Characterization of nano- and microplastics pollution and its mitigation by ionizing radiation

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There is increasing concern over the environmental and health impacts of micro- and nanoplastics, which can penetrate cell membranes and pose significant risks due to their small size and high surface area, effectively serving as vectors for toxins. Current detection methods, such as FTIR and SERS, have limitations, particularly in detecting nanoplastics, which has prompted the development of new analytical techniques like colocalized Raman spectroscopy and other methods for high-resolution detection and structural analysis. As part of an International Atomic Energy Agency (AIEA BRA705) project, we are exploring potential solutions for nanoplastic detection and presenting results from biochemical assays assessing the cytotoxic and genotoxic effects of these materials. Additionally, we are investigating eco-efficient methodologies for recycling polymeric waste using radiation technologies.

Conventional detection methods are inadequate for identifying nanoplastics below the diffraction limit, as these particles are too small to be visualized under a microscope. To address this challenge, we have developed a multi-technique approach that combines micro-Raman spectroscopy with atomic force microscopy. This approach successfully achieves single-particle spectra for nanoplastics as small as 25 nm, offering high-resolution detection comparable to more complex methods. This technique holds the potential to identify and characterize nanosized polymers in cell cultures, a future step in our ongoing cytotoxicity and genotoxicity assays using calibrated nanoplastics with diameters starting at 10 nm.

While our research, funded by FAPESP project (202104434-7), is at the forefront of nanoplastic detection, we also support a broad network of collaborators across Brazil in their efforts to address microplastic pollution. We assist in identifying microplastic content in diverse samples, specifying not only the type of plastic but, in some cases, also the type of contamination, ranging from herbicides to dyes and impact modifiers. Currently, we are involved in 18 projects with 10 collaborators, investigating microplastic contamination in various environments, including deep-sea fish, Amazonian water reservoirs, beaches, and bird nests.

Finally, mitigating plastic pollution is essential for effectively combating environmental degradation, safeguarding ecosystems, and ensuring the health and sustainability of our planet for future generations. To this end, we are working on multiple fronts, including the development of a mobile electron irradiation unit for wastewater treatment, the incorporation of waste plastics into asphalt binders, and the use of metal-organic frameworks on large carbon fiber sheets for the complete elimination of nano- to small microplastics.