Characterization of a New MiniCAST Generator (5201 Type BC) Including Diffusion and Premixed Flame Options

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Motivation

- Light-absorbing carbonaceous aerosols are an important fraction of aerosols present in the atmosphere.
- Black carbon (BC) is usually monitored by optical absorption methods (filter-based or filter-free).
- BC is a qualitative description of carbonaceous material[1] characterized by: strong visible wavelength-independent light absorption (Ångström absorption exponent α≈1), high mass absorption coefficient, heat stability, insolubility, aggregation, high sp^2-bonded carbon fraction.
- Filter-based quantification methods are affected by filter[2] and particle properties.
- Well-characterized model aerosols are necessary to quantify aerosol absorption in a standardized calibration procedure with traceability to primary standards.

➢ New miniCAST Type BC is characterized to test applicability as BC calibration source (generation of small BC-like soot particles possible?).

MiniCAST 5201 Type BC

- Combination of diffusion and premixed flame
- Variable propane to oxidation air ratio
- Mixing air instead of mixing N_2 -> premixed flame
- Tuneable quench N_2 and dilution air
- Possibility to add O_2 to oxidation air and quench N_2

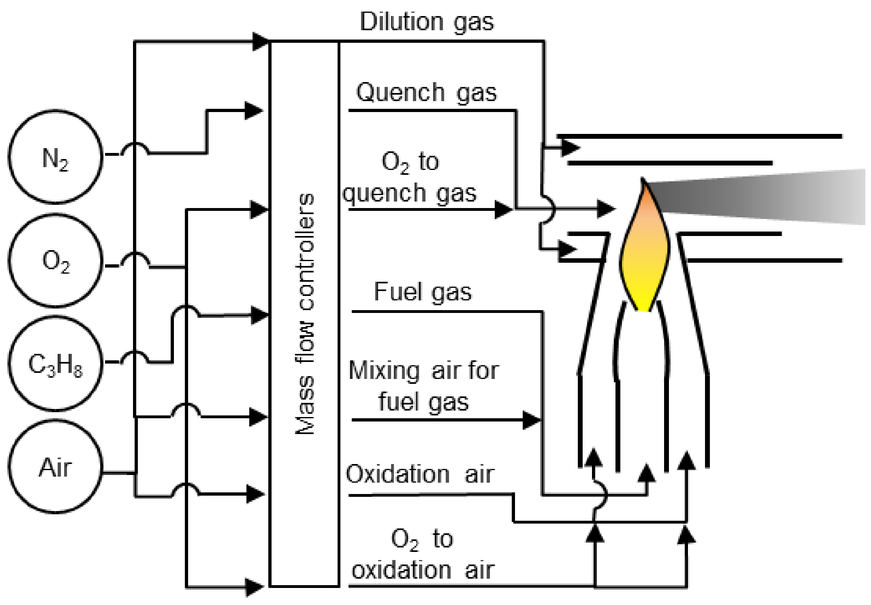


Figure 1: Scheme of the miniCAST 5201 Type BC.

Methodology

- Examination of particle number size distribution via SMPS (scanning mobility particle sizer); determination of GMD (geometric mean diameter), particle number concentration and geometric standard deviation.
- An Aethalometer is used to determine the BC mass concentration and the Ångström absorption exponent α quantifying the wavelength dependence of the absorption (C=1.39; MAC(880nm)=7.77 m^2g^{-1}).
- The chemical composition of the particles is determined by OC/EC-analysis, which splits the total carbon (TC) in elemental (EC) and organic carbon (OC).

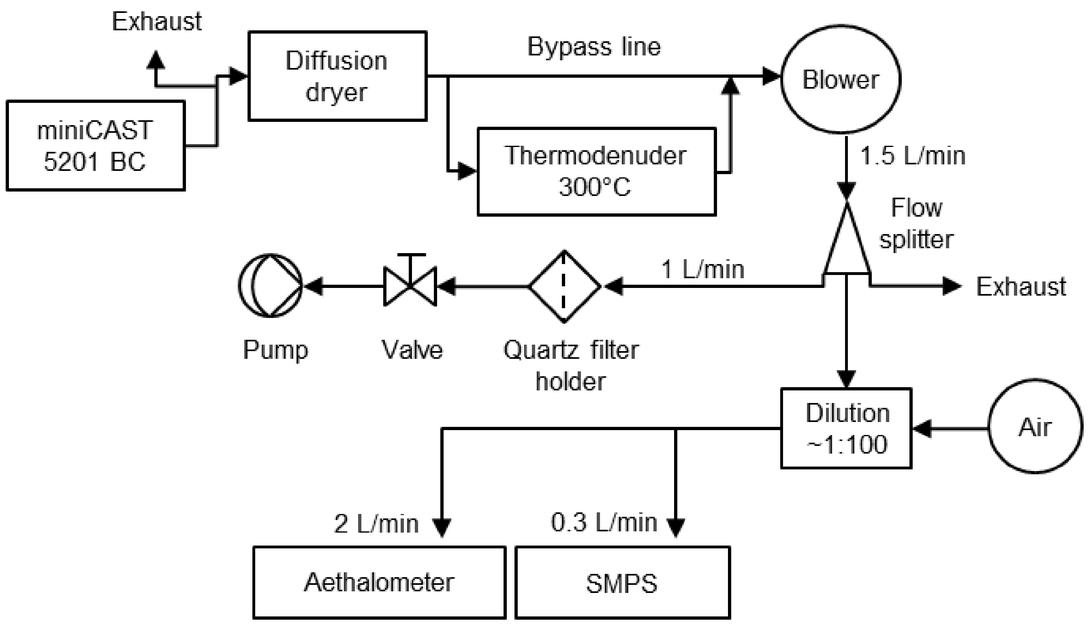


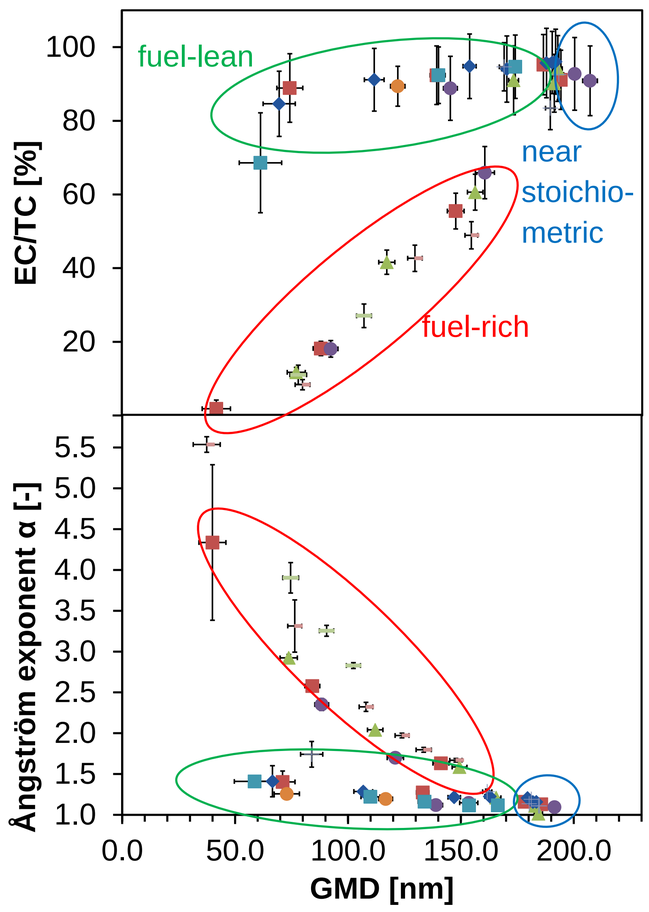
Figure 2: Experimental setup for the soot particle generation and characterization.

Literature

[1] Petzold, A., Ogren, J.A., Fiebig, M., Laj, P., Li, S.M., Baltensperger, U., Holzer-Popp, T., Kinne, S., Pappalardo, G., Sugimoto, N., Wehrli, C., Wiedensohler, A. and Zhang, X.Y. (2013). *Atmos. Chem. Phys.,* 13(16):8365–8379.

[2] Weingartner, E., Saathoff, H., Schnaiter, M., Streit, N., Bitnar, B. and Baltensperger, U (2003). *J. Aerosol. Sci.,* 34 (10) :1445-1463.

Diffusion Flame



- Near overall stoichiometric flame conditions generate biggest particles of high EC content.
- Fuel-rich flames produce soot with correlated size and EC content.
- Fuel-lean flames can produce smaller soot (50 nm< GMD<180 nm) with high EC content.
- Soot with high EC content possesses small Ångström absorption exponent α

n (GMD)=3;
error bars=u(GMD)
Error bars EC/TC propagated instrument uncertainties
n (α)>30; error bars=1σ

Figure 3: Relation of EC content resp. α and GMD of particles produced in diffusion flames.

Premixed Flame

- Mixture of premixed and diffusion flame as oxidation air is still present outside the premixed flame cone.
- Premixed air can influence particle size and particle concentration.
- Higher mixing air produces smaller particles at same fuel to air ratio.
- Flame fuel to air ratio still determines particle composition and absorption properties.
- Generation of one particle size with various compositions and Ångström absorption exponents possible.

n (GMD) =3;
error bars=u(GMD)
Error bars EC/TC propagated instrument uncertainties
n (α)>30; error bars=1σ

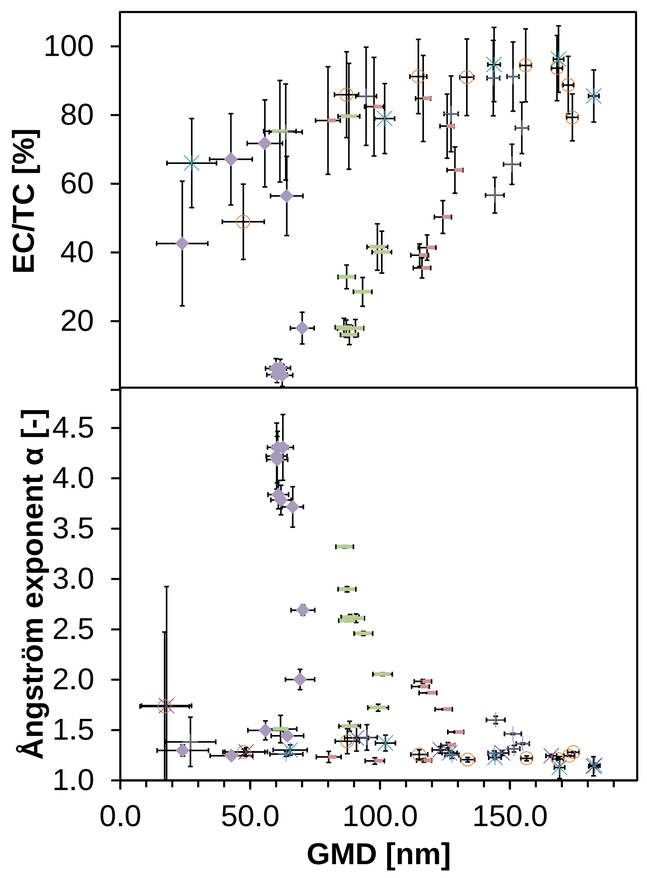


Figure 4: Relation of EC content resp. α and GMD of particles produced in premixed flames.

Summary and Outlook

- Stable and reproducible soot production.
- Soot composition and Ångström absorption exponent depend on overall flame conditions (fuel-lean; fuel-rich).
- Generation of high OC/TC containing soot (25-~100 %) with correlated particle size (150 nm>GMD>50 nm).
- **Generation of soot with high EC/TC ratio (>70 %) and low Ångström absorption exponent (<1.4) possible also for small particles (GMD≈40 nm), even without volatile particle remover.**

➢ Define and refine operation points of miniCAST 5201 BC.
➢ Further investigations of optical properties with different methods.
➢ Compare soot properties with those of other BC sources.

Acknowledgements

This work is part of the 16ENV02 Black Carbon project of the European Union funded through the European Metrology Programme for Innovation and Research (EMPIR). EMPIR is jointly funded by the EMPIR participating countries within EURAMET and the European Union. METAS was supported by the Swiss State Secretariat for Education, Research and Innovation (SERI) under contract number 17.00117. The opinions expressed and arguments employed herein do not necessarily reflect the official views of the Swiss Government.