Investigation of higher molecular organic compounds in a city waste incineration ash and comparison with real samples by single particle laser desorption bipolar mass spectrometry

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Airborne particulate matter (PM) typically consists of a wide variety of different compounds. They can be either inorganic or organic or a mixture of both and are also not evenly distributed over different particle sizes. Of particular interest are higher molecular organic compounds in PM because of their association with adverse health effects (Boström et al., 2002). In the case of organic matter especially polycyclic aromatic hydrocarbons (PAH) can be found in the particle phase because of their low vapour pressure compared to other organic precursors. Some of them are classified as carcinogen or mutagen, where carcinogenicity rises with increasing molecular weight (Armstrong et al., 2004). The presence of these compounds in natural and anthropogenic PM leads to its hazardous nature. The determination of all compounds in a sample of PM is usually carried out by different and very specific analytical techniques. In most cases a bunch of particles and not a single one provides the basis for the chemical characterization. For PAHs normally gas chromatography and sometimes aerosol mass spectrometry are the methods of choice (Zimmermann et al., 2003). In this study we investigate single particles on the presence of PAHs by bipolar time-of-flight single particle aerosol mass spectrometry with a 337 nm ionization laser.

The compact mobile laser mass spectrometer LAMPAS 3 (19" rack, 150 cm in height) was developed with improved instrumental parameters and options for a user-friendly long-term operation. The highly robust instrument is designed for operation under field conditions and can be easily transported. Aerosol particles are transferred into the instrument through a differentially pumped inlet system consisting of a nozzle a skimmer and an orifice. Particles are optically detected by two continuous laser beams inside the main chamber of the mass spectrometer. Particle size is determined using their size-dependent velocity. Afterwards, an actively triggered UV laser evaporates and ionizes the detected particles. The positively and negatively charged ions are then simultaneously analysed via a bipolar time-of-flight mass spectrometer. The mass spectrometric data are evaluated using a fuzzy clustering algorithm to characterize the particles. Particle size and mass distribution are additionally determined by a commercial optical particle counter (Grimm Aerosol Technik GmbH & Co. Kg). A low temperature plasma source combined with a high resolution mass spectrometer is used to determine the availability and accurate mass of the PAHs in the samples.

Typical sources for PAHs are the combustion of fossil fuels and biomass. Therefore, a standard ash from a city waste incineration is used as sample material. The standard particles are smaller than 40 µm and vaporized manually before introduced into the LAMPAS 3 instrument. The aerodynamic diameter of the measured particles is between 0.5 and 5 µm. The LAMPAS 3 provides the possibility to attenuate the laser beam energy to prevent fragmentation of the desired compounds. The measurements were done at different laser fluences. The acquired mass spectra show the presence of different organic compounds for the negative as well as for the positive ions. Even less or unfragmented ions in higher mass ranges at lower laser energies could be found. Additionally, some real particle samples were measured and compared with the spectra from the standard ash. The amount of particles containing PAHs is determined. From all samples the total chemical composition of inorganic and organic substances is measured and statistically evaluated with a fuzzy clustering method.

The so gathered results should allow for a better assessment of the pollution of PM with PAHs. Different particles that contain PAHs are addressed to different particle groups to determine the particle sources. Size of the particles is related with PAH contamination to get an idea of the appearance of these particles.

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