George Sarau
Silke H. Christiansen
Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Äußere Nürnberger Str. 62, 91301 Forchheim, Germany

george.sarau@ikts.fraunhofer.de

Correlative Spectroscopy and Microscopy Analysis of Micro- and Nanoplastics and Their Effects on Cells and Tissues

Plastics environmental pollution evolved into a planetary problem over the last decades. Especially the micro- and nanoplastics (MNPs) particles constitute a potential health hazard for humans because of ingestion and inhalation. To assess the exposure level and impact on human health, we developed a novel analytical and automatic relocalization workflow using the Nano-Global Positioning System (nanoGPS) and Particle Finder technologies from Horiba [1]. This workflow is based on the application of Raman spectroscopy (spontaneous and stimulated) supported by complementary microscopy techniques (optical, fluorescence, electron) at the same region of interest in method-specific instruments from different manufacturers. Micro-Raman spectroscopy combined with optical microscopy was used to quantify microplastics, pigment, and additive particles contamination in bottled mineral water with the smallest analysed particle size of ~1 µm [2]. To overcome optical resolution, scanning electron microscopy (SEM) was employed to exclude both overestimation of particle size and underestimation of particle number for clustered MNPs. Moreover, single nanoplastics particles found by SEM were blindly measured by micro-Raman through relocalization and overlapping of SEM and optical images [3]. Next, the influence of MNPs as found in bottled mineral water on in-vivo human podocytes as representative kidney cells prone to accumulation of particles during lifetime was investigated. We observed clear changes in the biological features of plastics-treated cells compared to non-treated controls, attributed to cell damage through surface adhesion and uptake of plastic particles, as confirmed by cell viability fluorescence assays [1]. Feeding experiments on mice showed increased accumulation of MNPs in tissues from various organs after dextran sulfate sodium (DSS)-induced colitis. This model is similar with human ulcerative colitis characterized by damaged mucosal barrier function facilitating the transfer of MNPs from inflamed gastrointestinal tract to other organs. Thus, Raman integrated in a correlative workflow enables the chemical identification, localization, counting, and risk assessment of MNPs in water and complex biological matrices.

References

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[2] B. E. Oßmann, G. Sarau, H. Holtmannspötter, M. Pischetsrieder, S. H. Christiansen, W. Dicke, Water Research, 141 (2018) 307-316
[3] G. Sarau, L. Kling, B. E. Oßmann, A. K. Unger, F. Vogler, S. H. Christiansen, Applied Spectroscopy, 74 (2020) 1155-1160

Figures

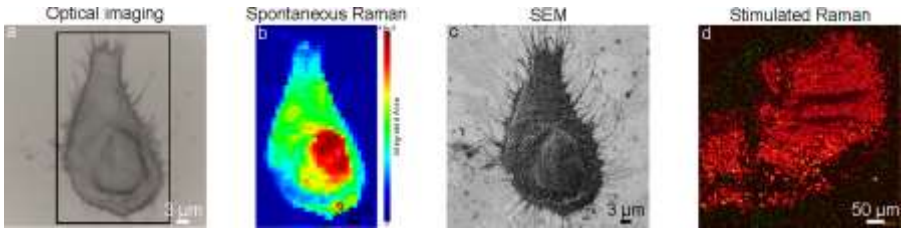

Figure 1: Spectroscopy and microscopy workflow applied to podocytes (a, b, c) and accumulation of MNPs in tissues (d).