CHARACTERIZATION OF INDIVIDUAL AEROSOL PARTICLES AND SAMPLING ARTEFACTS BY NANOSIMS

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INTRODUCTION

Atmospheric and work place aerosol particles are frequently heterogeneous on a nanometer scale (e.g., Ebert et al., 2002; Weinbruch et al., 2002). Up to now, these heterogeneities could only be studied by transmission electron microscopy (TEM). Recently, secondary ion mass spectrometry (SIMS) was extended to the nanometer scale, making this new technique (NanoSIMS) a very attractive tool for the characterization of individual particles. In principle, it is possible to analyze all elements including hydrogen with detection limits often in the ppb-range. In addition, it is also possible to determine isotopic compositions. Due to the sputtering process, depth profiles and 3-dimensional analysis can be performed. In the present contribution first results of NanoSIMS measurements of individual aerosol particles are shown.

METHODS

Measurements were performed with a Cameca NanoSIMS 50 at the Physics Department of the Washington University, St. Louis. This instrument has three major advantages compared to conventional SIMS. First, an extraordinary lateral resolution of 30 nm can be achieved. Second, the transmission at high mass resolution is almost two orders of magnitude higher compared to previous ion microprobes, leading to much higher sensitivity. Third, the capability to measure up to seven secondary ion signals simultaneously leads to an improved precision of isotopic measurements. Furthermore, NanoSIMS can complement transmission electron microscopy, as the measurements can be performed directly on TEM samples, without any additional sample preparation (Stadermann et al., 2002). It is, thus, possible to directly correlate the chemical, isotopic and mineralogical information from very small sample areas.

RESULTS

Different ambient aerosol samples and particles from a heavy-duty Diesel engine were investigated by NanoSIMS. The main goal of our investigations was the characterization of impactor sampling artefacts. In individual particle analysis of impactor samples by scanning electron microscopy (e.g., Ebert et al., 2000, 2002), we have often observed thin films and halos around particles, which could not be analyzed by energy-dispersive X-ray analysis due to small sample amount. In addition, nanometer-sized particles (presumably residues of larger volatile grains) are frequently encountered. Most films cover large regions (some \(\mu\text{m}^2\)) and were identified as very thin layers of organic material and in some cases of nitrates. Halos around individual particles mostly consist of sulfates. Compared to scanning electron microscopy, many additional halos were observed by Nano-SIMS.
The nanometer-sized particles, which were not collected directly by impaction, mostly consist of carbon (organic particles, soot).

In Fig. 1, the $^{12}\text{C}$, $^{16}\text{O}$, $^{32}\text{S}$, and $^{56}\text{Fe}$ ion signals and the secondary electron (SE) image of a typical organic film artefact of an ambient impactor sample (sampling site: Mainz, Germany) are shown (in the ion images brighter colors correspond to higher concentrations). In the secondary electron (SE) image, the film is clearly visible as grey area in contrast to the uncovered substrate which appears as dark area. The high count rates in the carbon ion image indicate high carbon concentrations in this film, while oxygen count rates are low. The high count rates at the edge of the film may be an artifact of the measurement, which will require more detailed studies in the future. Most of the visible individual particles (size range ~ 0.1 – 3 µm) are sulphate particles, besides a smaller abundance of carbon dominated particles and carbon/sulphate mixed particles.

Figure 1. Secondary electron image and $^{12}\text{C}$, $^{16}\text{O}$, $^{32}\text{S}$, and $^{56}\text{Fe}$ ion signals of artifacts of an ambient impactor aerosol particle sample (NanoSIMS measurement).

REFERENCES


