Continuous Measurements with high Time Resolution of Semi-Volatile Components in the Atmospheric Aerosol

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EU limit and guideline values for the protection of human health (DIRECTIVE 2008/50/EG) demand a continuous monitoring of the atmospharic aerosol, more precisely its fine dust fraction PM10 and PM2.5. The tresholds are being exceeded in many areas in Europe, primarily in congested urban areas, where many people are affected. Fine dust is rated harmful to health which therefore strongly needs action to be taken, in order to minimize this exposure.

The EU regulates, when exceeding the set limit and guideline values, to develop clean air plans, in which efficient reduction strategies have to be enlisted. These plans are based upon cause analysis, which assigns certain dust exposure to certain sources.
For monitoring the thresholds, many measuring technologies proved well, whereas in the past years especially the optical measuring technology gained in importance. The optical detection of the aerosol enables a non-contact, continuous, and temporally high resolved measurement of the aerosols in real-time, where next to the PM fractions also particle size as well as particle counts can be determined.

A significant part (up to 60% of the particle mass) of the atmospheric aerosol is determined by semi-volatile components (SVC), which varies depending on location and season. This meaningful fraction of the SVC impedes the exact determination of the aerosol mass: The volatile components get lost, when heating the aerosol while sampling, e.g. when using a heated sampling probe for drying the sample, or when dust clogged filters remain several days without cooling inside the sampler.

Thus it is important to determine the volatile fraction of the aerosol for two reasons: On the one hand this fraction is very helpful for the source identification of the dust, because different sources create different SVC fractions, and on the other hand it is very important to measure the SVC for comparing the results of different fine dust measuring devices, which reveal the difference in their losses of SVC while measuring.
Thus the gas-particle-conversion from nitrogen oxides to nitrates and ammonium compounds, or the condensation from gaseous emitted carbon hydrides leads to organic aerosols.

The company Grimm Aerosol Technik GmbH & Co. KG developed a compact, mobile, and highly efficient measuring instrument, which enables the continuous determination of the volatile fraction within the atmospheric aerosol. This device is in possession of two sampling probes with complementary characteristics:
One probe dries the particles by a nafion membrane in such a way, that no volatile aerosols get lost, while in the other probe the aerosol can be heated to a temperature of up to 300 °C. The aerosol is alternating being sucked through the sampling probes and subsequently analyzed inside the same optical chamber. This means, that in one interval all aerosol are analyzed and in the other one only the thermically stabilized aerosols. Forming this difference of both intervals, a determination of the volatile fraction is possible. There the volatile components are classified simultaneously into 31 size channels from 250 nm up to 32 µm, as well as a simultaneous detection of the PM10, PM2.5, and PM1 fractions (figure 1).

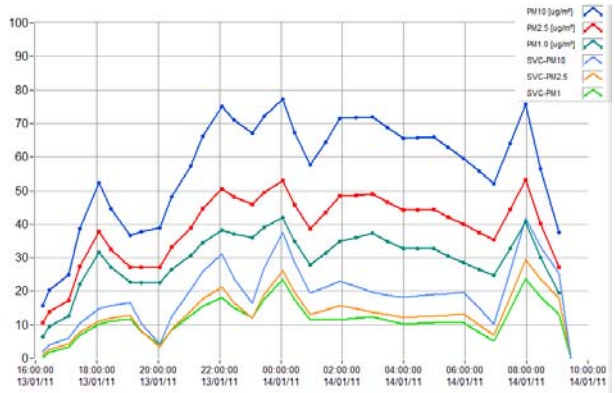

Figure 1: Temporal course of the PM fractions and its volatilecomponents at 100°C

The temporal resolution is 6 seconds. By limiting the size channels, measurements can be executed at 1 Hz, which enables the application of the Eddy-Correlation calculation for determination of aerosol flows.

Measurements at different locations prove the high temporal and spatial variability of the volatile aerosol components, and moreover provide valuable indication for the causes of fine dust exposure as well as a better understanding of the aerosol formation within the lower atmosphere.

Reference

REGULATION 2008/50/EG OF THE EUROPEAN PARLIAMENT AND THE COUNCIL for air quality and clean air for Europe