Multimodal Elemental and Molecular Bioimaging for Tissue Analysis

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To study the distribution and the biological effects of metallopharmaceuticals and other metal species in the human, animal or plant organism, imaging methods at the tissue scale with lateral resolution in the lower micrometer range have been found to be particularly valuable.

Traditionally, pathologists use formalin fixation and subsequent paraffin embedding as standard method for sample preparation prior to optical microscopic investigation of the tissue samples. (Immuno)histological staining may provide additional valuable information on the samples. However, rinsing steps during these procedures may either remove analytes or add contaminations. While this is not an issue for optical microscopy, chemical imaging techniques often require the use of fresh frozen tissue samples instead.

Elemental imaging of tissue samples is performed using micro X-ray fluorescence (μXRF) spectroscopy for pre-screening and imaging of analytes in the high ppm concentration range and above, while laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) provides quantitative imaging of (ultra)trace elemental concentrations. Complementary molecular information on functional groups is provided by infrared microscopy, and compound-specific images are generated by matrix-assisted laser desorption/ionization mass spectrometry (MALDI-MS). A workflow for multimodal tissue imaging based on all of these methods was developed under consideration of the fact that some of these methods are non-destructive, while others are destructive.

Applications of the multimodal workflow include a study of the distribution and the biological effects of metal nanoparticles in rat lungs as well as studies using gadolinium-based contrast agents for magnetic resonance imaging (MRI) and platinum cytostatics for cancer chemotherapy.