Traceable analysis of aerosols and advanced materials at the nano- and microscales by X-ray spectrometry

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The development of new materials and the assessment of aerosols require the correlation of the materials' functionality or particle toxicity with their chemical and physical properties. To probe these properties, analytical methods that are both sensitive and selective at the nano- and microscales are required. The reliability of most analytical methods is based on the availability of reference materials or calibration samples, the spatial elemental composition of which is as similar as possible to the matrix of the specimens of interest. However, there is a drastic lack of certified reference materials in particular at the nanoscale. PTB addresses this challenge by means of a bottom-up X-ray analytical method where all instrumental and experimental parameters are determined with known contributions to the uncertainty of the analytical results. This first-principle based approach does not require any reference materials but a complete characterization of the analytical instruments' characteristics and, in addition, of the X-ray fundamental parameters related to the elements composing the sample. X-ray spectrometric methods allow for the variation of the analytical sensitivity, discrimination capability, and information depth needed to effectively reveal the spatial, elemental, and chemical specimen parameters of interest. Examples of aerosols characterization, interfacial speciation, elemental depth profiling, as well as layer composition and thickness characterizations in advanced materials will be given. Recent instrumental achievements provide access to beam profiles in the nanometer range to qualify heterogeneous materials as well as towards the operando speciation of battery materials. X-ray spectrometry (XRS) under grazing incidence or detection is capable to reveal analytical and dimensional information from layered 2D and 3D systems as well as aerosols or particles deposited on flat substrate surfaces. The SI traceable XRS approach of PTB allows for the qualification of calibration samples for surface contamination as well as for nano- and micro-scaled layers to be employed in laboratory XRF instruments for the establishment of chemical traceability related to quality management purposes.

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