Instrumental optimization of the compact laser mass spectrometer LAMPAS 3 for on-line single particle analysis under various field conditions

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During the last two decades the development of mass spectrometric systems resulted in a variety of instruments for elemental analysis, bio-chemical investigations or control and identification of dangerous substances in the environment. In aerosol science online mass spectrometric instrumentation is often used to characterize particle ensembles or single particles without prior sampling and sample transportation. Transportable instruments of this type can be operated directly at sites of interest provide for a fast chemical and physical in situ characterization of individual particles combined with a high level of specificity. During the last few years the reduction of the size of such mass spectrometric instrumentation was one major requirement to make them accessible for new application fields such as quality control, public safety and clinical diagnostics (Hinz et al., 2011).

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 introduced into the instrument through a differentially pumped inlet system. Inside the mass spectrometer particles are optically detected by two continuous laser beams. Particle size is determined using their size-dependent velocity. Afterwards, an actively triggered UV laser evaporates and ionizes the detected particles. The generated ions are analysed with a bipolar time-of-flight mass spectrometer.

During optimization of the LAMPAS 3 system several instrumental features (voltage settings, delayed ion extraction, use of reflectron time-of-flight analysers, laser beam attenuation) were integrated to significantly improve mass resolving power and mass accuracy. An improved quality of results is also observed, using enhanced statistical classification and interpretation of data.

Several measurements were performed under laboratory and field conditions (e.g. on Jungfraujoch 2013) to optimize the instrumental parameters of the LAMPAS 3 system. Particles of various ambient origins and standard particles such as polystyrene latex spheres, salt particles and mineral particles were used to characterize the instrumental performance.

Results of the instrumental optimization and applications will be presented. E.g., spectra detected at the challenging site of Jungfraujoch at an altitude of 3580 m asl showed characteristic signal patterns of mineral and carbonaceous particles as well as mixtures of these particle types with secondary components such as ammonium, nitrate and sulphate. The aim of these investigations was, among others, the characterization of ice nuclei and of background aerosol in the lower troposphere for a better understanding of cloud formation and their influence on earth climate.

Instrumental improvements and optimization of the LAMPAS 3 results in an analytical system suitable for aerosol characterization under various conditions and requirements. In the future, the compact laser mass spectrometer LAMPAS 3 will offer the possibility of advanced in situ particle identification in various application fields.

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