# Sampling and Analytical Procedures for Characterization and Quantification of Particles in Aerosols by Electron Microscopy

Particulate matter (PM) pollution is recognized as a serious threat to health worldwide, as it has been linked to a broad spectrum of adverse chronic and acute human health effects. This has brought increased research, focus, and awareness on PM pollution, but there are still major knowledge gaps in the present understanding of the risks associated with PM exposure. It is well accepted that the current mass concentration metric is inadequate for assessing risk on its own, thus requiring additional air quality measures. However, existing scientific evidence is insufficient to estimate the relative importance of individual particle properties for specific health outcomes. Detailed physicochemical characterization of aerosols and individual particles is therefore essential in exposure scenarios as well as epidemiological and toxicological studies to close the current knowledge gaps and for determining the particle properties of most relevance for assessing PM hazard and risk. Though, there are many instruments for aerosol measurements, most bring no information on particle morphology, mixing state, and composition, which have been identified among the relevant parameters for evaluating PM health risks.

Scanning electron microscopy (SEM) coupled with Energy Dispersive X-ray spectroscopy (EDS) has the potential to quantify many of the relevant particle properties. The method has been demonstrated qualitatively in the past, but lacks standard sampling and analysis procedures to ensure reliable and comparable results as well as strategies to minimize user intervention and optimize analysis time. These needs are addressed in this PhD work, which aims at characterizing a particle sampling method as well as optimize the subsequent SEM/EDS analysis, before demonstrating its potential for providing detailed characterization of complex aerosols.

In this work impaction is investigated and characterized as an aerosol collection method for SEM/EDS analysis. A reproducible analysis procedure is developed to ensure a representative description of the sampled aerosol, which is verified by comparison to well-established techniques. Furthermore, a calibration approach is proposed and tested to estimate airborne concentrations directly from sample number densities, and an expression is established for estimating optimal sampling times from airborne concentrations. Optimal microscope and quantification settings are investigated for analysis of individual aerosol particles, and the findings and trade-offs are discussed. Finally, the method is tested for analysis of complex aerosols, consisting of particles with considerably different physicochemical properties, varying in size, elemental composition, shape, and density. The results are compared to other established techniques, highlighting the detailed aerosol and single particle characterization obtainable by SEM/EDS analysis and thus its relevance for exposure and risk assessments.