Novel measurement systems for the estimation of carbonaceous particle fraction of emissions including atmospheric aging

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Particulate matter emissions from biomass burning have a big impact on both climate and public health. According to the world health organization, alone the pollution from cooking with solid fuels causes yearly millions of premature deaths. The European Union is working towards a generalized legislation that will impose emission limits for biomass burning appliances to all member countries. This calls for a careful discussion about an appropriate metric, as legislation can only be as good as the method used to characterize the emissions.

Current candidate methods are not ideal for several reasons. Prominently, standards are based on total mass without differentiation by chemical composition and do not consider formation of secondary organic aerosol (SOA; i.e., formation of further particulate matter from gas-phase species due to atmospheric photo-oxidation). This is well discussed within the position paper of the European EN-PME-TEST project and on a later publication (Keller and Burtscher, 2017). Nevertheless, the suggested method to solve these short comings was considered only as a long-term approach due to the required infrastructure and the cumbersome quantification procedure. This is however no longer the case, as there are now a variety scientific prototypes that fulfil this task.

We will discuss the details of the so-called long-term approach of the EN-PME-TEST project. The method requires a precondition of the emissions using an oxidation flow reactor (OFR) followed by quantification of particle bound total carbon (TC). The OFR simulates atmospheric aging and incorporates the potential for SOA formation. TC is a good indicator of the quality of the combustion, has been linked to a much higher toxicity than non-carbonaceous material (Lelieveld et al., 2015; Sigsgaard et al., 2015). We will also present our own developments, a compact OFR designed for operation in high concentration of organic gaseous carbon and the fast thermal carbon totalizator (FATCAT). FATCAT is a portable semi-online instrument for the determination of TC. The instrument collects a sample on a filter, which is subsequently heated on site to 800°C under an oxidizing atmosphere. TC detection is done by means of a CO_2 measurement. The fast heating cycle of 50 seconds allows for a short analysis cycle, of less than two minutes, and generates a high CO_2 signal that results in a low limit of detection of LoD=0.3 ug of carbon (ug-C). Sampling rates can be set to one cubic meter per hour for ambient concentrations, with typical collection time between 30 minutes and one hour (or as low as 100mL/minute and a few minutes of collection for emission measurements). FATCAT uses a rigid metallic filter for sample collection and is, thus, not affected by filter damages or filter displacement errors. This is, to our knowledge, unique among carbonaceous aerosol measurement systems.

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Keller and Burscher (2017). Aerosol Science, **114**: 21-30
Lelieveld, J. et al. (2015). Nature, 525(7569):367–371.
Sigsgaard, T. et al. (2015). Eur. Respir J., 46(6):1577–88.