AGEUM – analytical laboratory evaluates health risks of environmental pollution

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The analytical laboratory for health and environmental research (AGEUM) at the Forchheim site of Fraunhofer IKTS with its novel, cutting-edge microscopy and spectroscopy techniques offers strong characterization and data analysis capabilities to assess potential human health risks caused by environmental pollution. Environmental factors such as smog, micro- and nanoplastics, brake dust and tire particles (ultrafine dust) constitute highly heterogeneous particulate matter and their biological interactions with living organisms are very complex. This is why, when it comes to characterizing them, the laboratory uses a complementary, multimodal and cross-scale approach. X-ray fluorescence (XRF) microscopy provides high elemental sensitivity down to carbon, variable probe spot sizes (100 µm for statistically significant large area scans and ~15 µm for spatially detailed elemental distribution mapping), and an additional transmission X-ray detector to image internal structures. XRF identifies and quantifies elements present in environmental samples, usually powders and air filters (Figure 1).

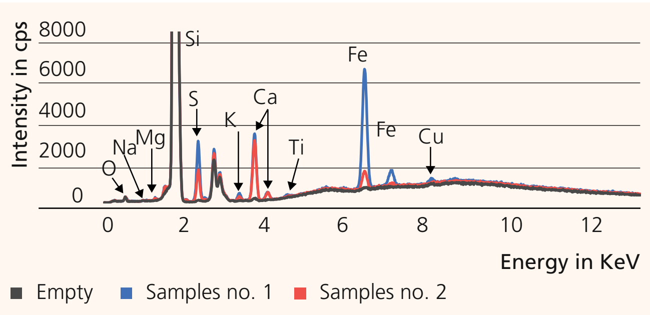

Figure 1: XRF of quartz filters exposed to urban (sample 1) and rural (sample 2) environmental pollution compared with an empty filter, indicating more iron (Fe) and sulfur (S) in the city due to increased human activity.

The integrated platform, incorporating coherent Raman scattering (CRS), second harmonic generation (SHG), fluorescence (FL), and fluorescence lifetime imaging microscopy (FLIM), offers high-throughput, high-resolution, and non-invasive detection of particles inside intricate biological matrices at the cell, organ tissue and small animal levels. CRS, including stimulated Raman scattering (SRS) and coherent anti-Stokes Raman scattering (CARS), chemically identifies different types of particles (plastic-, carbon- and metal oxide-based) and biological components (lipids, protein, collagen) without compromising the probe. This high sensitivity combined with machine learning algorithms can be employed to localize, count, and classify particles according to their size and shape despite intricate biological backgrounds (Figure 2). Moreover, CRS can be directly applied to samples from pathologists, ensuring human relevance by correlating the accumulation of particles inside organs and body fluids with existing patients' clinical data.

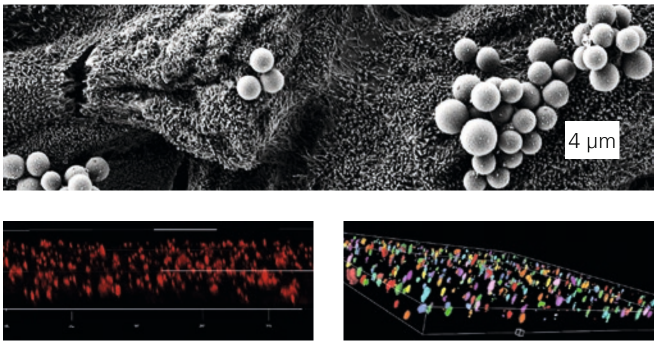

Figure 2: Top: SEM shows the presence of PS particles attached on top of the cells; bottom left: 3D distribution of polystyrene (PS) particles inside and on top of Calu-3 lung cells measured with SRS; bottom right: Machine learning reveals particle number, size, and shape.

Additionally, Fourier-transform infrared spectroscopy (FTIR) is able to measure vibrational modes of molecules associated with changes in dipole moment. FTIR thus provides high-throughput, high-sensitivity, label-free, and hyperspectral infrared imaging, enabling fast detection, characterization, and quantification of various environmental particles in complex biological entities. When combined, these three instruments will provide new insights into the biodistribution and penetration of particles across species, elucidating the potential impact of environmental pollution on human health.

Services and cooperation offered

- S2-bio-laboratory for sample preparation with cryo-workflow
- XRF for elemental analysis
- Integrated confocal microscope platform for label-free chemical imaging and molecular fingerprinting
- FTIR for hyperspectral chemical imaging
- Scanning electron microscope (SEM) with high-resolution in-operando nano-CT for 2D and 3D imaging

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