A potential reference standard for black carbon absorption measurements: Investigations on the optical properties and morphology of propane-based soot aerosol

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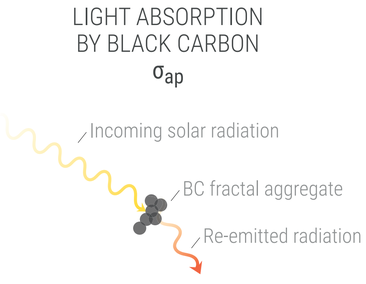
BACKGROUND



Single scattering albedo (SSA)

$$\omega_0 = \frac{\sigma_{sp}}{\sigma_{ap} + \sigma_{sp}}$$

Target SSA: **0.05 - 0.20**
for fresh soot

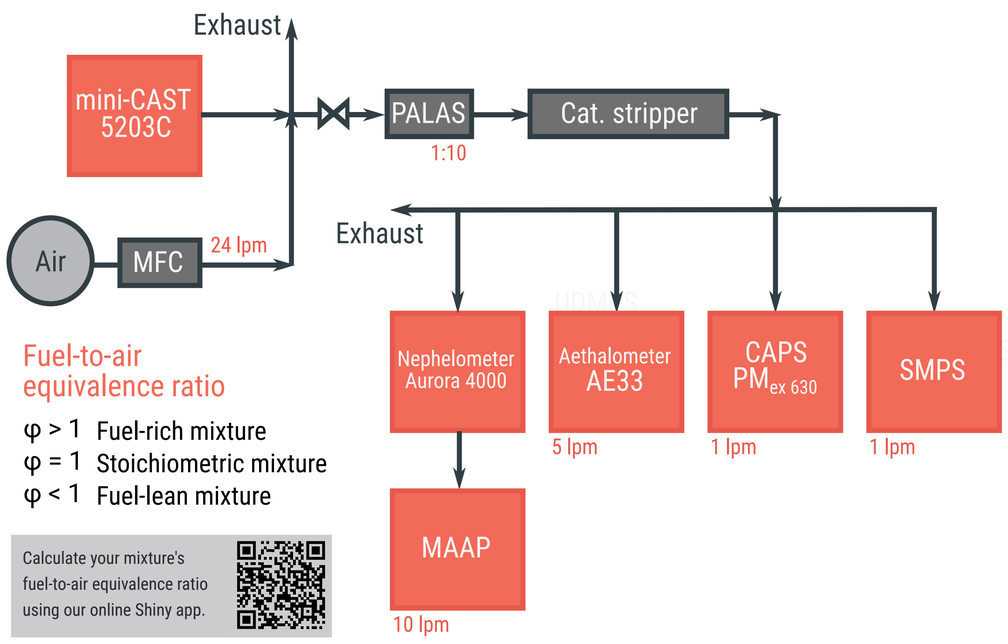
Incomplete combustion leads to the emission of black carbon (BC) aerosol particles, which are considered the second largest climate forcing agent and are associated with health effects. Measuring BC is commonly done by using optical instruments that measure light attenuation through a filter substrate or by opto-thermal methods like photoacoustic spectroscopy. Despite the widespread use of those techniques, there is no preparative BC reference soot standard available to calibrate absorption measurements. Calibration factors for the different absorption techniques need to be linked to a metrological defined reference aerosol and primary BC instrumentation, which is not available.

EMPIR BLACK CARBON PROJECT

This project aims to provide a reference "soot" (black carbon) material for the calibration of filter-based techniques and to put traceability and calibration mechanisms in place for the first time, enabling measurement of black carbon with a target uncertainty of ±10% (95% confidence level).

Visit our project's website

EXPERIMENTAL SETUP

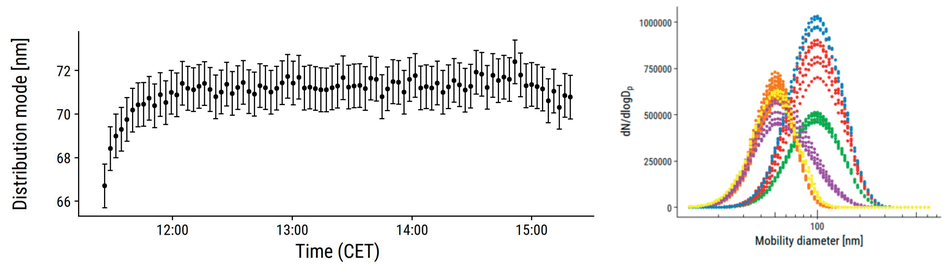


Fuel-to-air equivalence ratio

φ > 1 Fuel-rich mixture
φ = 1 Stoichiometric mixture
φ < 1 Fuel-lean mixture

Calculate your mixture's fuel-to-air equivalence ratio using our online Shiny app.

STABILITY AND PARTICLE SIZE DISTRIBUTIONS



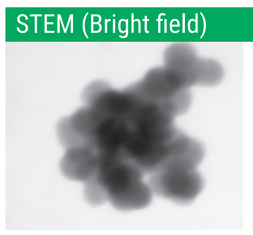
2σ = 0.64 nm
over 3 hours

40 min
warming-up time required

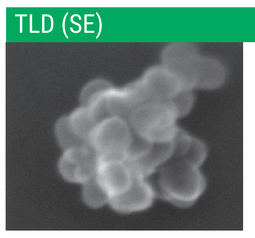
1.48 - 1.51
size distribution width

MORPHOLOGY

STEM (Bright field)

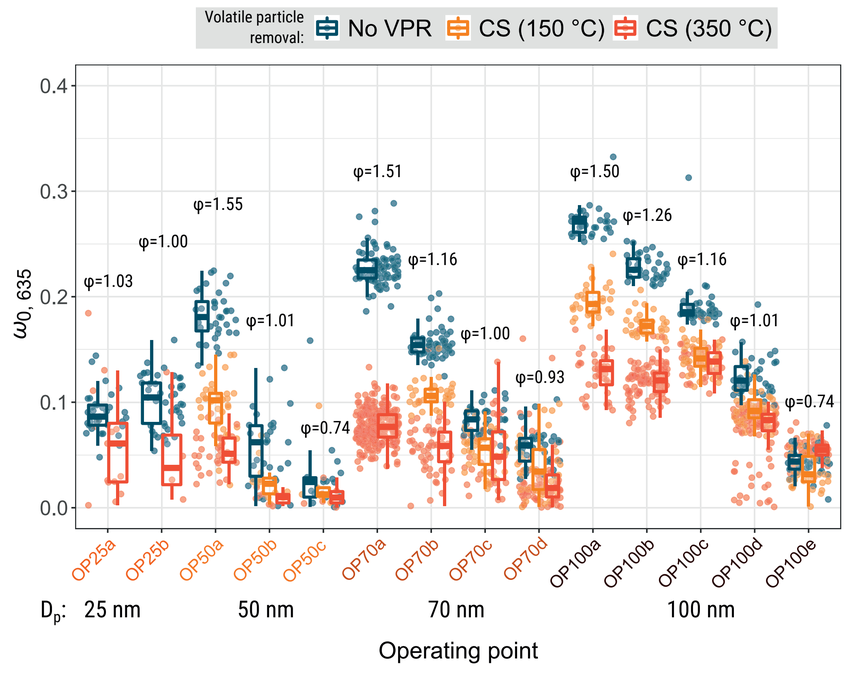


TLD (SE)



1.75 - 2.30
Fractal dimension
see poster by Romshoo et al.

SINGLE SCATTERING ALBEDO



φ ↗
↓
ω ↗

Fuel-rich combustion produces particles with higher SSA

VPR

No VPR required for fuel-lean combustion

CONCLUSIONS AND OUTLOOK

- The miniCAST 5203C offers a stable and reproducible way to generate aggregated BC aerosol particles with D_p in the range of **50 - 100 nm** and an SSA of **0.02 - 0.30.**
- The average aerosol SSA depends on the combustion fuel-to-air equivalence ratio. Fuel-lean mixtures produce soot particles with stable SSA values, with and without volatile particle removal systems.
- Further investigations will include the chemical characterization by EC/OC thermo-optical analysis and Raman microspectroscopy of the OPs presented here.
- A comprehensive comparison of different soot generators, including combustion- and spark-based and nebulisation of soot-like substances is being done by the consortium and aims to find the most suitable technique to be used as fresh soot standard reference material, as well as finding a feasible and portable generator for in-field calibration.

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