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Understanding human health hazards of micro- and nanoplastics Challenges and Debates

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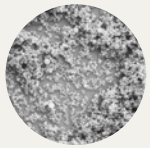
Size Classification of micro- and nanoplastics

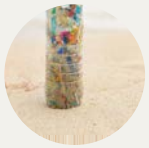
Microplastics

Particles smaller than 5 mm and larger than 1 µm
-L*arge Microplastics: 5 mm - 100 µm*
-*Small Microplastics : 100 µm - 1 µm*



Nanoplastics

Particles smaller than 1 µm



Categorization

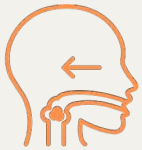
Secondary plastics are those formed by the degradation of primary plastics.

Polymers: substances (synthetic or natural) composed of macromolecules, very large molecules with molecular weights ranging from few thousand to as high as millions of grams/mol.

Plastics: polymer materials that have the capability of being molded or shaped, usually by the application of heat and pressure.

CEN ISO / TR 21960:2020; IUPAC. Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"); Science for Environment Policy (2023) Nanoplastics

Human Exposure to micro- and nanoplastics



Ingestion

Microplastics can be ingested through contaminated food and water, posing a potential health risk.

Inhalation

Nanoplastics small enough to be airborne can be inhaled, potentially leading to respiratory issues.

Dermal Absorption

Some evidence suggests microplastics may be able to penetrate the skin, though more research is needed.

Environmental Science and Technology, 2019, 53, 1748

Challenges in Assessing Health Risks

Analytical Limitations

Accurately detecting and quantifying micro- and nanoplastics in the environment and human samples is challenging.

Diverse Composition

Plastics contain a wide range of additives, making it difficult to assess the toxicity of individual particles.

Lack of Data

The long-term health effects of chronic exposure to micro- and nanoplastics are still unknown.

NanoImpact, 2023, 29, 100441

Analytical Limitations

Sampling

Developing reliable methods to sample micro- and nanoplastics in diverse environments is challenging.

Instrument Resolution Limits

Spatial resolution in the micron size range

Identification Complexity

Discerning micro- and nanoplastics from other carbon-based particles (or material) is very challenging

Polydisperse in size and shape

Inhert and hydrophobic

Concentration

The anticipated environmental concentrations range from mg/L to ng/L, yet existing methods lack the required sensitivity.

Chemosphere, 2022, 293, 133514; Chemical Reviews, 2021, 121, 11886; Analytical and Bioanalytical Chemistry, 2023, 415, 3007

Ongoing Scientific Debates and Uncertainties

Translocation and Bioaccumulation

It is unclear whether micro- and nanoplastics can translocate to other organs and bioaccumulate in the body

Dose-Response Relationships

Determining safe exposure levels is challenging due to the complexity of micro- and nanoplastic exposures

Toxicological Effects

It is unclear whether are the potential adverse effects on cellular function, inflammation, oxidative stress, genotoxicity, and immune responses

Exposure Routes

It is unclear which are the primary routes of exposure to micro- and nanoplastics for humans

Immune System Responses

Whether they trigger immune responses, inflammation, allergic reactions, or autoimmune diseases

Long-Term Effects

Uncertainties exist regarding the long-term health effects of chronic exposure to micro- and nanoplastics, including the potential for carcinogenicity, mutagenicity, and other chronic diseases

Lack of Standardized Methods

No standardization and harmonization

Science for Environment Policy (2023) Nanoplastics: state of knowledge and environmental and human health impacts. Future Brief 27. Brief produced for the European Commission DG Environment by the Science Communication Unit, UWE Bristol. Available at: https://ec.europa.eu/scienceenvironment-policy.

Lack of Standardization

ISO/DIS 16094-2; ISO 24187:2023; ISO/TR 21960:2020; ISO 17422:2018

Terminology

There is still no agreement on which materials can be classified as plastic.

Size

Plastic size classification is still under debate

Shape

Pellets, fibers, fragments, spheres, granules, etc.

Units

Plastics concentrations are reported in a wide variety of units

Controls

Many published studies lack proper controls

Regulatory and Policy Considerations

Identification

Establish standardized and harmonized methods to identify and quantify micro- and nanoplastics

Monitoring

Implementing comprehensive monitoring programs to track environmental and human exposure

Regulation

Develop regulations and policies to mitigate micro- and nanoplastic pollution

Mitigation Strategies and Solutions

Recycling

Improving plastic recycling methods to limit micro- and nanoplastic pollution

Removal

Develop advance methods to remove plastic waste including micro- and nanoplastics

Research

Investing in research to understand the sources, fate, and effects of micro- and nanoplastics

Policy

Implementing comprehensive policies to reduce plastic waste and promote sustainable practices

Research - BioNanomaterials Group

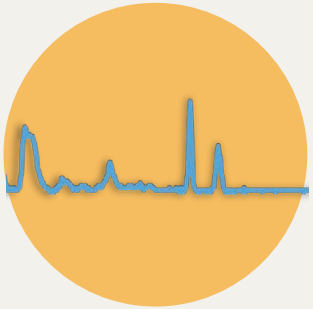
https://www.ami.swiss/bionanomaterials/en/

Fabrication

PE, PP, PET, PS

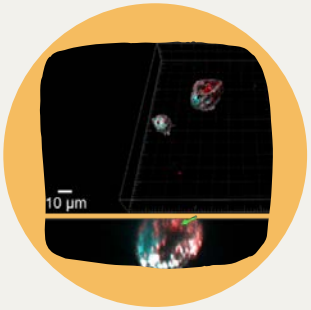
Characterization

Size, shape, chemical composition, concentration, presence of additives



Detection

Raman / SERS, IR, Microscopy, Light Scattering

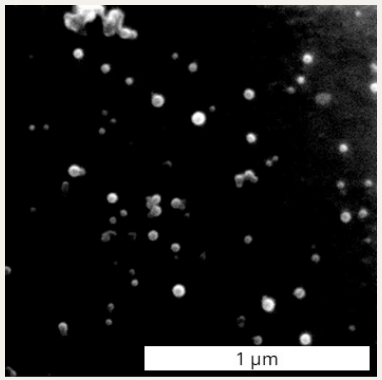


In vitro Exposure

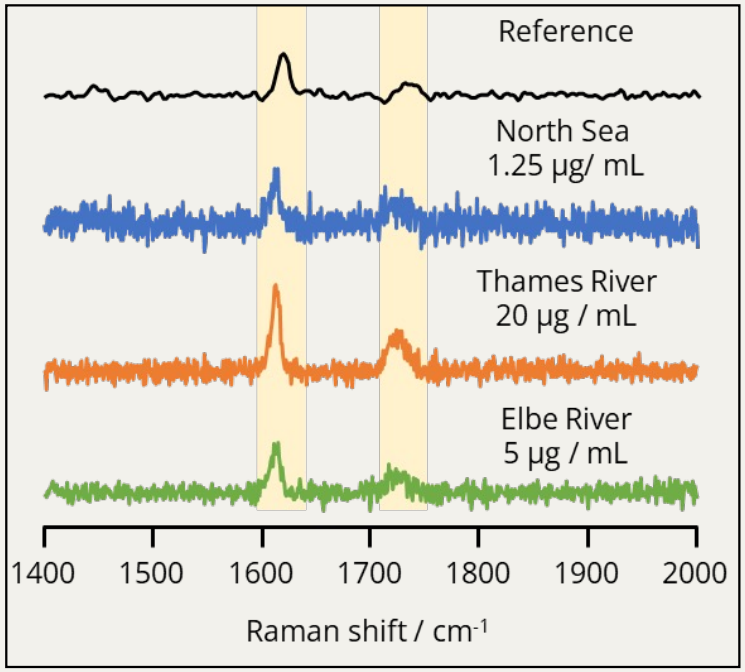
Human cells (Caco-2, MDMs, HT29-MTX, A549, etc.)

PE: Polyethylene; PP: Polypropylene; PET: Polyethylene terephthalate; PS: Polystyrene; SERS: Surface-Enhanced Raman Spectroscopy; IR; Infrared spectroscopy
Caco-2 and HT29-MTX: Human intestinal epithelial cell line; MDMs: Monocyte-derived macrophages; A549: Human alveolar epithelial cell line

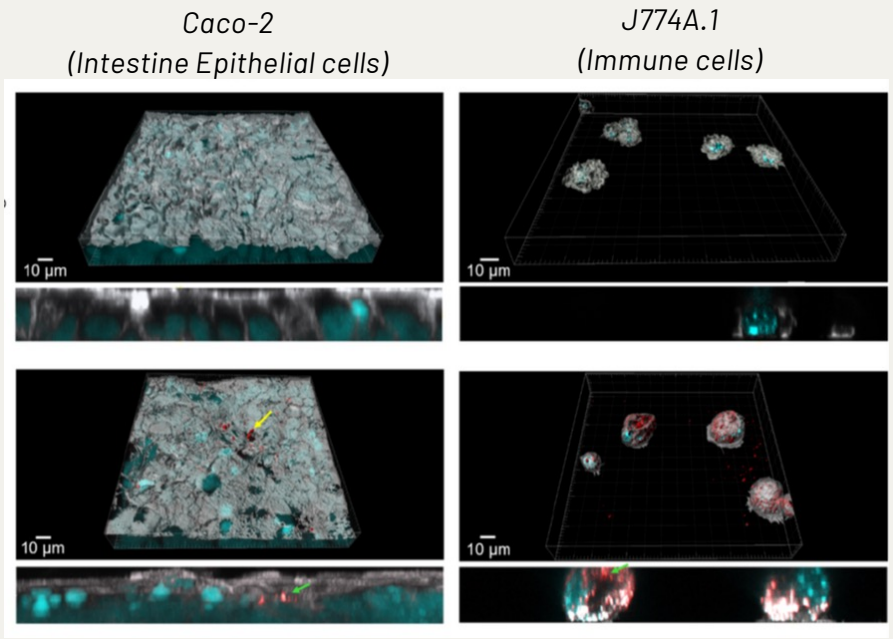
PET test nanoplastics



Scanning electron micrographs of the fabricated PET test nanoplastics



Detection of PET nanoplastics in environmental waters using Raman spectroscopy



In vitro exposure to PET nanoplastics

Environ. Sci.: Nano, 2021,8, 502-513; Marine pollution bulletin, 2024, Submitted

Conclusions and Future Research Directions

Emerging Concerns	Ongoing Research
Widespread presence of micro- and nanoplastics in the environment and human body	Improving detection and quantification methods
Potential health effects	Understanding toxicological mechanisms and bioaccumulation
Significant knowledge gaps and scientific uncertainties	Long-term epidemiological studies on human health impacts

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Thanks for your attention

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