Comparison of different soot generators: Towards a standard reference material for aerosol absorption

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BACKGROUND

This work is part of the EMPIR BC project, wich aims to provide traceability to black carbon (BC) absorption measurements.

The goal of this work was to investigate several candidate reference methods for use as BC source to generate **fresh-like soot** aerosol particles with the properties listed below:

PARTICLE DIAMETER
D_p **50 - 100 nm** Here reported as volume mean (mobility-)diameter (VMD), expected to be larger than particle number mean (mobility-)diameter.

ABSORPTION ANGSTRÖM EXPONENT
AAC **~1.0** Here reported as the result from a log-log fit applied to absorption at three wavelengths: 450, 530, and 630 nm.

SINGLE SCATTERING ALBEDO
SSA_{550} **0.05 - 0.20** Here reported at 870 nm.

EURAMET

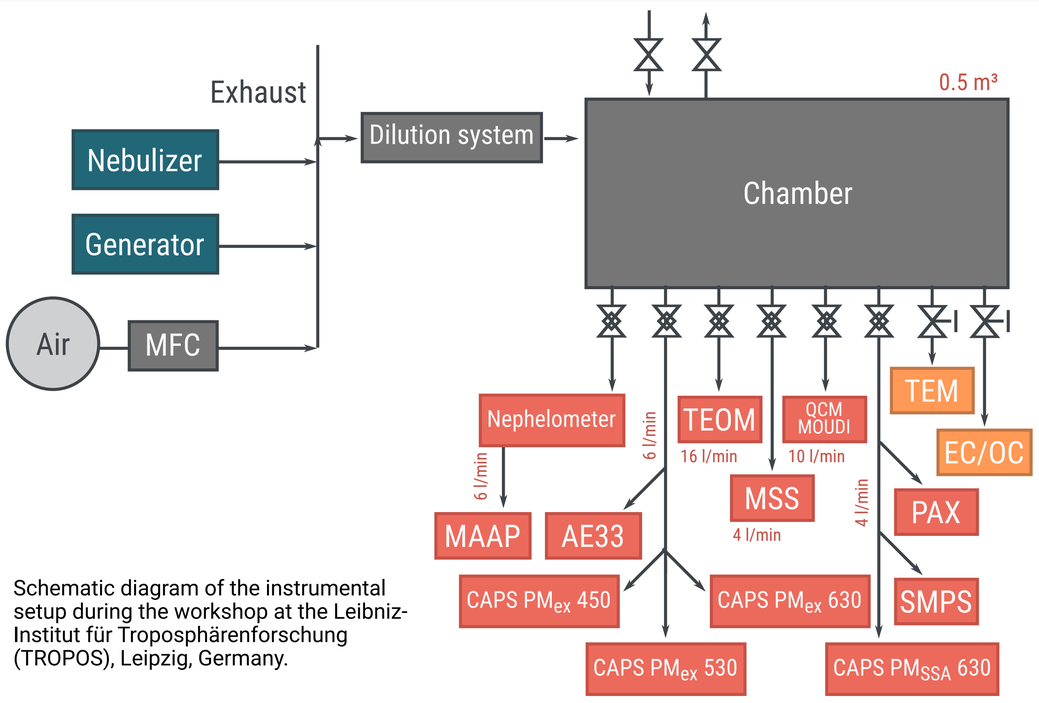
EMPIR BLACK CARBON

Follow the link for more details about the project

SOOT AEROSOL GENERATORS

🔥 COMBUSTION-BASED	mini-CAST 5201BC Fuel-lean combustion
	mini-CAST 5203C (x2) Fuel-lean combustion
	mini-CAST 5303C Fuel-lean combustion.
	Miniature inverted soot generator Propane flow rate from 60 to 110 sccm. Air flow rate from 7.5 to 9.5 slpm.
⚡ SPARK-BASED	PALAS GFG 1000
	FasmaTech spark generator
💦 ATOMIZED AEROSOL	Fullerene soot
	Colloidal graphite Aquadag®

EXPERIMENTAL SETUP



Schematic diagram of the instrumental setup during the workshop at the Leibniz-Institut für Troposphärenforschung (TROPOS), Leipzig, Germany.

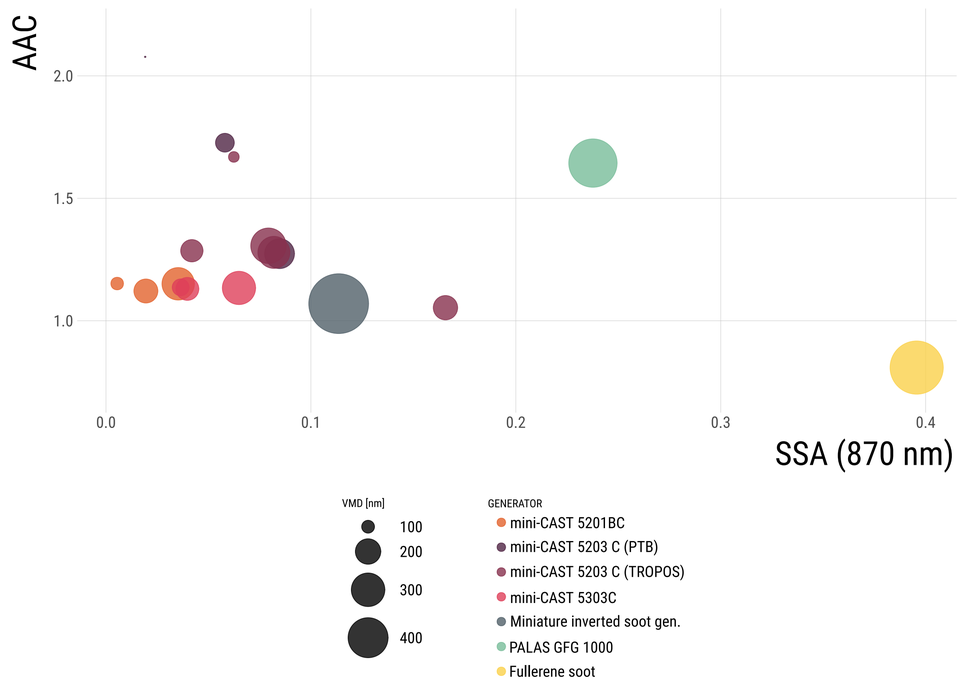
OPTICAL PROPERTIES

ID	Generator	VMD [nm]	VMD SD	SSA870	SSA870 SD	AAC	AAC SD	MAC630 [m²/g]
exp1	mini-CAST 5201BC	173	13	0.04	0.01	1.15	0.06	4.20
exp2	mini-CAST 5201BC	124	5	0.02	0.01	1.12	0.05	3.74
exp3	mini-CAST 5201BC	82	3	0.01	0.03	1.15	0.11	5.68
exp4	mini-CAST 5203C (PTB)	156	2	0.08	0.09	1.27	1.41	NA
exp5	mini-CAST 5203C (PTB)	68	4	0.02	0.02	2.08	0.04	2.19
exp6	mini-CAST 5203C (PTB)	102	4	0.06	0.03	1.73	0.05	NA
exp7	mini-CAST 5203C (TROPOS)	170	5	0.08	0.01	1.28	0.04	5.58
exp8	mini-CAST 5203C (TROPOS)	116	3	0.04	0.02	1.29	0.05	4.91
exp9	mini-CAST 5203C (TROPOS)	78	6	0.06	0.02	1.67	0.19	1.75
exp10	mini-CAST 5203C (TROPOS)	194	1	0.08	0.02	1.31	0.03	5.87
exp11	mini-CAST 5203C (TROPOS)	126	2	0.17	0.08	1.05	0.64	2.54
exp12	mini-CAST 5303C	178	1	0.06	0.01	1.13	0.07	6.30
exp13	mini-CAST 5303C	119	3	0.04	0.01	1.13	0.07	7.00
exp14	mini-CAST 5303C	95	4	0.04	0.01	1.14	0.09	4.41
exp15	FasmaTech spark generator	NA	NaN	0.27	0.02	0.79	0.06	0.61
exp16	PALAS GFG 1000	305	32	0.24	0.02	1.64	0.08	4.23
exp17	Aquadag	325	3	0.26	0.00	0.31	0.02	7.60
exp18	Fullerene soot	356	14	0.40	0.05	0.81	0.05	6.58
exp19	Miniature inverted soot generator	NA	NaN	0.23	0.01	0.83	0.04	8.56
exp20	Miniature inverted soot generator	433	24	0.11	0.01	1.07	0.09	5.27
exp21	Miniature inverted soot generator	NA	363	0.21	0.00	0.88	0.04	8.18

AAC is calculated from extinction minus scattering (CAPS, Neph.) measurements at 450, 530, and 630 nm.
SSA is calculated at 870 nm from PAX measurements.

MAC is calculated as the ratio of absorption (extinction minus scattering) at 630 nm to aerosol mass concentration from TEOM measurements.

ÅNGSTRÖM COEFF. vs. SINGLE SCATTERING ALBEDO



CONCLUSIONS AND OUTLOOK

• The combustion generators (all the mini-CAST and the miniature inverted soot generator) were able to provide BC aerosol particles with the desired SSA (< 0.2).

• Among the combustion generators, the diffusion flame models (5203C and 5303C) produced particles with the largest AAC. In this regard, the premixed flame model (5201BC) and the iniature inverted soot generator produced particles with AAC closer to 1.0 (the desired value for a fresh-like soot source).

• The desired particle diameters were obtained only from the four different mini-CAST burners. However, in the literature it can be found that spark generators and the miniature inverted soot generator are also able to produce particles with diameter < 100 nm.

• Further investigations will include the analysis of samples by EC/OC thermography, Raman microspectroscopy and transmission electron microscopy.

ACKOWLEDGEMENT This work is funded by the European Metrology Programme for Innovation and Research (EMPIR): Project 16ENV02 Black Carbon Metrology for light absorption by atmospheric aerosols.

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