ВТОРАЯ ВСЕРОССИЙСКАЯ
КОНФЕРЕНЦИЯ
С МЕЖДУНАРОДНЫМ УЧАСТИЕМ

"МИКРОПЛАСТИК В НАУКЕ
О ПОЛИМЕРАХ"

1-5 октября 2024 г., Великий Новгород,
Россия

СБОРНИК ТЕЗИСОВ

Великий Новгород
НовГУ
2024

УДК 691.175.5/.8, 504.75
ББК 24.7

Вторая Всероссийская конференция с международным участием «Микропластик в науке о полимерах»: сборник тезисов.— Великий Новгород: НовГУ, 2024.— 89 с.

Сборник содержит тезисы пленарных докладов конференции, устных и стендовых докладов секций.

УДК 691.175.5/.8, 504.75
ББК 24.7

Организаторы конференции:

Новгородский государственный университет им. Ярослава Мудрого
Отделение химии и наук о материалах Российской академии наук
Московский государственный университет им. М.В. Ломоносова
Федеральная служба по надзору в сфере природопользования

При поддержке:

ПАО «Сибур Холдинг» Фонд Экология

Организационный комитет:

С.В. Люлин – председатель
С.Н. Калмыков
А.Р. Хохлов
М.П. Егоров
Ю.С. Боровиков
С.Г. Радионова

Программный комитет:

А.А. Ярославов
И.Ю. Коган
Prof. J.M. Kenny
Ш.Р. Поздняков
Е.Г. Багрянская
И.А. Балова
Д.С. Воробьев
И.М. Зорин
С.С. Карлов
И.П. Чубаренко
М.А. Проскурнин
А.А. Гуртовенко
Т.А. Кузнецова
Е.А. Филимонова
Ю.А. Франк
Н.Н. Шевченко

Локальный комитет:

Ю.С. Боровиков – председатель
А.А. Бурмистрова – секретарь
А.Б. Ефременков
А.П. Новикова
С.В. Дидковский
К.Н. Харламов
О.А. Фихтнер
В.А. Исаков
Е.Л. Тульцев
Г.В. Лебедева
У.В. Васильева

ПРОГРАММА КОНФЕРЕНЦИИ

October 2, Wednesday / 2 октября, среда

9:30–10:00	Opening Ceremony (Sergey Lyulin, Yuriy Borovikov, El'mira Morozova)

10:00–11:00	Morning Plenary Session

Chairperson: **Sergey Lyulin**

PL-01	**Aleksei Khokhlov**	Pollution of the Planet with Macro-, Micro- and Nano-Plastic: Emotions and Scientific Approach
PL-02	**Jose Kenny**	New Approaches to Solving Microplastics Problem as a Potential Threat to Humans and Environment

11:00–12:00	Oral Session 1

Chairperson: **Sergey Lyulin**

O-01	**Tatiana Kuznetsova**	Development of an international legally binding instrument pursuant to the UNEA Resolution № 5/14 "End plastic pollution: Towards an international legally binding instrument".Current issues and solutions
O-02	**Ivan Zorin**	Primary microplastics: experience in isolation and analysis
O-03	**Marina Antsiferova**	Pollution of the waters of the Lower Volga with microplastics
12:00–12:20	Coffee-break	
12:20–14:00	Oral Session 2	

Chairperson: **Yulia Frank**

O-04	**Tatiana Rauen**	Plankton's role in the vertical transport of marine microplastics from surface to seafloor
O-05	**Liliya Fatkhutdinova**	Methodological Approaches to Assessing the Health Impacts of Microplastics: Lessons Learned from Nanoparticle Research
O-06	**Boris Chubarenko**	Hydrological-ecological screening monitoring of the mouth of the Pregolya River (South-Eastern Baltic): search for potential retention zones for microplastic particles
O-07	**Andrey Pedchenko**	EXPANSION OF VNIRO RESEARCH ON MICROPLASTICS IN RUSSIAN MARGINAL SEAS
O-08	**Maksim Remchukov**	Key challenges in Microplastics for petrochemical industry
14:00–15:30	Lunch and Poster Discussion	

15:30–16:30	Afternoon Plenary Session	
Chairperson: **Elena Filimonova**		
PL-03	**Elena Bagryanskaya**	The microplastics effect on environmental water objects and living organisms
PL-04	**Svetlana Khashirova**	Microplastics monitoring: from the plain to the highlands

16:30–17:10	Oral Session 3	
Chairperson: **Elena Filimonova**		
O-09	**Natal'ya Shevchenko**	Influence of the shape of polystyrene microplastic particles on sorption properties
O-10	**Elena Tkachenko**	Microplastics investigations for Arctic seas sediments
17:10–17:30	Coffee-break	

17:30–18:10	Oral Session 4	
Chairperson: **Natal'ya Shevchenko**		
O-11	**Yulia Frank**	Uptake and transfer of polystyrene microspheres in fish and invertebrates
O-12	**Dmitrii Osipov**	Enzymatic breakdown of PET-containing microplastics
O-13	**Elena Trofimchuk**	An approach for obtaining model microplastic particles with various potential pollutants

October 3, Thursday / 3 октября, четверг

10:00–11:00	Morning Plenary Session	

Chairperson: **Andrey Gurtovenko**

PL-05	**Aristides Tsatsakis**	The slippery progress of science and consequences in risks for society - Paradigm microplastics
PL-06	**Rawil Fakhrullin**	Dark-field microscopy for micro- and nanoplastic characterisation in vitro and in vivo

11:00–12:00	Oral Session 5	

Chairperson: **Andrey Gurtovenko**

O-14	**Pavel Komarov**	Challenges in Modeling Aging Microplastic Nanoparticles
O-15	**Dmitry Polovyanenko**	Application of pyrolytic gas chromatography with mass detection for the analysis of microplastics as a pollutant in environmental objects and living organisms
O-16	**Igor Zhdanov**	Distribution of surface microplastics in the Pacific Ocean, Sea of Okhotsk and Sea of Japan
12:00–12:20	Coffee-break	
12:20–14:00	Round Table: Microplastics in Agriculture	
14:00–15:30	Lunch and Poster Discussion	
15:30–17:00	Afternoon Plenary Session	

Chairperson: **Irina Chubarenko**

PL-07	**Francesco Saliu**	Microplastics from Textiles: Current Analytical Challenges and Possible Solutions
PL-08	**Aleksandr Mel'tser**	Actual issues of the impact of microplastics on public health
PL-09	**Ahmad Manbohi**	The latest findings on microplastics in the Iranian coastal regions
17:00–17:20	Coffee-break	
17:20–18:20	Oral Session 6	

Chairperson: **Elena Bagryanskaya**

O-17	**Viliam Sarian**	A real opportunity to provide interdisciplinarity in practical research related to the detection, characterization and study of the effects of microplastics on human health and the environment
O-18	**Sergey Shishlyannikov**	Microbiological synthesis of polyhydroxyalconoate, a promising biodegradable
O-19	**Anatolii Khripun**	Instrumental Solutions for the Detection, Identification and Characterization of Microplastics in Environmental Samples

19:00–22:00	Conference Dinner

October 4, Friday / 4 октября, пятница

10:00–11:00	Plenary Session	
Chairperson: **Mikhail Proskurnin**		
PL-10	**Abdumutolib Atakhanov**	Experience and plans in solving the problem of plastic waste in Uzbekistan
PL-11	**Aleksei Polotsky**	The self-consistent field method as a promising approach for studying microplastics
11:00–12:00	Oral Session 7	
Chairperson: **Mikhail Proskurnin**		
O-20	**Shamil' Pozdnyakov**	Methods for studying microplastics in Lake Ladoga
O-21	**Mikhail Tolstunov**	Sample preparation for pyrolysis-gas chromatography with mass-spectrometric detection
O-22	**Evgeny Krysanov**	Effects of polydisperse microplastic particles on proliferative activity in fish pronephros
12:00–12:20	Coffee-break	
12:20–14:00	Oral Session 8	
Chairperson: **Shamil Pozdnyakov**		
O-23	**Denis Kraskevich**	Overview of microplastics entry routes and potential risks to human health
O-24	**Vitalii Vorob'ev**	Nanocellulose among microplastic: bacterial cellulose as a model object
O-25	**Irina Chubarenko**	Processes of (micro)plastics sorting in the wave run-up zone
O-26	**Svetlana Tuzova**	Preventing the Loss of Intellectual Property in the Development and Market Launch of Innovative Polymer Products
O-27	**Aleksandra Ershova**	A look at the problem of pollution of the Gulf of Finland and the south-eastern part of the Baltic Sea with plastic and paraffins
14:00–15:30	Lunch and Poster Discussion	
15:30–17:30	Oral Session 9	
Chairperson: **Ivan Zorin**		
O-28	**Yuri Yurasov**	Analysis of the distribution of microplastics in bottom sediments from the Don River to the Sea of Azov
O-29	**Igor Volgin**	Exploring Arctic marine microplastics: IR spectral database analysis using machine learning methods
O-30	**Tatiana Gusel'nikova**	Determination of the impurity composition of polyethylene terephthalate, expanded polystyrene, and polypropylene by atomic-emission spectrometry
O-31	**Aleksandr Khaustov**	Genetic identification of microplastics in urban dust
O-32	**Elena Proskurnina**	Effects of nanoplastics on cell survival and genes of key signaling pathways in human cells
O-33	**Mikhail Ermolin**	Water-oil systems for continuous-flow separation and preconcentration of microplastics from natural waters

O-34	**Mikhail Glagolev**	Efficient construction of stability diagrams of aged polymer nanoparticles

POSTER PROGRAM

October 2, Wednesday / 2 октября, среда, 14:00–15:30

P.1-01	**Anastasiia Badikova**	Cellulose particles as a model of biodegradable microplastics
P.1-02	**Aleksandra Blazhenko**	Prospects of using the species oryctolagus cuniculus as a biological model for assessing the impact of microplastics on animal reproduction
P.1-03	**Victor Nazarychev**	An inquiry on the interactions between microplastics and antibiotics: all-atom molecular dynamics simulation
P.1-04	**Vladimir Toshchevikov**	Self-consistent field modeling of microplastics particle formation
P.1-05	**Kirill Yuzhanin**	Magration of cationic polymer between model microplasticparticles
P.1-06	**Vladislav Forer**	Interaction of pollutants with microplastics in water: atomistic molecular dynamics simulations
P.2-01	**Mavluda Abduvalieva**	The study of microplastics in the reservoirs of the Ferghana Valley
P.2-02	**Anna Apenkina**	Adsorption behavior of antibiotics on latex nanoparticles
P.2-03	**Vladislav Khabibullin**	Analysis of thermal and optical properties of aqueous dispersions of polystyrene nanoparticles by thermal lens spectrometry

October 3, Thursday / 3 октября, четверг, 14:00–15:30

P.3-01	**Anna Arzamasova**	Development of an information-analytical system on microplastics in natural environments on the territory of the Russian Federation
P.3-02	**Natalia Bereznikova**	Biodegradation of polyethylene particles by Zophobas morio larvae
P.3-03	**Irina Bocherikova**	Comparisone of microplastics (0.5-2 mm) content in different marine environments.
P.3-04	**Danil Vorobiev**	Microplastics in the Tom River: monitoring results
P.3-05	**Nikol Davydova**	Assessment of microplastic contamination in fractured karst aquifer (Zvenigorod, Russia)
P.3-06	**Alexandra Ershova**	Microplastics in Antarctica: first results
P.3-07	**Polina Krivoshlyk**	Temporal variability of microplastics in the wave run-up zone on the Vistula Spit
P.3-08	**Olga Lobchuk**	Assessment of microplastic contamination of the Pregolya river mouth area (south-eastern Baltic)
P.3-09	**Natalia Malygina**	Атмосферное поступление микропластика на Алтае
P.3-10	**Timur Nizamutdinov**	Potential sources of microplastics inputs to terrestrial and aquatic ecosystems of Antarctica

October 4, Friday / 4 октября, пятница, 14:00–15:30

P.3-11	**Irina Panova**	Biocidal properties of complexes from model microplastic particles and polycation
P.3-12	**Maria Pogojeva**	Microplastics in the Black Sea sediments
P.3-13	**Mariya Podzorova**	Functional materials with the addition of secondary polymer raw materials: structure and properties
P.3-14	**Yulia Sotnikova**	Investigation of microplastics and organic pollutants in the water and bottom sediments of the Ob River
P.3-15	**Petr Fetin**	Microplastics to improve properties of dirt roads
P.4-01	**Anastasia Vainberg**	Microplastic bioaccumulation in pinnipeds (Pinnipedia): a literature review
P.4-02	**Gleb Maltsev**	Migration of microplastic particles in a porous medium
P.4-03	**Liubov Ozeretskaya**	Experimental study of the effect of nanoplastics on the gastrointestinal tract
P.4-04	**Aleksandra Osechkova**	Investigating the accumulation and effects of microplastics on health and rate of aging: a pilot study
P.5-01	**Ekaterina Kachalova**	Polysaccharides as an alternative to synthetic polymers in packaging materials
P.5-02	**Arseny Bekishev**	Hansen solubility parameters in chemical recycling of polystyrene plastics
P.5-03	**Marina Filinkova**	Magnetic sedimentation of polyethylene microparticles from aqueous solutions

ОГЛАВЛЕНИЕ

PL-01 POLLUTION OF THE PLANET WITH MACRO-, MICRO- AND NANO-PLASTIC: EMOTIONS AND SCIENTIFIC APPROACH

Khokhlov A.R.[1,2]

1 - Physics Department, M.V. Lomonosov Moscow State University, Moscow, Russia
2 - A.N. Nesmeyanov Institute of Organoelement Compounds, Russian Academy of Sciences, Moscow, Russia
khokhlov@polly.phys.msu.ru

Contamination of the environment with polymer waste has recently acquired the features of a global challenge to humanity. During a hundred years of development of polymer science and the polymer industry, about 10 billion tons of waste from used polymer materials have accumulated in the world, which degrade extremely slowly in natural conditions. A particular danger is associated with the pollution of water environments - rivers, lakes, seas and oceans.

To solve this problem, some environmental scientists propose a radical reduction in the global production of polymer materials. This cannot be agreed with, since these materials are an integral part of modern world civilization. Instead, scientists working in the field of polymer science should offer their own approaches that are not associated with reversing global scientific and technological progress.

The report will provide an overview of the main areas of scientific research in the field of polymer science, which will ensure the evolution of the polymer industry towards the creation of environmentally friendly production and minimal impact on the environment.

Sorting waste for their subsequent use can only delay littering the environment. Polymer material can be recycled at best several times. Eventually, it will end its life cycle in a landfill or be incinerated. Therefore, the key issues are: (a) thoughtful design of landfills; (b) effective catalysts that prevent air pollution during combustion of polymer materials.

The problem of micro- and nano-plastics (i.e., polymer waste particles smaller than 5 mm) will be discussed separately. The harm from micro- and nano-plastics to living organisms is probably overestimated. Only particles smaller than 5 μm can penetrate the blood, and only objects smaller than 50 nm can pass through cell membranes. In natural aquatic environments, these particles will be covered with a layer of surfactants, so that the immune response to these particles will be similar to that for small dust/sand particles, with which many organisms have coexisted for many millions of years.

PL-02 NEW APPROACHES TO SOLVING MICROPLASTICS PROBLEM AS A POTENTIAL THREAT TO HUMANS AND ENVIRONMENT

Kenny José M. J.M.[1,2]

1 - Department of Civil and Environmental Engineering, University of Perugia, Italy
2 - European Center for Nanostructured Polymers, Terni, Italy
jose.kenny@unipg.it

This presentation is mainly focused on the Megagrant project recently awarded with the main goal to develop and integrate new scientific approaches to address the problem of microplastics. Currently, the problem of microplastics and their potential threats to human health and to the environment is one of the global challenges facing our planet. In fact, the uncontrolled accumulation of microplastics in nature leads to an increase in anthropogenic loads on the environment to a scale that threatens the reproduction of natural resources, which is considered as one of the "big challenges" of modernity. Within the framework of the project, it is planned to create the first interdisciplinary laboratory in the Russian Federation, coordinated by the Novgorod State University, which will integrate research scientists from different scientific fields (chemistry, physics, biology, mathematics, medicine) to develop new approaches to solving the global problem of microplastics.
In this regard, the project will address the following objectives:

1. Assess the adverse effects on human health and the environment of the most hazardous size microplastics (50 micrometers and smaller) in three major environments - water, soil, and living organisms - using a wide range of theoretical and experimental methods ranging from in silico to in vivo.
2. Establishment of the adsorption and transport of various health hazardous pollutants (pesticides, antibiotics, polycyclic aromatic hydrocarbons, heavy metal ions, etc.) on microplastic particles.
3. Development of approaches for detection and characterization of microplastics smaller than 50 micrometers. Development of regulations for detection and characterization of microplastics in different environments.
4. Study of the processes of "aging" of microplastic particles in nature and in artificial laboratory conditions, as well as assimilation of microplastic at the final stage of destruction (polymer particles of nanometer sizes).
5. Development of the technology for obtaining biodegradable polymers as an alternative to some industrial large-tonnage polymers.

The presentation of the project will we integrated with a revision of the current European research initiatives and regulations to address industrial and commercial restrictions concerning the control of the microplastics problems.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant).

PL-03 THE MICROPLASTICS EFFECT ON ENVIRONMENTAL WATER OBJECTS AND LIVING ORGANISMS

Bagryanskaya E.G.[1], Sotnikova Yu.S.[1], Nefedov A.A.[1], Karpova E.V.[1], Osechkova A.E.[1], Song Dae I.I.[1], Ershova A.V.[2], Stefanova N.A.[3], Kolosova N.G.[3], Polovyanenko D.N.[1]

1 - N.N. Vorozhtsov Novosibirsk Institute of Organic Chemistry of SiB RAS, Novosibirsk, Russia
2 - PlasticLab, Russian State Hydrometeorological University, St. Petersburg, Russia
3 - Institute of Cytology and Genetics, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russia
egbagryanskaya@nioch.nsc.ru

During the last decade there has been a notable increase in the number of studies examining microplastics (MNPs) in the environment and the study of the effects of microplastics on living organisms. Microplastics was recently detected in human blood, heart, human penis, etc. The number of studies investigating microplastic contamination continues to grow, the extent of this contamination is becoming increasingly evident, from urban coastal surface waters to the remote deep ocean depths. It is of paramount importance to gain a deeper understanding of the distribution and fate of microplastics and nanoplastics (MNPs) in the environment if we are to assess their bioavailability and potential effects on living organisms. This knowledge is also required to enable appropriate action to be taken and to define environmental quality standards. A number of analytical challenges currently impede the conduct of studies investigating the environmental contamination by MNPs, affecting both the accuracy of quantification and the comparability of study results. Ultimately, the MNPs of interest must be successfully and representatively separated from the sample matrix without risk of damage or contamination of the sample.

It should be taken into account that environmental pollutants may be both MNPs and/or may be absorbed by MNPs, including organic pollutants, heavy metals, bacteria, and fungi. For instance, bisphenol A and phthalates can leach from polyethylene, polyethylene terephthalate, polystyrene and polyvinyl chloride. Mammals are exposed to MNPs through ingestion and inhalation, with humans at the top of the food chain being particularly vulnerable. Once MNPs enter mammals and reach organs, they are likely to cause adverse effects on mammals, their offspring, and even fetuses. Nevertheless, the capacity of MNPs to traverse diverse human barriers and the underlying mechanisms of transportation and toxicity remain uncertain. The optimal approach to study the accumulation of microplastics in the organism and the mechanisms of their influence on health is the use of laboratory animals such as mice, rat and etc.

This report presents the overview of latest research obtained in NIOCh SB RAS, Institute of Cytology and Genetics SB RAS and St. Petersburg Russian State Hydrometeorological University on the approaches to the quantitative analysis of microplastic content in the environment, in particular in water and bottom sediments. Another direction of our investigation was MNPs accumulation and impact on model animals (the OXYS strains of laboratory rats – a unique model of premature aging, which is manifested by the early development of a complex of “senile” diseases).

PL-04 МОНИТОРИНГ МИКРОПЛАСТИКА: ОТ РАВНИНЫ ДО ВЫСОКОГОРЬЯ

Хаширова С.Ю., Агоева Э.А., Ламашвили Л.С.

Кабардино-Балкарский государственный университет им. Х.М. Бербекова, Нальчик, Россия
sveta_daova@mail.ru

В работе приведены результаты мониторинга микропластика (МП) от равнины до высокогорья.

Объектом изучения стали речные водосборы, истоки которых расположены на северном склоне Центрального Кавказа, которые перетекая в равнинные области западной части Кабардино-Балкарской республики (КБР) являются источником их питания, а также почва, расположенная в данных районах. Таким образом, исследования охватили все геоморфологические зоны КБР – высокогорная, горная, предгорная и равнинная. В ходе проведённых исследований было определено, что содержание микропластика в водных и почвенных образцах увеличивается по мере удалённости от высокогорий к равнине, что указывает на положительную корреляцию в пространственно-количественной зависимости содержания микропластика.

Также определено, что размер частиц микропластика в различных геоморфологических зонах КБР различается, причём здесь выявлена отрицательная корреляция в пространственно-размерной зависимости в водных образцах, т.е. чем выше водосбор, тем мельче размер частиц микропластика, что предположительно связано с особенностями высокогорных водосборов. Для почвенных образцов данной зависимости не выявлено.

Проведение дальнейших исследований позволит оценить миграцию частиц микропластика в окружающей среде.

PL-05 CURRENT RISK ASSESSMENT AND THE SPEEDY - SLIPPERY PROGRESS OF SCIENCE: PARADIGM MICROPLASTICS

Tsatsakis A.[1], Vlăsceanu A.[2]

1 - University of Crete, Department of Toxicology, Heraklion, Greece
2 - Carol Davila University of Medicine and Pharmacy, Bucharest, Romania
tsatsaka@uoc.gr

Environmental chemical exposure is a constant reality, with people of all ages encountering a complex mix of xenobiotics through various pathways daily. Traditional long-term toxicity assessments, which generally focus on single chemicals, are no longer sufficient due to the complexity and scale of real-world exposures that involve multiple interacting chemicals. These conventional methods often fail to account for the non-linear and cumulative risks associated with chemical mixtures, potentially leading to an underestimation of true hazards [1-2].

This lecture will explore the limitations of current regulatory frameworks for assessing mixture toxicity and will present innovative methodologies designed to better mirror real-life exposure scenarios. Central to this discussion is the Real-Life Risk Simulation (RLRS) approach, which evaluates the combined and varying exposures to low doses of multiple environmental stressors, providing a more accurate representation of actual human exposure patterns [3]. Recent findings from RLRS studies demonstrate that prolonged exposure to low levels of multiple chemicals, previously deemed safe, can disrupt biological functions, highlighting the urgent need for updated risk assessment strategies [4].

In addition, the lecture will address advanced techniques such as in chemico, in silico, in vitro, and high-throughput multi-omics methods, which have become critical in identifying molecular changes triggered by chemical exposures. For these techniques to be effectively employed in risk assessment, it is crucial that their findings are strongly linked to adverse effects observed in both in vivo and epidemiological studies [5].

This presentation will discuss the integration of diverse models and methodologies to improve the accuracy and reliability of chemical risk assessments. The focus will be on utilizing multidimensional data and computational approaches to enhance our understanding of chemical impacts through systems biology and to define toxicity signatures based on molecular endpoints, representing a significant step forward in identifying chemical risks.

The increasing concern of the health dangers posed by microplastics (MPs) in the environment has resulted in a substantial increase in investigations into these particles in recent years. Toxicological consequences have been observed at elevated concentrations of microplastics, particularly polystyrene, the most prevalent type of microplastic; nevertheless, predominantly short-term impacts have been investigated [6,7]. The long persistence of plastics can result in the contamination of various environmental components, including surface waters, sediments, groundwater, soils, and the atmosphere [8,9]. Microplastic contamination can also occur from packaging materials, such as bottled water, beer, milk, beverages, and takeaway food containers [10-12].

The precise amounts of microplastics inhaled and ingested, subsequently accumulating in the human body, remain unknown. Additional research is required to assess the effects of microplastic contamination at low concentrations over extended periods.

References

1. Goumenou M, Tsatsakis A. Proposing new approaches for the risk characterisation of single

chemicals and chemical mixtures: The source related Hazard Quotient (HQS) and Hazard Index (HIS) and the adversity specific Hazard Index (HIA). Toxicol Rep. 2019 Jun 21;6:632-636. doi: 10.1016/j.toxrep.2019.06.010.
2. Hernández AF, Tsatsakis AM. Human exposure to chemical mixtures: Challenges for the integration of toxicology with epidemiology data in risk assessment. Food Chem Toxicol. 2017 May;103:188-193. doi: 10.1016/j.fct.2017.03.012.
3. Docea AO, Cirstea AE, Cercelaru L, Drocas AI, Dinca V, Mesnage R, Marginean C, Radu A, Popa DG, Rogoveanu O, Mitrut R, Antoniou MN, Tsatsakis A, Hernández AF, Calina D. Effect of perinatal exposure to glyphosate and its mixture with 2,4-D and dicamba on rat dam kidney and thyroid function and offspring's health. Environ Res. 2023 Nov 15;237(Pt 1):116908. doi: 10.1016/j.envres.2023.116908.
4. Aschner M, Mesnage R, Docea AO, Paoliello MMB, Tsatsakis A, Giannakakis G, Papadakis GZ, Vinceti SR, Santamaria A, Skalny AV, Tinkov AA. Leveraging artificial intelligence to advance the understanding of chemical neurotoxicity. Neurotoxicology. 2022 Mar;89:9-11. doi: 10.1016/j.neuro.2021.12.007.
5. Sergievich AA, Khoroshikh PP, Artemenko AF, Zakharenko AM, Chaika VV, Kodintsev VV, Stroeva OA, Lenda EG, Tsatsakis A, Burykina TI, Agathokleous E, Kostoff RN, Zlatian O, Docea AO, Golokhvast KS. Behavioral impacts of a mixture of six pesticides on rats. Sci Total Environ. 2020 Jul 20;727:138491. doi: 10.1016/j.scitotenv.2020.138491.
6. Karzi V, Ozcagli E, Tzatzarakis MN, Vakonaki E, Fragkiadoulaki I, Kalliantasi A, Chalkiadaki C, Alegakis A, Stivaktakis P, Karzi A, Makrigiannakis A, Docea AO, Calina D, Tsatsakis A. DNA Damage Estimation after Chronic and Combined Exposure to Endocrine Disruptors: An In Vivo Real-Life Risk Simulation Approach. Int J Mol Sci. 2023 Jun 10;24(12):9989. doi: 10.3390/ijms24129989.
7. Dinca V, Docea AO, Drocas AI, Nikolouzakis TK, Stivaktakis PD, Nikitovic D, Golokhvast KS, Hernandez AF, Calina D, Tsatsakis A. A mixture of 13 pesticides, contaminants, and food additives below individual NOAELs produces histopathological and organ weight changes in rats. Arch Toxicol. 2023 May;97(5):1285-1298. doi: 10.1007/s00204-023-03455-x.
8. Wang L, Wu W, Bolan NS, Tsang DCW, Li Y, Qin M, Hou D (2021) Environmental fate, toxicity and risk management strategies of nanoplastics in the environment: current status and future perspectives. J Hazard Mater 401:123415.
9. Fan W, Salmond JA, Dirks KN, Cabedo Sanz P, Miskelly GM, Rindelaub JD (2022) Evidence and mass quantification of atmospheric microplastics in a Coastal New Zealand City. Environ Sci Technol. 56:17556-17568.
10. Shruti VC, Pérez-Guevara F, Elizalde-Martínez I, Kutralam-Muniasamy G (2020) Toward a unified framework for investigating micro (nano) plastics in packaged beverages intended for human consumption. Environ. Pollut. 268:115811.
11. Sewwandi M, Wijesekara H, Rajapaksha AU, Soysa S, Vithanage M, Microplastics and plastics-associated contaminants in food and beverages; Global trends, concentrations, and human exposure, Environmental Pollution, Volume 317, 2023,120747.
12. Borriello L, Scivicco M, Cacciola NA, Esposito F, Severino L, Cirillo T. Microplastics, a Global Issue: Human Exposure through Environmental and Dietary Sources. *Foods*. 2023; 12(18):3396.

PL-06 DARK-FIELD MICROSCOPY FOR MICRO- AND NANOPLASTIC CHARACTERISATION IN VITRO AND IN VIVO

Fakhrullin R.

Kazan Federal University, Kazan, Republic of Tatarstan, Russia
kazanbio@gmail.com

Detection and precise identification of miniature polymer particles, both in situ (e.g., environmental water, sediments, soils, etc.) and in biological specimens (in vitro and in vivo) is a crucial step during microplastic toxicity studies. In addition, assaying uptake pathways and biodistribution in cells and tissues requires a potent tool to unequivocally locate and identify microplastics. As a result, researchers have focused on development of microscopy methods to image and chemically identify microplastics. Among others, dark-field microscopy has recently been applied for microplastics imaging and identification. Its capability to visualise particles well below the resolution limit of bright field or fluorescence optical microscopy, supplemented with spectral chemical analysis, allows for effective identification and monitoring of a number of polymer materials at the nanoscale. In this talk, the recent advances of dark-field hyperspectral microscopy in the area of environmental and biomedical research on nano- and microplastics are covered [2-6].

References

1. Fakhrullin R., Nigamatzyanova L., Fakhrullina G. Sci. Total Environ. **772**, 145478 (2021)
2. Nigamatzyanova L, Fakhrullin R, Environmental Pollution, **271**, 116337 (2021)
3. Ishmukhametov I., Nigamatzyanova L., Fakhrullina G., Fakhrullin R. Anal. Bioanal. Chem. **414**, 1297 (2022)
4. Ishmukhametov I., Batasheva S., Fakhrullin R. Analyst **147**, 4616 (2022)
5. F Akhatova F., Ishmukhametov I., Fakhrullina G., Fakhrullin R. Int. J. Molec. Sci. **23**, 806 (2022)
6. Batasheva S., Akhatova F., Abubakirov N., Fakhrullin R. Sci. Total Environ. **854**, 158574 (2023)

PL-07 MICROPLASTICS FROM TEXTILES: CURRENT ANALYTICAL CHALLENGES AND POSSIBLE SOLUTIONS

Saliu F.L.

Earth and Environmental Science, University of Milano Bicocca, Milano, Italy
francesco.saliu@unimib.it

Since the early stages of research on plastic pollution, various types of fibers and filaments made of different materials have been observed in the environment (1). Plastic microfibers have often been considered a subset of microplastics but rarely included in monitoring campaigns due to difficulties in controlling airborne contamination (2). Moreover, natural and semisynthetic microfibers have been excluded from studies under the assumption that they are easily biodegradable and/or harmless. Only in recent years, more attention to the occurrence and chemical characteristics of microfibers has started to be paid, and this has led to the recognition of microfibers as the most widespread man-made particle pollutant, from subsurface water (3) to deep-sea sediment (4), from polar ice (5) to mountain glaciers (6). In addition, the application of spectroscopic techniques has revealed that not all the detected fibers are 'plastic'; the most significant portion is made of natural or chemically modified cellulose instead, in contrast with the actual trends of textile fiber production (3). Building on this, it has been proposed to consider microfibers as an independent type of contaminant of emerging concern rather than a subgroup of microplastics (7). This has also sparked a debate on the need for new and common definitions, as well as standardized analytical methodologies. These are crucial for identifying the major sources of microfiber dispersion in the environment, understanding the key factors contributing to fiber release from textiles and apparel, and ultimately finding new solutions to mitigate this insidious form of pollution. Starting from this basis, this presentation will focus on the current challenges in detecting microfibers and their associated contaminants, with a particular emphasis on the application of mass spectrometry for their thorough quantification.

References

1. *Buchanan*. **Marine Pollution Bulletin** 2 (2). Pollution by synthetic fibres, 1971,
2. *Woodall et al.* **Marine Pollution Bulletin 95(1).** Using a forensic science approach to minimize environmental contamination and to identify microfibres in marine sediments 2015
3. Suaria et al. **Science Advances, 6(23).** Microfibers in oceanic surface waters: A global characterization, 2020
4. Sanchez-Vidal et al. **PLoS One, 13(11).**The imprint of microfibres in southern European deep seas
5. *Chubarenko et al.* **Marine Pollution Bulletin, 185 (A).** Microplastics in the first-year sea ice of the Novik Bay, Sea of Japan, 2022
6. *Napper et al.* ***ONE Earth 3:5621***. Reaching new heights in plastic pollution—preliminary findings of microplastics on Mount Everest, 2020
7. *Liu et al.* **Environmental Science and Pollution Research, 26(28).** Microfibers: A preliminary discussion on their definition and sources, 2019

PL-09 THE LATEST FINDINGS ON MICROPLASTICS IN THE IRANIAN COASTAL REGIONS

Manbohi A.

Iranian National Institute for Oceanography and Atmospheric Science, Tehran, Iran
ahmad.manbohi2666@gmail.com

The Iranian coastlines in the Caspian Sea (north of Iran) and the Oman Sea-the Persian Gulf (south of Iran) stretch approximately 820 km and 2250 km, respectively. These coasts are among Iran's top tourist destinations, attracting many visitors annually. However, intensive tourism, urban density, fishing, fish farming, construction, and pollution from inland basins have made these areas some of the most polluted marine environments globally. These activities introduce a large amount of pollution, including microplastics, into the marine environments. Microplastics are plastic litters in the environment with the size <5 mm in diameter. Many researchers have reported microplastic pollutions in the coastal areas of north and south of Iran. In this lecture, I will review the latest findings on the occurrence and distribution of microplastics in these regions. Additionally, I will discuss research on the presence of microplastics in marine biota. The discussion will cover the types of microplastics (size, color, type, and shape), their potential sources, and a comparison of microplastic quantities in these areas with those in other parts of the world. This lecture will enhance our understanding of microplastic pollution in Iran's marine ecosystem. Ultimately, based on these findings, I will offer recommendations for managing and minimizing microplastic entry into coastal areas.

PL-10 ОПЫТ И ПЛАНЫ В РЕШЕНИИ ПРОБЛЕМЫ ПЛАСТИКОВЫХ ОТХОДОВ В УЗБЕКИСТАНЕ

Атаханов А.А., Кудышкин В.О., Ашуров Н.Р., Саримсаков А.А., Рашидова С.Ш.

Институт химии и физики полимеров Академии Наук Республики Узбекистан, Ташкент, Республика Узбекистан
a-atakhanov@yandex.com

Благодаря возможности сочетания нескольких свойств в одном материале, применение и производство пластмасс резко выросло за последние 50 лет и, как ожидается, снова удвоится в течение следующих 20 лет. В Узбекистане также развивается производство пластмасс и в настоящий момент функционируют три крупных компаний (ШГХК, СП «Uz-Kor Gas Chemical, АО Navoiyazot) по выпуску полиэтилена, полипропилена и поливинилхлорида мощностью более 100 тыс.тонн/год готовой продукции.
Долговечность, которая является одним из специфических показателей пластиков, в то же время является весьма вредным. Срок службы некоторых пластмассовых предметов измеряется десятилетиями, а срок использования упаковки очень короткий. Это приводит к образованию больших пластиковых загрязнений, который принимает угрожающие масштабы. В Европе количество пластиковых отходов на душу населения колеблется от 9 до 39 кг/чел. В Узбекистане, учитывая, что в год образуется более 5 млн.тонн твердых отходов и из них доля пластиковых отходов более 15%, это показатель около 21-22 кг/чел.
Растущий спрос на пластмассы неизбежно приводит к проблемам с утилизацией отходов. Поскольку пластиковое загрязнение приняло угрожающие масштабы, этой проблеме по всему миру уделяется много внимания и реализуются различные инициативы. В этом направлении Узбекистан имеет свой опыт и подходы по урегулированию и утилизации твердых, в том числе и пластиковых, отходов. Правительством утверждена стратегия по обращению с твердыми отходами на 2019-2028 гг; внедряются принципы «zero waste». Поставлена задача увеличить объем переработки отходов до 50% в 2026 году и для этого привлекаются иностранные инвестиции, представляются субсидии и льготные кредиты предприятиям, перерабатывающим отходы.
Функционируют десятки предприятий по переработке пластиковых отходов на основе полиэтилена, полипропилена, полиэтилентерефталата и др. с получением новой продукции. Запущены два крупных предприятия по переработке полиэтилентерефталата, что позволило применять их при производстве преформ, использующихся в производстве упаковки прохладительных напитков.
В НИИ проводятся исследовательские работы по утилизации и переработке отходов, образующихся при производстве полиэтилена и получены весьма востребованные продукции, такие как низкомолекулярный полиэтилен, различные растворители и др. Начаты исследования по выявлению биоразлагаемости полиолефинов микробиологическим подходом, в частности, с использованием восковых червей. Продолжаются работы по созданию биоразлагаемых материалов на основе полиолефинов, путем получения композиций с добавками природных полимеров, оксоразлагаемых добавок и др. Начаты исследования по выявлению и определению состава и формы микропластиков на притоках реки Сырдарья.
Увеличение пластиковых отходов требует рациональных комплексных подходов для

решения данной проблемы в кооперации представителями науки, производственных компаний и др.

В этом направлении планируется проведения комплексной работы по решению проблем пластиковых отходов, в частности, пути разделения пластиковых отходов по составу; получение низкомолекулярных соединений путем деструкции; получение композиционных и нанокомпозиционных материалов для различных отраслей; использование биоразлагаемых природных и синтетических полимеров; пути снижения образования и распространения микропластика.

PL-11 THE SELF-CONSISTENT FIELD METHOD AS A PROMISING APPROACH FOR STUDYING MICROPLASTICS

Polotsky A.A.[1,2], Ivanova A.S.[1,2], Mercurieva A.A.[1,2], Toshchevikov V.P.[1,2]

1 - Institute of Macromolecular Compounds of the Russian Academy of Sciences, Saint Petersburg, Russia
2 - Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia
alexey.polotsky@gmail.com

The Scheutjens-Fleer self-consistent field (SF-SCF) method [1] is based on the numerical solution of the self-consistent field equations on a regular lattice. The lattice geometry is determined by the symmetry properties of the system under study. The SF-SCF method has a high speed of convergence; this allows to vary the system parameters in a wide range and to obtain extensive information about its structure and thermodynamics. The SF-SCF method has become an indispensable approach for studying polymer systems of complex architecture and chemical composition such as polymer brushes or block copolymers, polymer adsorption onto surfaces of various geometries, micellization, bilayer lipid membranes, etc. It has also proved its efficiency in revealing the properties of single macromolecules, in particular, the mechanical unfolding of polymer globules formed by macromolecules of linear and comb-like architectures.

A new field of application of the SF-SCF is related to the study of microplastics particles formation by macromolecules of linear and branched architectures and the adsorption of low- and macromolecular pollutants onto such particles. In our talk, we present the main ideas of the SF-SCF method and demonstrate its capabilities using a number of examples, including the formation of microplastics particles and their interaction with macromolecules (high molecular weight pollutants).

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant).

Reference

[1] *Fleer, G. J., Cohen Stuart, M. A. Scheutjens, J. M. H. M., Cosgrove, T., Vincent, B.* Polymers at Interfaces. London, Chapman and Hall, 1993.

O-02 PRIMARY MICROPLASTICS: EXPERIENCE IN ISOLATION AND ANALYSIS

Zorin I.M.[1], Chelushkin P.S.[1], Fetin P.A.[1], Lyulin S.V.[2]

1 - Saint-Petersburg State University, Saint-Petersburg, Russia
2 - Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia
i.zorin@spbu.ru

Microparticles of synthetic polymers, along with particles of natural origin, are widely used as soft abrasives in detergents and cosmetics. Among these, it is necessary to name the personal care products such as scrubs for the skin, cleansing products for the body (shampoos, shower gels) and hands, as well as household detergents (for dishwashing, kitchen surfaces, toilets, etc.) [1, 2]. The use of all these products inevitably leads to the ingress of microplastic particles into the urban sewage system and further into the water processing station. Hand detergents may represent a possible exception; the target audience of which is people who have no access to the water supply and sewage systems at the right time — summer residents, drivers, and builders, so part of the microplastics from the detergents is sent straight to the environment. After that, the microplastics becomes one of the types of dispersed particles (aerosols, hydrosols, and other dust), as well as microparticles of proteins (leather, wool), polysaccharides (cellulose, chitin), minerals (aluminosilicates, carbonates), and soot.

Among the consumer means of construction chemistry, acrylic water-emulsion paints, primers, fillers, seem to be the most important supplier of microplastics into the environment especially processes associated with the washing of the tools, equipment, containers, improper disposal of residues.

In the presentation, we would discuss the experience of analyzing several types of cosmetic and detergents presented on the market in the Russian Federation in order to detect abrasive particles in them. The extracted particles were analyzed with common available methods, such as SEM, laser diffraction, elemental analysis, FTIR- and Raman spectrometry, with the disclosure of the composition and chemical structure according to the spectral databases.

It is obvious that there is a need to apply several analytical methods based on different physical principles for confident judgement on the composition and chemical nature of the discovered particles. The degree of trust in commercial spectral databases and software for their analysis should not be absolute.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant).

The study was performed with technical assistance of the resource centers of St. Petersburg State University: "Centre for Optical and Laser Materials Research", "Chemical Analysis and Materials Research Centre".

References

1. Guerranti, C. Environmental Toxicology and Pharmacology 68, 75–79, (2019)
2. Lei, K. Marine Pollution Bulletin 123(1-2), 122-126, (2017)

O-03 ЗАГРЯЗНЁННОСТЬ ВОД НИЖНЕЙ ВОЛГИ МИКРОПЛАСТИКОМ

Анциферова М.А.[1,2]

1 - Южный Федеральный Университет, Институт Наук о Земле, Ростов-на-Дону, Россия
2 - Южный Научный Центр Российской Академии Наук, Ростов-на-Дону, Россия
m12antsiferova@mail.ru

В работе представлены результаты исследования загрязнённости микропластиком вод Нижней Волги, целью которого являлось определение характеристик частиц, их количества и анализ распределения.

Сбор материала производился в сентябре 2023 года – пробы воды отбирались тралением нейстонной сети, с размером ячеи 0,3 мм на глубине до 20 см. Обработка выполнялась согласно модифицированному методу NOAA [1]. Подсчёт и изучение характеристик микропластика производилось в ходе визуальной сортировки, состав определялся спектроскопией комбинационного рассеяния и инфракрасной спектроскопией; основываясь на полученных данных устанавливался вес частиц, и соответственно их вынос речным стоком. Рассчитывался индекс опасности полимеров, по формуле: $PHI = \sum Pn \times Sn$ где «PHI» – общий индекс опасности полимера; «Pn» – процент конкретных типов обнаруженных полимеров, а Sn – баллы их опасности по классификации [2].

Средние концентрации микропластика в водах Нижней Волги составляют 81,06 шт./м^3 (0,0028 гр./м^3). Отмечено три точки с высокими значениями: 100 шт./ м^3 на участке реки, относящейся к респ. Калмыкии (место водозабора), в Астрахани 98 шт./ м^3, Волгограде 92 шт./ м^3. Если в двух последних случаях очевидна приуроченность загрязнения к урбанизированной территории, то в первом, скорее всего, главными были природные факторы – пробы отбирались после ливня и некоторые частицы могли попасть в воду с дождевым стоком.

Морфологические и морфометрические характеристики частиц не отличаются разнообразием: наиболее распространены прозрачные волокна, длиною до 1 мм, что свойственно взвешенному микропластику. Вторая по частоте встречаемости форма – фрагменты, к распространённым цветам также можно отнести чёрный, белый, синий. В процессе идентификации состава установлено наличие в пробах полиэтилена, полиэтилентерефталата, полиамида, реже зафиксированы полистирол и полипропилен. Большая часть полимеров (75%) относятся ко 2-му классу опасности, согласно рассчитанному PHI. Последним этапом исследования установлено, что общий вынос частиц стоком Волги, в течении 2023 года составил 5,8 тыс. т/г.

Публикация подготовлена при финансовой поддержке Минобрнауки России (Соглашение №075-15-2024-528 от 24.04.2024 г. на реализацию КНП по приоритетным направлениям научно-технического развития).

Список литературы

1. Зобков М.Б., Есюкова Е.Е. (2018) Микропластик в морской среде: обзор методов отбора, подготовки и анализа проб воды, донных отложений и береговых наносов // Океанология. Т. 58. № 1. С. 149–157. DOI: 10.7868/S0030157418010148

2. Xu P., Peng G., Su L., Gao Y., Gao L., Li D. (Microplastic risk assessment in surface waters: A case study in the Changjiang Estuary, China // Marine Pollution Bulletin. 2018. Vol. 133. P. 647–654. DOI: 10.1016/j.marpolbul.2018.06.020.

O-04 PLANKTON'S ROLE IN THE VERTICAL TRANSPORT OF MARINE MICROPLASTICS FROM SURFACE TO SEAFLOOR

Rauen T.V.[1], Mukhanov V.S.[1,2], Sakhon E.G.[1]

1 - A.O. Kovalevsky Institute of Biology of the Southern Seas, Russian Academy of Sciences, Sevastopol, Russia
2 - Institute for Advanced Research, Sevastopol State University, Sevastopol, Russia
taschi@mail.ru

Marine microplastic (MP) pollution is a growing environmental threat, with 5 to 13 million metric tons entering oceans annually. Understanding the fate of these pollutants is crucial, yet their vertical distribution patterns remain poorly explained. This study investigates plankton's role in the vertical transport of MPs from surface waters to the seafloor. We conducted laboratory experiments and field observations in the Black Sea to elucidate plankton-mediated MP transport mechanisms. In the lab, we exposed polystyrene microparticles (4.3 μm diameter, ~0.4 × 10^6 particles/ml, 16 mg/L) to cultures of the cryptophyte Rhodomonas salina (RHO) and the green alga Tetraselmis suecica (TET). Field studies examined biofouling formation on polyethylene terephthalate (PET) fragments at different depths and seasons.

Laboratory results revealed that phytoplankton exudates significantly enhance MP flocculation and surface adhesion. The presence of phytoplankton exopolymers in the medium led to a significant increase in the rate of adhesion of microplastic particles on submerged surfaces, with the magnitude of the effect being species-specific. TET, producing more extracellular polysaccharides, ensured maximum adhesion rate and was most effective at clearing MPs from the medium. Interestingly, despite comparable sizes of microplastic particles and microalgal cells, their coagulation and formation of hetero-aggregates did not occur, likely due to turbulent mixing of the medium and cell motility. In the non-axenic cultures, high abundances of free bacteria were observed (8.8 × 10^6 cells/ml for TET and 5.6 × 10^6 cells/ml for RHO), which could also be a source of exopolymers and serve as flocculation and adhesion agents for plastic particles.

Field observations in the Black Sea revealed distinct vertical and seasonal patterns in biofouling. We found lower biofouling rates in surface waters compared to middle and near-bottom water columns, attributed to turbulent mixing disrupting biofilm formation. The highest biofouling rates and community diversity were observed during summer months. The epibiotic assemblage included 11 diatom taxa, 3 dinoflagellate taxa, green algae, filamentous cyanobacteria, small flagellates, and ciliates. A key discovery was identifying the green alga (probably, Ulvella sp.) as a potential bioindicator for estimating plastic debris residence time. Its discoid thalli were consistently observed across all colonization stages and seasons, offering a promising tool for assessing the age of plastic pollution in the ocean.

Our findings highlight plankton's multifaceted role in vertically transporting microplastics in marine ecosystems. Biofilms modify MP hydrophobicity, buoyancy, degradation rate, and toxicity. Biomass accumulation on MP surfaces initiates descent to deeper waters, and MPs likely undergo sinking and rising cycles as biofilms grow and detach. This process significantly influences plastic pollution distribution from surface to seafloor and its interactions with marine life at various depths.

This research was conducted in the frame of the Russian state assignments No. 1023032700553-3 and 124022400152-1.

О-05 МЕТОДОЛОГИЧЕСКИЕ ПОДХОДЫ К ОЦЕНКЕ ВОЗДЕЙСТВИЯ МИКРОПЛАСТИКА НА ЗДОРОВЬЕ: УРОКИ, ИЗВЛЕЧЕННЫЕ ИЗ ИССЛЕДОВАНИЙ НАНОЧАСТИЦ

Фатхутдинова Л.М., Тимербулатова Г.А.

Казанский государственный медицинский университет, Казань, Россия
liliya.fatkhutdinova@gmail.com

Учитывая физико-химическое сходство (например, плохую растворимость, высокую стойкость, широкий диапазон размеров и сложную природу), существуют существенные параллели между пластиковыми частицами и наноматериалами.

Собственный опыт токсикологических и эпидемиологических исследований в области нанотоксикологии и нанобезопасности позволяет выделить следующие основные научные вызовы, которые необходимо рассматривать как приоритетные при оценке влияния микро- и наноразмерных пластиковых частиц на здоровье: экспозиционные сценарии, включая описание биологически релевантных метрик для оценки экспозиции, разработка практических подходов для оценки уровней воздействия, выявление органов/тканей/клеток-мишеней и оценка потенциального вреда здоровью, в том числе в ходе панельных биомаркерных и лонгитудинальных исследований, характеристика типа зависимости «доза-эффект», изучение эффектов комбинированного и сочетанного действия. Среди экспозиционных сценариев наиболее неизученным и одновременно сопряженным с потенциально высоким риском здоровью является ингаляционное воздействие.

Одновременно существует необходимость учета и преодоления ряда социальных и регуляторных проблем. В частности, одним из серьёзных препятствий для проведения эпидемиологических исследований по изучению влияния искусственных наночастиц на здоровье населения, в первую очередь работников, явилась в свое время позиция многих работодателей и регуляторов, связанная с опасениями задержки развития инновационной отрасли при избыточном, с их точки зрения, внимании к потенциально неблагоприятным эффектам новых перспективных материалов, а также обеспокоенностью потерей конфиденциальной информации. Напротив, чувствительность к потенциальным, но еще неизвестным рискам позволили отдельным работодателям своевременно разработать корпоративные нормативы и стандарты охраны труда, здоровья и окружающей среды, предоставив им впоследствии конкурентные преимущества.

В последующем потребности развития наноотрасли привели к пониманию необходимости разработки критериев безопасности и использовании принципа разумной предосторожности как основы профилактических мероприятий. Тем не менее, первоначальное отставание в этой сфере привело к отсутствию, несмотря на высокую динамику развития отрасли, национальных нормативов, а также стандартных подходов по оценке экспозиций, токсикологических исследований и медицинскому сопровождению.

Проблема регулирования и предупреждения неблагоприятного воздействия пластиковых частиц на здоровье населения и окружающую среду является следующим этапом в изучении новых материалов и должна опираться на уже накопленный опыт, что позволит обеспечить устойчивое развитие данных производств.

O-06 HYDROLOGICAL-ECOLOGICAL SCREENING MONITORING OF THE MOUTH OF THE PREGOLYA RIVER (SOUTH-EASTERN BALTIC): SEARCH FOR POTENTIAL RETENTION ZONES FOR MICROPLASTIC PARTICLES

Chubarenko B.V., Dvoeglazova N.V., Esiukova E.E., Lobchuk O.I., Chubarenko I.P., Kileso A.V., Dikii D.I., Zakirov R.B.

Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia
chuboris@mail.ru

Attention to the issues of microplastic contamination of river-sea contact areas (Schmidt et al., 2017) is associated with an attempt to establish whether there is a zone of microplastic retention or accumulation there, in order to concentrate remediation efforts. The study in the Neva Bay of the Gulf of Finland (Pozdnyakov et al., 2020; Mironova et al., 2021) showed that the concentration of microplastic particles changes in accordance with the behavior of passive admixture, i.e. decreases monotonically with distance from a source. A more refined result (Jalón-Rojas et al., 2024) is that the spatial distribution of microplastic particles depends not only on the specific features of the study water area, but, to a large extent, on the physical properties of the particles and their transformations in connection with bio-fouling and flocculation. However, the estuarine microplastic maxima (EMPM) appears to be common in estuaries (Jalón-Rojas et al., 2024).

In the Pregola River (South-Eastern Baltic, Kaliningrad Oblast), the estuarine conditions are realized virtually throughout the year (Chubarenko, Shkurenko, 2001; Boskachev, Chubarenko, 2022). Therefore, its mouth section is a good example for studying the characteristics of the distribution of microplastic particles specifically in estuarine conditions, where the Baltic Sea brackish waters mix with a fresh river waters.

Screening monitoring included regular surveys (twice a month, from March to October 2024) at a fixed network of stations using automated probes to determine the vertical structure of salinity, temperature, dissolved oxygen, pH, Eh, water transparency and the comparison of these data with sampling for the content of microplastic particles.

The data obtained clearly illustrated the seasonal dynamics of the estuarine zone, its spreading in the spring, and, conversely, the gradual localization and shift upstream in the summer-autumn low-water period. According to preliminary data, there is a tendency in the presence of an intermediate maximum in the number of microplastic particles. The question, is this maximum related with an estuarine conditions or is a consequence of the release of wastewater from treatment facilities in Kaliningrad City, will be answered via continuation of monitoring efforts. The working hypotheses is that number of fibers illustrate the sewage contribution, while the fragments and films are mostly related to natural background of microplastic contamination.

The unexpected result that the highest concentration of microplastic particles and particles >5 mm was at a point located in the Baltic Sea, outside the estuarine zone, was not reliably confirmed.

The research is supported by the Russian Science Foundation under grant No. 24-44-20027.

O-07 EXPANSION OF VNIRO RESEARCH ON MICROPLASTICS IN RUSSIAN MARGINAL SEAS

Belyaev V.A., Pedchenko A.P.

All-Russian Research Institute of Fishery and Oceanography (FGBNU "VNIRO"), Moscow, Russia
belsea@inbox.ru

At present there is an expansion of research on microplastic pollution of waters and bioresources in the marginal seas of Russia [1]. Started in August-October 2019-2022, and research on this problem in the Arctic Seas has been continued first time in all marginal seas of Russia (Far Eastern Basin, Western Basin, Southern Basin) 2023-2024.
Samples of microplastics were and are collected on the surface of the seas by Manta 335 μm and processed according to the unified methodology. The conducted and carried out research fills the gaps in knowledge about the real level of microplastic pollution in the marine environment of the Arctic region, the Baltic, Black, Azov and the Far East Seas.
At the same time, it is especially important to compare in the areas of observation large-scale localizations of microplastics in the World Ocean and the level of plastic pollution of surface waters of the marginal seas of Russia, although we have previously established a relatively insignificant level of pollution of Arctic waters. We point out the relevance of the assumption that a significant part of microplastic fragments and fibers are transported by various currents to the basins of certain seas. In 2018-2022 selective examination of fish in commercial catches for microplastic contamination revealed an episodic single occurrence of its fragments and fibers in the GI tract of some fish individuals (pink salmon, chum salmon, herring, Atka mackerel, pollack) caught in the seas of the North Pacific Ocean [2] and perch and bream of Lake Kubenskoe (Vologda Oblast) [3]. In 2023-2024 research were expanded, representative sample collections of GI tract of capelin, herring, Polar cod sampled in the Barents Sea and Atka mackerel, pink salmon, chum salmon, red salmon, pollack - in the Far Eastern Seas.
The global increase of microplastic content in the seas of the Northern Hemisphere, aggravated by climate change, requires a transition from exploratory scientific observations to regular interdisciplinary study of plastic pollution of biotopes of ecosystems of the seas of the Arctic, North Pacific and Atlantic, as well as the southern region. Key provisions and objectives of monitoring of microplastic pollution of waters and biological resources in the Russian fishing areas provide for the expansion of research in the marginal seas of Russia and naturally obtain objective and comparable assessments based on the use of unified methods of sample collection and processing, as well as ecosystem approach to prevent environmental risks and ensure food safety.

References

1. *K.V. Kolonchin, A.P. Pedchenko, V.A. Belyaev* (2023). Studies of microplastic content in water and commercial fish: from scientific research to large-scale monitoring. Trudy VNIRO. **V.193**. pp. 162-173. DOI:10.36038/2307-3497-2023-193-162-173 *(in Russian).*
2. *A.P.Pedchenko, A.V.Sogrina, E.V.Vedishcheva, I.I.Gordeev, A.N.Starovoitov, S.P.Bomko, S.V.Novokrestennykh, G.A.Kantakov, P.S.Belyaev*. (2024). On the occurrence of microplastics in the gastrointestinal tract of fish of the Far Eastern Seas. (2024) Materials of the II ISPC "The fisheries complex of Russia: 300 years of Russian academic science". Moscow: VNIRO. **Vol.3**. pp. 222-232 *(in Russian).*
3. *N.Yu.Tropin, S.N.Rakhmatullina, E.D.Vorobiev, D.S.Vorobiev, Yu.A.Frank*. (2024). Microplastic Content in the Gastrointestinal Tract of Some Fish Species of Lake Kubenskoe (Vologda Oblast). Inland Water Biology, **Vol.17**, No. 2, pp. 336–344. DOI: 10.1134/S1995082924020196.

O-09 INFLUENCE OF THE SHAPE OF POLYSTYRENE MICROPLASTIC PARTICLES ON SORPTION PROPERTIES

Shevchenko N.N.[1,2], Yakobson O.[1,2], Zorin I.[3]

1 - Institute of Macromolecular Compounds, Russian Academy of Sciences, Saint-Petersburg, Russia
2 - Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia
3 - St. Petersburg State University, Institute of Chemistry, Saint-Petersburg, Russia
natali.shevchenko29@gmail.com

Research on the effects of microplastics on the environment is an urgent task today. In order to understand the effect of secondary microplastics, researchers are studying model particles. Typically, polystyrene-based spherical particles are chosen as model particles. However, real microplastic particles that are found in the environment (water or soil) are predominantly non-spherical in shape. In this regard, the question remains open whether we can use spherical polystyrene particles as model ones. Emulsion polymerization methods make it possible to synthesize polystyrene-based particles not only of spherical shape, but also particles in shape close to real microplastic particles. In this work, non-spherical particles based on polystyrene were obtained (particles with a diameter from 5 to 30 microns). Varying the polymerization conditions (compositions of the monomer phase and dispersion medium, temperature, etc.) makes it possible to control both the wall thickness of hollow microspheres and the diameter of the resulting non-spherical particles. The dependence of the influence of the structure of polystyrene microplastic particles on the adsorption of dye molecules was studied.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant).

О-10 ИССЛЕДОВАНИЯ МИКРОПЛАСТИКА В МОРСКИХ ОСАДКАХ АРКТИКИ

Ткаченко Е.А., Севастьянов В.С., Душенко Н.В., Федулова В.Ю., Федулов В.С., Лоренц К.А., Воропаев С.А.

Институт Геохимии и Аналитической химии им. Вернадского РАН, Москва, Россия
tkachenko@geokhi.ru

Ключевые слова: микропластик, пластиковое загрязнение, пластиковый мусор, антропогенное загрязнение, морские осадки, Карское море, Арктика, электронная микроскопия, ИК-спектроскопия, геохимия углерода.

Исследованы и дана оценка наличия микропластика (МП) в морских осадках морей Арктики, в частности Карского моря. Определены размеры частиц МП и оценен химический состав. Выделение микропластика из осадков проводилось с помощью раствора хлорида цинка. Во избежание гидролиза соли, добавлялась соляная кислота. Проведённые анализы с помощью сканирующего электронного микроскопа и ИК-спектрометра показали наличие в осадке микропластиков различных составов. В образцах, взятых на различных станциях и глубинах, преобладали плёнки и волокна. Исследование размеров частиц микропластика показало, что в пробах имеются частицы размером от 5 до 25 мкм.

Исследования выполнены по теме:
"Геохимия углерода от зарождения биосферы и формирования ископаемых форм к современным технологиям и экологическим и археологическим исследованиям". номер гос. задания: FMMZ-2024-0035.

O-11 UPTAKE AND TRANSFER OF POLYSTYRENE MICROSPHERES IN FISH AND INVERTEBRATES

Frank Y.A.[1], Interesova E.A.[1,2], Simakova A.V.[1], Varenitsina A.A.[1], Babkina I.B.[1], Andreeva Y.V.[1], Vorobiev D.S.[1]

1 - Tomsk State University, Tomsk, Russia
2 - Institute of Systematics and Ecology of Animals of Siberian Branch of Russian Academy of Sciences, Novosibirsk, Russia
yulia.a.frank@gmail.com

Microplastics (MPs) are dispersed throughout the environment and inevitably come into contact with living organisms [1]. As tiny plastic particles pose potential risks to wildlife and human health [2,3], it is necessary to investigate the mechanisms, patterns and rates of MP transport in aquatic and terrestrial biosystems. Our study reports quantitative data on the uptake and transfer of polystyrene (PS) microspheres 2 and/or 10 µm in diameter by invertebrates and fish in model experiments using *Artemia salina* L., blood-sucking mosquitoes *Aedes aegypti* L. and *Anopheles* spp., larvae of *Coregonus peled* Gmelin and *Acipenser ruthenus* L. The data obtained in the current study can be used to model the transport and circulation of MPs under 10 µm in the environment.

Three weeks old *C. peled* larvae were found to ingest 2 µm PS microspheres in a direct correlation with their concentration in water (5 to 500 µg/L) with $r_s = 0.956$ ($p < 0.01$). Larvae of *C. peled* did not significantly accumulate MPs in the gastrointestinal tract for 6 days, nor did nauplii of *A. salina* and larvae of sterlet (*A. ruthenus*). In the experiments with 2 and 10 µm PS particles, the size of the MPs was estimated to influence their uptake rate by *A. salina* and *A. ruthenus* at an initial concentration of 500 µg/L. The uptake of PS spheres of 10 µm diameter by *A. salina* nauplii (ng/individual) was significantly higher ($p < 0.01$, Mann-Whitney U-test) than that of 2 µm particles at the same mass concentration. Sterlet larvae also consumed more 10 µm microspheres (by mass) both directly from the water and during trophic transfer from *Artemia*, up to 119 and 3.1 ng/individual, respectively, and excreted 10 µm particles more slowly, with a T_{50} of 45.3 hours.

A series of experiments demonstrated that in cultured blood-sucking mosquitoes *Ae. aegypti* and malaria mosquitoes *Anopheles* spp. from natural populations, 2 µm PS microspheres can be transferred from feeding larvae to non-feeding pupae and land-flying adults. In *Ae. aegypti*, quantitative reductions in MP content at an initial concentration in water of 8×10^6 items/mL or 35.5 mg/L ranged from 7.3×10^6 items per larva to 15.8 items per pupa and 10.9 items per adult; in malaria mosquitoes, ontogenetic transfer of PS microspheres was associated with losses averaging from 3.9×10^6 items per larva to 110 items per pupa and 3 items per adult. The ontogenetic transfer of MPs by blood-sucking mosquitoes determines the potential of these amphibian insects to transport particles from the aquatic environment to land.

The study was financially supported by the Development Program of Tomsk State University (Priority-2030), Project No. 2.2.3.22 ONG.

References:

1. *Bank M.S. and Hansson S.V.* Environ. Sci. Technol. **53**, 7177–7179 (2019).
2. *Li Y., Tao L., Wang Q., Wang F., Li G., and Song M.* Environ. Health. **1**, 249–257 (2023).
3. *Zolotova N., Kosyreva A., Dzhalilova D., Fokichev N., Makarova O.* PeerJ. **10**, e13503 (2022).

О-12 ФЕРМЕНТАТИВНОЕ РАЗРУШЕНИЕ ПЭТ-СОДЕРЖАЩИХ МИКРОПЛАСТИКОВ

Осипов Д.О.[1], Рожкова А.М.[1], Зоров И.Н.[2,1], Синицын А.П.[2,1]

1 - Федеральный исследовательский центр “Фундаментальные основы биотехнологии” Российской академии наук, Москва, Россия
2 - Московский государственный университет имени М.В. Ломоносова, Москва, Россия
doosipov@gmail.com

Полиэтилентерефталат является одним из самых используемых полимеров. Не смотря на то, что он также является лидером по вторичному использованию, его микрочастицы встречаются в почве, воде, пыли жилых помещений и живых организмах. Перспективным методом удаления микрочастиц ПЭТ является их деполимеризация с помощью ферментов.
Нами был получен рекомбинантный штамм гриба *P. verruculosum*, экспрессирующий ген ПЭТазы из микробного метагенома в виде внеклеточного фермента, способного гидролизовать ПЭТ с выделением моно(2-гидроксиэтил)терефталата. В модельных экспериментах было показано, что обработка частиц ПЭТ размером 2-5 мм ПЭТазой при 60° C и pH 8 приводит к уменьшению их массы на 10% за 72 часа, обработка частиц размером 250 мкм – на 80% за 168 часов, пылевой фракции, содержащей частицы размером от 60 мкм до нескольких мм – на 30% за 72 часа. Дальнейшее совершенствование процесса может способствовать более высокой степени гидролиза микрочастиц ПЭТ.

O-13 AN APPROACH FOR OBTAINING MODEL MICROPLASTIC PARTICLES WITH VARIOUS POTENTIAL POLLUTANTS

Trofimchuk E.S.[1], Moskvina M.A.[1], Dedushenko S.K.[2], Novoskoltseva O.A.[1]

1 - M.V. Lomonosov Moscow State University, Department of Chemistry, Moscow, Russia
2 - NUST MISIS, Moscow, Russia
elena_trofimchuk@mail.ru

Microplastic pollution is currently considered as one of the most important issues that requires thorough research. The largest number of studies focus on collecting microplastic particles and determining their concentration and chemical composition. In addition to the polymer matrix, which is usually inert, microplastic particles may contain pollutants of different types. They are often chemical additives, such as plasticizers, flame retardants and dyes, which are added during the manufacturing process to give plastic products their desired properties. Additionally, once in the environment, microplastic particles, which have a large specific surface area, tend to adsorb on their surface and accumulate other environmental pollutants, such as surfactants and metal ions. Therefore, one of the important tasks is to develop methods for obtaining model systems of microplastic particles containing various fillers [1], as well as to study the processes of sorption-desorption of these potential pollutants.

Monodisperse polystyrene latex particles, whose sizes can be easily varied and controlled, are often used as a model for microplastic systems. The disadvantage of these systems is their ideal spherical shape and the possibility of contamination with emulsifiers. Other method is to break down polymer macro-samples into smaller particles using laser ablation, ultrasonication, or mechanical processing. The result is a mixture of particles with different sizes and irregular shapes, which have surface defects similar to those found in real microplastics. However, the problem of obtaining model microplastics based on a wide range of industrial polymers containing a specific low-molecular additive has not yet been solved. This work proposes an original method for obtaining these filled microplastic particles. Crazing was used to introduce additives, which could potentially be pollutants, into the polymer. This process involves the uniaxial stretching of the original polymer film in a liquid medium that contains the required additive dissolved in it. During stretching, zones of plastic deformation with a nanoscale fibrillar-porous structure, known as crazes, form in the polymer and become filled with the surrounding solution. As the tensile strain increases, the proportion of the polymer material that transforms into crazes and volumetric porosity increase. The non-volatile additive remains in a highly dispersed form in the polymer volume after the liquid medium has been removed. Then the resulting films with filler can be crushed using mechanical processing, and thereby obtain model microplastic particles based on the desired polymer and containing the required additives, including water-soluble ones.

The report shows the morphological characteristics of polylactide microplastic particles, as well as the kinetics of the release of additives, including copper nitrate, brilliant green dye, and surfactant sodium dodecylbenzene sulfonate, into the aquatic environment.

References
[1] *S. Reynaud, A. Aynard, B. Grassl, J. Gigault*. Current Opinion in Colloid & Interface Science. **57**, 101528, (2022).

O-14 CHALLENGES IN MODELING AGEING MICROPLASTIC NANOPARTICLES

Komarov P.V.[1,2], Glagolev M.K.[1,2], Malyshev M.D.[2,3], Baburkin P.O.[3]

1 - A.N. Nesmeyanov Institute of Organoelement Compounds RAS, Moscow, Russia
2 - Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia
3 - Tver State University, Tver, Russia
pv_komarov@mail.ru

Polymer materials have become widely used due to their ease of manufacture, lightweight and relatively low cost in mass production, as well as the ability to tune their properties by changing their chemical structure. Recently, in addition to the pollution problems associated with polymer waste, the issue of microplastics (particles between 5 mm and 1 micron in size) has come to the foreground. Microplastics enter the environment as a result of thermal and photochemical degradation of polymer waste. They have been found in air, water, soil, food, including fish and seafood, honey, sugar and beverages. The harmful effects of microplastics on human health are linked to their ability to accumulate in the body and cause inflammatory reactions, allergies, asthma, etc. Therefore, the problems of studying the formation, degradation of microplastic particles into smaller nanoparticles and their interaction with tissues of living organisms are urgent tasks.

At present, computer modelling has become a powerful tool for studying polymer materials. However, polymer degradation issues related to the influence of external factors such as solar irradiation, water and oxygen exposure have hardly been considered. At the same time, research using only full-atom models is not feasible today due to methodological limitations imposed by the time scale (tens of microseconds) and system size (hundreds of thousands of atoms). In this case, the use of coarse-grained modelling methods can be a compromise method that allows to study the basic mechanisms of this process while saving computational resources.

The report discusses methods for the design and implementation of computer models aimed at studying the processes of structural degradation of nanoplastic particles of various polymeric materials. An example of predictive modelling of the degradation of polyethylene and polyvinyl chloride nanoparticles using Langevin dynamics is considered.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant). All calculations are carried out using the equipment of the shared research facilities of HPC computing resources at Lomonosov Moscow State University" [1].

References

1. *Vl. Voevodin, A. Antonov, D. Nikitenko, P. Shvets, S. Sobolev, I. Sidorov, K. Stefanov, Vad. Voevodin, S. Zhumatiy.* Supercomputing Frontiers and Innovations, **6**, 4-11 (2019).

O-15 APPLICATION OF PYROLYTIC GAS CHROMATOGRAPHY WITH MASS DETECTION FOR THE ANALYSIS OF MICROPLASTICS AS A POLLUTANT IN ENVIRONMENTAL OBJECTS AND LIVING ORGANISMS

Polovyanenko D.N.[1], Nefedov A.A.[1], Sotnikova Yu.S.[1], Karpova E.V.[1], Osechkova A.E.[1], Song D.Il.[1], Ershova A.A.[2], Stefanova N.A.[3], Kolosova N.G.[3], Bagryanskaya E.G.[1]

1 - N.N. Vorozhtsov Novosibirsk Institute of Organic Chemistry of Siberian Branch of Russian Academy of Sciences, Novosibirsk, Russia
2 - Russian State Hydrometeorological University, Saint-Petersburg, Russia
3 - Institute of Cytology and Genetics, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russia
dpolo@nioch.nsc.ru

Plastics cause environmental degradation and are high on the list of environmental issues requiring regulation. Micro- and nanoplastics can adsorb other toxic compounds including pesticides, polychlorinated biphenyls, phthalates, which due to their toxicity can have adverse effects on living organisms.

There are many different analytical approaches to analyze the properties and content of microplastics, such as particle number and size, identification of polymers and additives, and degree of degradation. In contrast to spectroscopic and microscopic methods, thermoanalytical methods provide mass quantitative information and plastic type identification. Pyrolytic gas chromatography with mass detection (pyro-GC-MS) is the most promising method in the field of microplastic analysis for the identification and quantification of polymer types of microplastic particles as well as bound organic additives in plastics. It allows detection of micro- and nanoplastics below the detection limit of conventional microscopy and spectroscopy, offering low detection limits in the range of up to ng. In pyro-GC-MS analysis, the sample is thermally decomposed in an inert atmosphere before separation and analysis by mass spectrometry. Pyro-GC-MS can also be used to quantify microplastic polymer content in complex environmental and biological samples, including soil, water, and living organisms.

The paper reviews methods and approaches for the analysis of microplastics in various media and living organisms. The pyro-GC-MS method is considered as the most promising one, including the data of ASTM standard for identification and analysis of microplastic particles and fibers content in water.

Recent results of works, including those obtained in NIOCH SB RAS, devoted to the study of microplastics in water, bottom sediments, tissues and organs of living organisms on the example of experiments with laboratory rats, as well as the content of organic compounds in particles and on the surface of microplastic particles are presented.

O-16 DISTRIBUTION OF SURFACE MICROPLASTICS IN THE PACIFIC OCEAN, SEA OF OKHOTSK AND SEA OF JAPAN

Zhdanov I.[1,2], Polivanova T.[3]

1 - P.P. Shirshov Institute of Oceanology (SIO RAS), Moscow, Russia
2 - Yaroslav-the-Wise Novgorod State University (NovSU), Veliky Novgorod, Russia
3 - Lomonosov Moscow State University (MSU), Moscow, Russia
zhdanovaeroplast@gmail.com

Data on surface microplastic concentrations (0.5 - 5 mm) in the Pacific Ocean, Sea of Okhotsk and Sea of Japan were obtained. Sampling was carried out during cruise 23/4 of the R/V “Professor Multanovsky” in August 2023 using a neuston net (330 µm). A Perkin Elmer FT-IR ATR Spectrum Two spectrometer was used to identify the polymer composition of microplastic particles. More than 4000 potential microplastic particles were detected at 98 stations. The water area of the southeastern tip of the Kamchatka is insignificantly polluted with microplastics. Surface water samples are almost free of microplastic particles. At 20 % of stations microplastic was not found, the concentration varied in the range from 0 to 0.04 pieces/m3, average concentration of microplastic in the area was 0.02 pieces/m3. The southwestern part of the Kamchatka, from the side of the Sea of Okhotsk, is exposed to microplastic pollution to a greater extent. After passing the southern tip (Cape Lopatka), the number of particles found increased significantly, not less than 30 pieces per station. In addition, macro-particles of polypropylene, expanded polystyrene and fragments of fishing nets were also encountered. In the Sea of Okhotsk, 46 stations were sampled and concentrations in this region ranged from 0.1 to 3.1 particles/m3 (average concentration 0.3 particles/m3). The highest concentrations were observed in the open Sea of Okhotsk (up to 800 microplastic particles per station). The Sea of Okhotsk is an important fishing area with active shipping traffic, which in turn is a significant source of microplastics in the marine environment. Due to the peculiarities of the water area (closed region, cyclonic current system, internal anticyclonic cycles) this region is prone to accumulation of anthropogenic debris.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant).

О-17 РЕАЛЬНАЯ ВОЗМОЖНОСТЬ ОБЕСПЕЧИТЬ МЕЖДИСЦИПЛИНАРНОСТЬ В ПРАКТИЧЕСКИХ ИССЛЕДОВАНИЯХ, СВЯЗАННЫХ С ОБНАРУЖЕНИЕМ, ХАРАКТЕРИЗАЦИЕЙ И ИССЛЕДОВАНИЕМ ВЛИЯНИЯ МИКРОПЛАСТИКА НА ЗДОРОВЬЕ ЧЕЛОВЕКА И ОКРУЖАЮЩУЮ СРЕДУ

Сарьян В.К.[1], Мещеряков Р.В.[2], Босомыкин Д.В.[1]

1 - ФГБУ НИИР, Москва
2 - ИПУ РАН, Москва
saryanvk@niir.ru

Обеспечение возможности исследования междисциплинарности основано на успехах построения цифрового общества, формирования глобального связанного мира (ГСМ) основан на единой глобальной конвергентной информационно-телекоммуникационные среды (ИКС), в которой огромное и геометрически растущее число объектов взаимодействуют в режиме реального времени: человеко-машинные системы (HMS), человеко-машинные системы , машинные системы, системы искусственного интеллекта , системы Интернета вещей (IoTS). Поскольку технология IoT подразумевает, в соответствии с определением, преобразование всех подключенных к IoTS объектов в IoTS, то их информационное взаимодействие одной ИКС с другой ИКС предоставляет поистине беспрецедентные возможности ГСМ в ближайшем будущем. Это означает, что все инертные и живые объекты природы могут в принципе вступать в глобальное информационное взаимодействие, принадлежащее к одному и тому же виду или стоящее на разных стадиях развития. Таким образом, ГСМ, который можно рассматривать как глобальную сложно взаимосвязанную междисциплинарную динамическую систему, в которой функционирование любых сложных систем различного характера будет осуществляться в аналогичных условиях - в условиях локальной, глобальной и нерегуляциарной коммуникации. Изоляция исчезает, и остается универсальная доступность и объекты, которые являются частью стабильных структур и нарушают их стабильность (то есть способствуют бифуркации). Выделяя нужные для исследования объекты в любом месте Земли можно в реальном времени исследовать все задачи, поставленные перед участниками конференции.

Можно также решить и вопросы ранней (краткосрочной, среднесрочной и долгосрочной) индикации предикативных сигналов возможного катастрофического воздействия скопившегося микропластика в данной локации окружающей среды, если рассматривать МП как источник ЧС и использовать все имеющие у МЧС средства , а может быть разработать новые для предупреждения данного вида ЧС или радикального смягчения его вредных последствий.

Авторы готовы, если будет проявлен интерес, подготовить и провести эксперимент.

О-18 МИКРОБИОЛОГИЧЕСКИЙ СИНТЕЗ ПОЛИГИДРОКСИАЛКОНОАТА - ПЕРСПЕКТИВНОГО БИОРАЗЛАГАЕМОГО ПОЛИМЕРА

Шишлянников С.М.[1], Люлин С.В.[2]

1 - Санкт-Петербургский политехнический университет Петра Великого, Санкт-Петербург, Россия
2 - Новгородский государственный университет имени Ярослава Мудрого, Великий Новгород, Россия
sershilin@gmail.com

Полигидроксиалканоаты (ПГА) представляют собой семейство биоразлагаемых полиэфирных соединений, вырабатываемых многочисленными микроорганизмами. ПГА — это термопластичные или эластомерные материалы с температурой плавления от 40 до 180°C. В последние годы растет интерес к промышленному получению ПГА. Их потенциал для снижения загрязнения окружающей среды микропластиком значителен, поскольку, обладая физико-химическими свойствами, аналогичными синтетическим пластикам, ПГА разлагаются в почве и в водной среде значительно быстрее и безопаснее, что имеет решающее значение для снижения загрязнения пластиком. ПГА могут быть синтезированы бактериями при росте на различных субстратах, включая отходы сельскохозяйственных и пищевых производств. Это не только обеспечивает устойчивый процесс промышленного производства, но и способствует управлению и организацией утилизацией отходов. Интеграция биотехнологического производства с утилизацией отходов является ключевым элементом в переходе к более устойчивым и экологически чистым технологиям. Такое сочетание позволяет как эффективно перерабатывать отходы, а также получать ценные продукты, что позволяет экономить ресурсы и снизить негативное воздействие на окружающую среду.

В наших исследованиях по оптимизации получения бактериального ПГА мы сравнивали эффективность внутриклеточного синтеза полимера при росте детергент-деградирующей бактерии Pseudomonas helmanticensis P1на солях жирных кислот и глицерине как основных источников углерода. В оптимизированных условиях (48 г/л глицерина, 0,82 г/л источника азота, 0,5 г/л SDS, 96 ч культивирования) Ps. helmanticensis P1 продуцирует 0,8 г/л полигидроксиалканоатов со средней длиной алкильных заместителей мономерных звеньев (mcl-ПГА). Полученный полимер имеет средневесовую молекулярную массу 100 кДа, с узким молекулярно-массовым распределением (1,5) и включает в состав преимущественно следующие мономеры: гидроксиоктаноат, гидроксидеканоат и гидроксидодеканоат.

Применение ПГА варьируется от изготовления упаковочных материалов до биомедицинских применений, где биосовместимость полимера играет особо важное значение. Поэтому ПГА интенсивно исследуют для использования в медицинских целях, таких как системы доставки лекарств, тканевая инженерия и хирургические материалы. Полученный нами бактериальный полимер был использован в исследованиях по созданию новых полимер-липидных наночастиц. Нами было показано, что mcl-ПГА играет важную роль в стабилизации, получаемой наноэмульсии. Данные частицы могут быть использованы для доставки в различные типы тканей широкого спектра терапевтических средств. *Исследование выполнено за счет гранта Российского научного фонда (проект № 23-25-00165).*

О-20 МЕТОДЫ ИССЛЕДОВАНИЯ МИКРОПЛАСТИКА В ЛАДОЖСКОМ ОЗЕРЕ

Тихонова Д.А.[1], Поздняков Ш.Р.[2]

1 - Институт озероведения Российской академии наук – обособленное структурное подразделение ФГБУН «Санкт-Петербургский Федеральный исследовательский центр Российской академии наук», Санкт-Петербург, Россия
2 - Институт исследований континентальных водных объектов РГГМУ, Санкт-Петербург, Россия
tbgmaster@mail.ru

Микропластик в Ладожском озере исследуется Институтом озероведения РАН – СПб ФИЦ РАН с 2018 года (Иванова, Тихонова, 2022). Работы показали необходимость исследования микропластика не только в поверхностном слое водной толщи, но и на других водных горизонтах. Фильтровальная установка, разработанная в ИНОЗ РАН – СПб ФИЦ РАН (Поздняков и др., 2021) позволяет отбирать пробы с различных водных горизонтов, а также точно оценивать объем пробы. С помощью данной установки были проведены работы по исследованию как пространственного (Иванова, Тихонова, 2022), так и вертикального распределения микропластика в водной толще (Tikhonova et al., 2024). Результаты исследований показали, что повышенные концентрации микропластика наблюдаются в поверхностном слое водной толщи при плотностной стратификации озера и наличии слоя температурного скачка в отличие от более равномерного распределения частиц в условиях гомотермии.

Для отбора проб в поверхностном слое также часто используются буксируемые сети типа манта. Использование разных методов отбора затрудняет сравнение данных, полученных разными научными группами. Было проведено сравнение сети манта и фильтровальной установки как методов отбора проб воды на микропластик. Результаты показали, что концентрации микропластика выше при отборе проб фильтровальной установкой, что вероятно связано с меньшим объемом проб по сравнению с сетью манта, а также с возможными потерями частиц при отборе тралируемыми сетями. В то же время при помощи сетей можно получить более репрезентативный объем пробы и отобрать большее количество частиц микропластика, пригодных для анализа спектральными методами. Оба метода имеют различные достоинства и недостатки и дополняют друг друга.

Работа выполнена в рамках государственного задания ИНОЗ РАН – СПб ФИЦ РАН (тема FFZF-2024-0002 "Современные угрозы водным объектам и инновационные методы их сохранения, восстановления и рационального использования"). Сеть манта приобретена при поддержке Фонда поддержки молодых ученых имени Геннадия Комиссарова.

Список литературы:

1. *Иванова Е. В., Тихонова Д. А.* Оценка содержания частиц микропластика на акватории Ладожского озера. Труды КарНЦ РАН. **6**, 58-67, (2022).
2. *Поздняков Ш.Р., Каретников С.Г., Иванова Е.В., Тихонова Д.А., Лапенков А.Е., Гузева А.В.* Опыт использования фильтрационной установки для изучения вертикального распределения микропластика в водной толще. Российский журнал прикладной экологии. **4(28)**, 41-45, (2021).
3. *Tikhonova D.A., Karetnikov S.G, Ivanova E.V., Shalunova E.P.* The Vertical Distribution of Microplastics in the Water Column of Lake Ladoga. Water Resources. **51**, 146-153, (2024).

О-21 ПРОБОПОДГОТОВКА ПРИ ИСПОЛЬЗОВАНИИ МЕТОДА ПИРО-ГАЗОВОЙ ХРОМАТОГРАФИИ С МАСС-ДЕТЕКТИРОВАНИЕМ

Толстунов М.И.[1,2], Губаева И.Ш.[1], Шляпцева С.А.[2]

1 - ЮНЦ РАН, Ростов-на-Дону, Россия
2 - ЮФУ, Ростов-на-Дону, Россия
miftol@yandex.ru

Определение микропластика – это сложный и трудоемкий процесс, который включает в себя несколько ключевых этапов. На первом этапе происходит сбор образцов из окружающей среды или биологических материалов. Одной из самых трудоёмких задач остаётся концентрирование и очистка образцов от органической и неорганической матрицы. Небольшая концентрация частиц микропластика и разнообразие его состава делают процесс экспресс анализа без предварительной подготовки практически невозможным. Как известно, определение концентрации частиц микропластиков в тканях животных требует только процедуры мокрого дожигания от тканей и в редких исключениях плотностного разделения. Но в процессе осуществления мониторинга его содержания в почве, воде, воздухе требуется проведение отделения неорганических и органических остатков, путем плотностного разделения и мокрого дожигания.

Установлено, что при большой концентрации частиц (более 0,3% по массе) и после осуществления процедуры мокрого дожигания органической матрицы возможно определение качественного и количественного состава микропластиков без плотностного разделения, но при условии незначительного присутствия составляющих растений методом пиро-газовой хроматографии с масс-детектированием. Данные полученные таким образом и при проведении плотностного разделения отличаются не более, чем 10% при модельном выполнении эксперимента.

При меньших содержаниях частиц микропластика погрешность возрастает и необходимо проведение плотностного разделения для выделения частиц микропластика. Большую погрешность вносит содержание органических полимеров, содержащихся в растениях. Плотностное разделение ни мокрое дожигание не помогаеют избавится от нее и зачастую исследователи вручную отбирают частицы растений из пробы. Перспективным является проведение процесса ацилирования целлюлозы с последующим растворением продукта в спирте. Проведение данного процесса после мокрого дожигания позволяет избавиться от остатков целлюлозы и после высушивания пробу можно анализировать методом пиро-газовой хроматографии с масс-детектированием, причем не проводя процедуру плотностного разделения. Такой метод показал неплохие результаты, однако в процессе выполнения технологических операций частицы микропластика распределяются по неорганической матрице неравномерно, что может внести существенный вклад в результаты экспериментов. И для минимизации ошибки необходимо проведение последующего плотностного разделения. После проведения процедуры пробоподготовки одним из самых перспективных методов является использование пиро-газовой хроматографии с масс-детектированием, которое способно дать информацию о количественном и качественном составе пробы.

Работа выполнена в рамках научного проекта «Разработка методологии определения количественного и качественного содержания микропластика в природной поверхностной воде» и ГЗ ЮНЦ РАН (124022100017-6).

O-22 EFFECTS OF POLYDISPERSE MICROPLASTIC PARTICLES ON PROLIFERATIVE ACTIVITY IN FISH PRONEPHROS

Krysanov E.Yu., Simanovsky S.A., Ordzhonikidze K.G., Abramenko N.B., Pel'gunova L.A.

Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow, Russia
krysanov@sevin.ru

The effect of polydisperse secondary microplastics on the proliferative activity of fish pronephros cells and chromosomal aberrations in fish was evaluated. The fish pronephros is the main organ of haematopoiesis in fish (mammalian bone marrow analogue). Microplastics were prepared from nylon fabric for making tea brewing pyramids. Two fractions of microplastics were obtained in the ranges ≤ 2 μm and ≤ 8 μm. Next, fish of *Nothobranchius rachovii* species were placed in 10 L all-glass aquaria with microplastics concentration of 10 mg/L in both cases. The duration of exposure was 5 days. The fish were not fed throughout the experiment. Controllable aquarium conditions were as follows: temperature 26 ℃, light regime 14 hours day/10 hours night. There were 10 specimens of male fish aged 1.5 months in each experimental group and in control. After exposure, the fish were euthanized with MS-222 anesthetic and the pronephros was removed for analysis. Microscopic slides were prepared and mitotic index and chromosome aberrations were evaluated. The mitotic index was calculated according to the standard method ((N dividing cells/N all cells) * 100). The results showed that in fish exposed to water with microplastics (MI = 0.02±0.01 for the particles ≤ 8 μm, MI = 0.03±0.02 for particles ≤ 2 μm) the values in experimental group were lower than control values (MI = 0.05±0.02). For the particles of ≤ 8 μm range, the difference with control values was significant ($p < 0.01$). For all groups no difference in the frequencies of aberrant cells was found. A number of works performed on plants (Maity et al., 2020, Kaur et al., 2022) also showed a decrease in mitotic index in onion roots exposed to the medium with microplastic. The authors attributed the mitodepressive activity of microplastics to the inhibition of cell cycle regulators and disruption of its normal course. Our results suggest that exposure to polydisperse secondary microplastics may lead to cell cycle disturbances in fish pronephros.

References

1. Maity, S., Chatterjee, A., Guchhait, R., De, S., & Pramanick, K. (2020). Cytogenotoxic potential of a hazardous material, polystyrene microparticles on Allium cepa L. *Journal of Hazardous Materials*, (385), 121560. https://doi.org/10.1016/j.jhazmat.2019.121560
2. Kaur, M., Xu, M., & Wang, L. (2022). Cyto–Genotoxic Effect Causing Potential of Polystyrene Micro-Plastics in Terrestrial Plants. *Nanomaterials*, (12(12)). https://doi.org/10.3390/nano12122024

О-23 ОБЗОР ПУТЕЙ ПОСТУПЛЕНИЯ МИКРОПЛАСТИКА В ОРГАНИЗМ И ПОТЕНЦИАЛЬНЫХ РИСКОВ ДЛЯ ЗДОРОВЬЯ ЧЕЛОВЕКА

Краскевич Д.А.[1,2]

1 - ФГАОУ ВО Первый МГМУ им. И.М. Сеченова Минздрава России (Сеченовский Университет), Москва, Россия
2 - ФБУЗ "Центр гигиены и эпидемиологии в городе Москве", Москва, Россия
dkraskevich@gmail.com

Загрязнение микропластиком является не только экологической, но и социальной проблемой. Было проведено много исследований источников, распространенности и распространения микропластика в окружающей среде, но понимание путей поступления, уровней воздействия на человека и потенциальных рисков для здоровья остается весьма ограниченным. Люди постоянно глотают и вдыхают микропластик, что усиливает опасения по поводу рисков для здоровья от воздействия микропластика. Несмотря на распространенность загрязнения, было проведено ограниченное количество исследований воздействия микропластика на здоровье человека, и большинство исследований на сегодняшний день анализируют воздействие на модельные организмы, а вероятное воздействие на здоровье человека выводится путем экстраполяции.
Цель – обобщить и систематизировать сведения путях поступления микроплатика в организм человека и влияние на организм человека.
В обзор включены современные научные исследования из реферативных баз данных: eLIBRARY.RU, PubMed, NCBI, Web of Science, Scopus. В обзор включались статьи, опубликованные в период с 2019 по 2024 год.
Микропластик попадает в организм человека преимущественно через пищу и дыхательные пути, накапливаясь в тканях легких и желудочно-кишечного тракта. По результатам исследования накопление микропластика в тканях было обнаружено наибольшее количество частиц обнаружена в легочной ткани (14,19 ± 14,57 частиц/г), за ней следуют тонкий кишечник (9,45 ± 13,13частиц/г), толстый кишечник (7,91 ± 7,00 частиц/г) и миндалины (6,03 ± 7,37 частиц/г) [1]. Микропластик в организме человека в основном сосредоточен в размерах менее 50 мкм, а основными полимерами являются полиэтилен (ПЭ), полипропилен (ПП) и полиэтилентерефталат (ПЭТ) [2]. Самое главное, что микропластик небольшого размера может распространяться в тканях и органах через кровеносную систему [3]. Результаты лабораторных токсикологических экспериментов показали, что микропластик негативно влияет на организм человека, вызывая повреждение клеточной мембраны, иммунный стресс, нарушения в микрофлоре кишечника, изменения в энергетическом обмене и потенциальные проблемы с репродуктивной системой.
Наибольшая концентрация микропластика обнаружена в легочной ткани, а также в органах пищеварительной системы, что указывает на основные пути его поступления в организм – через дыхательные пути и с пищей и водой. Результаты исследования подчеркивают необходимость дальнейших исследований для изучения механизмов проникновения микропластика в организм, а также для оценки его долгосрочного воздействия на здоровье человека.

Список литературы

1. Zhu, L., Kang, Y., Ma, M., Wu, Z., Zhang, L., Hu, R., Xu, Q., Zhu, J., Gu, X., & An, L. (2024). Tissue accumulation of microplastics and potential health risks in human. The Science of the total environment, 915, 170004.
2. Ma, M. D., Zhao, Y. C., Zhu, L., Wang, W. P., Kang, Y. L., & An, L. H. (2024). Huan jing ke xue= Huanjing kexue, 45(1), 459–469.
3. Leslie, H. A., van Velzen, M. J. M., Brandsma, S. H., Vethaak, A. D., Garcia-Vallejo, J. J., & Lamoree, M. H. (2022). Discovery and quantification of plastic particle pollution in human blood. Environment international, 163, 107199.

O-24 NANOCELLULOSE AMONG MICROPLASTIC: BACTERIAL CELLULOSE AS A MODEL OBJECT

Vorobiov V.K.[1,2], Andreeva V.S.[1,2], Batishcheva E.V.[1,2], Sokolova M.P.[1,2], Smirnov M.A.[2]

1 - Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia
2 - Branch of Petersburg Nuclear Physics Institute named by B.P. Konstantinov of National Research Centre «Kurchatov Institute» - Institute of Macromolecular Compounds, Saint Petersburg, Russia
vrbvrbvrb@mail.ru

Micro-particles and fibers from regenerated/modified cellulose (cotton, viscose, acetylcellulose) constitute a significant portion (up to 50%) of the total amount of microplastics released into the environment [1]. Despite their biodegradability, natural cellulose can pose a threat to the biosphere as it is a non-bioresorbable polymer when present in body's tissues [2]. Microplastic particles smaller than 2 μm can penetrate animal and human cells, reducing their viability [3]. This also implies a similar possibility for nanoscale cellulose particles, which may result from the degradation of microfibers. Moreover, toxic pollutants adsorbed on the surface of nanocellulose, whose occurrence increases with worsening environmental conditions in urban areas, can also be introduced into cells. Therefore, the study of nanocelluloses is relevant due to their potential adverse impact on living organisms.

Bacterial cellulose nanofibers (CNFs) are of interest as model particles due to their chemical purity and ease of modification. We hypothesize that the behavior of CNFs in physiological solutions and their biological impact on cells can vary depending on their structure. To advance knowledge in this area, the use of a green analogue of ionic liquids – deep eutectic solvents (DES) – to disintegrate bacterial cellulose and produce CNFs of varying diameters, chemical structures, and surface morphologies is relevant. For instance, a method for obtaining CNFs with various diameter and disordering surface structure using DES based on ethylene glycol/choline chloride (ChCl) and glycerol/ChCl has been described in literature [4]. Considering that weathered microplastic isolated from seawater has a negative charge [5], it is also of interest to study CNFs with a negative surface charge.

Acknowledgements. This work was supported by Ministry of Science and Higher Education of the Russian Federation within State Contract №075-15-2024-629 (megagrant).

References:
[1] *Wang X., Wei N., Liu K., Zhu L., Li C., Zong C., Li D.* Science of The Total Environment. **849**, 157702, (2022). [2] *Mendes P.N., Rahal S.C., Pereira-Junior, O.C. M., Fabris, V.E., Lenharo S.L.R., de Lima-Neto J.F., da Cruz Landim-Alvarenga F.* Acta Veterinaria Scandinavica. **51**, 1–8, (2009). [3] *Fiore D.C., Ishikawa Y., Wright S.L.* Journal of Hazardous Materials. **464**, 132991, (2023). [4] *Batishcheva E.V., Sokolova D.N., Fedotova V.S., Sokolova M.P., Nikolaeva A.L., Vakulyuk A.Y., Smirnov M.A.* Polymers, **14(1)**, 78, (2021). [5] *Fotopoulou, K.N., Karapanagioti, H.K.* Mar. Environ. Res. **81**, 70–77, (2012).

O-25 PROCESSES OF (MICRO)PLASTICS SORTING IN THE WAVE RUN-UP ZONE

Chubarenko I.P., Esiukova E.E., Krivoshlyk P.N., Zobkov M.B., Fetisov S.V.

Shirshov Institute of Oceanology RAS, Kaliningrad, Russia
irina_chubarenko@mail.ru

The risks posed to living organisms by plastic pollution in the marine environment are alarming. However, the distribution of this new contaminant is highly variable in time and space. This makes it difficult to assess and monitor contamination levels and requires larger samples and more replicates. Our studies show that intense mixing and natural sorting of material in the wave run-up zone of sandy marine beaches in the southern and south-eastern Baltic Sea leads to a relatively stable abundance of microplastics in the size range 0.5-2 mm (S-MPs). Surveys along 1200 km of the Baltic Sea shore and measurements of MPs (0.5-5 mm) contamination over a period of 14 months at the same site confirm that the contamination of sands in the run-up zone with MPs in the size range of 0.5-2 mm is quite conservative in both space and time, and is currently of the order of 30-60 items/kg DW. No statistically significant correlation of S-MPs content with the current wind speed, significant wave height and sand characteristics (mean grain size, sorting, percentage of certain size fractions) was found. Physical reasons for this independence are discussed, such as dynamics of MPs particles in the run-up zone under the wave action and in the sheet flow, influence of sediment porosity, permeability, pore size distribution. It is concluded that natural processes are capable of effectively sorting of MPs particles in the run-up zone under wave action. As a next step, laboratory and in-situ experiments are underway, the results of which should allow the application of the conclusions to beaches with different sediments and environmental conditions.

Investigations are supported by the Russian Science Foundation, grant No. 24-17-00099.

О-26 ПРЕДОТВРАЩЕНИЕ ВОЗМОЖНОСТИ УТРАТЫ ИНТЕЛЛЕКТУАЛЬНОЙ СОБСТВЕННОСТИ ПРИ РАЗРАБОТКЕ И ВЫВОДЕ НА РЫНОК ИННОВАЦИОННЫХ ПРОДУКТОВ В ОБЛАСТИ ПОЛИМЕРНЫХ МАТЕРИАЛОВ

Тузова С.Ю., Полякова А.А., Скудро М.И., Клочкова Е.О.

Федеральный институт промышленной собственности (ФИПС), Москва, Россия
svetlana.tuzova@rupto.ru

Разработка и вывод на рынок уникального высокотехнологичного продукта вызывает повышенный интерес как у коллег, работающих в той же или смежных областях, так и конкурентов по бизнесу, заинтересованных в ускоренном выпуске собственных инновационных продуктов. Недобросовестная конкуренция в ряде случаев сопряжена с риском утери интеллектуальной собственности, охрана которой выстроена ненадлежащим образом.

В подобных условиях уже на ранних стадиях выявления перспективности разрабатываемого продукта необходимо заботится о выстраивании стратегии охраны своего технического решения, предотвращающей возможную утечку информации.

Ограничительные меры по охране технического решения вырабатываются в зависимости от стадии развития научно-технического проекта, что, прежде всего, обуславливается сущностью и техническими аспектами конкретной разработки. Так, в области полимерных материалов результатами интеллектуальной деятельности являются, как правило, не индивидуальные соединения или механизмы, а продукты, имеющие композиционный состав или многоэлементные технологии. Подобные сложные продукты (как материалы, так и технологии, включая сложное аппаратурное оформление технологических процессов) требуют комплексной всесторонней охраны разноплановых объектов, входящих в состав конечного технического решения. Так, например, охрану легковыявляемых составов ключевых полимерных материалов, вспомогательных продуктов, а также конструкцию оборудования предпочтительно оформлять с помощью нескольких взаимосвязанных патентов, а патентную охрану трудновыявляемых технологических режимов получения продуктов дополнять охраной в виде секрета производства.

Следует отметить, что надежность патентной охраны продукта прежде всего зависит от верного выбора объекта охраны и формы его охраны. Правильное описание в формуле изобретения диапазона характеристик продукта, являющихся легковыявляемыми индикаторами технологии, позволяют, при необходимости, со значительной долей достоверности идентифицировать факт нарушения прав на интеллектуальную собственность, что особенно важно в случае композиционных материалов и защиты сложных технологических процессов их получения.

Экспертами ФИПС были проанализированы и систематизированы наиболее типичные ошибки разработчиков полимерных материалов, допускаемые при составлении формулы изобретения. Также были выявлены наиболее эффективные стратегии патентования как полимерных материалов, так и сложносоставных продуктов с их использованием. Построение верной стратегии комплексного патентования как ключевых, так и переферийных продуктов позволяет использовать патентные документы не только для привлечения инвестирования в проект, но и задействовать патенты в качестве инструмента по извлечению максимальной прибыли при коммерциализации продукта путем занятия целевых рыночных ниш.

О-27 ВЗГЛЯД НА ПРОБЛЕМУ ЗАГРЯЗНЕНИЯ ФИНСКОГО ЗАЛИВА И ЮГО-ВОСТОЧНОЙ ЧАСТИ БАЛТИЙСКОГО МОРЯ ПЛАСТИКОМ И ПАРАФИНАМИ

Булдаков П.Ю.[1], Гаврило М.В.[2,3], Глазов Д.М.[4], Еремина Т.Р.[5], Есюкова Е.Е.[6], Ершова А.А.[5], Кантаков Г.А.[7], Чубаренко И.П.[6]

1 - Центр Технологических Проектов Политех, Санкт-Петербург, Россия
2 - Арктический и Антарктический НИИ, Санкт- Петербург, Россия
3 - Ассоциация «Морское наследие: исследуем и сохраним», Санкт-Петербург, Россия
4 - Институт проблем экологии и эволюции им. А.Н. Северцова РАН, Москва, Россия
5 - ПластикЛаб, РГГМУ, Санкт- Петербург, Россия
6 - Институт Океанологии им. П.П.Ширшова РАН, Москва, Россия
7 - НПО ДЭКО, Южно-Сахалинск, Россия
npodeco@gmail.com

Представлены современные результаты исследований пластиков в Балтийском море по данным собственных исследований группы авторов и по опубликованным источникам. Показано, что новые концентрации микропластика нп поверхности в юго-восточной части моря находится на уровне 10^6 шт./км^2 (без учета волокон), что выводит Балтику в один из самых загрязнённых пластиками водоемов планеты, превышая на порядки предыдущие оценки региональных исследователей. Отмечается особая роль парафинов в пластиковом загрязнении Балтики в ее юго-восточной части. Делается вывод о необходимости налаживания мониторинговых исследований микро, - макропластика путем развития существующих направлений и специализаций групп исследователей, включая внедрение новых методов наблюдений, пробоотбора, аналитической обработки и развивая полученные результаты. Авторы, основываясь на проведенных работах и опыте комплексных исследований, предлагают продолжить оценки выбранных и сложившихся мест мониторинга пластиков – юго-восточной части Балтики и Финском заливе на регулярной основе, включая и развивая как специализированные, так и экосистемные исследования, не дожидаясь координации совместных работ по линиям международных коопераций - HELCOM, ICES и др. Работы по пластикам Балтики, как пилотный проект, могут стать методически базовыми для оценки влияния пластиков на экосистемы остальных полузамкнутых и замкнутых морей – Аральского, Белого, Каспийского и Черного. Такого рода исследования придадут импульс многим разделам региональной океанографии – от дистанционных методов наблюдений, организации специализированных экспедиций по пластику, до моделирования его жизненных циклов и последствия нагрузок разных видов пластмасс на экосистемы Балтийского моря и его берегов.

О-28 АНАЛИЗ РАСПРЕДЕЛЕНИЯ МИКРОПЛАСТИКА В ДОННЫХ ОТЛОЖЕНИЯХ ОТ РЕКИ ДОН ДО АЗОВСКОГО МОРЯ

Юрасов Ю.И., Толстунов М.И., Клещенков А.В.

Федеральный исследовательский центр Южный научный центр Российской академии наук, Ростов-на-Дону, Россия
yucomp@ya.ru

Одним из направлений исследований является изучение современного седиментогенеза в Азовском море и влияния на него климатических и антропогенных факторов. Многолетние изменение температуры и солености Азовского моря, рост уровня моря и активная гидродинамика водоема обуславливает необходимость выявления влияния этих изменений на осадконакопление. Еще одним фактором является смена типов и масштабов антропогенного загрязнения донных отложений в последние десятилетия. В частности, рост пластикового загрязнения Азовского моря.

В седиментационных процессах непосредственную роль играют планктонные организмы. Микроводоросли выделяют экзоферменты, которые склеивают взвешенные частицы и способствуют их осаждению на дно. При значительном загрязнении водоема микропластиком (МП) может влиять на биогеохимические циклы. МП покрывается биопленками, потребляется зоопланктоном с дальнейшим выделением МП упакованного в экскременты.

Пластик влияет на донных детритофагов (это бактерии отвечающие за разложение отмерших остатков) и, если пластик опускается на дно, то детритофаги часто погибают, т.к. в некоторых промышленных полимерах присутствуют различные антибактериальные добавки. В результате как таковое разложение отмерших остатков биомассы организмов с каждым годом уменьшается с увеличением осаждения микропластиковых отходов, тем самым меняются геохимические процессы в придонных отложениях, что в свою очередь влияет на бактериальное сообщество.

При разложении органического вещества происходит выделение углекислого газа и метана, которые являются климатически активными веществами. Соответственно увеличение отмирания детритофагов за счет роста поступления микропластика в море может влиять на выделение парниковых газов. Поэтому изучение механизмов взаимодействия микропластика на седиментационные процессы может позволить улучшить понимание его антропогенного воздействия на экосистему.

Для понимания распределения микропластика в донных отложений проведен ряд отбора проб в 2024 г. на научных судах ЮНЦ РАН НИС «Профессор Панов» и «Денеб». Экспедиционные работы проводились в реке Дон и в Азовском море. Пробы отбирались дночерпателем Ван-Винна с площадью захвата 0,1 м^2 на глубину 0,2 м. Всего было отобрано 20 проб донных отложений.

Исследования донных отложений были проведены различными методами анализ размера и разновидность частиц донных отложений проводились лазерном анализаторе микрочастиц «ЛАСКА-ТД», количественное распределение МП осуществлялось при помощи пиролизной газовой хроматографии с масс-спектрометрией (пиролизная ГХ–МС, PyrGC–MS).

Работа выполнена при финансовой поддержке Минобрнауки России (Соглашение .N'!! 075-15-2024-528 от 24.04.2024 г. на реализацию КИП по приоритетным направлениям научно-технологического развития)».

O-29 EXPLORING ARCTIC MARINE MICROPLASTICS: IR SPECTRAL DATABASE ANALYSIS USING MACHINE LEARNING METHODS

Volgin I.V.[1,2], Zhdanov I.A.[1,3], Lyulin S.[1,2]

1 - Yaroslav-the-Wise Novgorod State University (NovSU), Veliky Novgorod, Russia
2 - Institute of Macromolecular Compounds, Russian Academy of Sciences (IMC RAS), St. Petersburg, Russia
3 - Shirshov Institute of Oceanology, Russian Academy of Sciences (IO RAS), Moscow, Russia
i.v.volgin@gmail.com

Microplastic pollution in marine environments is increasingly recognized as a critical issue in contemporary environmental science. Addressing this challenge demands an in-depth analysis of microplastic samples, particularly focusing on their chemical composition across diverse marine regions. Traditionally, such analyses are conducted using various spectral techniques, which are time-consuming. Recently, machine learning (ML) has become a transformative tool to mitigate this time constraint, enabling more efficient investigations. Nonetheless, the development of ML models hinges on the manual compilation of a comprehensive database of polymer samples. Currently, there exists only a limited number of publicly accessible polymer datasets containing spectra of authentic environmental polymers. These datasets are typically utilized during the model development and testing phases, leaving the matter of ultimate model validation for future research. In this study, we tackle this issue by analyzing a novel database comprising over 1500 microplastic particles sourced from the seas of the East Siberian Arctic, collected during expeditions from 2019 to 2023. These microplastic particles were harvested from the sea surface layers using a neuston net with mesh sizes from 5 mm to 0.5 mm, and subsequently analyzed with a Perkin Elmer FT-IR ATR Spectrum Two in four-time scanning mode, without prior mineral/organic purification of the samples. This database is used to evaluate the classification accuracy of existing ML models for microplastic identification. Additionally, we examine the diversity of this database in comparison with other available open-source microplastic IR spectra datasets.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant).

О-30 ОПРЕДЕЛЕНИЕ ПРИМЕСНОГО СОСТАВА ПОЛИЭТИЛЕНТЕРЕФТАЛАТА, ПЕНОПОЛИСТИРОЛА И ПОЛИПРОПИЛЕНА МЕТОДОМ АТОМНО-ЭМИССИОННОЙ СПЕКТРОМЕТРИИ

Гусельникова Т.Я., Орлов Н.А., Цыганкова А.Р.

Институт Неорганической химии СО РАН, Новосибирск, Россия
gtya18@gmail.com

Микропластики имеют физические и химические характеристики (размер, наличие пор и отношение площади поверхности к объему), которые способствуют сорбированию химических веществ, в том числе тяжелых металлов [1]. Накопление различных загрязняющих веществ значительно увеличивает токсичность микропластиков. Накопление тяжелых металлов в микропластиках может усугубить локальное загрязнение тяжелыми металлами биосферы, гидросферы, почвы и атмосферы. Таким образом, определение элементного состава пластиков является одной из важнейших проблем аналитической химии. Для решения этой задачи первостепенным фактором является создание многоэлементных методик количественного анализа. Поэтому целью работы было разработка методики анализа пластиков полиэтилентерефталата (ПЭТ), пенополистирола (ПС) и полипропилена (ПП) методом атомно-эмиссионной спектрометрии с индуктивно-связанной плазмой (АЭС ИСП). В работе исследовали растворение пластиков в смесях различных неорганических кислот при нагревании не выше 90°С. На примере ПП изучили воздействие следующих смесей: HNO_3:HCl (1:3); HNO_3:H_2O_2 (5:1); HNO_3:$HClO_4$ (2:1); HNO_3:H_2SO_4 (10:1). Использование HNO_3:H_2SO_4 (10:1) приводит к полному растворению навески ПП. Эта смесь кислот также оказалась подходящей для ПС и ПЭТ. Таким образом, предложен простой способ подготовки пластиков, наиболее распространенных в использовании. Изучили матричное влияние ПЭТ, ПП, ПС на аналитические сигналы (АС) примесных элементов в присутствии пластиков (400-2800 мкг/мл). Присутствие до 2800 мкг/мл пластиков не оказывает существенного влияния на АС более чем 50 элементов. Однако, депрессирующее влияние на АС элементов оказывает смесь кислот. Обнаружено снижение аналитических сигналов Ag, Al, Au, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Ga, Hg, In, Mg, Mn, Mo, Ni, Pb, Rb, Re, Sb, Si, Sn, Sr, Tb, Ti, V, W и Zr на ~15%. Присутствующие в растворах пластики не влияют на условия возбуждения. Оценку проводили с помощью комплексного параметра – показателя жесткости ИСП (отношение интенсивности ионной линии магния 280.270 нм к атомной 285.213 нм). Для коррекции АС элементов применили метод внутреннего стандарта. Пределы обнаружения 56 элементов находятся в диапазоне концентраций от $n \cdot 10^{-3}$ до $n \cdot 10^{-6}$ % мас. Правильность разработанной методики анализа подтвердили экспериментом введено-найдено. Проведен анализ образцов ПП и ПС по разработанной методике. В образцах ПП обнаружены: Al, Ba, Ca, Co, Cu, Fe, K, Mg, Mn, Na, P, Si, Sn, Sr, Ti, Zn и Zr. В образцах ПС обнаружены Al, Ca, Cr, Cu, Fe, K, Li, Mg, Mn, Na, P, Si, Sr, Ti и Zn. *Работа поддержана Российским научным фондом, проект № 24-23-00105, https://rscf.ru/en/project/24-23-00105/*.

Список литературы

1. *Brennecke D., Duarte B., Paiva F.,* Cacador I., Canning-Clode J. Estuarine Coastal and Shelf Science, **V. 178**, Microplastics as vector for heavy metal contamination from the marine environment, (2016).

O-31 ГЕНЕТИЧЕСКАЯ ИДЕНТИФИКАЦИЯ МИКРОПЛАСТИКА В ГОРОДСКОЙ ПЫЛИ

Хаустов А.П., Редина М.М., Горяинов С.В., Нартов А.С., Васильев В.Г., Нечаева П.Ю.

ФГАОУ ВО "Российский университет дружбы народов имени Патриса Лумумбы", Москва, Россия
akhaustov@yandex.ru

Один из основных источников микропластика в городской среде – «дорожная пыль». Это продукты транспортной активности, прежде всего, истирание материала протекторов, шин, самого дорожного полотна.

В 2018-2024 гг. нами были отобраны пробы атмосферного воздуха (многократные замеры твердых частиц на 33 точках на территории кампуса Российского университета дружбы народов) и проведен анализ состояния снегового покрова (г. Москва, площадь 114 га), а также дорожной пыли с целью оценки влияния транспорта на территорию и верификации расчетных методик анализа транспортной нагрузки. Роль транспорта как источника поступления в атмосферу пылевых частиц (включая наиболее опасные, PM10 и PM2,5) была подтверждена расчетами и экспериментальными данными. Выявлено постоянное присутствие в приземном слое атмосферы 20 г частиц PM2.5 и 36 г частиц PM10. [3]. Такие частицы опасны как сами по себе (вероятность поступления в организм), так и за счет их роли в переносе токсичных соединений, ассоциирующихся с их поверхностью и в формировании аэрозолей.

Загрязнение атмосферы городов, в том числе и микропластиком зависит от многих факторов. Отсюда проблема четкой идентификации источников поступления микрочастиц с применением современных методов анализа (ГХ/МС, ИК-Фурье спектроскопия и др.) [1]. По данным зарубежных исследований основной вид микропластика, поступающего в атмосферу за счет деградации шин и протекторов – нейлон. В этой связи важны специальные оценки генезиса совокупности частиц микропластика в атмосфере города на основе индикаторных соотношений полиаренов [2]. В ходе эксперимента в составе твердого осадка снеготаяния и дорожной пыли нами были идентифицированы маркерные соединения (полициклические ароматические углеводороды, ПАУ), по соотношениям которых был определен генезис твердых частиц.

Подавляющее большинство проб демонстрируют пирогенное происхождение частиц. Это позволяет однозначно сделать вывод о том, что присутствующие в составе дорожной пыли микрочастицы пластика переносят на себе ПАУ, преимущественно образовавшиеся в результате процессов высокотемпературного сгорания топлив (более 300^{o}C). Таким образом, загрязнение представляет собой комплексы токсичных соединений, влияние которых на организм сочетает токсическое действие с механическими повреждениями за счет контакта живых тканей с частицами микропластика. Процессы «связывания» (сорбции) ПАУ на поверхности частиц микропластика различного происхождения и состава – предмет дальнейшего анализа. В частности, актуальным направлением представляется разработка специальных индикаторных соотношений ПАУ, способных взаимодействовать с микропластиками различного состава и формы, а также поиск новых более стойких материалов для изготовления шин и средств обработки дорожного полотна для снижения пылеобразования.

Список литературы

1. *Франк Ю.А., Воробьев Е.Д., Рахматуллина С.Н. и др.2022.* Экология и промышленность России/ 26(9), 67-71, 2022.
2. *Хаустов А.П., Редина М.М.* Геохимия. **1**, 57–67, 2017.
3. *Хаустов А.П., Редина М.М.* Транспортное строительство. **1**, 29–32, 2024.

O-32 EFFECT OF NANOPLASTICS ON CELL SURVIVAL IN HUMAN EMBRYONIC LUNG FIBROBLASTS

Proskurnina E.V.[1], Kostyuk S.V.[1], Savinova E.A.[1], Ershova E.S.[1], Kameneva L.V.[1], Veiko N.N.[1], Proskurnin M.A.[2], Yaroslavov A.A.[2], Shevchenko N.N.[3], Ivanov V.K.[4]

1 - Research Centre for Medical Genetics, Moscow, Russia
2 - Department of Chemistry, Lomonosov Moscow State University, Moscow, Russia
3 - Institute of Macromolecular Compounds of the Russian Academy of Sciences, Moscow, Russia
4 - Kurnakov Institute of General and Inorganic Chemistry of the Russian Academy of Sciences, Moscow, Russia
proskurnina@gmail.com

A large-scale production of plastics leads to wide environmental pollution with micro- and nanoplastics that necessitates research of its effects on humans and animals. Nanoplastics enters the body mainly through the gastrointestinal tract, as well as through inhalation. Biochemical effects of nanoplastics include oxidative stress, inflammation, immune dysfunction, neurotoxicity, neoplastic processes, metabolic and energy disorders. Currently, there are no regulatory documents regarding nanoplastics, which is due to the lack of analytical methods for quantitation, as well as insufficient knowledge about its effect on living systems. The toxicity of nanoplastics depends on the chemical composition, the presence of plasticizers, particle size, concentration, surface charge, and on the cell type.
Here, we aimed to study the survival of human embryonic lung fibroblasts using a standard test with methyl tetrazolium (MTT test) for nanoplastics of various chemical composition (polystyrene and polymethyl methacrylate), size (from 65 to 150 nm), the presence of an adsorbed substance (fuchsin) and purification (dialysis).
Human embryonic lung fibroblasts of the 4th passage from the collection of cell cultures of the Research Centre for Medical Genetics were used to study the toxicity of the compounds. The cells were incubated with nanoplastics samples for 24 hours. The maximum concentration value at which 80% of the cell population was preserved (IC_{20}) was determined. Particles based on a copolymer of styrene with sodium styrene sulfonate and particles based on polymethyl methacrylate were used as objects of study. The synthesis was carried out in the absence of surfactants.
Results. 1) For polystyrene nanospheres with sizes of 65, 80 and 150 nm, IC_{20} was 28, 1.5, and 28 ppm, respectively; thus, the greatest toxicity is characteristic of nanoparticles with a size of 80 nm. 2) For polymethyl methacrylate nanospheres with sizes of 70 and 90 nm, IC_{20} was 0.08 and 532 ppm, respectively; thus, the greatest toxicity is characteristic of nanoparticles with a size of 70 nm. 3) For polystyrene nanoparticles with a size of 150–200 nm, purification by dialysis did not have a significant effect on cell survival. 4) Surface functionalization with fuchsin significantly increases cell survival for polymethyl methacrylate; IC_{20} values were 532 ppm for 70 nm nanoparticles and over 2300 ppm for 90 nm nanoparticles. For polystyrene and polymethyl methacrylate, the greatest toxicity is associated with the size of 70–80 nm. Outside the Goldilocks zone, dialysis does not have a significant effect on survival. Surface functionalization with fuchsin greatly increases cell survival. The results obtained are the basis for further experiments to study the effects of nanoplastics on human genes.

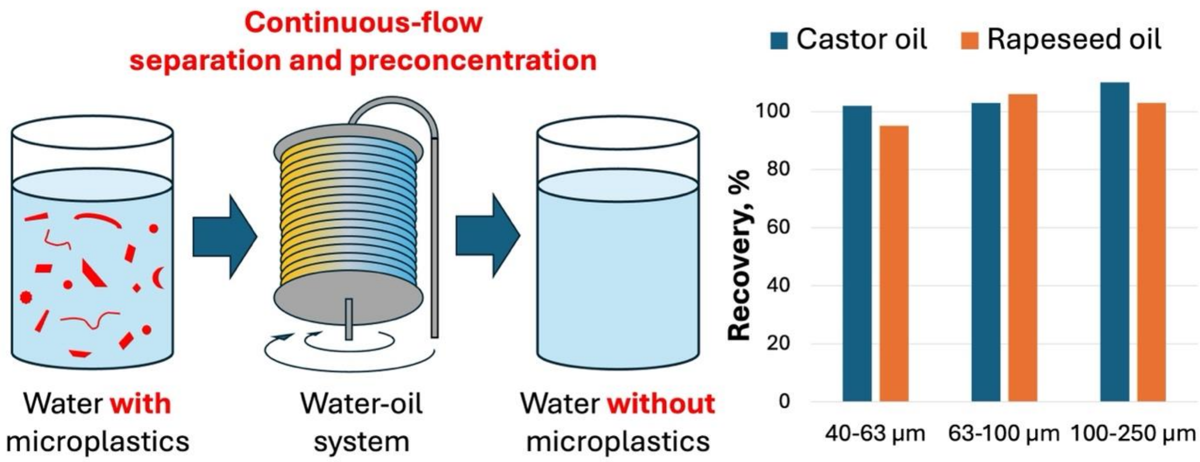
References
A. Banerjee, W.L. Shelver Sci Total Environ **755** 142518 (2021).

O-33 WATER-OIL SYSTEMS FOR CONTINUOUS-FLOW SEPARATION AND PRECONCENTRATION OF MICROPLASTICS FROM NATURAL WATERS

Ermolin M.S., Savonina E.Yu., Ivaneev A.I., Maryutina T.A., Fedotov P.S.

Vernadsky Institute of Geochemistry and Analytical Chemistry of the Russian Academy of Sciences, Moscow, Russia
ermolin@geokhi.ru

Aquatic ecosystems are the main sink for microplastics entering the environment. Estimation of the content of microplastics in natural waters is necessary for the assessment of pollution of water bodies and potential risks for their inhabitants. As a rule, the content of microplastics in natural waters is low, so the development of new efficient particle separation methods that allow one to selectively separate and preconcentrate microplastics from natural waters is an urgent task. The present study is aimed at the development of a new method of separation and preconcentration of microplastics from natural waters in a rotating coiled column (RCC) using two-phase water-oil systems. The retention parameters of systems based on vegetable (castor, tung, linseed, soybean, sunflower, sesame, rapeseed, olive, turpentine, limonene) and synthetic (Vaseline and engine) oils in RCC are determined and the applicability of these systems for separation of microplastics from water samples is assessed. The effect of RCC rotation speed and mobile phase flow rate on the retention of the oil phase in the column is studied. By the example of microparticles of polyethylene, polypropylene, polystyrene, polyvinylchloride, and polyethylene terephthalate of different sizes (40–63, 63–100, and 100–250 μm), the high efficiency of microplastics separation (about 100%) in RCC using water-oil systems is shown. It is found that the efficiency of separation does not depend on the salinity of water samples, so the proposed method can be used for separation of microplastics from both fresh and sea waters. The developed method of separation and preconcentration of microplastics is promising for treatment of wastewater from microplastics.



The work was carried out with the financial support of the Russian Science Foundation, project 23-13-00263.

O-34 EFFICIENT CONSTRUCTION OF STABILITY DIAGRAMS OF AGED POLYMER NANOPARTICLES

Glagolev M.[1,2], Komarov P.[1,2,3]

1 - Yaroslav-the-Wise Novgorod State University, Novgorod, Russia
2 - Institute of Organoelement Compounds RAS, Moscow, Russia
3 - Tver State University, Tver, Russia
mikhail.glagolev@gmail.com

Computer simulations can be an efficient tool for studying the degradation of microplastics in the environment. In our report, we discuss the first results of determining the diagrams of stability of polymer nanoparticles depending on different factors, such as the degree of chain scission and the monomer unit composition. Variation in the type of monomers in polymer chains is used to simulate the rate of the degradation of nanoparticles under the influence of ultraviolet light, oxygen, and temperature. Under a coarse-grained approach, the diagrams of stability are built using Langevin dynamics or dissipative particle dynamics simulations and can then be cross-checked with all-atom simulations. This validation will allow us to predict the stability of the polymer nanoparticles on the spatial and temporal scales inaccessible to all-atom molecular dynamics simulations.
Although the coarse-grained simulation techniques offer high performance, the construction of the diagrams depending on multiple parameters using grid search or random search approaches is prohibitively complex. Here we apply the deep learning methods to determine the boundaries between the different states using fewer simulations. This is achieved by ranking the points in the parameters space by a certainty of different simulation outcomes and conducting simulations where the result is least certain. The proposed method can be scaled to run in parallel and can serve as an automated alternative to expert selection of the simulation parameters in frameworks of molecular dynamics simulations.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant). The calculations were carried out using the equipment of the shared research facilities of HPC computing resources at Lomonosov Moscow State University" [1].

List of references

1. *Vl. Voevodin, A. Antonov, D. Nikitenko, P. Shvets, S. Sobolev, I. Sidorov, K. Stefanov, Vad. Voevodin, S. Zhumatiy.* Supercomputing Frontiers and Innovations, **6**, 4-11 (2019).

P.1-01 CELLULOSE PARTICLES AS A MODEL OF BIODEGRADABLE MICROPLASTICS

Badikova A.G.[1,2], Skrybykina M.R.[1], Grokhovskaya T.E.[1], Efimova A.A.[1,2], Yaroslavov A.A.[1,2]

1 - M.V. Lomonosov Moscow State University, Department of Chemistry, Moscow, Russia
2 - Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia
badikovaag@my.msu.ru

The accumulation of microplastics (MP) in the environment is a topical issue. Despite the increasing interest of scientists in this field, there is still insufficient information on the effects of MP on biological organisms. When external factors initiate decomposition of polymers, the particles of various sizes and shapes, which are able to adsorb and transport toxic substances, are produced. The potentially harmful effects of MP are associated with these processes. It is known that these days intensive efforts are in progress to develop new materials using biodegradable polymers that undergo rapid degradation under the influence of environmental factors. In this case, particles classified as MP appear in the environment quickly. Adsorption of various substances on these biodegradable particles can significantly change the rate of polymer decomposition. Research on the biodegradation processes of such «decorated» particles is currently negligible. Therefore, it is important to find model systems of biodegradable MP with the appropriate composition, size and morphology, investigate the physicochemical aspects of the interaction of these particles with various adsorbates and study the effect of adsorbed substances on the rate of biodegradation.
Crystalline cellulose particles were used as a model of biodegradable MP. It has been shown that the average hydrodynamic diameter of these particles is in the range from 300 to 800 nm and they are stable for a month in a water-salt media. The concentration of negatively charged groups on the particle surface was estimated. The cellulose particles were modified with a cationic polymer, caustamine, which is used for wastewater treatment. The composition of the resulting complexes and their ability to dissociate into the initial components in water-salt media under various conditions (temperature, salt concentration) were studied. The effect of caustamine on the rate of biodegradation of particles under the action of enzymes has been studied.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant).

P.1-02 ПЕРСПЕКТИВЫ ИСПОЛЬЗОВАНИЯ ВИДА ORYCTOLAGUS CUNICULUS В КАЧЕСТВЕ БИОЛОГИЧЕСКОЙ МОДЕЛИ ДЛЯ ОЦЕНКИ ВОЗДЕЙСТВИЯ МИКРОПЛАСТИКА НА ВОСПРОИЗВОДСТВО ЖИВОТНЫХ

Кореневский А.В.[1,2], Блаженко А.А.[1,2], Пачулия О.В.[1,2], Постникова Т.Б.[1,2], Михель А.В.[1,2]

1 - ФГБОУ ВО «Новгородский государственный университет имени Ярослава Мудрого», Великий Новгород, Россия
2 - ФГБНУ «Научно-исследовательский институт акушерства, гинекологии и репродуктологии имени Д.О. Отта» Санкт-Петербург, Россия
alexandrablazhenko@gmail.com

Загрязнение окружающей среды пластиком – одна из главных проблем человечества в этом столетии. Интенсивное производство и использование пластмасс, наряду с неэффективной утилизацией отходов, привело к беспорядочному выбросу миллиардов тонн пластиковых частиц в окружающую среду. Микропластик обнаруживается в ряде продуктов питания человека, таких как питьевая вода, молоко, безалкогольные напитки, консервы, сахар, соль и так далее.

Исследования на животных показали, что микропластик размером всего 150 мкм может проникать через клеточную мембрану в органы, создавая угрозу для здоровья, включая окислительный стресс, воспалительные эффекты, различные нарушения обмена веществ и дефекты потомства. Несколько исследований клеточных линий человека показали, что воздействие микропластика вызывает воспалительные реакции, подавляет рост клеток, изменяет морфологию клеток и вызывает изменения в микробиоте кишечника. В настоящее время комплексная оценка воздействия с помощью исследований биомониторинга становится все более важной задачей, позволяющей лучше понять степень внутреннего воздействия микропластика на человека и оценить его реальную концентрацию и последствия его присутствия. Это вызвало новый интерес к исследованиям, направленным на определение содержания микропластика в организме человека.

По данных литературы, частицы микропластика выявляются в плаценте, что указывает на то, что микропластик передается от матери к нерожденному плоду и представляет опасность для новорожденных.

Исследования, проведенные на грызунах, показали, что микро- и нанопластики способны разрушать кишечный барьер, накапливаться в различных органах, вызывать дисбактериоз кишечника, снижать секрецию слизи, вызывать метаболические изменения и нейротоксичность, а также другие патофизиологические эффекты. Более крупные млекопитающие, такие как кролики (Oryctolagus cuniculus), также могут поглощать микропластик при пероральном приеме. Oryctolagus cuniculus является ценной биологической моделью в медицине, предлагая многообещающие возможности для изучения воздействия микропластика на этот модельный организм. Кроме того, мы предполагаем, что Oryctolagus cuniculus представляет собой выгодную и высокоэффективную модельную систему для оценки воздействия пластиковых частиц на воспроизводство животных, использующую конечные точки репродуктивного поведения и клеточные показатели в качестве ключевых. Эта модель позволяет провести всесторонний анализ влияния микропластика на развитие плаценты и плода у животных, а также биохимическое подтверждение этих эффектов.

Ожидается, что это исследование позволит определить смертельную дозу, связанную с пероральным введением микропластика, а также выяснить уровни концентрации этого вещества в исследуемых плацентах и плодах.

Данное исследование выполнено при поддержке Министерства науки и высшего образования Российской Федерации (государственный контракт № 075-15-2024-629, МегаГрант).

P.1-03 AN INVESTIGATION OF THE INTERACTIONS BETWEEN MICROPLASTICS AND ANTIBIOTICS USING ALL-ATOM MOLECULAR DYNAMICS SIMULATION

Nazarychev V.[1,2]

1 - Yaroslav-the-Wise Novgorod State Universit, Veliky Novgorod, Russia
2 - Branch of Petersburg Nuclear Physics Institute named by B.P. Konstantinov of National Research Centre «Kurchatov Institute» - Institute of Macromolecular Compounds, St. Petersburg, Russia
nazarychev@imc.macro.ru

The investigation of antibiotic adsorption on microplastics (MP)s is important because of the associated environmental and health problems. The presence of microplastics poses a risk because they can transport other pollutants, including antibiotics. These interactions can lead to complex effects and affect antibiotic toxicity. The adsorption of antibiotics onto microplastics can lead to the development and spread of antibiotic-resistant bacteria. The consumption of water and food contaminated with microplastics can adversely affect human health. Therefore, studying the adsorption of antibiotics in MPs is important to understand and reduce their environmental and health impacts. Molecular simulations play a key role in unraveling the molecular mechanisms of these interactions, providing information that can be used for both experimental studies and environmental decision-making to address MPs and antibiotic contamination.

In this study, all-atom computer simulations were employed to investigate the surface interactions between three of the most prevalent microplastic molecules in the aqueous environment—polyethylene terephthalate (PET), polystyrene (PS), and nylon 6 (NYL6)—and five antibiotic molecules (amoxicillin (AMO), ciprofloxacin (CIP), doxorubicin (DOX), sulfadiazine (SUL), and tetracycline (TET)). The study explored the interactions between antibiotic molecules with different chemical structures and the surface of microplastics in an aqueous environment at room temperature (298 K). The interaction energy between the surfaces of the antibiotics was strongly dependent on the type of microplastics and the chemical structure of the antibiotics. The adsorption of antibiotic molecules onto the surface of microplastics is determined by the strength of their electrostatic and van der Waals interactions.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant). Computer simulations were performed using the computational resources of the Branch of Petersburg Nuclear Physics Institute named by B.P. Konstantinov of National Research Centre «Kurchatov Institute» - Institute of Macromolecular Compounds, the equipment of the shared research facilities of HPC computing resources at Lomonosov Moscow State University, the resources of the Federal collective usage center "Complex for Simulation and Data Processing for Mega-science Facilities" at the NRC "Kurchatov Institute" (http://ckp.nrcki.ru/), and supercomputers at the Joint Supercomputer Center of the Russian Academy of Sciences (JSCC RAS).

P.1-04 SELF-CONSISTENT FIELD MODELING OF MICROPLASTICS PARTICLE FORMATION

Toshchevikov V.P.[1,2], Mercurieva A.A.[1,2], Ivanova A.S.[1,2], Polotsky A.A.[1,2]

1 - Branch of Petersburg Nuclear Physics Institute named by B.P. Konstantinov of the National Research Centre «Kurchatov Institute» – Institute of Macromolecular Compounds, Saint Petersburg, Russia
2 - Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia
tvp75@mail.ru

Microplastics (MP) particles have a high ability to adsorb low- and high-molecular pollutants on their surface, which increases the potential hazard of MP to human health. The peculiarity of adsorption onto MP particles is that its surface is not an ideal sharp solid-liquid interface, but has a “fringe” of finite thickness. It is known that increasing the range of the adsorption potential significantly facilitates adsorption. For example, for the case of a flat surface, the critical adsorption energy of a polymer chain U_c depends on the width of the adsorption potential W as $U_c \sim 1/(W + 1/2)^{-5/3}$and $U_c \sim 1/(W + 1/2)^{-2}$ a good and □–solvent, respectively [1].
One of the most efficient approaches for theoretical study of polymer adsorption is the Scheutjens-Fleer self-consistent field (SF-SCF) method [2]. The present work is devoted to the development of a protocol for model MP particles formation for further study of polymer adsorption on these particles by using the SF-SCF method. We study formation of model microplastic particles by homopolymer macromolecules in a thermodynamically poor solvent. Under such conditions, the chains collapse, forming microparticles of a spherical shape, with a constant polymer density inside the particle and a “fringe” on its periphery. Two ways of particle formation are considered: from a solution of linear macromolecules and via the collapse of a single multi-arm polymer star with long arms. We show how to control the particle size and the thickness of the “fringe” by varying the length of the chains, the number of chains in the “simulation box” and the solvent quality.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant).

References
[1] *Klushin L. I., Polotsky A. A., Hsu H.-P., Markelov D. A., Binder K. Skvortsov A. M.* Phys. Rev. E. **87**, 022604 (2013).
[2] *Fleer G. J., Cohen Stuart M. A.. Scheutjens J. M. H. M., Cosgrove T., Vincent B*. Polymers at Interfaces. London, Chapman and Hall, 1993.

P.1-05 MIGRATION OF CATIONIC POLYMER BETWEEN MODEL MICROPLASTIC PARTICLES

Yuzhanin K.I.[1,2], Panova I.G.[1,2], Yaroslavov A.A.[1,2]

1 - M.V. Lomonosov Moscow State University, Department of Chemistry, Moscow, Russia
2 - Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia
0073158@mail.ru

Recently, the problem of microplastics (MP) – polymer particles 5 mm in size or less which are formed during the degradation of plastic waste, has become urgent. Particularly dangerous are particles of submicron size (< 1 micron), which can penetrate the biological membranes and cause various negative consequences.
In addition to the original MP particles, MP complexes with toxic substances, which include heavy metals, dyes, persistent organic pollutants and polymers with cationic groups (polycations), can be potentially dangerous. The latter are actively used in water purification processes. MP particles with adsorbed polycations can spread over long distances with surface and ground waters. The redistribution of cationic macromolecules between different MP particles increases the number of particles with potentially toxic effects.
In the work, the adsorption of cationic polymers on the surface of anionic latex particles modelling real MP particles has been studied. The size (diameter) of latex particles was of 400 nm, their negative charge was due to the surface carboxylic groups. All polymers used were bound quantitatively to the latex particle surface. The binding was accompanied by neutralization of the latex particle charge and aggregation of the resulting complex; the largest aggregates was formed at a complete neutralization of the particle charge by the adsorbed polycation.
Reducing the concentration of both components and the molecular weight of the polymer maintained the efficiency of polymer binding to particles and did not lead to particle aggregation. Under these conditions, adsorbed macromolecules were able to migrate between individual latex particles, resulting in a uniform distribution of the polymer between all particles in the system. The results obtained indicate that the migration of adsorbed polymer between particles should be taken into account when discussing the spread of toxic substances.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant).

P.1-06 INTERACTION OF POLLUTANTS WITH MICROPLASTICS IN WATER: ATOMISTIC MOLECULAR DYNAMICS SIMULATIONS

Forer V.D., Topalo A.S., Denisova N.V., Lyulin S.V.

Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia
iosif10.10@mail.ru

The adsorption of pollutants onto the surfaces of micro- and nanoplastics particles in the environment, their bioavailability, and the potential for subsequent release are currently considered as one of the major health risks associated with microplastics. [1] Most polymer particles are chemically inert and, as a result of adsorption, bind pollutants through weak van der Waals forces. [2] Since the energy corresponding to the physical adsorption of pollutants on microplastics typically does not exceed 10 kJ/mol [3], in the absence of other types of interactions, the estimated time of small pollutant molecules in the adsorbed state can be very short, around ~2.5 ÷ 25 ps [4]. Such short timescales and resource-intensive experimental physicochemical methods for analyzing nanoscale systems necessitate the use of computer simulations using molecular dynamics with full-atom models to investigate the adsorption of small pollutant molecules on micro- and nanoplastics particles.

This work involved microsecond simulations of nanoplastic particles and flat microplastic surfaces (the last represent part of the microplastics) of common polymer types (such as polyethylene (PE), isotactic polypropylene (iPP), atactic polystyrene (aPS), atactic polyvinyl chloride (aPVC), and polylactide (L-PLA)) with different pollutants (i.e., pesticides: cypermethrin, its two metabolites, DDT, PCB-169, as well as some polyaromatic hydrocarbons: anthracene, pyrene, and psoralen). The adsorption process was simulated in water at a temperature of 25°C and a pressure of 1 atm. Based on the obtained microsecond trajectories, the potential energies of interaction of the pollutant with both the polymer and water were calculated.

The calculation of the difference in potential energy between the interaction of the pollutant with the polymer and the pollutant with water indicates that in the polymer series PLA>PS>PVC>PE>PP, the binding energy of the pollutant molecules to the adsorbent decreases. The same order is observed for the three flat microplastic surfaces considered (PS>PVC>PP). Anthracene, pyrene, DDT, and PCB-169 molecules diffused into the bulk of the polymer surfaces most often, while psoralen molecules and cypermethrin metabolites were able to easier desorb from the adsorbent into solution.

References
[1] *Thompson, R. C., Courtene-Jones, W., Boucher, J., Pahl, S., Raubenheimer, K., & Koelmans, A. A.,* Science, **eadl2746**, (2024).
[2] *Tourinho, P. S., Kočí, V., Loureiro, S., & van Gestel, C. A.* Environmental Pollution, **252**, 1246-1256. (2019).
[3] *Gong, W., Jiang, M., Han, P., Liang, G., Zhang, T., & Liu, G.* Environmental Pollution, **254**, 112927, (2019).
[4] *Frenkel, J.* Zeitschrift für Physik, **26(1)**, 117-138, (1924).

P.2-01 THE STUDY OF MICROPLASTICS IN THE RESERVOIRS OF THE FERGHANA VALLEY

Khusanov A.K., Abduvalieva M.A., Nizomov J.B., Yaxyoyev A.

Andijan State University, Andijan, Uzbekistan
abduvalievaholishon0@gmail.com

Nowadays, air pollution is becoming a global problem all over the world. There is a lot of research being done on this way to prevent these problems. The most concerning of these is the problem of plastic and its constituent particles. Plastics have been mass produced and widely used since the mid-20th century. Improper disposal and subsequent fragmentation of plastic waste contributes to the formation of microplastics (MPs) <5 mm in size and, consequently, global environmental pollution.

Due to their physicochemical properties and small sizes, MPs are prone to transport to different parts of the Earth and circulate in soils, the hydrosphere, the atmosphere and the biosphere. MPs can persist in nature for a long time (20–500 years) due to the extremely low rate of decomposition. Quantitative analysis of MP pollution in rivers and flowing lakes in external runoff zones is especially important, since these plastic polymers pose a major global threat and, moreover, rivers play a decisive role in the transfer of terrestrial MPs into the aquatic environment. The content and circulation of MP in watercourses in Central Asian countries have not been adequately studied. Large-scale pollution of water resources from industrial wastewater and agricultural waters has been reported in Kazakhstan, Uzbekistan and Tajikistan [1].

In the course of our study, MP contents were studied in the surface waters of some rivers of Andijan, Namangan and Fergana regions Republic of Uzbekistan, which originate primarily fed by snow and glacial waters from the mountains of Kyrgyzstan. Samples were collected during 2023 at 22 locations using a microprobe (AGU, Andijan, Republic of Uzbekistan) with a neuston net (330 microns) to catch floating plastic debris from the upper 15 cm layer of water. The sampler was equipped with a flow meter (Hydro-Bios, Altenholz, Germany) to measure the water volume. For sampling, the microprobe was installed at a depth of 50 cm for 15 minutes, catching floating plastic debris. The water speed is determined by a water flow sensor installed on a microprobe. The volume of water passing through the tank in 1 day was determined depending on the time of the experiment. As a result, the daily norm for the amount of microplastic in the region in which the experiment was conducted was determined.

Next, all solid particles were collected in individual screw-top jars by rinsing the mesh with river water, and then the samples were transported to the laboratory. The samples were then transported to the laboratory. Sample processing was carried out in several steps, including density separation using NaCl, oxidation of organic residues, collection of particles on a glass fiber membrane, visual analysis of particles using a microscope using a hot needle test, and the use of microscopy combined with Raman spectroscopy (micro-Raman) to determine the type of polymer. As expected, these plastic particles were found in all water samples.

Analysis of water samples from reservoirs in the Fergana Valley showed the presence of microplastic particles in all samples in average concentrations from 2.89 to 7.00 pieces/m3. Most of these particles are thread-like synthetic fibers and fragments of polymer particles, of different colors, ranging in size from 0.15 to 4.0 mm. We also examined and analyzed the chemical composition of microplastic samples from six rivers using spectrometry. Fibers were the most common types of microplastics, while fragment and film polymers were very rare. For each category of microplastic samples, the average concentration of fibers in each location is significantly higher (83.7%) and at the same time this figure is significantly lower for fragments and films - 14.4 and 1.9%, respectively.

Among the main sources of river pollution with artificial microfibers, the authors indicate the textile industry, untreated wastewater and discharges from municipal wastewater treatment plants, which do not fully preserve microfibers. Textile fibers of 1mm–5mm, which are released when clothing and household textiles are worn, washed and dried, are identified as a distinct type of environmental pollutant that can pose a risk to human health.

Identification of particles by chemical composition was carried out mainly for all samples with different sizes (from 0.15 to 4.0 mm). Polymer analysis revealed that the isolated material was composed of commonly occurring plastic compounds. Our samples consisted of polymers polyethylene terephthalate (PET), polyethersulfone (PES blends), thermoplastic elastomers (TPE), nylons (PA), polypropylene (PP), polycyclohexylene dimethylene terephthalate (PCT), polymethylpentene (PMP blends), polyphenylene sulfone (PPSU).

Both µRaman analysis showed that about half of all detected particles were PET, which is the polymer base of polyester products and is widely used in clothing and home textiles, either as a single material or mixed with cellulose fibers to improve mechanical properties and durability. Given that fibers are the most common microplastic morphology and PET is the main fiber component, wastewater treatment plant discharges and private household wastewater can be considered the most likely sources of local contamination. The polymer composition of MP samples found in the rivers of the Fergana Valley confirms the leading role of synthetic textile fibers in the pollution of watercourses in Uzbekistan.

To confirm the hypothesis about the leading role of synthetic textiles in MP pollution of watercourses in various regions of Uzbekistan, we plan to conduct regular sampling and monitoring studies in the immediate vicinity of discharge sites and treatment facilities. The data obtained are the second evidence of MP pollution in the tributaries of the rivers of the Republic of Uzbekistan and watercourses of Central Asia in general. However, the distribution and circulation of MPs in surface waters of Uzbekistan requires a comprehensive study to create a large-scale observation network to identify sources of pollution.

References

1. Frank, Y.; Khusanov, A.; Yuldashov, M.; Vorobiev, E.; Rakhmatullina, S.; Rednikin, A.; Tashbaev, S.; Mamatkarimova, S.; Ruchkina, K.; Namozov, S.; et al. Microplastics in the Syr Darya River Tributaries, Uzbekistan. Water 2023, 15, 3698. https://doi.org/10.3390/w15203698

P.2-02 ADSORPTION BEHAVIOR OF ANTIBIOTICS ON LATEX NANOPARTICLES

Apenkina A.V., Timchenko Y.V.

Lomonosov Moscow State University, Moscow, Russia
annavs758440@gmail.com

Plastic waste, decomposing under the influence of the environment, becomes a source of nano- (less than 1 μm) and microplastics (from 1 μm to 5 mm, MP), which is a new challenge for the global scientific community. Microplastic particles can easily penetrate organisms, disrupting cellular processes, and can also be carriers of organic pollutants such as pesticides, components of pharmaceuticals, etc.

In addition, much attention is now being paid to the problem of environmental pollution by components of pharmaceuticals as a result of their widespread and uncontrolled usage. Active substances of pharmaceuticals, such as antibiotics, have high biological activity and may threaten living organisms of natural ecosystems and human health. Their components can be sorbed on microplastics, resulting in complex contamination and combined toxic effects.

Currently, the processes of sorption/desorption of pharmaceutical components on microplastics are poorly studied. These studies are complicated by various chemical nature and sizes of MP particles, changes in their properties due to aging, and different external conditions (temperature, pH, ionic strength, etc.). Most studies are limited to analyzing a single type of pharmaceuticals and MPs under model conditions, lacking systematicity. There is no unified approach to sample preparation, group extraction of components, and their subsequent highly sensitive determination in MPs. To develop such an approach, the utilization of high-performance liquid chromatography-mass spectrometry (HPLC-MS) looks promising since it can provide a reliable simultaneous determination of target analytes.

The report will present the developed approach for the simultaneous determination of antibiotics in aqueous media by HPLC-MS. This method was used to explore the adsorption behavior of antibiotics on microplastics. Twenty-six substances belonging to nine different classes of antimicrobials, including beta-lactams (penicillins, cephalosporins, carbapenems), macrolides, nitroimidazoles, nitrofurans, sulfonamides, fluoroquinolones, tetracyclines, lincosamides, and chloramphenicol, were considered as target components. In addition, we studied the stability of model solutions of antibiotics and their mixtures to identify their transformation products that can be formed in aqueous media under the influence of external factors, such as environmental conditions. By using representatives of different groups of antibiotics, it is possible to reveal the dependence of adsorption on plastic particles on the nature of the sorbed substance. Therefore, we explored the adsorption behavior of certain antibiotic groups on synthesized latex nanoparticles from aqueous matrices at different pH values, temperature, and ionic strength. As a result, we compared the adsorption ability of different classes of drugs under varying conditions. This can be further used for their selective extraction from the particle surface and subsequent determination by HPLC-MS.

The authors would like to thank the division of High Molecular Compounds of the department of Chemistry of the Lomonosov Moscow State University (headed by Yaroslavov A.A.) for providing samples of nanoplactics.

P.2-03 ANALYSIS OF THERMAL AND OPTICAL PROPERTIES OF AQUEOUS DISPERSIONS OF POLYSTYRENE NANOPARTICLES BY THERMAL LENS SPECTROMETRY

Khabibullin V.R.[1], Shevchenko N.N.[2], Proskurnin M.A.[1]

1 - Analytical Chemistry Division, Chemistry Department, M.V. Lomonosov Moscow State University, Moscow, Russia
2 - Institute of Macromolecular Compounds RAS (IVS RAS), St. Petersburg, Russia
proskurnin@gmail.com

The analysis of polymer micro- and nanoparticles in objects of various nature is of particular importance for medicine, chemical analysis, materials science, and environmental science and technology. The complex morphology of nano- and microparticles of plastics, the special dynamics of physicochemical transformations and ultralow levels of particle content in various objects require original approaches and methods of qualitative and quantitative analysis.
Photothermal spectroscopy (PTS) is a highly sensitive, non-destructive molecular-spectroscopy method that combines optical spectroscopy and methods for assessment of thermophysical properties. PTS combines the methods of registration of non-radiative relaxation of excited molecules (changes in the temperature of the object under study) after absorption of electromagnetic radiation. Thermal lens spectrometry (TLS) is based on recording changes in the refractive index of the medium. TLS is highly sensitive to the physicochemical properties of liquid samples, which makes it possible to accurately measure absorbances down to 10^{-7} and thermophysical parameters of objects (temperature change, thermal diffusivity, temperature coefficient of refractive index) with high precision.
This study demonstrates the possibility of TLS in the assessment of thermal diffusivity and optical absorption of dilute aqueous dispersions of polystyrene nanoparticles with sizes of 65 and 80 nm. Photothermal studies have shown complex heating dynamics that are not typical for dispersions of metal nanoparticles (iron oxides, silicon oxide, gold and silver nanoparticles) and organic nanomaterials (graphene oxide, carbon nanotubes, fullerenes). The presence of polystyrene nanoparticles at concentration levels below 0.1 wt. % leads to a decrease in thermal diffusivity, which indicates the influence of polystyrene nanoparticles on heat transfer in the system. At the same time, an uneven dynamic of decrease in thermal diffusivity with increasing concentration is observed: in the region of 0.001% a sharp decrease in thermal diffusivity is recorded, which may indicate either the occurrence of aggregation/disaggregation or a change in the heat release mechanism. This behavior was not previously discovered for disperse systems and requires additional research.
The results obtained expand the understanding of thermophysical phenomena occurring in polymer dispersed systems and are useful for applied problems in the fields of environmental management, environmental science, materials science, and fundamental research of nano- and microplastics, and also contribute to the development of thermooptical analysis.

The work was carried out with financial support from the Ministry of Science and Higher Education of the Russian Federation: AAAA-A21-121011590089-1.

P.3-01 DEVELOPMENT OF AN INFORMATION-ANALYTICAL SYSTEM ON MICROPLASTICS IN NATURAL ENVIRONMENTS ON THE TERRITORY OF THE RUSSIAN FEDERATION

Arzamasova A.D., Frank Yu.A.

National Research Tomsk State University, Tomsk, Russia
eco-life@mail.ru

The continuous growth of production and consumption of plastic-containing products and packaging is accompanied by an increase in the amount of plastic waste generation, as well as an increase in the volume of microplastics (MPs) penetrating into various components of the natural environment. The quantity and multifaceted consequences of the wide distribution of MPs in the environment are actively studied by scientists [1]. The increasing amount of data and scientific groups involved in MP research require the design of summarising information systems.

This work is devoted to the creation of a unified information and analytical system to illustrate and summarise the results of research conducted by the members of the Consortium “Microplastics in the Environment” (https://microplasticsiberia.com). Its purpose is a comprehensive assessment of the scale, consequences and forecast of the complex nature of pollution. The system structure and technical task for web-development of the system, meeting the needs of different target groups of its potential users, were formed including: (1) For scientists, researchers and students – a database of research results to compare research methods, pollution consequences, as well as the search for scientific teams for collaboration and further research; (2) For government representatives and public activists – a database of international and Russian laws, standards and methods adopted to prevent plastic and MP pollution; (3) For representatives of business/producers – information resource on best practices and available technologies, successful examples of closed cycle economy and ESG projects in Russia and abroad; (4) For residents of the Russian regions – an information resource with adapted, easy-to-remember, research-based information on consumer contribution to plastic waste and debris, sources of MP in food and drinking water (the project “Microplastics is closer than it seems”), advantages and opportunities for sorting garbage and reducing the ecological footprint in different regions.

The proposed system is interactive and provides an opportunity for Consortium members to edit contact information, receive newsletters. It is possible to conduct research on the system's website and measure the level of problem awareness or consumer habits in terms of plastic handling.

The study was financially supported by the Development Program of Tomsk State University (Priority-2030), Project No. 2.2.3.22 ONG.

References

1. Results of the query for articles on the keyword "microplastics" in the MDPI database of scientific publications. – 1996–2024. Available at:URL: https://www.mdpi.com/search?q=microplastics (accessed on 1 March 2024).

P.3-02 BIODEGRADATION OF POLYETHYLENE PARTICLES BY ZOPHOBAS MORIO LARVAE

Bereznikova N.A., Vezhenkova I.V.

Saint Petersburg Electrotechnical University "LETI", Saint Petersburg, Russia
natalibereznikova9@gmail.com

This paper examines an alternative to the burial and thermal decomposition of polyethylene – its processing by Zophobas morio larvae [1].
Past studies have demonstrated the ability of larvae to process polystyrene foam during digestion [2,3], but now their ability to process other materials is of interest.
To conduct the experiment, larvae from one batch were divided into three groups of three colonies, each containing 50 larvae. The first group was given dry and wet feed, the second group was given polyethylene. The third group was left starving. All colonies were kept under the same conditions for a month.
On average, larvae ingested polystyrene foam at a rate of 0.03 mg/day per individual. The survival rate of individuals was 38%, the proportion of cases of cannibalism was 26%. The biomass of larvae in the experimental group was two times lower than in the control group.
To test whether Zophobas morio larvae are able to degrade the polyethylene they ingest, FTIR spectroscopy of larval excrement was performed. Figure 1 shows the result of the analysis.

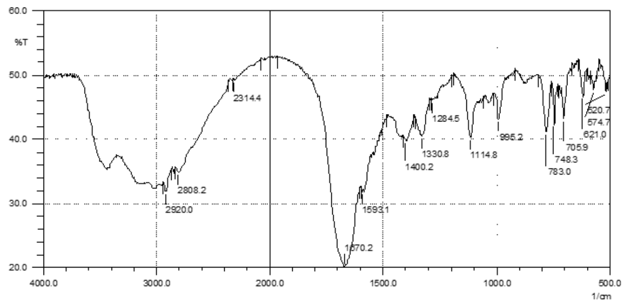


Fig. 1. Infrared transmission spectrum of a sample of excrement of larvae that fed on polyethylene

In the infrared spectrum of the excrement of larvae that fed on polyethylene, there are no absorption peaks characteristic of it (the most obvious is the peak at 713.6 cm^{-1}, which gives a doublet). This may indicate the absence of polyethylene in the substances that make up the waste products of the larvae.

References
1. *Sun J., Prabhu A., Aroney S.T.N.* Microbial genomics. **8**, 1–19, (2022).
2. *Yang Y., Wang J., Xia M.* Science of the Total Environment. **708**, 1–24, (2019).
3. *Березникова Н.А., Веженкова И.В.* Микропластик в науке о полимерах. Великий Новгород, (2023). **1**, 84.

P.3-03 COMPARISON OF MICROPLASTICS (0.5-2 MM) CONTENT IN DIFFERENT MARINE ENVIRONMENTS

Bocherikova I.Y.[1,2], Chubarenko I.P.[1], Esiukova E.E.[1]

1 - Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia
2 - Immanuel Kant Baltic Federal University, Kaliningrad, Russia
ibocherikova@yandex.ru

Investigations of microplastics (MPs) contamination of the Baltic beach sands show relatively uniform concentrations of MPs of the size range of 0.5-2 mm in the wave run-up zone. For about 600-km long southern Baltic shore (Esiukova et al., 2021), 100-km long shore of the Curonian Spit (Chubarenko et al., 2020), 14 month-long study at the Vistula Spit (Krivoshlyk, Chubarenko, 2021) the contamination is about 30-60 items/kg DW (including fibers), being independent of the current wind-wave conditions and sand characteristics in the given region. Other beach zones and MPs size fractions show much larger spatial and temporal variability. The aim of this effort is to relate this unexpectedly conservative and easy-to-obtain indicator to contamination with MPs (0.5-2 mm) of water column, beach and bottom sediments of the Baltic Sea.

The paper (Chubarenko et al., 2022) analyzed data on MP (0.5-2 mm) contamination in bottom sediments from 8 cruises of research vessels in the Gotland, Gdańsk, and Bornholm basins of the Baltic Sea. Literature review indicated that in the Bornholm Basin the mean abundance of MPs varied significantly between the stations – from 37 up to 141 items/kg DW. In the Gdańsk Basin, the mean contamination was 45 items/kg DW. Contamination in the Gotland Basin varied between the stations – from 16 up to 245 items/kg DW. In the southeastern sector of the Baltic Sea, the mean contamination was 130 items/kg DW (Chubarenko et al., 2022). Thus, the contamination of the bottom sediments of the Baltic Sea with MPs is unevenly distributed. The highest one was in the sample obtained in the Kaliningrad Bay (near the Baltiysk) and amounted to 513 items/kg DW.

The research is supported by the Russian Science Foundation under grant No. 24-17-00099.

References:

1. Chubarenko, I., Esiukova, E., Khatmullina, L., Lobchuk, O., Grave, A., Kileso, A., Haseler, M. From macro to micro, from patchy to uniform: Analyzing plastic contamination along and across a sandy tide-less coast. Marine Pollution Bulletin. Vol. 156. 111198. (2020) https://doi.org/10.1016/j.marpolbul.2020.111198.
2. Krivoshlyk, P.N., Chubarenko, I.P., Seasonal variations in the content of microplastic particles in the sands of the beach swash zone. Journal of Oceanological Research. Vol. 49. №2. P.57–66 (In Russian). (2021). DOI: 10.29006/1564-2291.JOR-2021.49(2).4 https://jor.ocean.ru/index.php/jor/article/view/680.
3. Chubarenko I, Esiukova E, Zobkov M, Isachenko I. Microplastics distribution in bottom sediments of the Baltic Sea Proper. Marine Pollution Bulletin. Vol. 179. 113743. (2022).
4. Esiukova, E., Lobchuk, O., Haseler, M., Chubarenko, I.,. Microplastic contamination of sandy beaches of national parks, protected and recreational areas in southern parts of the Baltic Sea. Marine Pollution Bulletin. Vol. 173. 113002. (2021) https://doi.org/10.1016/j.marpolbul.2021.113002.

P.3-04 MICROPLASTICS IN THE TOM RIVER: MONITORING RESULTS

Vorobiev D.S., Frank Y.A., Vorobiev E.D., Rakhmatullina S.N.

Tomsk State University, Tomsk, Russia
danilvorobiev@yandex.ru

Rivers are considered to be a pathway for the transport of microplastics (MPs) to the ocean and an important reservoir of particles. In order to improve the knowledge of sources, transport and redistribution in river systems and to estimate the global amount of plastic transport to the oceans, it is necessary to study rivers in different regions of the world. This is particularly relevant for Siberian rivers, which are among the watercourses with the largest catchment areas and discharge volumes, and which can transport MPs to the Arctic seas. This study is devoted to the assessment of the seasonal and interannual dynamics of MP content in the surface waters of a large tributary of the Ob, the Tom River, based on the results of three years (2021-2023) of monitoring at the same site within the city limits of Tomsk. The abundance and distribution of particles in the ice of the Tom River at the end of the winter period 2022-2023 were also assessed.
The content of MP particles in the size range 0.15-5 mm in the Tom River water reached 9.97 ± 1.42 items/m^3 and 2.33 mg/m^3 in December and August 2022, respectively. The predominant groups of MPs by morphology were microfibers and irregularly shaped fragments. Particles with a size of 300-2000 μm along the maximum axis were the most abundant. According to the μRaman data, a significant fraction of the particles in the Tom River water is represented by PET (from 18.3 in 2021 to 39.5% total MPs in 2023), plastics such as ASA, PAN, PCT, PE, PP, PPSU, PS were identified, mixtures based on polymethylpentene and polysulfones were also found.
No pronounced patterns of intra-annual dynamics of MP content in the surface waters of the Tom River were observed from year to year. The average particle content in the water by year (items/m^3 and mg/m^3) did not vary significantly in different hydrological phases. The average total content of MPs in the water of the Tom River in 2021-2023, both in absolute terms and by mass, did not depend significantly on the water level. No such dependence was found for MPs in the form of fibers and fragments of irregular shape. It was shown that the content of films and spheres (items/m^3) in the surface water of the Tom River during the observation period was significantly dependent on the water level in the river ($p < 0.01$) with $r_s = 0.733$ and 0.691, respectively. The mass of films (mg/m^3) was also significantly dependent on the water level in the Tom ($p < 0.05$) with $r_s = 0.671$, whereas the mass of spheres and MPs as a whole was not. High levels of MPs were found in the ice cover at the Tom River monitoring site, with morphology and polymer composition similar to that found in water. In ice cores of 60 to 70 cm thickness sampled at the end of March 2023, MP concentrations ranged from 20700 ± 5170 items and 19.5 ± 6.61 mg to 38900 ± 20430 items and 4379 ± 1691 mg per cubic meter, which is significantly higher ($p < 0.001$) compared to the particle content in river water.
Thus, the following was established: (1) seasonal changes in the content of MPs with sizes of 0.15-5.0 mm in the Tom River in 2021-2023 are not expressed; (2) the quantitative content of particles in the form of spheres and films in the Tom River water reliably depends on the water level; (3) the river ice accumulates MPs during the ice-out period.
The study was funded by the Development Program of Tomsk State University (Priority-2030), Project No. 2.2.3.22 ONG.

P.3-05 ASSESSMENT OF MICROPLASTIC CONTAMINATION IN FRACTURED KARST AQUIFER (ZVENIGOROD, RUSSIA)

Davydova N.K.[1], Filimonova E.A.[1], Chistyakova A.V.[1,2]

1 - Lomonosov Moscow State University, Faculty of Geology, Moscow, Russia
2 - Schmidt Institute of Physics of the Earth, Moscow, Russia
nikol.davydova2017@yandex.ru

Due to the active growth of plastic production and its long-term decomposition (up to 1 million years), the problem of recycling polymer waste arises. As a result of the destruction of plastic debris, microplastic particles (1 μm<MP<5 mm) are formed, which are found in a wide variety of natural environments, including surface and groundwater. MPs are dangerous hydrophobic radicals, that can adsorb and transport heavy metals and persistent organic pollutants [2].

The assessment of MP contamination is carried out on the territory of the nature reserve - the Zvenigorod Biostation, located in the Odintsovo district, Moscow region. MP particles were found in the Carboniferous aquifer overlaid by Jurassic clay and Quaternary alluvial deposits. The aquifer is composed of fractured and karsted limestones and it is confined. Groundwater is recharged by leakage from shallow water with higher head, sometimes during floods the may be recharged by river water through the floodplain. Aquifer discharges into the Moscow River and into the overlying sediments on the floodplain.

To study MPs bottom sediments, using bulk method, and groundwater, using volume reduce method from a hydrogeological well, were sampled. Sample preparation was carried out according to work [1] and included: drying of selected samples, sieving, liquid peroxidation, density separation (flotation), filtration.

The visual characterization of MPs was carried out by Nikon eclipse e400 POL and Olympus BX53M light microscopes and analytical identification by Raman spectroscopy using an EnSpectr 532 spectrometer. MPs are represented by fragments, microfibers and films, which indicate groundwater contamination by secondary microplastics. The concentration of identified particles was 0.66 item/L [3].

Jurassic clays and Quaternary loams make it difficult for polymers to penetrate the aquifer directly in the watershed. According to the proposed hypothesis, MP particles flow down the slope with surface runoff, and then they transport through alluvial deposits on the upper floodplain terrace, where clay deposits are practically absent.

References

1. *Зобков М.Б., Есюкова Е.Е.* Микропластик в морской среде: обзор методов отбора, подготовки и анализа проб воды, донных отложений и береговых наносов // Океанология. 2017. Т. 58. № 1. С. 149-157.

2. *Казак Е. С., Филимонова Е. А., Преображенская А. Е.* Микро- и нанопластик в природных водах России и проблемы его определения. // Вест. Моск. ун-та. 2022. №6. С. 110-124

3. *Филимонова Е.А. и др.* Микропластик в подземных водах: Первые результаты исследований на территории России // Труды Всероссийской научной конференции с международным участием «Современная гидрогеология: актуальные вопросы науки, практики и образования». М.: Изд-во МГУ, 2023. С. 512-517.

P.3-06 MICROPLASTICS IN ANTARCTICA: FIRST RESULTS

Ershova A.[1], Vesman A.[2]

1 - Russian State Hydrometeorological University, St Petersburg, Russia
2 - Arctic and Antarctic Research Institute, St. Petersburg, Russia
amberx19@gmail.com

Snow near Russian Antarctic stations and sub-surface waters of adjacent Southern Ocean were studied in 2022 in frames of Russian Antarctic Expedition (RAE). Sub-surface seawater (4-5 m) was sampled onboard RV ”Akademik Treshnikov” by the built-in vessel flow-through filtering system with mesh-size 100 microns making at least 2 m3 of filtered seawater for each sample. Snow of various age during seasonal works (from Dec to May) was sampled near 5 stations: 5 L of snow for each sample. All samples were treated in the clean lab conditions in St.Petersburg in PlasticLab, including the field and procedural blanks, and contamination control at each stage of work. Laboratory treatment included Fenton reagent protocol for snow and KOH protocol for seawater samples, with 100% of particles identification by Raman spectroscopy. Average concentration of microplastics in snow in 2022 was 4,9 items per liter of melted snow, ranging from 0,7 to 10 items/l. Maximum concentrations were observed in late autumn in old firn snow at stations Oasis Bangera, Novolazarevskaya and Molodezhnaya. The minimum concentrations were observed in fresh snow at stations Progress and Mirny. Morphology of microplastics in snow (mostly films and fragments) differs much from those found in seawater (microfibers). Results show little or no microplastics in sub-surface Antarctic seawaters in 2022. All of the particles are microfibers (blue, black, transparent) made of PET or cellulose with various pigments, making these particles of anthropogenic origin. Average concentration of anthropogenic microfibers around the Atlantic and Indian part of Antarctica was 0,97 items/m3 (that is close to the limit of detection) and ranging from 0 to 2,02 items/m3, where 3 stations had zero amounts of particles.

The study is supported by RSF project № 23-27-00456.

P.3-07 TEMPORAL VARIABILITY OF MICROPLASTICS IN THE WAVE RUN-UP ZONE ON THE VISTULA SPIT

Krivoshlyk P.[1,2]

1 - Shirshov Institute of Oceanology, Russian Academy of Sciences; Moscow, Russia
2 - Immanuel Kant Baltic Federal University, Kaliningrad, Russia
poka20106@yandex.ru

Plastic contamination of the marine environment is now widespread, but its distribution is highly variable in time and space [1]. This complicates the assessment and monitoring of contamination levels and requires larger samples and replicates. This research presents the results of 175 samples collected in the wave run-up zone during 42 monitoring surveys (from November 2019 to January 2021) at 6 stations along the coast of the Vistula Spit (Baltic Sea). The methods of sample preparation and analysis were kept the same as in [1;2], so the obtained results are fully comparable with those studies. The residue was treated according to the NOAA method [3] for the extraction of MPs from a sediment sample, with the recommendations of [4].

A total of 10,696 anthropogenic items were found, of which 10,366 items (97%) belong to the size range of MPs (0.5-5 mm). Among the MPs, 68% of the items (7286) belong to the S-MPs size range (0.5-2 mm). In terms of shape, the majority of MPs (0.5-5 mm) found were thread-like and fibrous (98.6%), while fragments and films accounted for 1.2% and 0.2%, respectively. Among the MPs, the most widespread were transparent items (69%), followed by blue (11%), green (7%), black (7%), white (7%), red (2%), and the least common in terms were particles of yellow and brown color. Among the identified materials, the majority were CE particles (28%), polymer blend (16%), PET (9%), PES (14%), Carbon (13%), PET (10%) and other (12%). Spectrometric verification did not indicate the necessity for data correction.

For all 175 samples, the total abundance of MPs (0.5-5 mm) varied in the range of 9-476 items/kg DW, with a mean of 95±66, median 78 items/kg DW. For S-MPs (0.5-2 mm) and L-MPs (2-5 mm) separately, the global mean abundances were 64±36 (median 55, CV=56%) and 29±33 (median 17, CV=114 %) items/kg DW. The samples included 163 sand samples and 12 granules. Both maximum and minimum contamination (9 and 443 items/kg DW) were found in sand samples at the station 4. The averaging of all the sand samples collected during 14 months for a particular station gives the following pattern. For all MPs (0.5-5 mm), the abundance varies from 105±91 (median 70) items/kg DW (station 4) to 62±36 (44) items/kg DW (station 0). The monthly means showed the highest contamination in January 2020: 216.6±115.3 items/kg DW (median 197.9, range 86-476). The lowest values were obtained in March (60±32 items/kg DW, median 58, the range of 31-163) and October (59±23 items/kg DW, median 62, range 9-101).

The research is supported by the Russian Science Foundation under grant No. 24-17-00099.

The authors are grateful to the staff of the Laboratory of Atlantic Geology for the opportunity to use the equipment for this purpose. Special thanks to B. Chubarenko for assistance with sampling, and to A. Zubin, A. Kundalevich, and E. Demiskevich for Raman spectrometry analyses.

References

1. Esiukova, E. et al., From macro to micro: dataset on plastic contamination along and across a sandy tide-

less coast (the Curonian Spit, the Baltic Sea). Data in Brief 30 (2020).
2. Chubarenko, I. et al., From macro to micro, from patchy to uniform: Analyzing plastic contamination along and across a sandy tide-less coast. Marine Pollution Bulletin 156, 111198 (2020).
3. Masura, J. et al., Laboratory methods for the analysis of microplastics in the marine environment: recommendations for quantifying synthetic particles in waters and sediments (2015).
4. Zobkov, M., Esiukova, E., Microplastics in Baltic bottom sediments: Quantification procedures and first results. Marine Pollution Bulletin 114, 724–732 (2017).

P.3-08 ASSESSMENT OF MICROPLASTIC CONTAMINATION OF THE PREGOLYA RIVER MOUTH AREA (SOUTH-EASTERN BALTIC)

Lobchuk O.I., Esiukova E.E.

Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia
olga_may87@mail.ru

A study was conducted at the mouth of the Pregolya River (South-Eastern Baltic) in the spring of 2024. The study's objectives include the assessment of the contamination of the river watercourse with microplastic particles (MP) of a range of 0.3-5 mm, as well as particles larger than 5 mm. Additionally, the study aims to identify the spatial distribution of these particles. The water samples were collected at a depth of 1-1.5 m from the water surface using a bathometer, based on the results of preliminary hydrological profiling. Sampling was conducted at eight points (in triplicate at each sampling station, i.e. 3 samples per 10 liters each) in accordance with the estuarine zoning classification. The sampling points were designated as follows: 1) river, 2) mixing zone, 3) sea (in the coastal part). The preliminary data indicated that particles with a size of 0.3–5 mm constituted 95.2% of all collected particles. The particle concentrations were found to range from 33 to 185 particles per 10 liters (for MP particles with a size of 0.3–5 mm) and from 1 to 15 particles per 10 liters (for particles with a size greater than 5 mm). The predominant form of particles was identified as fibers (98%), with a diameter of less than 20-30 µm. Fragments constituted 2% of the total number of particles found. The most prevalent colors observed in the particles were black/gray (~31%), blue/cyan (~27%) and transparent/matte (~24%) for MP particles 0.3-5 mm. The size distribution of fibers demonstrated a clear prevalence of sizes 0.5-1 mm (accounting for over 24%) and 1-1.5 mm (approximately 22%). Of the fragments discovered, the predominant size was found to be 0.3-0.5 mm, accounting for approximately 56% of the total.

The research is supported by the Russian Science Foundation under grant No.24-44-20027.

Р.3-09 АТМОСФЕРНОЕ ПОСТУПЛЕНИЕ МИКРОПЛАСТИКА НА АЛТАЕ

Малыгина Н.С.[1,2], Бирюков Р.Ю.[1], Курятникова Н.А.[1], Черных Д.В.[1]

1 - ИВЭП СО РАН, Барнаул, Россия
2 - ТюмНЦ СО РАН, Тюмень, Россия
natmgn@gmail.com

На Алтае в конце трех холодных периодов (2021, 2022, 2023 гг.) были отобраны пробы снежного покрова, в которых определяли микропластик. Полученные результаты для антропогенно не нарушенных территорий (31±20 шт./л) были сопоставимы с данными для Гималаев и в 5 раз меньше, чем для Швейцарских Альп (190 шт./л). Варьирование между сезонами средних значений не превышало 30 шт./л, что указывает на схожие пути поступления микропластика. Во всех пробах снега Барнаульской агломерации, так же был обнаружен микропластик (до 600 шт./л.) что меньше, чем было определено для ряда крупных городов Европы. Выявлено, что на урбанизированной территории крупные элементы естественной ландшафтной структуры (связанные с макроформами рельефа) в меньшей степени влияют на концентрацию микропластика в снежном покрове, чем элементы ландшафтов антропогенного происхождения, это подтверждает, что подавляющая часть микропластика имеет местное (локальное) происхождение.

P.3-10 POTENTIAL SOURCES OF MICROPLASTICS INPUTS TO TERRESTRIAL AND AQUATIC ECOSYSTEMS OF ANTARCTICA

Abakumov E.V.[1,2], Nizamutdinov T.I.[1,2]

1 - Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia
2 - Department of Applied Ecology, Faculty of Biology, St. Petersburg State University, St. Petersburg, Russia
e_abakumov@mail.ru

Antarctica is usually characterized by low levels of pollution of the environment. Nevertheless, despite the existence of the Antarctic Treaty System (1959) and the Protocol on Environmental Protection to the Antarctic Treaty (1998), intensive chemical, physical, noise, biological pollution of the snow and ice free territories (Antarctic oases) and coastal marine territories [1,2,3] is currently taking place.

Microplastics in Antarctic ecosystems can come both from local sources and in the process of long-range (atmospheric and marine) transport:

- Incomplete incineration of wastes resulting in shredding of plastic packaging and accumulation of microplastics in soils and water bodies in the vicinity of polar stations. Accompanied by a sharp increase in concentrations of polycyclic aromatic hydrocarbons in soils, waters, plant materials, etc. The average exceedance of maximum permissible concentrations (MPC) for benz(a)pyrene on King George Island is 20-30 times, and in areas where incinerators are located - even more;
- Recreational source - at least 10 tourists arrive at King George Island stations every day in summer. Illegal and semi-legal tourism leads to the formation of accumulations of plastic and food waste up to 10 km away from the tourist sites.
- The use of equipment, clothes and containers (for example, from bottled water) having different types of plastic in their composition leads to accumulation of microplastics in different components of the Antarctic ecosystems [4];
- Illegal dumping of plastic debris into the sea, including plastic containers, synthetic ropes, fishing nets, garbage bags, etc. A huge amount of plastic ends up on the shores of King George and Nelson Islands. On the latter, plastic is used to build illegal structures by tourists;
- Emergency removal of plastic building components and destruction of dilapidated abandoned structures at stations and field camps results in mechanical pulverization of the constituent parts of the structures in extreme winds.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant).

References

1. *Mishra, A. K.; Singh, J.; Mishra, P. P.* Microplastics in polar regions: an early warning to the world's pristine ecosystem. Science of the Total Environment, **784**, 147149 (2021).
2. *Rota, E.; Bergami, E.; Corsi, I.; Bargagli, R.* Macro-and microplastics in the Antarctic environment: ongoing assessment and perspectives. Environments, **9(7)**, 93, (2022).
3. *Waller, C. L., Griffiths, H. J., Waluda, C. M., Thorpe, S. E., Loaiza, I., Moreno, B., ... & Hughes, K. A.* Microplastics in the Antarctic marine system: an emerging area of research. Science of the total environment, **598**, 220-227, (2017).
4. *Aves, A. R.; Revell, L. E.; Gaw, S.; Ruffell, H.; Schuddeboom, A.; Wotherspoon, N. E.; LaRue, M.; McDonald, A. J.* First evidence of microplastics in Antarctic snow, The Cryosphere, **16**, 2127–2145, (2022).

P.3-11 BIOCIDAL PROPERTIES OF COMPLEXES FROM MODEL MICROPLASTIC PARTICLES AND POLYCATION

Panova I.G.[1,2], Rozova A.Yu.[3], Loiko N.G.[4], Belov A.A.[1], Yuzhanin K.I.[1,2], Yaroslavov A.A.[1,2]

1 - M.V. Lomonosov Moscow State University, Department of Chemistry, Moscow, Russia
2 - Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia
3 - Department of Chemistry and Technology of Macromolecular Compounds, MIREA—Russian Technological University, Moscow, Russia
4 - Department of Microbiolog, Federal Research Center "Fundamentals of Biotechnology" of the Russian Academy of Sciences, Moscow, Russia
igpan@mail.ru

Spread of highly dispersed and reactive microplastics (MP) is of concern due to their potential toxicity. MP particles loaded with biocidal compounds are especially dangerous. The toxicity of MP-biocide complexes can greatly depend on their composition and environmental properties. In the work, the antimicrobial properties of binary complexes of model MP particles, microspheres of butadiene-styrene copolymer with carboxyl groups on the surface, and the toxic cationic polydiallyldimethylammonium chloride (PDADMAC).
PDADMAC was quantitatively adsorbed on the surface of microspheres. Complexes resistant to aggregation were synthesized at a molar ratio of the functional groups of the polycation and microspheres $Z = [N^+]/[COO^-] \leq 0.7$ and $Z \geq 1.2$; in the first case, negatively charged complexes were formed, in the second, positively charged ones.
Aqueous dispersions of microspheres did not exhibit antimicrobial activity against gram-positive and gram-negative bacteria; on the contrary, the polycation showed high activity against both types of microorganisms. The antimicrobial activity of the "cationic" complex with $Z = 1.2$ was comparable to that of the native polycation. "Anionic" complexes with $Z \leq 0.7$ had less toxicity, which decreased as the polycation was distributed over more and more MP particles.
Addition of microsphere-PDADMAC complexes into the soil did not have a toxic effect on soil microorganisms.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant).

P.3-12 MICROPLASTICS IN THE BLACK SEA SEDIMENTS

Pogojeva M.P.[1,2], Cincinelli A.[3,4,5], Scopetani C.[3], Chelazzi D.[3,4], Martellini T.[3,4], Slobodnik J.[6]

1 - N.N. Zubov's State Oceanographic Institute, Roshydromet, Moscow, Russia
2 - Shirshov Institute of Oceanology, Russian Academy of Science, Moscow, Russia s
3 - University of Florence, Florence, Italy
4 - Consorzio Interuniversitario per lo Sviluppo dei Sistemi a Grande Interfase, Italy
5 - National Interuniversity Consortium for Environmental Sciences, Italy
6 - Environmental Institute, Slovak Republic
pogojeva_maria@mail.ru

In this study the occurrence, morphology and identification of microplastics in Black Sea sediments collected at different depths (range 22–2131 m) were determined for the first time. The study explored the advantages and limitations of using a non-invasive method consisting of filtration of the supernatant from the mixture of sediment with saturated NaCl solution followed by FTIR 2D imaging for the identification of natural and synthetic polymers. The proposed method confirmed its potential for clear identification of polyethylene, polypropylene, acrylonitrile, polyamides and cellulose-based fibers, but more difficulties when the filter substrate neighboring the fibers exhibits intense absorptions in the 1800–1000 cm^{-1} range. Microplastics (MPs) were determined in 83% of the investigated sediment samples. The average abundance in all samples was 106.7 items/kg. The highest pollution occurred on the North-Western shelf where the abundance of MPs was 10 times higher than in sediments from the deep sea. The most abundant plastic polymers were polyethylene and polypropylene, followed by acrylate and acrylonitrile copolymers. Polyamide and cellulose-based textile fibers were also found. The most frequent microplastic colors observed were black, blue and clear/transparent, while fibers represented the dominant microplastics in sediments.

P.3-13 ОБРАЗОВАНИЕ МИКРОПЛАСТИКА В ПРОЦЕССЕ ДЕСТРУКЦИИ КОМПОЗИЦИОННЫХ МАТЕРИАЛОВ НА ОСНОВЕ ПОЛИЛАКТИДА

Подзорова М.В.[1], Масленникова Д.А.[1], Якубова Л.Ю.[1], Тертышная Ю.В.[1,2]

1 - Российский экономический университет имени Г.В. Плеханова, Москва, Россия
2 - Институт биохимической физики имени Н.М. Эмануэля РАН, Москва, Россия
mariapdz@mail.ru

В настоящее время полимерные отходы являются одной из центральных экологических проблем. Несмотря на то, что доля отходов полимеров составляет около 10-12% всех ТБО, загрязнение почв и водоемов представляет серьезную угрозу окружающей среде. Нацеленность многих стран на сокращение выбросов, рациональное природопользование и ресурсосбережение стимулирует появление новых научно-технических подходов и технологий. Так, в сельскохозяйственной отрасли мульча из полиэтиленовой пленки широко признана за ее важную роль в экономии воды и стимулировании роста растений. Но, к сожалению, ежегодное применение полимерной мульчи, наоборот, снижает урожайность в среднем на 11 % из-за образования микропластика. Воздействие биотических и абиотических факторов на различные агроэкосистемы остается в центре внимания научного сообщества. Микропластики признаны стойкими антропогенными загрязнителями благодаря своим химическим свойствам. Таким образом, разработка новых функциональных материалов позволит уменьшить экологическую нагрузку.

В работе исследована способность к деструкции функциональных пленочных композиционных материалов на основе полиэтилена низкой плотности с добавлением вторичного полиэтилена (30 мас.%) и полилактида (30 мас.%), а также на основе полилактида с поликапролактоном (29 мас. %) с добавлением янтарной кислоты для нужд сельского хозяйства. Установлено, что показатель степени водопоглощения при добавлении вторичного полиэтилена повышается на 3% в сравнении со смесью ПЭНП/ПЛА, что может улучшить деструкцию материала в окружающей среде. При этом в процессе гидролиза в течение 90 дней при Т=22±^{o}С, лучше показал себя материал ПЛА/ПКЛ/янтарная кислота. Методом оптической микроскопии отмечается эрозия поверхности, методами ДСК и ИК показано снижение всех показателей и начало деструкции материала. В процессе исследования фотодеструкции установлено, что матрица полилактида активно подвержена воздействию УФ-излучения, что позволяет разрушаться всем материалам более эффективно. Несмотря на возможное образование микропластика, получение композитов, разрушающихся под влиянием внешних факторов является актуальным направлением исследований.

Таким образом, функциональные композиционные материалы с добавкой полиэфиров могут стать альтернативной традиционной пластиковой мульче. Наличие биоразлагаемого полиэфира в смесях позволяет улучшить деструкцию материала под влиянием агрессивных факторов окружающей среды.

Работа выполнена при финансовой поддержке РЭУ им. Г.В. Плеханова.

P.3-14 INVESTIGATION OF MICROPLASTICS AND ORGANIC POLLUTANTS IN THE WATER AND BOTTOM SEDIMENTS OF THE OB RIVER

Sotnikova Yu.S., Song D.I., Karpova E.V., Nefedov A.A., Osechkova A.E., Polovyanenko D.N., Bagryanskaya E.G.

N.N. Vorozhtsov Novosibirsk Institute of Organic Chemistry of Siberian Branch of Russian Academy of Sciences, Novosibirsk, Russia
sotnikova@nioch.nsc.ru

Plastic materials are employed in a multitude of industrial sectors and, due to their adaptability, have become an indispensable component of contemporary life. In the event of inadequate handling, plastic waste accumulates in all components of the environment, where it disintegrates under the influence of external and mechanical forces, resulting in the formation of microplastics (MPs) – plastic particles smaller than 5 mm. Microplastics are found in all environments, but their greatest interest lies in aquatic systems, as it is mainly through water that MPs is able to enter the organism of living beings. Rivers play an important role in the global MPs cycle, as they are closely connected with the terrestrial environment and provide important transportation routes. The Ob River is one of the largest rivers in Russia, and on its banks is the most populated city in Siberia, Novosibirsk, which is also one of the largest industrial centers of Western Siberia.

This paper presents the results of a study investigating the content of microplastics and organic pollutants (persistent organic pollutants, polycyclic aromatic hydrocarbons, organochlorine pesticides) in samples of natural and waste water, and bottom sediments collected in the Ob River.

To determine the amount of microplastics, samples were prepared using a newly developed two-stage approach. The first stage involved the removal of the inorganic matrix using a heavy liquid based on sodium heteropolyoxotungstate with a density of 1.70 g/cm^3. The second stage entailed boiling the samples in peracetic acid, followed by the addition of Fenton's reagent to remove organic natural components. Subsequently, the samples were subjected to further analysis by means of infrared microscopy in order to ascertain the number of particles present, and pyrolysis gas chromatography–mass spectrometry (GC-MS) was employed in order to determine the mass of the polymers present. The standard certified methods were employed for the determination of organic pollutants, including those within the accreditation area of the Analytical Center of NIOCH SB RAS. The process involved the extraction of substances into an organic solvent and subsequent analysis by the GC-MS method.

The study of microplastic content in water and bottom sediments of the studied objects revealed that the highest content was observed in samples taken in the area of the Ob River beaches. Additionally, the analysis revealed that the concentration of organic pollutants in the natural and waste water samples collected from the Ob River did not exceed the threshold limit value (TLV) of 0.1.

P.3-15 MICROPLASTICS TO IMPROVE PROPERTIES OF DIRT ROADS

Fetin P.A., Minov A.E., Zorin I.M.

St. Petersburg State University, Saint Petersburg, Russia
p.fetin@spbu.ru

One of Russia's eternal problems is roads. Today, despite the increase in the length of paved roads, a significant share of the total length (29.33%) is made up of unpaved dirt roads. In some regions of Russia, for example, the Sakha Republic, they make up more than half of the total road network. A significant problem of unpaved roads is dust that forms the top layer of the road surface. Under the influence of climatic conditions or vehicle traffic, a dust rises into the air, after which it settles over a long period of time (fig. 1). The dust harms the health of surrounding people when inhaled, creates emergency situations due to reduced visibility, and contaminates various surfaces.

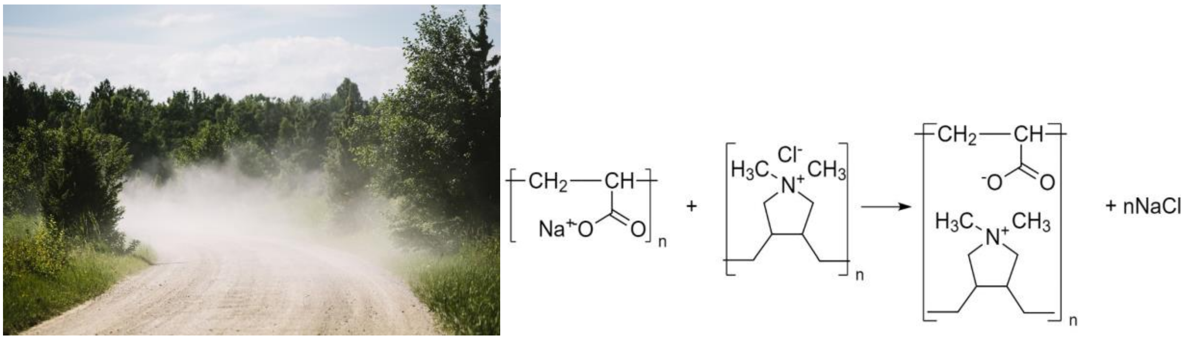


Fig. 1. The problem of dirt roads and the proposed method for solving it based on oppositely charged polyelectrolytes

The main method of combating road dust is to retain moisture in the surface layer. This is done thanks to inorganic salts, for example calcium chloride. Using special equipment, the coating is treated with solutions of these salts, at the same time the surface is wetted and moisture-retaining agents are added. However, this method has a significant drawback - due to the impact of precipitation, there is a need for regular re-treatment. In this work, based on laboratory experiments on dust removal, we propose a composition based on a combination of oppositely charged polyelectrolytes (large-scale products of chemical synthesis) for these purposes (fig. 1).

Due to the formation of a three-dimensional polymer network, such a coating on a dirt road can withstand the effects of precipitation and the presence of polar fragments retains moisture. Based on laboratory tests, the proposed formulation exhibits better performance properties in comparison with the classic road dust removal reagent based on calcium chloride.

The work was supported by the research park of St. Petersburg state university: RC of Magnetic resonance and Chemical Analysis and Materials Research Centre.

P.4-01 MICROPLASTIC BIOACCUMULATION IN PINNIPEDS (PINNIPEDIA): A LITERATURE REVIEW

Vainberg A.S.[1,2], Abakumov E.V.[1,2]

1 - Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia
2 - St.Petersburg State University, St. Petersburg, Russia
ace.12dv@gmail.com

This literature review reports on the bioaccumulation of microplastics by three families of pinnipeds *(Pinnepedia):* true seals *(Phocidae)*, eared seals *(Otariidae)*, and walruses *(Odobenus)*, encompassing 21 studies.
Microplastics are ingested by at least 701 species of organisms. The high trophic level and long lifespan of marine mammals make them susceptible to bioaccumulation of aquatic chemical pollutants.
The aim of this study – review the literature on microplastic bioaccumulation in pinnipeds (Pinnepedia), synthesize existing literature, and identify gaps in current research.
A search of relevant peer-reviewed literature was conducted in April 2024, using two online publication databases: PubMed and ScienceDirect.
Results: a total of 21 articles were selected.
The majority of studies focused on true seals *(Phocidae)* (57%; n = 12), with half of these studies investigating the grey seal *(Halichoerus grypus)* (n = 6). Slightly less attention has been given to microplastic bioaccumulation in eared seals *(Otariidae)* (38%; n = 8), and only one study (5%; n = 1) examined the interaction between walruses *(Odobenus)* and microplastic particles.
Plastic material was detected in 18 studies. Most studies used animal feces as the study material, with a few studies using gastrointestinal tract contents.
Direct comparison of results across studies is hindered by the lack of a standardized protocol for conducting such research. Authors employed a variety of methods to isolate and identify microplastic particles. However, Fourier-transform infrared spectroscopy was the predominant method used to characterize polymer types in studies from the past five years. The most common types of polymers detected were polyethylene, polyamide, and polypropylene.
Microplastics are present in the majority of the analyzed gastrointestinal tract contents and feces samples of the studied animals.
To fully assess microplastic bioaccumulation, further research is needed on different pinniped *(Pinnepedia)* species, with an emphasis on standardizing material collection and analysis protocols.

This study was supported by the Ministry of Science and Higher Education of the Russian Federation (state contract no. 075-15-2024-629, MegaGrant).

P.4-02 MIGRATION OF MICROPLASTIC PARTICLES IN A POROUS MEDIUM

Maltsev G.S., Filimonova E.A., Novoskoltseva O.A.

Lomonosov Moscow State University, Moscow, Russia
glebmaltsev75@gmail.com

Since 2020 articles began to appear on the topic of microplastic transport through a porous medium. Their main goal is to study the properties of a porous medium as a natural barrier for microplastics (MPs). The mechanism of all studies is similar. Sand, soil or other soil (sandy loam, loamy) is filled into the column. Then microplastic particles are placed in the upper part of the column and after that pumping water. MPs are picked up by water and gradually filtered through the column. Water with MPs drains through the column bottom, where samples are collected for further analysis.
Based on the results of studies of microplastic transport in a porous medium, the following conclusions were made: the distance, passed by microplastic particles, depends on the amount of water entering the column, on the speed of its supply and on many other factors.
An experiment was conducted at the Department of Hydrogeology of Lomonosov Moscow State University. Glass column with volume of 10 ml and diameter of 17.36 mm was used. Sand fractions of 0.16 – 0.25 mm were screened out for the experiment. The flow rate of the water solution with microplastic particles was 1.13 ml/min.
Carboxylated styrene-butadiene latex was used in the work, with 50 % by weight of the solid phase, the particles of which consisted of a copolymer of butadiene, methacrylic acid and methyl styrene at their mass ratio of 70:30:2, the content of residual styrene was 0.01 % by weight (JSC Voronezhsintezkauchuk, Russia).
The average hydrodynamic diameter of the particles was determined by the method of dynamic light scattering at a fixed scattering angle (90°) in a thermal cell on the Brookhaven Zeta Plus device (USA). The diameter values were calculated using the DynaLS software. The electrophoretic mobility (EFP) of particles was determined by laser microelectrophoresis in a thermostatic cell using a Brookhaven Zeta Plus device (USA) and embedded software. All measurements were carried out at a temperature of 25 °C.
In a dilute aqueous solution (10^{-3} % by weight) the initial latex is characterized by a monomodal distribution of particle size, the average hydrodynamic diameter of which is 160 nm, and the electrophoretic mobility is -4.8 (μm/s).
After passing 0.01% by weight aqueous latex solution through a column with sand in opalescent white samples, particles with an average hydrodynamic diameter of 220-280 nm are recorded, characterized by a bimodal distribution with maximum at 100 and 450 nm. With an increase in the transmission time through the column, the mode at 450 nm practically disappears.
After storage in plastic vials at a temperature of +4 °C in all 3 solutions, the signal level increases (the number of samples per second is 2.5 Msps), and negatively charged particles with an average hydrodynamic diameter of 150 nm, characterized by a narrow monomodal distribution, are registered.
Ultrasonic treatment in the bath for 15 minutes does not affect the particle size.

P.4-03 EXPERIMENTAL STUDY OF THE EFFECT OF NANOPLASTICS ON THE GASTROINTESTINAL TRACT

Ozeretskaya L.V., Zolotova N.A., Makarova O.V.

Petrovsky National Research Center of Surgery, Moscow, Russia
lozloz.o@yandex.ru

Today, one of the most widely used materials is plastic. Plastics decompose slowly, but quickly fragmentize into small particles, which called microplastics (MP, size less than 5 mm) and nanoplastics (NP, size less than 100 nm). MP and NP are easily carried by wind and water polluting the environment. People consume MP and NP daily with water and food. Therefore, an important issue is the assessment of their effect on the human body. Laboratory rodents are most often used as a model for studying toxic effects of various substances. There are many studies demonstrating the negative effect of MP on the gastrointestinal tract of laboratory mice [1], however, the effects of smaller NP particles have not been sufficiently studied. Therefore, the aim of our study was to evaluate the effect of NP on the gastrointestinal tract of C57BL/6 mice.

A suspension of polystyrene nanoparticles of 50 nm in diameter (PS-NP) in distilled water with a concentration of 0.5, 5 or 50 micrograms of PS-NP/ml was poured into drinkers for male C57BL/6 mice (approximate consumption doses of 0.1, 1 and 10 mg/kg body weight /day). The animals were euthanized on day 42 of PS-NP consumption.

A histological examination of the stomach, small intestine and colon was performed. There were no obvious morphological changes in the stomach under the PS-NP exposure. The most pronounced changes were observed in the small intestine. Cellular infiltration of the lamina propria was noted, mostly due to an increase of plasma cells number, alongside with the expansion of the lymphatic vessels of the intestinal villi. These changes probably indicate an increased permeability and the activation of immune response in the small intestine. In the colon, distinct reactions of goblet cells were detected due to PS-NP exposure. In some cases, the number of goblet cells decreased, whereas in other ones these cells were significantly enlarged. Probably, the hypersecretion and an increased mucus production by goblet cells had occurred, which is a protective reaction of the colon mucosa to stress effects. The severity of changes in the small and large intestines was increased with an increase of the PS-NP dose.

Our results are consistent with other researchers reports [2][3] and show the presence of dose-dependent proinflammatory and stressful effects of NP on the mucous membrane of the small and large intestine. Thus, NP should be considered as one of potent factors contributing to the development of intestinal diseases.

References

1. *da Silva Brito, Walison Augusto et al.* “Consequences of nano and microplastic exposure in rodent models: the known and unknown.” Particle and fibre toxicology **19(1)** 28 (2022).
2. *Liang, Boxuan et al*. “Underestimated health risks: polystyrene micro- and nanoplastics jointly induce intestinal barrier dysfunction by ROS-mediated epithelial cell apoptosis.” Particle and fibre toxicology **18(1)** 20 (2021).
3. *Zhang, Zhichun et al*. “Continuous oral exposure to micro- and nanoplastics induced gut microbiota dysbiosis, intestinal barrier and immune dysfunction in adult mice.” Environment international **182** (2023).

P.4-04 INVESTIGATING THE ACCUMULATION AND EFFECTS OF MICROPLASTICS ON HEALTH AND RATE OF AGING: A PILOT STUDY

Osechkova A.E.[1], Sotnikova Yu.S.[1], Stefanova N.A.[2], Nefedov A.A.[1], Kolosova N.G.[2], Polovyanenko D.N.[1], Bagryanskaya E.G.[1]

1 - N.N. Vorozhtsov Novosibirsk Institute of Organic Chemistry of Siberian Branch of Russian Academy of Sciences, Novosibirsk, Russia
2 - Institute of Cytology and Genetics of Siberian Branch of Russian Academy of Sciences, Novosibirsk, Russia
osechkova@nioch.nsc.ru

Environmental pollution by micro- and nanoplastics is currently considered an increasing threat to human health. Unfortunately, despite numerous claims about the toxic effects of microplastics (MPs), there is no convincing evidence of direct adverse health effects at the concentrations currently found in the environment. It can be expected that MPs may have adverse health effects with prolonged exposure, but it is impossible to isolate their effects on the human body against the background of the combined effects of multiple factors. The optimal approach to study the accumulation of microplastics in the organism and the mechanisms of their influence on health is the use of laboratory animals. The rate of ageing, which is associated with the development of associated diseases, can serve as an objective indicator of health status.

The present study aimed to evaluate the effect of microplastic particles accumulation on the health status of Wistar and OXYS rats (ICG SB RAS), a unique model of premature ageing. This is manifested by early development of a complex of "senile" diseases. From the age of 1.5 months, the animals were fed with 3-5 μm MPs particles (polyethylene terephthalate) in two doses. The rats were administered 10 and 100 mg/kg of microplastic particles. After two months of MPs administration, the state of phenotypic manifestations of premature aging in OXYS rats was evaluated. This included an examination of the rats' behavior, cognitive functions, and the degree of cataract and retinopathy development, which was found to be similar to age-related macular degeneration in humans. This was based on an ophthalmoscopic examination. Wistar and OXYS rats that did not receive MPs were used as controls.

Following the observation of phenotypic manifestations of premature ageing in rats, the animals were removed from the experiment in order to study the content of microplastic in their organs. The course of the study led to the development of an integrated approach to the assessment of the accumulation and distribution of plastic particles in the organs and tissues of the body, with a view to evaluating the cumulative effects on health. This paper presents preliminary results of quantitative determination of polyethylene terephthalate in rat organs (brain, heart, etc.) by pyrolysis gas chromatography–mass spectrometry using the developed methodology of tissue sample preparation in living organisms.

P.5-01 ПОЛИСАХАРИДЫ КАК АЛЬТЕРНАТИВА СИНТЕТИЧЕСКИМ ПОЛИМЕРАМ В УПАКОВОЧНЫХ МАТЕРИАЛАХ

Качалова Е.А., Масленникова М.С., Смирнова Л.А., Зайцев С.Д.

Нижегородский Государственный Университет им. Н.И. Лобачевского,
Нижний Новгород, Россия
katerina_k1997@mail.ru

На сегодняшний день все чаще поднимается вопрос обнаружения микро-(МП) и нанопластика (НП) в различных матрицах окружающей среды. Так МП сначала был найден в снегах на вершинах гор, куда попал по воздуху, после в водопроводной воде, в городской пыли, в организмах рыб и обитателей водоемов. Сейчас уже имеются подтвержденные данные о нахождении МП в организме человека: в крови, в желудочно-кишечном тракте, в семенниках. Настоящие исследования связывают рост риска сердечно-сосудистых заболеваний и снижение количества сперматозоидов у мужчин с присутствием МП в жидкостях и тканях человеческого организма. В связи с этим актуальной является задача по снижению количества МП и НП, посредством разработки биоутилизируемых пластмасс на основе природных полисахаридов.
Целью данной работы является синтез пленочных материалов на основе природных модифицированных полисахаридов крахмала (КР) и хитозана (ХТЗ) с высокими прочностными характеристиками. Два этих полисахарида выбраны не случайно, их молекулы удобны для модификации, они имеют возобновляемые сырьевые источники (картофель и панцири ракообразных), являются биодеградируемыми и не токсичными. При совмещении КР и ХТЗ необходимо было решить вопрос с растворимостью КР только в щелочной среде, а ХТЗ только в кислой. Для этого была проведена химическая модификация КР путем привитой сополимеризации с акриламидом (АА). Полученный полимер растворим в широком диапазоне pH, что позволяет беспрепятственно совмещать его с ХТЗ. Также требовалась модификация нативного ХТЗ для придания эластичных свойств пленкам на его основе. ХТЗ подвергали обработке энантовым альдегидом (ЭА) от 1 до 10 масс.%, с образованием оснований Шиффа. Модифицированные полимеры совмещали и из полученного раствора формировали пленки методом полива. Для усиления физико-механических свойств добавляли наночастицы (НЧ) диоксида титана (TiO_2). Добавление НЧ в общую массу композиции повышает прочность пленок на разрыв в два раза. Введение добавки пластификатора - глицерина влияет на эластичность пленок, увеличивая ее на 50%. Исследование биодеградируемости пленочных материалов на основе $ХТЗ_{ЭА}$:КР:АА показало разложение композиции на 53% в течение 28-дневеной инкубации под действием плесневых грибов Aspergillius Niger. Продукты биодеструкции анализировали методом хромато-масс-спектрометрии, по истечению четырех недель не обнаружены остатки синтетических полимеров, что свидетельсвует о безопасной утилизации в окружающей среде.
Полученные результаты исследования позволяют по-новому взглянуть на пути решения проблемы образования и накопления микропластика.

Работа выполнена при финансовой поддержке гранта РНФ № 23-13-00342.

P.5-02 ПАРАМЕТРЫ РАСТВОРИМОСТИ ХАНСЕНА В ХИМИЧЕСКОМ СПОСОБЕ ПЕРЕРАБОТКИ ПОЛИСТИРОЛЬНЫХ ПЛАСТИКОВ

Бекишев А., Ларичева Ю.

ПолиЛаб Пермь, Сибур-Химпром, Пермь, Россия
larichevaiua@shp.sibur.ru

Проблема микропластика в современном мире стоит весьма остро. Появляется всё больше масштабных исследований, показывающих, насколько глубоко микропластик проникает во все части экосистемы, от почв до организма человека [1]. Однако при существующем уровне развития техники и потребностей человека полный отказ от использования пластиков не представляется возможным. Таким образом, наряду с разработкой новых видов биоразлагаемых пластиков весьма перспективным является направление переработки и использования вторичного пластикового сырья.

Полистирольные пластики (в частности, полистирол вспенивающийся) – одни из самых популярных на текущий момент полимерных материалов, имеющих распространение практически во всех сферах жизнедеятельности человека. Можно выделить два основных способа переработки: механический и химический [2]. Механический способ включает в себя дробление и прессование, что продлевает срок жизни полимерных материалов, однако является дешёвым, но лишь временным решением. Среди химических способов переработки наиболее перспективным является растворение полистирольных пластиков в различных органических растворителях, в том числе, в природных эфирных маслах, с получением новых перспективных продуктов.

Мы полагаем, что параметры растворимости Хансена [3], учитывающие дисперсионное и межмолекулярное взаимодействие, а также водородные связи, могут служить полезным инструментом для предсказывания и анализа условий растворимости полистирольных пластиков в химических способах вторичной переработки полимерных материалов.

References

1. *Munhoz D.R., Harkes P., Beriot N., Larreta J., Basurko O.C.* Microplastics. **2**, 1, (2023). *Singh N., Abdullah M. M., Ma X., Sharma V. K.* Critical Reviews in Environmental Science and Technology. **53**, 1613, (2023).
2. *Maharana T., Negi Y.S., Mohanty B.* Polymer-Plastics Technology and Engineering, **46**, 729, (2007). *Thakur S., Verma A., Sharma B., Chaudhary J., Tamulevicius S., Thakur V.K.* Current Opinion in Green and Sustainable Chemistry. **13**, 32, (2018).
3. *Stefanis E., Panayiotou C.* International Journal of Thermophysics. **29**, 568, (2008). *Fink J.K.* Dispersions, Emulsions, and Foams. Petroleum Engineer's Guide to Oil Field Chemicals and Fluids (Third Edition). Leoben, Gulf Professional Publishing, 2021.

P.5-03 MAGNETIC SEDIMENTATION OF POLYETHYLENE MICROPARTICLES IN WATER MEDIA

Filinkova M.S.[1], Bakhteeva Iu.A.[1], Medvedeva I.V.[1,2]

1 - M.N. Mikheev Institute of Metal Physics of UB RAS, Yekaterinburg, Russia
2 - Ural State Mining University, Yekaterinburg, Russia
filinkova-ms@yandex.ru

Monitoring the distribution of microplastics in natural waters requires the development of new methods for preparing water samples. It is important that all the particles are separated from the water for subsequent analysis, including submicron-sized particles that are currently not captured by traditional sampling with meshes [1]. Efficient extraction of microplastic from water can be achieved by the magnetic separation method, in which the target particles form heteroaggregates with added magnetic particles which are subsequently extracted from water under the action of a gradient magnetic field [2]. In this work, the magnetic sedimentation method to separate microparticles of commercial polyethylene (MPE) with sizes of 10-200 μm from the aqueous solutions imitating natural waters was investigated. To the NaCl, Na_2SO_4, $NaH_2PO_4{\cdot}2H_2O$, $CaCl_2$ water solutions (10 and 100 mM) with the dissolved sodium dodecyl sulfate, as a surfactant (SDS, 3 mM), the $Fe_3O_4@SiO_2\text{-}NH_2$ (FSN) composite magnetic nanoparticles were added and dispersed. Afterwards, the magnetic sedimentation process was monitored for various conditions.

Composite magnetic nanoparticles (FSN) (d_h = 200 nm) with a magnetic core and a coating layer providing electrostatic attraction to oppositely charged polyethylene particles were synthesized and characterized. It has been shown that the magnetic nanoparticles form heteroaggregates with polyethylene microparticles, the properties of which can be tuned by changing the mass ratio of the components and by the time of their interaction. The sedimentation of the aggregates was carried out in a gradient magnetic field generated by a system of Sm_2Co_{17} strip permanent magnets and soft magnetic steel inserts (B_{zmax} = 0.44 T). The efficiency of magnetic separation was estimated from the residual concentration of plastics in water, which was determined by spectrophotometry. It has been detected that the addition of magnetic nanoparticles at a concentration of c = 0.01 g/L to aqueous suspensions of polyethylene, c = 0.1 g/L ensures MPE separation efficiency of up to 98%. The optimal conditions of the magnetic sedimentation regime for a NaCl, NaH_2PO_4 or $CaCl_2$ solution with a salt concentration of c = 10 mM are a preliminary exposure of the heterosuspension for 30 minutes and a subsequent magnetic sedimentation for 15 minutes. It was shown that in solutions imitating river and sea water in the presence of SDS (3mM), up to 90% of polyethylene microparticles can be separated from water in 30 minutes of magnetic sedimentation.

The research was carried out within the state assignment of Ministry of Science and Higher Education of the Russian Federation (themes "Magnet" No. 122021000034-9, "Pressure" No. 122021000032-5), supported in part by youth science project of IMP UB RAS (project No. M 9-23).

References

1. *Costa C.Q.V., Cruz J., Martins J., Teodósio M. A.A., Jockusch S., Ramamurthy V., da Silva J. P.* Environ. Chem. Lett. **19**, 1797-1802, (2021). 2. *Bakhteeva I.A., Medvedeva I.V., Filinkova M.S., Byzov I.V., Minin A.S., Zhakov S.V., Uimin M.A., Patrakov E.I., Novikov S.I., Suntsov A.Yu., Demin A.M.* Int. J. Environ. Sci. Technol. **20**, 11837– 11850, (2023).