Size distribution and light scattering properties of standard test fire aerosols

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Introduction

Aerosol particles in smoke, produced by combustion processes, are widely used by fire alarm systems for early fire detection. Most existing smoke detectors belong to one of the two types: ionisation or photoelectric detectors. The photoelectric type detectors are taking over the market share from the ionization detectors because the ionization detectors use radioactive sources that lately get banned in many countries.

The detection of smoke in a photoelectric detector is based on the detection of the light scattered by the aerosol particles present in the smoke. In order to better understand and/or to improve the performance of the photoelectric detectors, the properties of the fire produced aerosol particles determining their optical scattering has to be measured.

Aerosol properties of 7 different standard EN54 test fires (see Table 1 for details about the fires) were measured in a fire laboratory. The particle number size distribution and it's time evolution were measured by a scanning mobility particle sizer (SMPS, TSI) and a white-light optical particle counter (WELAS digital 2000, Palas). The angular and time dependence of the differential scattering coefficient at 660 nm wavelength was measured by a home developed instrument: The aerosol is brought into a closed chamber where a laser diode illuminates the particles that can be found in the sampling volume. The scattered light is then detected simultaneously by avalanche photodiodes at 7 different angles.

Table 1. The different standard EN54 test fires

Name	Type of fire
TF1	flaming wood
TF2	smouldering wood
TF3	smouldering cotton
TF4	flaming polyurethane foam
TF5	flaming *n*-heptane with 5% toluene
TF6	flaming ethanol
TF8	flaming decalin

Results

Figure 1 shows the time evolution of the particle number size distribution for a flaming wood fire. Shortly after the ignition of the fire at 14:05 very small particles around 25 nm mobility diameter were formed. As the fire got larger, the previously mentioned mode disappeared suddenly, particles with a mean diameter around 150 nm became dominant and the particle number concentration has increased fast. At 14:13 the flame has died out, and therefore the concentration has started to decrease, however the width and the mean size of the size distribution has continued to increase.

Both the aerosol size distribution and scattering properties of the different fire types show a significant variability, e.g. the mean diameter of the number size distribution had values between 60 and 300 nm.

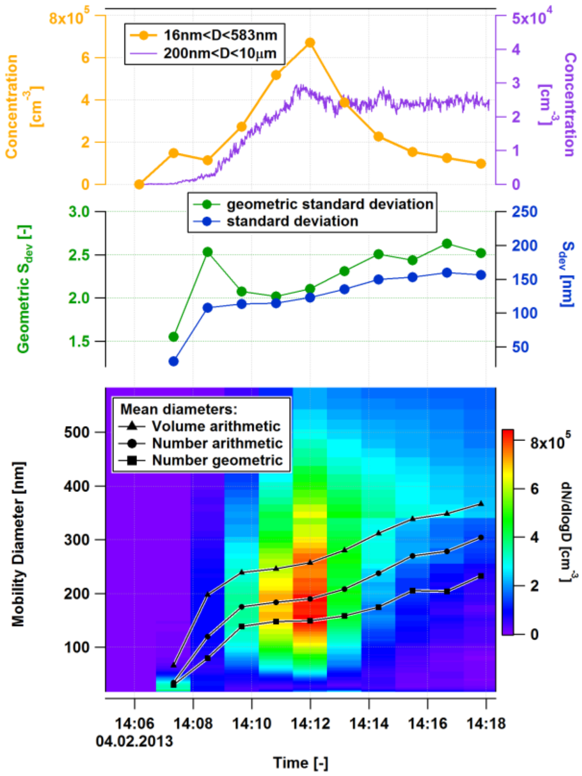

Figure 1. Size distribution properties for TF1 standard test fire

The overlapping size range between the mobility diameter and the optical diameter based size distribution measurement will be used to merge the two size distributions together. The angular light scattering will be compared to theory.

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