Microplastics in Animal Tissue

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Introduction

Mussels are established sentinel organisms for coastal microplastic monitoring. As suspension feeders, they filter large amounts of water and accumulate particles from the surrounding water column, and their tissue load reflects local contamination over time. Establishing the polymer identity of the accumulated particles requires chemical characterization rather than visual inspection alone. Particles recovered from digested tissue span a wide size range and occur alongside mineral and organic debris that cannot be distinguished from plastics by eye.

FT-IR imaging, however, can produce spatially resolved chemical maps of large filter areas and even entire filters, identifying each particle by its infrared spectrum and delivering size and morphology data in the same measurement. This application note describes its use for microplastic characterization in two mussel species from Guanabara Bay, Rio de Janeiro, sampled across two seasons, as described by Dr. J. Paulo Felizardo and Dr. C. Rodrigues from UFF Brazil.

Experimental

A total of 120 mussel individuals were collected from two aquaculture sites in Guanabara Bay: Jurujuba and the Rio–Niterói Bridge area. Two species were sampled: the brown mussel Perna perna and the Asian green mussel Perna viridis. Collections took place during the rainy season (February 2025) and dry season (August 2025) to account for seasonal variability in particle load.

Sample preparation was performed by alkaline digestion using a 10% KOH solution at a solution-to-sample volume ratio of 5:1. Samples were incubated at 40°C for 72 h. The digested material was then filtered through a stainless 25 µm steel mesh, and the retained fraction was transferred to glass beakers. Density separation was carried out by adding 10 mL of NaI solution (4.4 mol/L; 1.8 g/cm³), followed by sonication for 15 min and mechanical agitation for at least 15 min. During agitation, an additional 10 mL of NaI solution was added. This cycle was repeated twice. The samples were subsequently centrifuged at 500 × g for approximately 2 min, with centrifugation repeated if suspended material remained visible. Finally, the low-density supernatant was vacuum-filtered onto 0.2 µm Anodisc aluminum oxide filters. To validate the sample preparation process, a procedural blank was carried through all preparation steps, omitting only the biological tissue.

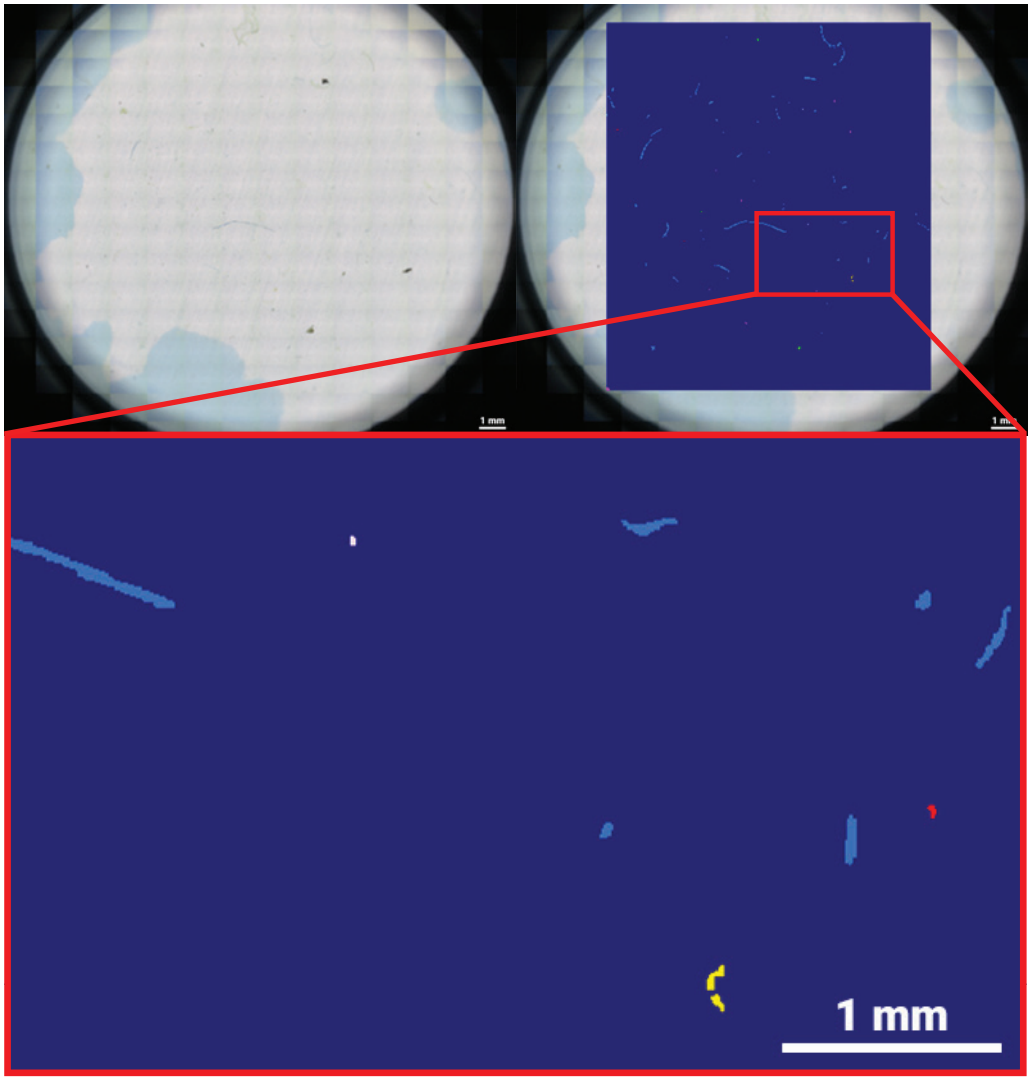

Fig. 1
Data obtained from a Guanabara Bay mussel tissue sample. Left: transmitted-light mosaic of the Anodisc filter following alkaline digestion and density-based extraction. Right: corresponding hyperspectral µFT-IR map acquired with the Bruker LUMOS II and evaluated with the Bruker MPID software. Images courtesy of Dr. J. Paulo Felizardo and Dr. C. Rodrigues.

Results

Anodisc filters were analyzed in transmittance mode using the Bruker LUMOS II FT-IR imaging microscope, while data were processed with the Microplastic Identifier (MPID) software, which uses machine learning to detect and identify particles. Microplastic particles were detected in all 120 sampled individuals within the analyzed size range, indicating widespread particle exposure in Guanabara Bay under the applied preparation and µFT-IR imaging workflow. This 100% occurrence rate reflects the degree of particulate pollution in Guanabara Bay and the sensitivity of the analytical method.

The data showed that Perna viridis carried a higher absolute particle count per individual (mean 5.4 particles per individual) compared to P. perna (mean 2.2 particles per individual). When normalized to soft tissue mass, the relationship reversed: P. perna showed significantly higher contamination at 0.54 ± 0.45 particles/g versus 0.19 ± 0.13 particles/g in P. viridis. This difference may reflect species-specific body mass, tissue composition, filtration behavior, or site-related exposure patterns, and should therefore be interpreted in the context of biological and environmental covariates.

Polypropylene (PP) was the dominant synthetic polymer across both mussel species. In P. perna, PP accounted for mainly fragments (92%), with mean dimensions of 4.33 µm width and 35.77 µm length. Its prevalence is consistent with PP's low density and widespread use in packaging, ropes, and other marine-related materials, although polymer identity alone does not allow source attribution.

Spectra | List | Particles | Particle statistics

Area [µm^2]	Width [µm]	Length	Substance	Identification Quality	Fiber	Particle fiber size
1347.30	53.34	53.40	PE	828.38	False	31.65
414.55	50.87	30.56	PE	682.35	False	22.97
103.64	30.58	20.34	PE	757.39	False	11.49
466.37	38.95	31.79	PE	698.76	False	24.37
5492.85	107.90	83.49	PE	960.92	False	65.63
725.47	80.41	33.64	PET	714.06	True	21.20
3109.15	134.55	60.94	PET	699.84	True	40.72
1450.94	89.33	38.38	PET	711.09	True	27.46
725.47	50.96	30.51	PMMA	638.01	False	25.28
259.10	31.76	24.59	PMMA	549.75	False	18.16
155.46	30.52	20.37	PMMA	726.10	False	14.07
673.65	60.28	32.93	PMMA	531.61	False	22.05
518.19	69.47	29.92	PP	764.56	True	21.20
259.10	31.76	24.59	PP	712.34	False	18.16
103.64	32.96	14.73	PP	703.13	False	11.49
1088.20	61.04	40.75	PP	888.83	False	28.16
777.29	50.87	40.75	PP	880.62	False	25.28
362.73	30.52	30.56	PP	760.72	False	21.49
2850.06	81.53	61.01	PP	926.56	False	49.26
570.01	55.65	37.54	PP	832.73	False	23.24
1088.20	61.04	40.75	PP	771.37	False	26.96
9068.36	132.49	122.03	PP	913.37	False	186.89
103.64	30.52	20.37	PS	711.31	False	11.49
1606.39	61.15	50.84	PS	861.23	False	36.93
570.01	40.69	30.56	PU	667.05	False	23.24
466.37	38.95	31.79	PVC	640.26	False	24.37

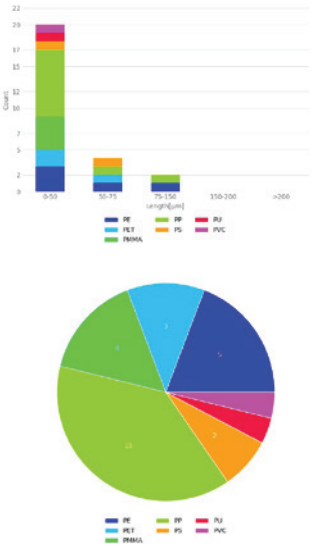

Fig. 2
Exemplary MPID result obtained from a Guanabara Bay mussel tissue sample. Extensive particle information is given together with an interactive classification map. When a particle or particle class is selected, all respective information is directly displayed.

Conclusion

FT-IR microspectroscopy is well suited to microplastic analysis in digested biological tissues, detecting particles below the visual-sorting size limit and enabling automated, chemically specific polymer identification that reduces operator variability.

Microplastics in all mussel samples demonstrate the extent of contamination in the Guanabara Bay. Differences in mass-normalized burdens between *P. perna* and *P. viridis* indicate that species-specific biological factors should be considered in standardized biomonitoring protocols.

As filter feeders, mussels accumulate microplastics from surrounding water and can serve as bioindicators of environmental contamination. Their role in marine food chains and consumption as seafood also create a potential exposure route for higher trophic levels. Continued monitoring is therefore necessary to assess ecological contamination and potential human exposure.

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