Thermal analysis of diesel emitted particulate matter

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The investigation of diesel particulate emission is nowadays an intensively studied issue for several reasons. Diesel soot has significant contribution to atmospheric carbonaceous particulate matter (CPM). CPM is the second most important anthropogenic pollutant regarding its radiative forcing. In addition, there are also severe human health effects attributed to CPM. As a result of their large surface area per unit carbonaceous particles have a strong capacity for adsorbing various toxic atmospheric substances. Lately, numerous studies have reported that although CPM is negligible in total aerosol mass it is the most dominant in terms of toxicity.

Diesel particulate emission has also been intensively studied from the pit of view of engine development. As vehicle emission is being continually restricted manufacturers are forced to develop engines in accordance with that. The various properties of diesel emission strongly depend on both the chemical composition of the fuels (e.g. biodiesel blend rate) and on the operational condition of the engine. Since diesel exhaust is in a constantly changing thermal equilibrium state with the local ambience the complex chemo-physical features of diesel exhaust can go through essential transition even during its relatively short ambient residence time. Currently only mass and number concentration is being regulated in the European Union however, the climatic and human health effects of diesel emitted particulate matter also depend on its complex non-regulated chemo-physical properties. There is no available standardized method that would be capable of determining the source specific relationships between the convoluted diesel exhaust properties or their climatic and health impacts. The main reasons for that can partly be attributed to the incomplete knowledge regarding aerosol mixing states and partly to the lack of proper instrumentation.

Concerning diesel exhaust investigation, the greatest challenge to face is accurate sampling. This is to be imputed to the extreme dynamic properties of the turbulent reactive plume in the tailpipe and dilution systems. Posterior temperature treatment of the diluted of the initially diluted and cooling tailpipe exhaust under controlled measurement conditions is prosperous candidate for investigation of the above mentioned complex processes.

In this study we are focusing on the dynamic changes and the thermal evolution of diesel exhausted particulate matter using commercial diesel and biofuel blends. The measurements have been carried out on a EURO4 engine dyno laboratory. Number concentration and size distribution of the exhaust was measured by a by a Scanning Mobility Particle Sizer (SMPS, GRIMM System Aerosol Technik, Germany) in the 10-1100 nm size range. Organic to elemental carbon ratio (OC/EC) was determined by a Sunset Laboratories Semi-Continuous OCEC Carbon Analyzer. Optical absorption spectra were investigated by our self-developed state-of-the-art four-wavelength photoacoustic spectrometer (4λ-PAS).

We have been investigating pure diesel (B0) and biodiesel with low biofuel content (B7). Three engine operational conditions were applied during the measurements (from idle to maximum engine load). The posterior temperature treatment was carried out by our self-developed updated version of the Burtscher-type low-flow thermodenuder (Burtscher, 2004). We have experimentally demonstrated, that even low biodiesel content in the fuel blend content and engine load have significant impact size distribution and absorption response. We have also shown that the wavelength dependency of the absorption spectrum - Absorption Angstrom Exponent (AAE) - can be a composition selective indicator of fuel types and can modify the interpretation of the SMPS data. We found relationship between the OC/EC ratio and the AAE of the emitted particles.

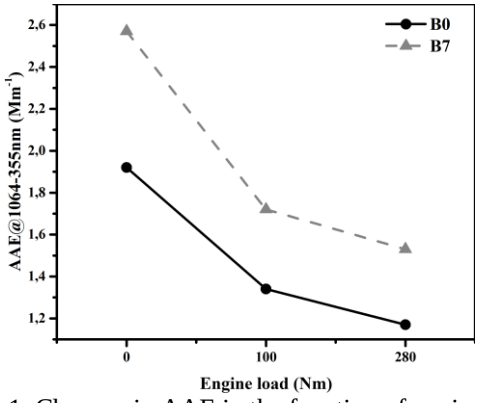

Figure 1. Changes in AAE in the function of engine load

Burtscher H., Baltensperger U., Bukowiecki N., Cohn P., HuKglin C., Mohr M., Matter U., Nyeki S., Schmatloch V., Streit N., Weingartner E. (2001) *Separation of volatile and non-volatile aerosol fractions by thermodesorption: instrumental development and applications*. Aerosol Science. 32, 427-442.