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DETECTION OF MICROPLASTICS IN WATER USING LASER-BASED TECHNOLOGY

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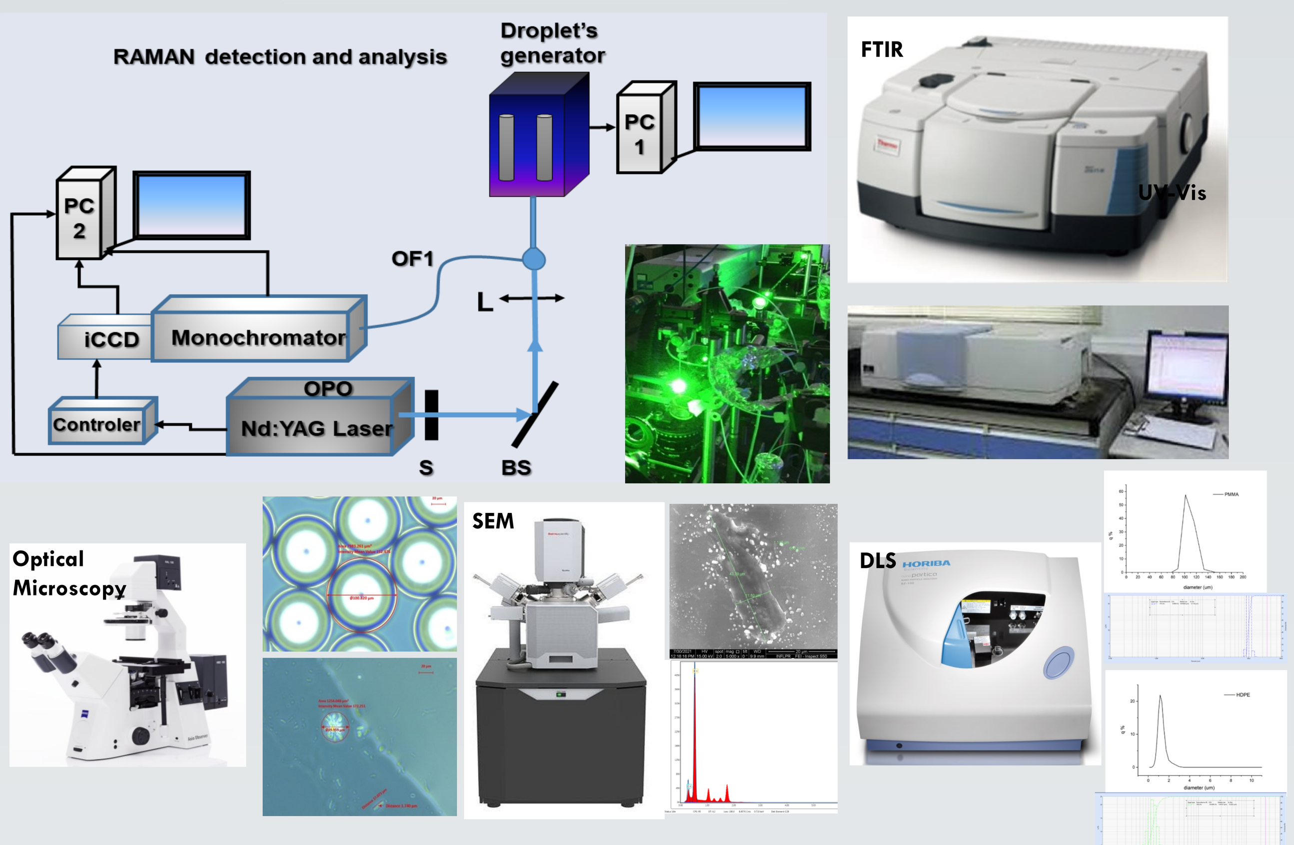
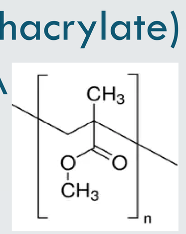
Aims

- Generation of stable microdroplets of water contaminated with microplastics (MPs);
- Detection of microplastics in micro-volumetric water droplets by Raman spectroscopy.

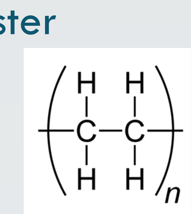
Experiment

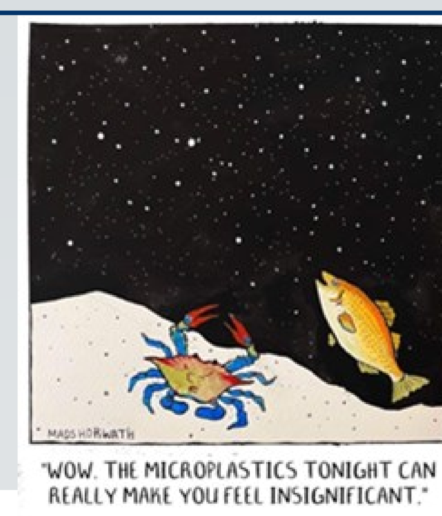


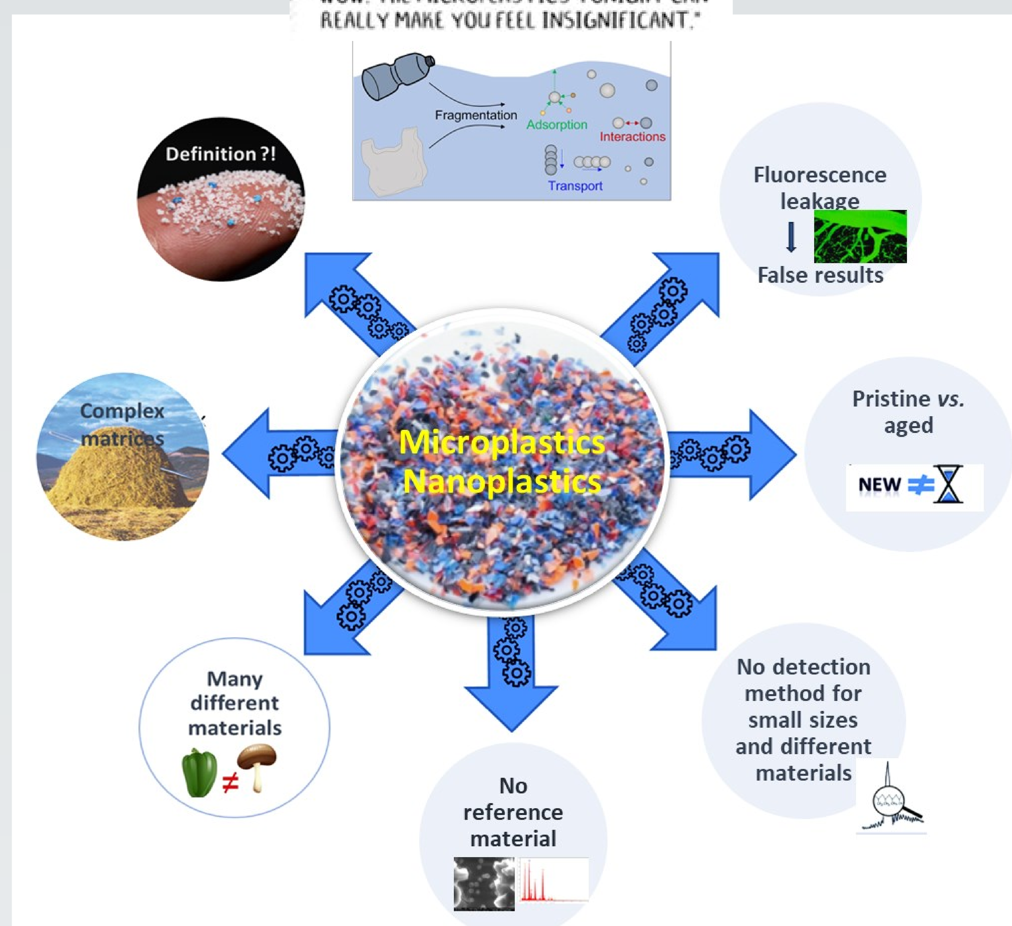
Poly(methyl methacrylate) PMMA



Polyester PE

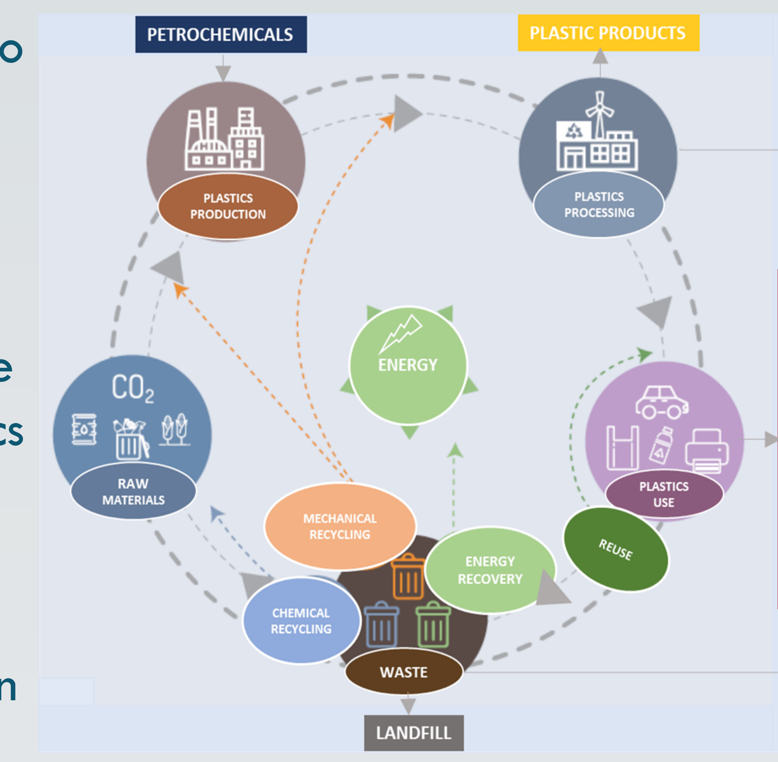






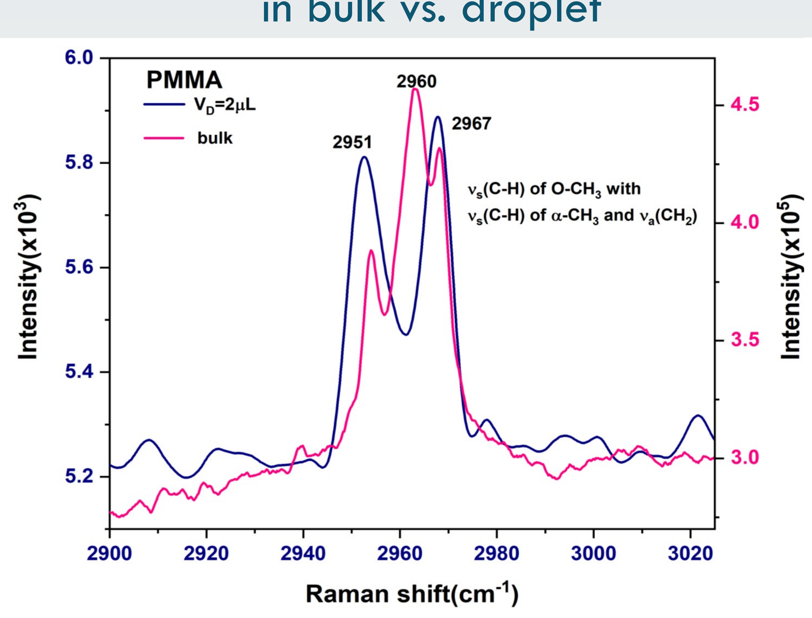
Background

- The consumption of plastics increases environmental pollution due to their low biodegradability, inappropriate use, and inefficient disposal;
- Exposure of plastic materials in the environment promotes physical, chemical, and biological degradation processes;
- Plastic degradation leads to accumulation of very small plastic fragments in the environmental ecosystems;
- Microplastics vary in size between 0.1–5000 mm. The smaller group of nanoplastics can be specified based on current definitions for nanomaterials as particles that range from 1–100 nm in size;
- Monitoring of MPs in different environmental matrices is necessary;
- Identifying MPs of different composition, shape, and size is a difficult goal [1];
- Many challenges in the field of micro- and nano-plastics research must be addressed [2].

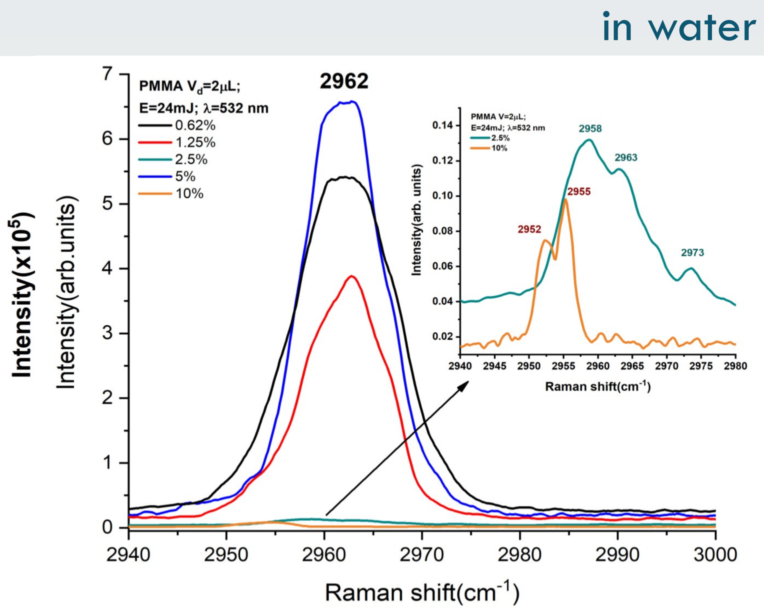


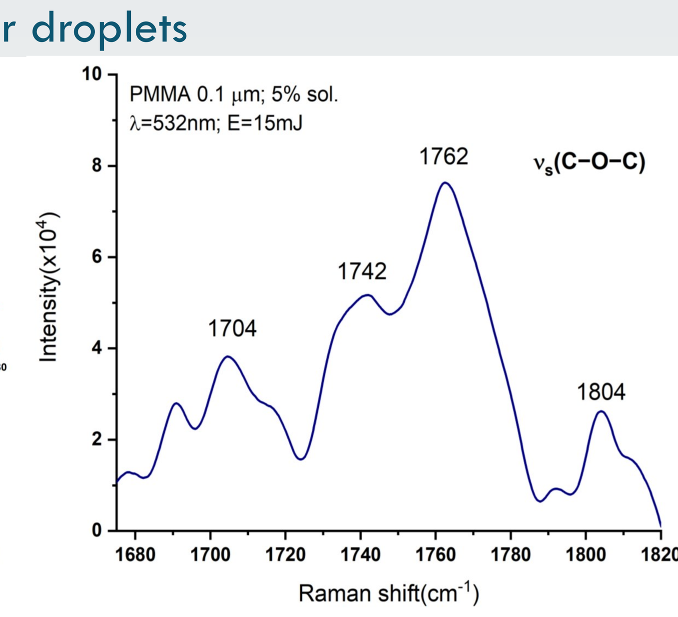
Results

The Raman spectra of PMMA in bulk vs. droplet

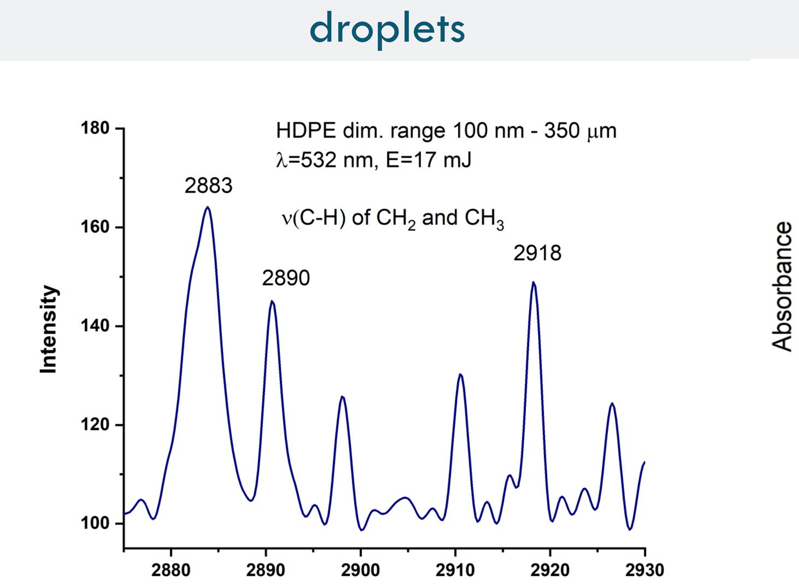


The Raman spectra of PMMA in water droplets

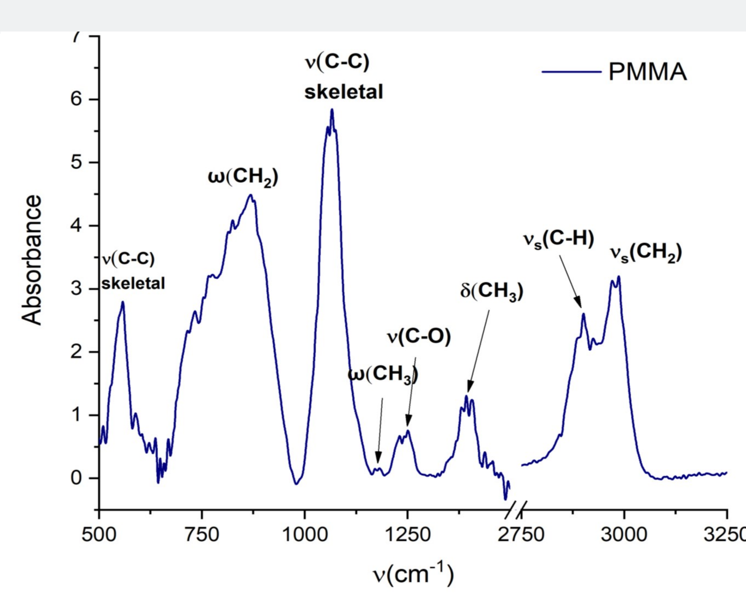




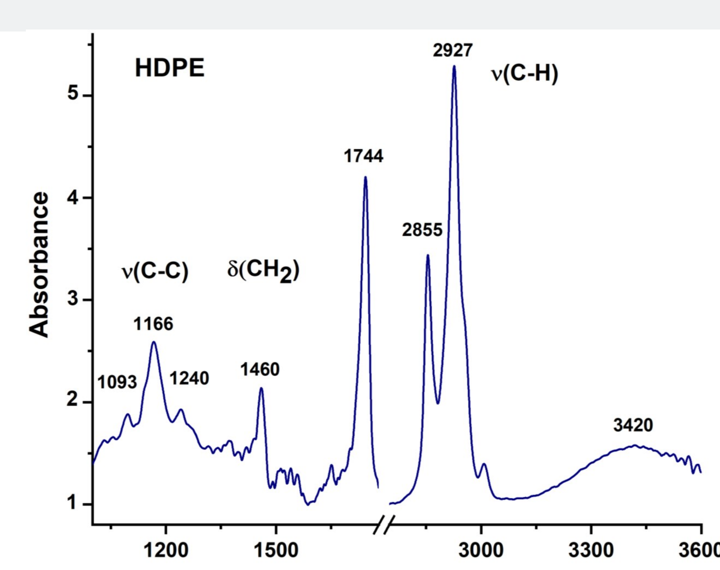
The Raman spectra of PE in water droplets



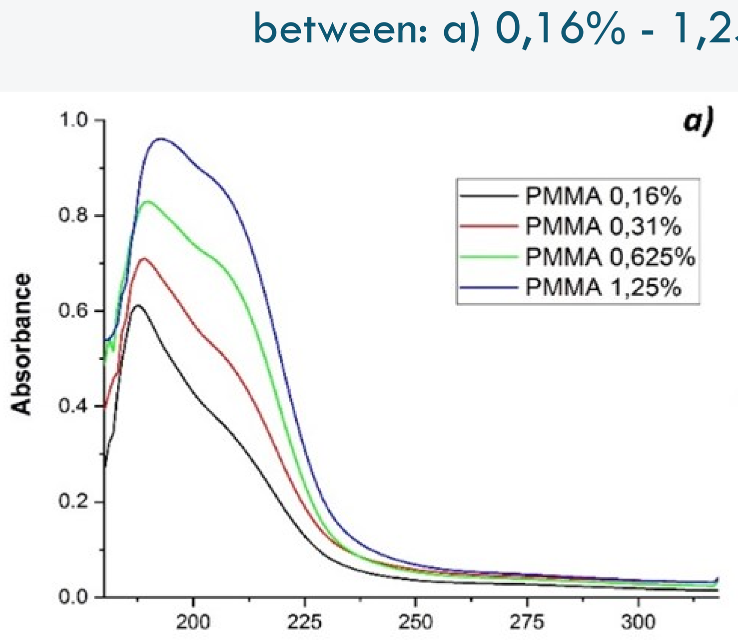
The FTIR spectrum of PMMA

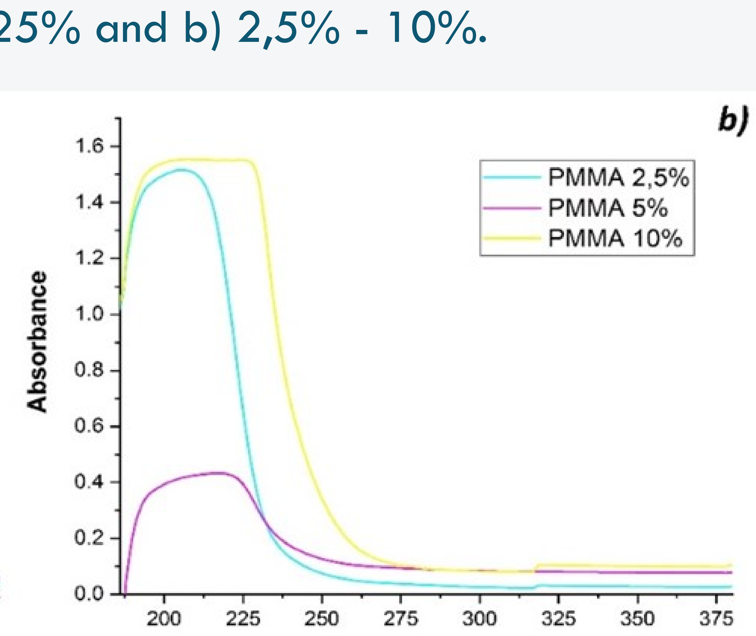


The FTIR spectrum of PE

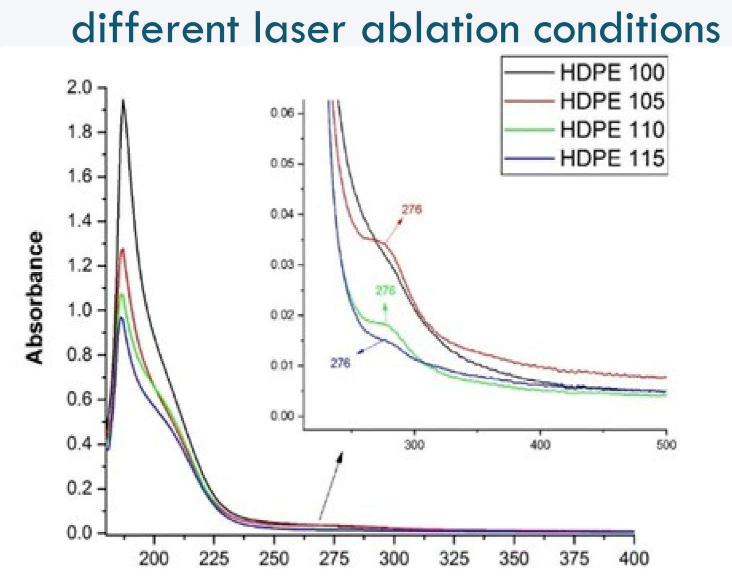


The UV-Vis absorption spectra of PMMA in water at concentrations between: a) 0,16% - 1,25% and b) 2,5% - 10%.





The UV-Vis absorption spectra of high density PE (HDPE) in water for different laser ablation conditions



Discussions and Outlook

- We performed Raman spectroscopy measurements on water droplets containing Poly(methyl methacrylate) – PMMA and Polyester - PE microparticles.
- Supplementary analysis were carried out by UV-Vis absorption and FTIR spectroscopy, optical and electronic microscopy (SEM), as well as by dynamic light scattering (DLS).
- Among the registered Raman bands of droplets containing PMMA, the most prominent one was observed at 2960 cm^{-1}, which corresponds to an overlap of the C-H stretching vibration modes of the CH_2 groups of the skeleton, of the α-CH_3 groups and of the CH_3 ester groups [3].
- We detected nanometric PMMA particles in water droplets based on the Raman spectra by identifying the band between 1700 - 1800 cm^{-1}, which corresponds to the stretching mode vibrations of the carbonyl bonds.
- FTIR experimental results are consistent with both the published data and the calculated spectra.
- The appearance of the UV-Vis absorption bands may be due to the fact that microplastic particles do not have the same roughness, so some samples have a higher scattering coefficient, thus influencing the light intensity passing through the sample.
- Raman spectroscopy is promising for detection of microplastics when water droplets are considered [4]. However, further challenge is to optimize the working parameters of the experimental system (optical, detection, microfluidic, optofluidic) when considering tens of micrometers to nanometer-sized particles.

References

1. Mariano, S. et al., Micro and Nanoplastics Identification: Classic Methods and Innovative Detection Techniques, Frontiers in Toxicology, 3 (2021).
2. Paul M.B. et al., Micro- and nanoplastics – current state of knowledge with the focus on oral uptake and toxicity, Nanoscale Adv., 2, 4350 (2020).
3. Thomas, K. J. et al., Raman spectra of polymethyl methacrylate optical fibres excited by a 532 nm diode pumped solid state laser. J. Opt. A: Pure Appl. Opt. 10, 055303 (2008).
4. Andrei I.R. et al., Unresonant Interaction of Laser Beams with Pendant Droplets in Laser Optofluidics in Fighting Multiple Drug Resistance, Ed. M.L.Pascu, Bentham, 2017.

Acknowledgement

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