Influence of photochemical aging on physical-chemical properties of ultrafine particulate matter from the exhaust emissions of a ship diesel engine

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There is growing concern that exposure to ultrafine particulate matter (UFP), especially from anthropogenic sources such as combustion processes or transport emissions, represents a hazard to human health not covered by current mass-based air quality guidelines. Moreover, the effects of atmospheric aging on the physical and chemical properties of UFP emitted by transportation emissions are largely unknown. This study investigated a one-cylinder ship diesel research engine in a laboratory setup at the University of Rostock. The respective emissions operating with two different fuels (marine gas oil and heavy fuel oil) were examined. Primary fresh exhaust particles and photochemically aged particles were analyzed for their physical-chemical properties and the changes of these properties upon the aging process.

The ship diesel engine was operated according to the test cycle E2 of ISO 8178-4. This cycle consists of four phases with different engine loads (25 %, 50%, 75%, 100% of maximum load), which run for 15 %, 15 %, 50 % and 20 % of the time, respectively. Photochemical aging was conducted using the Photochemical Emission Aging Flow Reactor (PEAR [1]) and was equivalent to roughly 1-2 days of atmospheric aging. Online methods included, for example, scanning mobility particle sizer (SMPS) for the particle size and number determination, a Tapered Element Oscillating Microbalance (TEOM) for particle mass concentration, and an aethalometer for black carbon concentration. Filter samples were taken for chemical analysis. Gas-chromatography/mass spectrometry covered Polycyclic Aromatic Hydrocarbons (PAH) and alkanes; elemental analysis (ICP-OES) selected heavy metals.

Fresh exhaust aerosol particles from the ship diesel engine consists of relatively small particles predominantly in the UFP region. Furthermore, heavy fuel oil exhaust particles transport a large number of various four- and five-ring PAH with them.

Photochemically aging of the ship engine exhaust particles showed a considerable impact on several important metrics for the characterization of ultrafine particulate matter. Particle mass and number concentrations increased upon aging. The mean diameter of the particles also increased after passing the aging device, but still stayed in the ultrafine particle region. The lung deposited surface area was enhanced as well. Aliphatic and aromatic hydrocarbons were reduced by oxidation during the aging process, and the aged particles exhibited an increased appearance of oxygen containing species.

In a follow-up step, correlation with the results from cell exposure experiments that took place in parallel with the same exhaust aerosols will allow a better understanding of the link between physical-chemical data and adverse health effects.

[1] Ihalainen et al. *Aerosol Science and Technology*, **2019**, DOI: 10.1080/02786826.2018.1559918.