovei A.R., Kopnova T.Yu., Chaplygin D.K., Arzhakova O.V. Flame-retardant hybrid organo-inorganic nanocomposite polymeric materials based on high-density polyethylene.....	20
Korsunova Ts.D-Ts., Baldanov N.D. Enzymatic activity and humic acids of soils in the Selenga river delta.....	21
Kovaleva N.O. Characteristics of soil organic matter in the Kola Subarctic.....	22
Lodygin E.D., Vasilevich R.S. Content of free radicals in humic substances from taiga and tundra soils.....	23
Medvedev A.V., Odelskii A.V., Shishkin M.A., Volkov D.S., Proskurnin M.A. Two-dimensional correlation spectroscopy as a method to construct absorption spectra of low quantities of humates.....	24
Odelskii A.V., Ovseenko S.T., Volkov D.S., Proskurnin M.A. Spectroscopic analysis of chernozem natural organic matter with preliminary separation using polycarbonate track-etched membranes.....	25
Polyakov V., Abakumov E., Nizamutdinov T. Estimation of carbon stocks and stabilization rates of organic matter in soils of the "Ladoga" carbon polygon.....	26
Potapov D.I. Fractal clusters is a form of existence of humic substances in soils.....	27
Puhalsky J.V., Loskutov S.I., Poloskov A.I., Mityukov A.S. Chemical composition of the different fractions humic substances of sapropel in the Pskov region.....	28
Solovei A.R., Arzhakova O.V. Photoactive hybrid organo-inorganic nanocomposite polymeric materials containing quantum dots.....	29
Vasilevich R.S., Gunderina E.D. Study of the humification of wood processing industry waste.....	30
Vishnyakova O.V., Ayurova D.B. Impact of soil tillage on humic substances transformation according to ¹³ C-NMR study.....	31
Volkov D., Rogova O., Proskurnin M. Two-dimensional correlation spectroscopy for characterizing mineral and organic-matter bands in soil fractions.....	32
Volkov D.S., Volikov A.B., Yiming Sun, Perminova I.V. On-line and off-line chromatographic separation with ultrahigh-resolution mass spectrometry of humic substances: comparison of FT-ICR-MS, Orbitrap and TOF.....	33

Volokitin S.O., Tolpeshta I.I., Izosimova Yu.G., Karpukhin M.M.	
Patterns of Pb(II) adsorption by the main genetic horizons of peaty-podzolic-gleyic soil.....	34
Yermagambet B.T., Kazankapova M.K., Kassenova Zh.M., Malgazhdarova A.B., Rychlewska K.	
Obtaining and purification of fulvic acids from oxidized coal.....	35
Zavarzina A.G.	
Alkaline extraction and secondary synthesis in humic research.....	37
Zhang Y., Sobolev N.A., Larionov K.S., Konstantinov A.I., Perminova, I.V.	
Synthesis of phenol-modified humic ligands with enhanced reducing properties and their use for preparation of silver nanoparticles.....	38
Zhdanova A.V., Zhernov Yu.V., Avvakumova N.P., Krivopalova M.A.	
Comparative characteristics of hepatoprotective activity of humic peloid preparations.....	39

Humic substances in processes and technologies for reducing anthropogenic impact

Azovtseva N.A., Varlamov E.B., Lasareva E.V., Parfenova A.M., Frantsev V.V.	
Investigation of the effect of humus on some properties of urban soils.....	42
Belokonova N.A., Golitsina K.O., Tikhomirova E.I.	
The activity of copper cations to form complexes with natural organic impurities.....	43
Belokonova N.A., Naronova N.A., Medvedeva O.M.	
Improving the environmental monitoring system.....	44
Efremenko E., Perminova I.	
Humic substances in methanogenesis.....	45
Faddeeva A.S., Rzhetskaya A.V., Romanchuk A.Yu., Kalmykov S.N.	
Behavior of plutonium in the mineral-natural organic matter system.....	46
Grechishcheva N.Yu., Korolev A.M., Zavorotny V.L., Perminova I.V.	
Evaluation of the effectiveness of the use of humic-bentonite washing agents for cleaning oil-contaminated soils.....	47
Kolchanova Ks.A., Kotelnikova A.D., Rogova O.B., Volkov D.S., Egorov F.	
Dynamics of removal of rare earth and heavy metals with water-soluble organic matter from soils when phosphogypsum is applied (in a laboratory experiment).....	48
Kopnov A.Yu., Zvonova A.A., Kopnova T.Yu., Chaplygin D.K., Arzhakova O.V.	
Selective sorption materials based on mesoporous polymers for oil recovery and water treatment.....	49
Kudryasheva N.S., Bondareva L.G.	
Direct and indirect detoxification effects of humic substances.....	50
Lasareva E.V., Parfenova A.M.	
The effect of humic acid and chitosan on coagulation of iron(III) hydroxide by NaCl.....	51
Rozhko T.V., Kolesnik O.V., Kudryasheva N.S.	
Reduction of radiation effects of tritium and americium on luminescent bacteria by humic substances.....	52
Skipkina T.S., Bychkov A.L., Lomovskiy I.O., Lomovsky O.I.	
Transformations of humic acids and redistribution of rare earth elements during mechanochemical treatment of metal-bearing lignite.....	53
Sokolova I.V., Fedorova A.A., Selyanina S.B.	
The humic acids impact on the photodegradation process of some phenolic derivatives under UV irradiation in aqueous solution.....	54
Vladimirov S.A., Nikolaeva A.V., Zhurba V.S., Larionov K.S., Makarov M.S., Volkov D.S., Perminova I.V.	
Assessment of efficiency of several surfactants in combination with humic substances for cleaning oil polluted sand.....	55
Volikov A.B., Karpukhina E.A., Perminova I.V.	
Complexes of polyacrylic acid with amino organosilanes as dust suppressants.....	56
Vozhdaeva M.Yu., Kholova A.R., Trukhanova N.V., Melnitskiy I.A., Serebryakov P.V., Konstantinov A.I., Perminova I.V., Kantor E.A., Beloliptsev I.I.	
Cluster analysis of different water quality indicators.....	57
Yermagambet B.T., Kazankapova M.K., Kassenova Zh.M., Adam T., Spietz T., Dobras S.	
Studies on CO ₂ absorption using humic substances.....	58

Humic substances as biologically active compounds in biomedical technologies

Agunbiade Joel Oluwadare, Adewale Isaac Olusanjo	
Studies on latent and soluble polyphenol oxidase from <i>Moringa oleifera</i> Lam. leaves.....	62
Belokonova N.A., Tikhonova I.L., Naronova N.A., Tikhomirova E.I.	
Assessment of the complexing ability of humic substances in natural substances and fertilizers in relation to metal ions.....	63

Bratishko K.A., Zykova M.V., Zhirkova A.M., Kuznetsova M.V., Buyko E.E., Ivanov V.V., Pershina A.V., Belousov M.V., Perminova I.V. Antioxidant activity of iron-containing humic compounds with antianemic activity.....	64
Buyko E.E., Zhirkova A.M., Bratishko K.A., Ufandeev A.A., Shestakov K.D., Mikhalev D.A., Ivanov V.V., Zykova M.V., Belousov M.V., Perminova I.V. Cytotoxic properties of humic substances-containing wound healing ointments.....	65
Dugarjav J., Ganbold Ya., Bilegsaikhan D., Avid B. Clinical studies of humic acids.....	66
Fedoseeva E., Terekhova V., Sergeeva Yu. Effect of humic products on the antagonistic properties of micromycetes.....	67
Galuza O.A., Demkina E.V., Nikolaev Yu.A. Survival of lactic acid bacteria in silanol-humate gels.....	68
Kopnov I.S., Zykova M.V., Ivanov V.V., Ufandeev A.A., Bratishko K.A., Buyko E.E., Mikhalyov D.A., Rabtsevich E.S., Perminova I.V., Belousov M.V. Research of zinc-containing humic compounds wound-healing properties and zinc assay content in biomaterial after their topical application.....	69
Kopnova T.Yu., Kopnov A.Yu., Yakupova L.R., Skuredina A.A., Kudryashova E.V., Arzhakova O.V. Antibacterial materials based on levofloxacin and mesoporous polymer matrices.....	70
Kretinin K.A., Mikhalyov D.A., Zenkov I.S., Elkin G.S., Logvinova L.A., Belousov M.V., Zykova M.V. The drug plants extracts and humic substances based functional nutrition product development to improve the quality of men's health "GentlemenHum".....	71
Kukhar Ye.V. Experience in the use of humic ointment for the treatment of burns.....	72
Kukhar Ye.V., Bissekenova S.S. Development and quality control of humic ointment.....	73
Kuznetsova M.V., Zykova M.V., Trofimova E.S., Danilets M.G., Ligacheva A.A., Bratishko K.A., Logvinova L.A., Mikhalyov D.A., Perminova I.V., Belousov M.V. The effects of silver and zinc-containing humic pharmaceutical compositions on the functional state of peritoneal macrophages.....	74
Larionov K.S., Sobolev N.A., Volikov A.B., Volkov D.S., Perminova I.V. Study of the slow release of Zn ²⁺ and Ag ⁺ from gels loaded with ZnO and Ag nanoparticles.....	75
Larionov K.S., Volikov A.B., Kozlov D.A., Sobolev N.A., Peminova I.V. Sol-gel synthesis of zinc oxide nanoparticles with controlled dimensions in the environment of humic substances.....	76
Logvinova L.A., Zykova M.V., Ivanov V.V., Ufandeev A.A., Buyko E.E., Bratishko K.A. Nootropic activity of humic substances.....	77
Lysenko I.V., Miroshnichenko A.G., Zykova M.V., Perminova I.V., Belousov M.V. Antimicrobial activity of humic-based bionanomaterials containing silver against opportunistic pathogens.....	78
Mikhalyov D.A., Zykova M.V., Ivanov V.V., Ufandeev A.A., Buyko E.E., Bratishko K.A., Perminova I.V., Belousov M.V. The study of wound-healing and antibacterial properties of bionanomaterials based on humic substances and silver nanoparticles <i>in vivo</i>	79
Pigarev S., Zhanataev A., Bykov V., Drachev I., Panchenko A., Anisimov V., Anisina E., Chayka Z., Durnev A., Yurova M., Tyndyk M., Fedoros E. Trans-generational carcinogenesis induced <i>in vivo</i> and its mitigation by lignin-derived composition with ammonium molybdate (BP-C2).....	80
Shestakov K.D., Sobolev N.A., Volkov D.S., Perminova I.V. Determination of conversion degree of silver ions into nanoparticles in the presence of humic substances.....	81
Vasiliev M.V., Zhirkova A.M., Zaitsev K.V., Prishchenko A.A., Ushakova K.A., Konstantinov A.I., Perminova I.V. Synthesis of aromatic derivatives containing 1-hydroxy-1,1-bis(phosphonic) group.....	82
Yiming Sun, Shixia Xue, Sobolev N.A., Mikhnevich T.A., Rubtsoba M.Yu., Grigorenko V.G., Perminova I.V. Searching for bioactive drug lead compounds from natural humic substances.....	83
Zhirkova A.M., Volkov D.S., Buyko E.E., Zykova M.V., Perminova I.V. Comparison of synthetic pathways of iron (III) complexes with macroligands of fulvic acids for correction of iron deficiency anemia.....	84
Zykova M.V., Ivanov V.V., Ufandeev A.A., Buyko E.E., Lysenko I.V., Miroshnichenko A.G., Bratishko K.A., Logvinova L.A., Zima A.P., Mikhalyov D.A., Sobolev N.A., Larionov K.S., Zhang Y., Perminova I.V., Belousov M.V. The effects of humics-based Ag-nanomaterials on the pharmacological activity of antibiotic "Lincomycin" on the pyoinflammatory process model <i>in vivo</i>	85

Zykova M.V., Mareev I.V.

The effectiveness and safety clinical evaluation of the humic substances based product "FitoX" use in the undergone a new coronavirus infection (Covid-19) patients' rehabilitation..... 86

Humic substances in Arctic ecosystems

Dinu M.

Protective properties of humic substances in Arctic lakes: geochemical and technogenic influences..... 88

Khreptugova A.N., Volikov A.B., Sobolev N.A., Pechnikova G.S., Konstantinov A.I., Perminova I.V.

Molecular signatures of methane seeps unfold in the composition of dissolved organic matter of the Laptev and East-Siberian Seas..... 89

Mryasova D.S., Sobolev N.A., Larionov K.S., Makarov M.S., Volikov A.B., Perminova I.V.

Adsorption study of copper and nickel onto organic matter of peat in relationship with the anthropogenic pollution of the Russian Arctic..... 90

Nizamutdinov T., Pechkin A., Abakumov E.

Humic acids isolated from various types of podzols in Arctic ecosystems – ¹³C CP/MAS NMR spectroscopy..... 91

Pechnikova G.S., Khreptugova A.N., Perminova I.V.

Study of the molecular composition of dissolved organic matter in Arctic sea water..... 92

Samokhleb E.R., Kovaleva N.O., Okunev R.V.

Pool of amino acids in the mountain soils, Crimea..... 93

Yermagambet B.T., Kazankapova M.K., Kassenova Zh.M., Kalenova A. M.

The use of fulvic acids for the purification of heavy metals in the aquatic environment..... 94

Humic substances in the soil – plant system: new humic agrochemicals and agrotechnologies

Bondareva L.

Protective effect of humic acids. Pesticides of the pyrethroid class..... 98

Chukov S.N.

The concept of evolutionary humification..... 99

Grekhova I.V., Grekhova V.Yu.

Development of new humic fertilizers..... 100

Gruzdhenko D., Yakimenko O., Stepanov A., Panova I., Yaroslavov A.

Humic-based polyelectrolytes: effect on Cd and Pb mobility in contaminated soils..... 101

Kokhan S., Rudiak V.

Impact of growth regulator of humate and fulvate type on productive factors of potatoes, onions and tomatoes while using in the system of dribble irrigation..... 102

Miroshnichenko O., Kosolapova N., Protchenko E.

The application effectiveness of activated peat hydrosol based biopreparation for barley cultivation..... 104

Nikolaeva A.A., Filippova O.I., Kulikova N.A.

Priming with leonardite humate affects the early growth performance of common wheat in excessively wet and dry conditions..... 105

Popov A.I., Zhilkibayev O.T., Zelenkov V.N., Markov M.V., Teplyakova T.V., Romanov O.V., Tsivka K.I.,

Sazanova E.V., Kholostov G.D., Song Ge, Shalunova E.P., Simonova J.V., Leontev A.A., Bondarenko V.A.

The reasons of humic substances biological activity..... 106

Sevastyanova A.V., Zhdanova A.V., Glubokova M.N., Katunina E.E.

Characteristics of the group composition of peloids of various origins..... 107

Slamiya M. Kukhar E.V., Yermagambet B.T., Kassenova Zh.M., Kazankapova M.K.

Feed additive based on humic substances..... 108

Kassenova Zh.M., Yermagambet B.T., Kazankapova M.K., Imbayeva D.S., Saulebekova M.Ye.

Effect of modified organic fertilizers based on potassium humate on the growth of biological objects..... 110

Zherebtsov S.I., Votolin K.S., Malysenko N.V., Shpakodraev K.M., Ismagilov Z.R.

Influence of structural-group composition and some trace elements on the biological activity of brown coals humic compounds..... 111

Zhilkibayev O., Aitbayev T., Perminova I., Popov A., Shoinbekova S.

Effect of the humic drug "EldORost" on the yield of potatoes and vegetables..... 112

Author index

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Antimicrobial activity of humic-based bionanomaterials containing silver against opportunistic pathogens

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The antibacterial agents use led to the emergence and spread of resistant microorganisms, in some cases resistant to several classes of antibiotics. In this regard, the antimicrobial chemotherapy improvement, aimed at increasing the effectiveness of antibacterial agents and reducing the number of multiresistant strains of pathogens of infectious diseases, remains a highly relevant task.

The goal of this work was to research the antibacterial activity of humic-based bionanomaterials containing silver (HS-AgNPs) and their modification by naphthoquinone (HS-2OHNQ-Ag) and hydroquinone (HS-HQ-Ag), also study their effects on museum strains of *Escherichia coli* and *Klebsiella pneumoniae* and multidrug-resistant clinical strains of *Klebsiella pneumoniae* and Methicillin-resistant *Staphylococcus aureus* (MRSA).

Experimental samples were synthesized in the Natural Humic Systems Laboratory of the Chemical Faculty of Lomonosov MSU, there were 8 samples: the coal humic acid (HA) "Powhumus" (CHP-AgNPs), the peat fulvic acid "Fulvagra" (FA-AgNPs), the Sakhalin coal HA (CHS-AgNPs), the angustifolium (Peat1-AgNPs) and the sphagnum (Peat2-AgNPs) peat HAs, the Irkutsk coal HA (CHI-AgNPs), the "Genesis" coal HS (CHE-AgNPs), the unfractionated peat preparation (PHF-T3-AgNPs). All modification samples were synthesized on the CHP sample.

Minimum inhibitory concentrations (MIC) were determined for experimental substances with established antibacterial activity in combination with lincomycin. The study was done on the 96-well flat-bottomed tissue culture plate. Mineral nutrient medium M9 and Mueller-Hinton broth were used as nutrient medium. Results were evaluated after 24 h of incubation of the plates at a temperature of 37°C using spectrophotometry (605 nm).

As a result of the study of the effect of the studied substance on the development of periodical cultures of museum strains of *E. coli* and *K. Pneumoniae* in the mineral nutrient medium M9, it was found that CHS-AgNP, FA-AgNP, CHP-AgNP, Peat1-AgNPs, Peat2-AgNPs at concentrations of 0,5-8 mg / having pronounced antimicrobial activity, which manifests in the complete absence of bacterial growth in the wells. The antimicrobial activity of the studied substances against clinical multi-resistant strains of *K. pneumonia* was demonstrated by CHS-AgNP, FA-AgNP, CHP-AgNP, Peat1-AgNPs, Peat2-AgNPs at concentrations of 3-16 mg/l. The modification samples were studied on bacteria in the Mueller-Hinton nutrient broth and they showed the most stable results against opportunistic microorganisms. So, CHP-Ag, CHP-HQ-Ag and CHP-2OHNQ-Ag samples showed pronounced antibacterial activity at concentrations of 600-1200 mg/l to museum strains, which manifested itself in the absence of a change in the density of the contents of the well after 24 hours. The most pronounced activity was demonstrated by two substances - CHP -Ag and CHP - HQ Ag. These substances were tested on the possible potentiation of the action of lincomycin against the museum strain of MRSA. The CHP-Ag and CHP-HQ Ag samples were added to lincomycin at concentrations of 60 mg/l and 40 mg/l, respectively, as result the MIC of lincomycin was 0.1 mg/l, while without the addition of HS, it was more than 200 mg/l.

Thus, the humic-based bionanomaterials containing silver have an antibacterial effect and can potentiate the action of known antibacterial substances.

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