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Quantifying shape, size, and composition distributions of nanoparticle aerosols by impaction and electron microscopy

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Air pollution has become a growing concern in the past few years and is now recognized as one of the major contributors to the global burden of disease, with particulate matter as one of its central concerns. Here nanoparticles, PM_1 and $PM_{2.5}$ have been shown to pose the greatest risk due to their ability to penetrate deep into the lungs. Particles are released from a wide range of both natural and anthropogenic sources, where especially the transport sector is a major contributor. Simultaneously the use of nano materials in every day products is growing rapidly, bringing new exposure scenarios for both workers and users. As a result there is a need for exposure and risk assessments associated with the fabrication, use, and disposal of nano containing products, as well as in rural and general ambient environments. However, most of the current standard instruments bring no knowledge of particle composition or shape, which has recently been identified as crucial parameters in toxicological studies. New and additional measurement techniques are therefore needed to give a more detailed description of aerosol populations in order to establish standard procedures for measuring and regulating particulate exposure.

Here we present a procedure for sampling aerosol populations via impaction followed by automated software-based analysis using Scanning Electron Microscopy (SEM) and Scanning Transmission Electron Microscopy (STEM) coupled with Energy-Dispersive X-ray Spectroscopy (EDS). The automated analysis is capable of providing both detailed physical and chemical single particle information not provided by the current standard methods. Physical parameters such as area, diameter, and morphology is obtained, while automated EDS analysis is used to obtain elemental composition data, allowing size and morphology resolved chemical classification of each individual particle. The automated analysis is furthermore capable of systematically mapping large areas of a sample without user intervention, enabling fast and repeatable measurements, while obtaining sufficient data for statistical analysis.

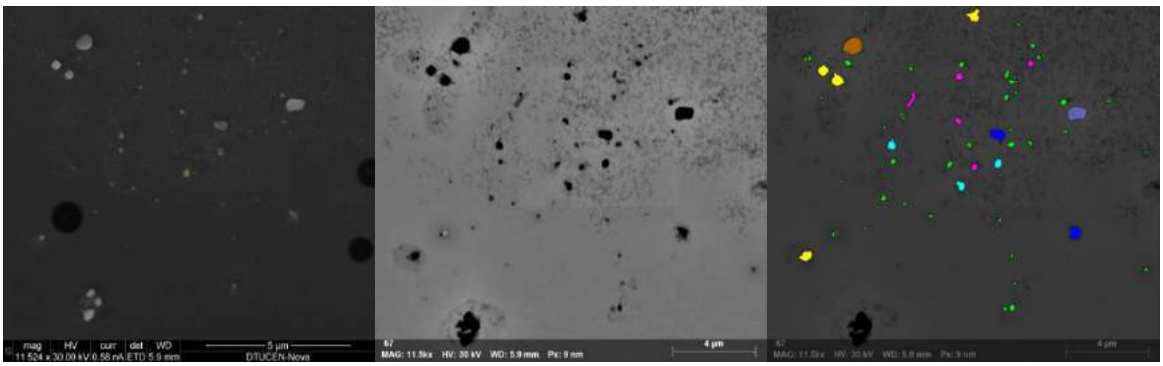

Figure 1. SEM images obtained from the automated analysis of an aerosol sample. Left: Secondary Electron (SE) image; Middle: Corresponding STEM image; Right: STEM image with particles marked for physical and elemental analysis.