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The Synthetic Carbonaceous Atmospheric Aerosol (SCAA) generator:

Towards the creation of an atmospheric aerosol standard

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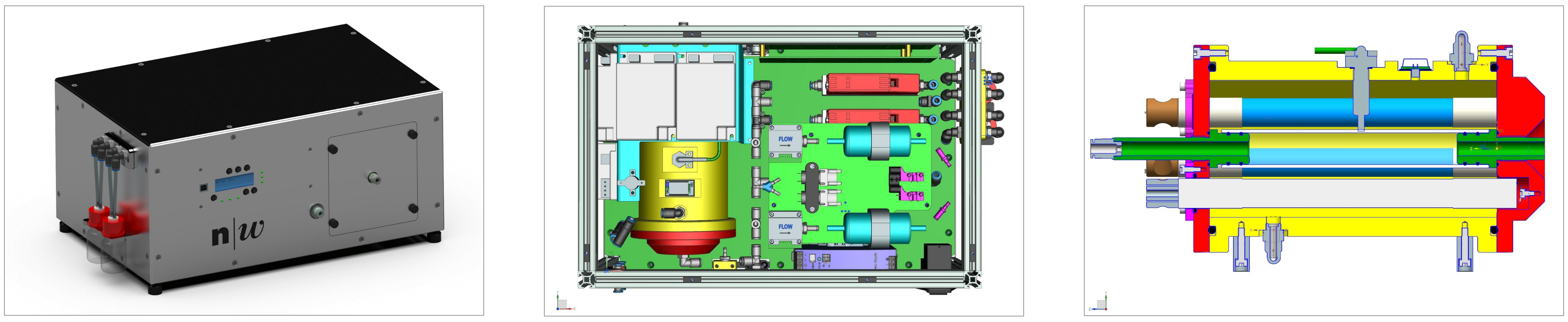

Fig. 1: CAD rendering of the coating unit for automatic VOC dosing system with integrated oxidation flow reactor of the SCAA generator(left and center). Envisioned is a system that will be capable of independently controlling the dosage of two different precursor substances simultaneously, including natural precursors, e.g. α-pinene, or anthropogenic substances, e.g. 1,3,5-Trimetylbenzene. The far right image is a sectional view of the miniature oxidation flow reactor with a residence time of only a few seconds. The components are dimensioned to work with high aerosol concentrations (like, e.g., miniCAST from Jing AG or another aerosol generator).

Motivation

Atmospheric particulate pollution has been linked to a broad spectrum of adverse health effects including respiratory problems, cardiovascular diseases and cancer. These effects depend not only on physical, but also on chemical properties of airborne particulate matter (PM). The latter is strongly influenced by chemical reactions occurring in the atmosphere (mainly atmospheric oxidation known as aging) that lead to the formation of secondary organic matter (SOM). Comparison of results between different research groups is difficult, on the one hand, due to the diversity of experimental procedures, especially for health effect studies, but also due to the complex and non-constant nature of atmospheric samples. A stand-alone stable aerosol generator mimicking atmospheric carbonaceous aerosols with tunable characteristics, e.g., coating size and composition or "atmospheric age" would help our understanding of the properties of the ambient aerosol mixture.

The SCAA generator

Within the framework of the EMPIR-AeroTox project (see poster 32 of the exhibition) the University of Applied Sciences Northwestern Switzerland will develop a portable setup to generate "tailored" reference aerosol mimicking real life atmospheric particles. The setup will use a well established aerosol generator (like, e.g., the miniCAST) and a novel coating unit (fig. 1) consisting of an automated VOC dosing system and a mini oxidation flow reactor (also known as micro smog chamber. See, e.g., Keller and Burtscher, 2012; Corbin *et al.*, 2014; Corbin *et al.*, 2015). This will enable, for the first time, to generate combustion particles simulating a large range of atmospherically relevant situations using portable devices.

The SCAA generator will replace current laboratory systems for very diverse applications. For instance, during the 16ENV02 Black Carbon and 16ENV07 Aeromet EMPIR projects, a manually operated laboratory system (fig. 2) was used to coat elemental carbon particles with α-pinene SOM (Ess *et al.* in preparation) and challenge measurement systems with particles of well defined chemical and optical properties (fig. 3 and 4). Furthermore, on a pilot study for AeroTox we used a similar setup (see Wednesdays' presentation by Z. Leni) to study the toxicity of aged atmospheric-like particles (i.e. soot particles coated with α-pinene and 1,3,5-Trimetylbenzene SOM) on the human respiratory epithelium using the (Nano)-Aerosol Chamber for In Vitro Toxicity (NACIVT, Jeannet et al., 2015).

While these experiments were carried out successfully, the resulting setup is hardly portable and, thus, cannot be used as a field instrument. Furthermore the reproducibility of the generated aerosol depends upon the operator skills. This adds uncertainties to measurements performed at different laboratories. The development of a SCAA aims to solve this by focusing on automating and miniaturizing the aerosol coating unit, producing a device capable of working with a variety of aerosol generators. The aim to create a transfer standard suitable for laboratory as well as for in-field operation.

Acknowledgements

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References

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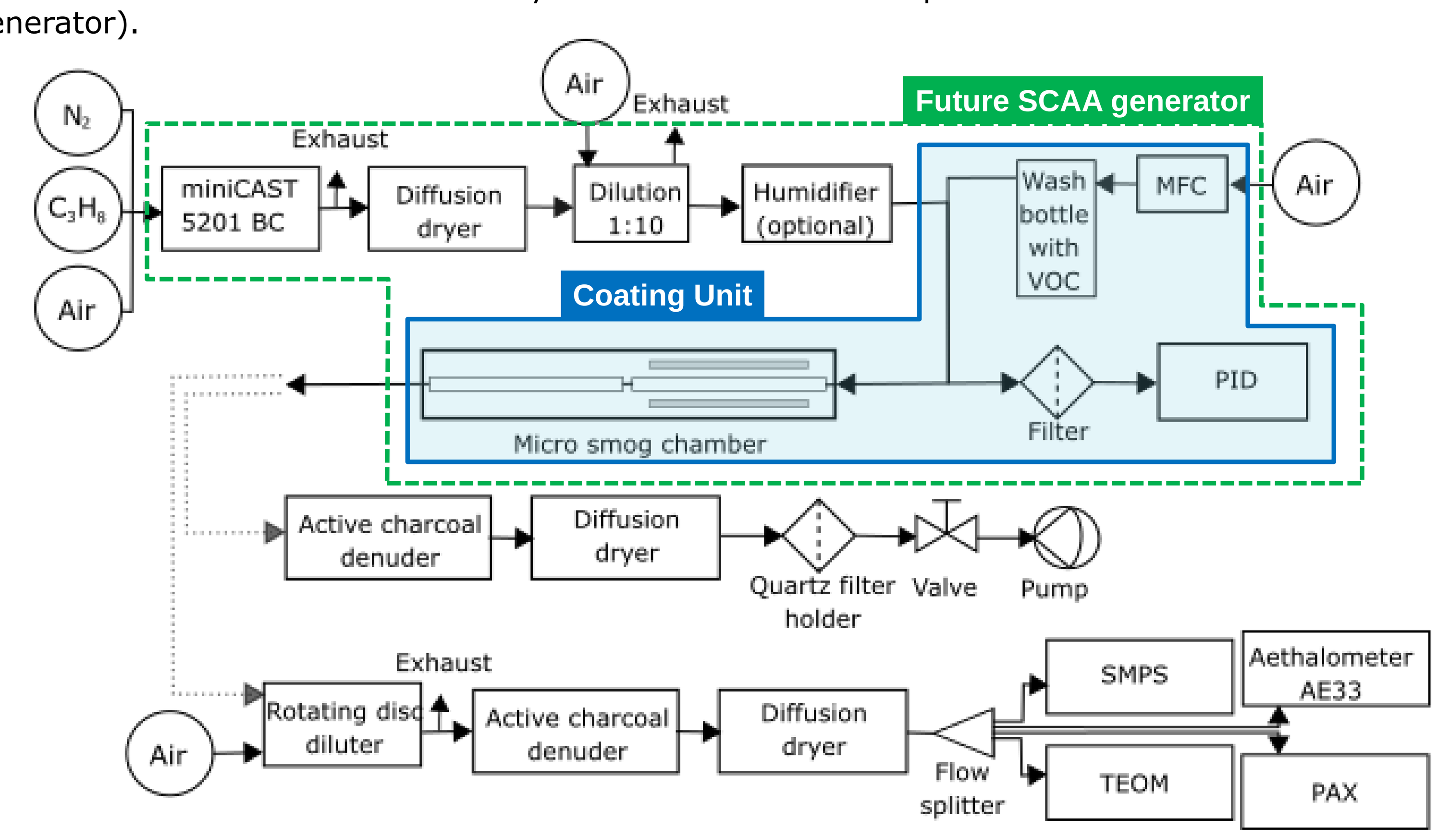

Fig 2: Laboratory setup used to coat soot particles produced by means of a miniCAST with secondary organic matter (SOM). The soot particles are mixed with a specific concentration, monitored by means of a photo ionization detector (PID), of a volatile organic compound (VOC) like, e.g., α-pinene. The mixture is "aged" inside an oxidation flow reactor (OFR; i.e., the micro smog chamber). The resulting aerosol is used to challenge different measurement systems located after the flow splitter downstream of the micro smog chamber. Quartz filters are collected for off-line analysis. The green line shows the current manually operated system which will be replaced by a portable, in-field operational, SCAA generator. Adapted from: Ess *et al.* in preparation.

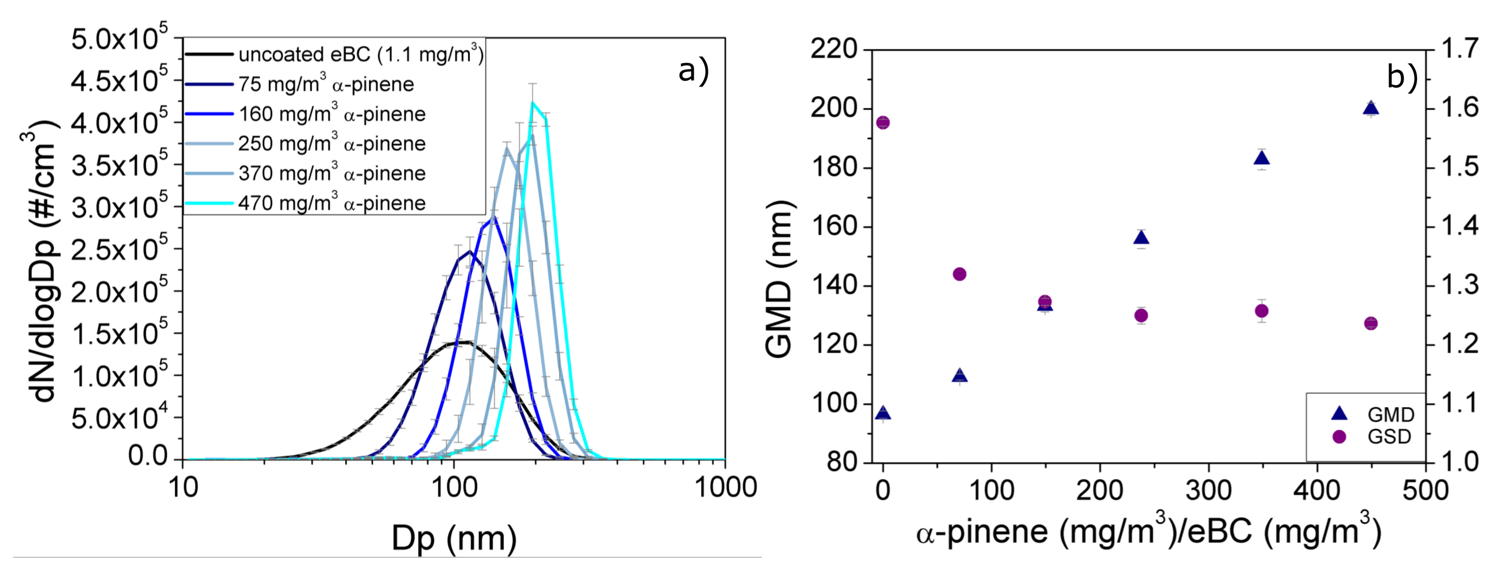

Fig 3: a) Number based size distributions of coated and uncoated soot and b) geometric mean diameter (GMD) and geometric standard deviation (GSD) as function of α-pinene content (n=3, error bars=1σ). Increasing the amount of α-pinene vapor while keeping soot concentration constant shifts the distribution to higher mobility diameters with a narrower GSD. Source: Ess *et al.* in preparation

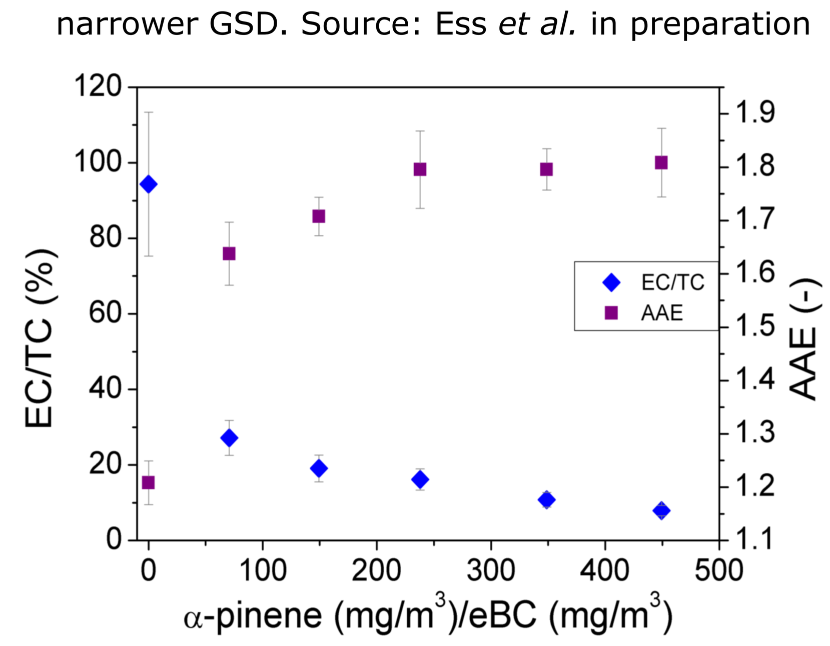

Fig 4: Elemental carbon to total carbon ratio (EC/TC) and Ångström absorption exponent (AAE; Error bars EC/TC propagated instrument uncertainties; n (AAE)>30; error bars=1σ) as function of α-pinene content. Higher α-pinene to soot ratios decrease EC/TC from 95 to 8 %. At the same time, the AAE increases, indicating a stronger wavelength dependence of the absorption due to the organic material of the coating. Source: Ess *et al.* in preparation

In Short

We plan to develop a tunable aerosol generator for synthetic reference aerosol mixtures that mimic real ambient aerosols. The EMPIR-AeroTox research project will focus on the health effects of atmospheric particles. However, applications extend to other research disciplines. For instance, thanks to their controlled and tunable properties these lab-generated particles have the potential to serve as reference aerosols to challenge common field instruments, such as aethalometers, photoacoustic sensors, or aerosol mass spectrometers in order to understand artifacts and measurement uncertainties.

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