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Semi Volatile Compounds (SVC) in PM Values

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Abstract

Air is the primary vector of SVCs to humans. They are deposited on animal feed such as grass and the contaminated feed is consumed by livestock. The SVCs are absorbed in the digestive tract and deposited in fatty tissue or milk fat, which in turn are the primary sources of human exposure to these compounds. Soil ingestion by livestock or humans is generally of little importance for human exposure, but the inhalation of some of these SVCs could cause severe problems. In addition, this is a certain part of the dust mass in the air and need to be determined. A new mass determination method will give access to a new automatic, continuous and real time calculation of the PM10, PM2.5 and even the PM1 mass concentrations of the SVC in µg/m³. Results from some field tests will be shown.

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SVC are semi-volatile compounds of dust, that co-exist at outdoor temperature ranges in solid, liquid, and gas phases. These substances are mainly nitrate and ammonium compounds as well as organic substrates. The SVC are largely not emitted directly, but come predominantly via photochemical reaction from gases, such as sulphur dioxide, nitrogen oxide, and organic carbon compounds into existence in the atmosphere. These precursor substrates are emitted worldwide in combustion processes, such as power plants, automotive industries, or production in general. Even natural sources such as oceans and woods emit significant amounts of precursor substrates of SVC.

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SVC are essential for air hygienic analysis as well as threshold surveillance of PM10 and PM2.5, because these substances may be the major fraction of the dust masses, as well as the particle counts: depending on location, season, or climate the SVC compounds may cause significant values of the total mass fraction up to 60% or more. For particle counts they may be even higher, specifically determined through fine and ultrafine condensation aerosols that are thermically not stable. Unfortunately the SVC are often lost in an undefined process and therefore cannot be measured accurately. Primarily filter applications or devices with a heated sampling probe for reducing the condensation and drying the particles are prone to this effect.

The company GRIMM Aerosol Technik GmbH & Co. KG is worldwide known as the expert for development, production and distribution of the latest equipment to measure particles in the atmosphere. For 30 years we have pioneered compact and mobile Aerosol Spectrometers, initially to measure dust concentrations for work environment and indoor applications. This GRIMM Enviro-family of products has now been extended by the 365-SVC.

The new device is technically based on the proven and robust GRIMM Environmental Dust Monitor EDM 365 and has been designed to specifically determine the Semi Volatile Compounds – SVC in the environment. A unique feature is to measure the mass fractions TSP, PM10, PM2.5, and PM1, as well as particle counts, and in addition the correlated fraction of the semi-volatile dust components. Picture 1 shows the EDM 365-SVC in action at a rural site (Ainring, Bavaria).

Fig. 1. EDM 365-SVC in Ainring, Bavaria

The classical approach to determine the SVC fraction is via sampling on filters, where a subsequent analysis in the lab with ion chromatography or gas- and liquid chromatography provide detailed information. These methods are labor- and cost-intensive with a significant time delay of 2-3 days for the analysis. Besides, the sampling time is typically 24h, and hence has an outstanding poor time resolution with respect to a correlation of SVC measurements to specific sources.

The new approach of GRIMM is based on measuring particles via two different probe inlet paths; one is the proven and known GRIMM Nafion dryer without the loss of particles and semi-volatile particles, the other one uses in addition a heated sampling probe head prior to the optical measurement.

This sampling probe head can be heated, depending on the application, up to an arbitrary temperature of max. 300 °C. A mechanical valve switches automatically in adjustable intervals between the two sample air inlet paths.

A standard sampling time is 10 minutes with Nafion dryer and subsequent 10 minutes with the heated sampling probe inlet (with a heating of the particles up to approx. 70 °C). Measurements via the Nafion dryer include all particles, as well the SVC. Measurements via the heated probe inlet will lose the SVC in correlation with the preset temperature.

Calculating the difference between the two measurements allows not only the determination of the SVC for TSP, PM10, PM2.5, PM1, and for the total counts but also – and this is unique at GRIMM – for the size resolution in 31 channels starting at 0.25 µm up to > 32 µm.

Due to the high time resolution and a continuous measurement of the SVC fraction, a detailed surveillance of the air quality, i.e. of industrial plants or farming is possible.

In addition, it is possible to determine the loss of the SVC fraction due to the use of gravimetric samplers. Hence it is possible to validate the use of empiric correction factors and to determine these in a quantitative way.

The EDM 365-SVC allows the politically required correlation of the dust fractions due to sources like industry, power plants, traffic, farming, and natural sources.

The system provides information regarding the chemical composition of dust online and on a continuous basis. Low SVC fractions can be observed if inert dispersion aerosols dominate, caused by turbulences of vehicles or wind (sand). High SVC fractions indicate a significant amount of secondary aerosols, such as Ammonium Nitrate and organic compounds in dust.

Figure 2 shows a measurement of particle mass, carried out with the EDM 365-SVC. Over time, clear differences may be observed due to the SVC fraction. Apparent is the size dependence of the SVC fraction. Particularly, the losses in the PM2.5 and PM1 fraction are obvious (valley of the green and blue line).

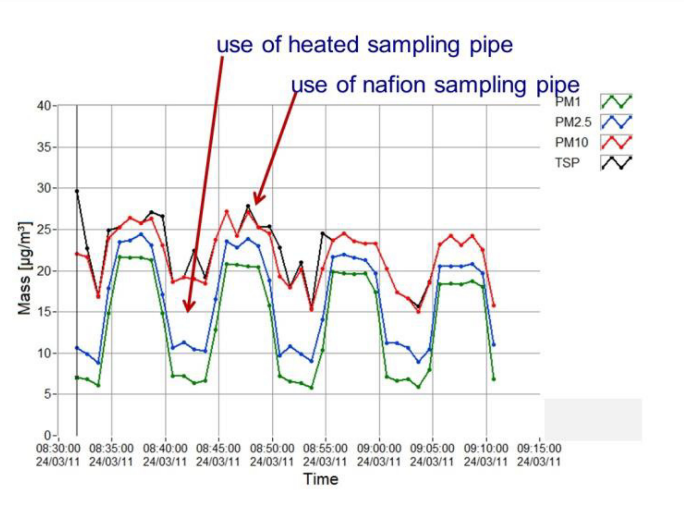

Fig. 2: Measurement of the particle mass with EDM365-SVC

The ratio of the SVC in dust is even more significant, analysing the particle counts (figure 3). The counts are reduced by almost 70%, which means the SVC fraction makes up for 70% of the detected particles.

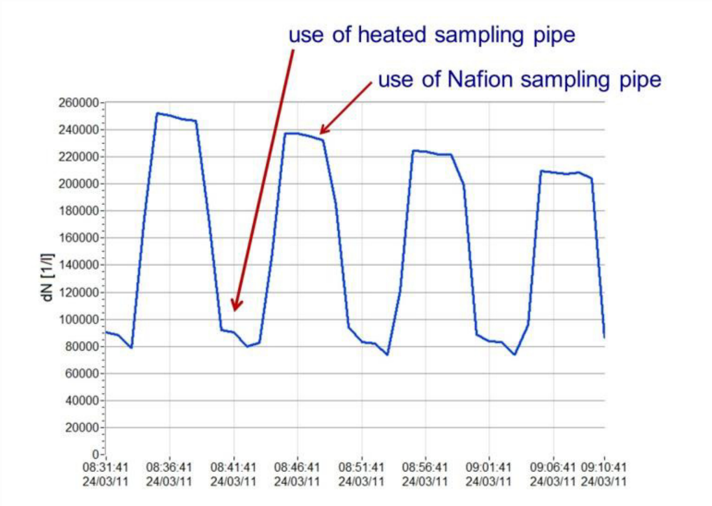

Fig. 3: Measurement of the particle counts with EDM 365-SVC

Figure 4 shows the particle mass distribution and the corresponding SVC fraction. Most significant are the losses of small particles in the range between 265 nm and approx. 500 nm due to heating; apparently the SVC fraction is very high. In the coarse dust fraction the losses are visible, however not as much as in the fine dust fraction. These particles contain less SVC in relation.

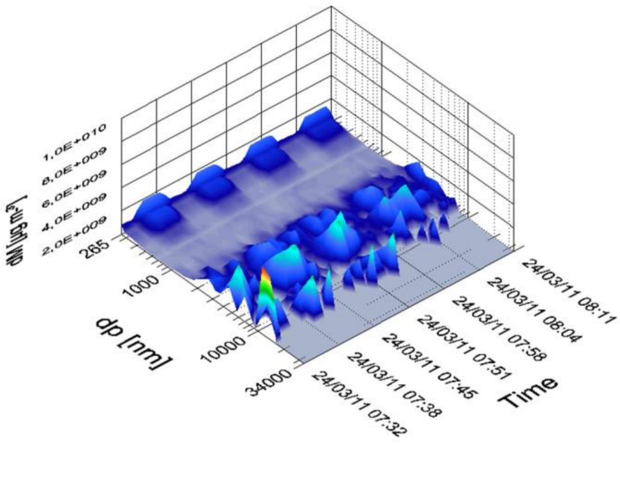

Fig. 4: Measurement of the particle mass distribution with the EDM 365-SVC

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