Shades of Grey

The relation between optical absorption and thermal properties of Carbon

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"Soot", elemental Carbon (EC) and Black Carbon (BC)

"Soot" is a weakly defined expression for aerosols consisting mainly of organic carbon (OC) and "elemental" Carbon (EC). Soot in the atmosphere is a product of incomplete combustion of fossil fuels in transportation, heating and power generation" [1]. EC is the most effective light-absorbing species in the visible spectral range, and therefore often called "Black Carbon" (BC).

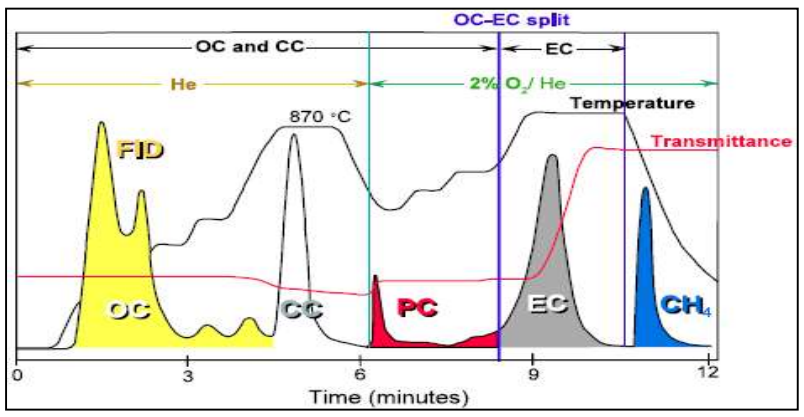
We have investigated some aspects of the relation between EC and BC

The Measurement of EC and OC

The "evolved gas analysis" (EGA) method analyzes the thermal properties of carbonaceous materials. It is considered a quasi-standard for soot measurements, determining mass concentrations [g/m^3] of EC and OC.

The evolved CO_2 of a sample, collected on a filter, is measured as a function of temperature. According to e.g. the NIOSH 5040 protocol first in an inert atmosphere (He), to quantify the evaporated OC mass. Next EC is measured in an oxidizing atmosphere (O_2/He). (For details and the meaning of CC, PC and CH_4 see, e.g. [1], [2]).

For the measurement of EC we used a commercially available "quasi-continuous" OC/EC analyzer from Sunset Labs.

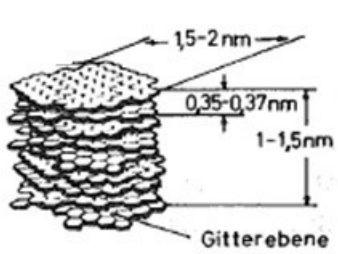


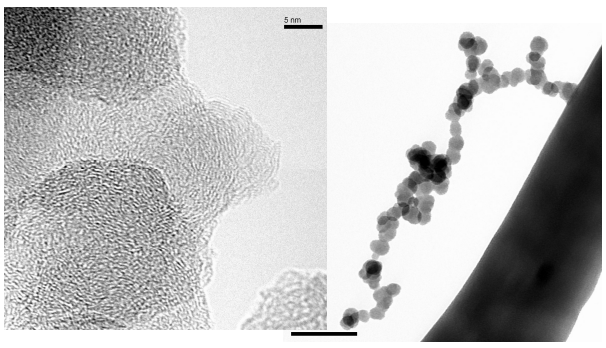
The Measurement of eBC

The structure of EC in combustion generated particles is highly variable [3], [4], [5]. A high grade of "graphitization", i.e. sp^2 bonds in a regular structure, results in a high mass specific optical absorption coefficient MAC [m^2/g] [6].

How can the widely used photoacoustic (PA) instruments for BC measurement [7], [8]. display results as mass concentration? By calibrating such instruments with particles of known or fixed MAC an "equivalent" mass concentration, eBC [9], is obtained. The product of measured eBC and the calibration MAC is related to the specific atmospheric warming effect, and therefore the relevant quantity for environmental monitoring.

The MAC for the particles used for the calibration of our PA instrument is 8 ± 1 [m^2/g] according to literature [6], [10].



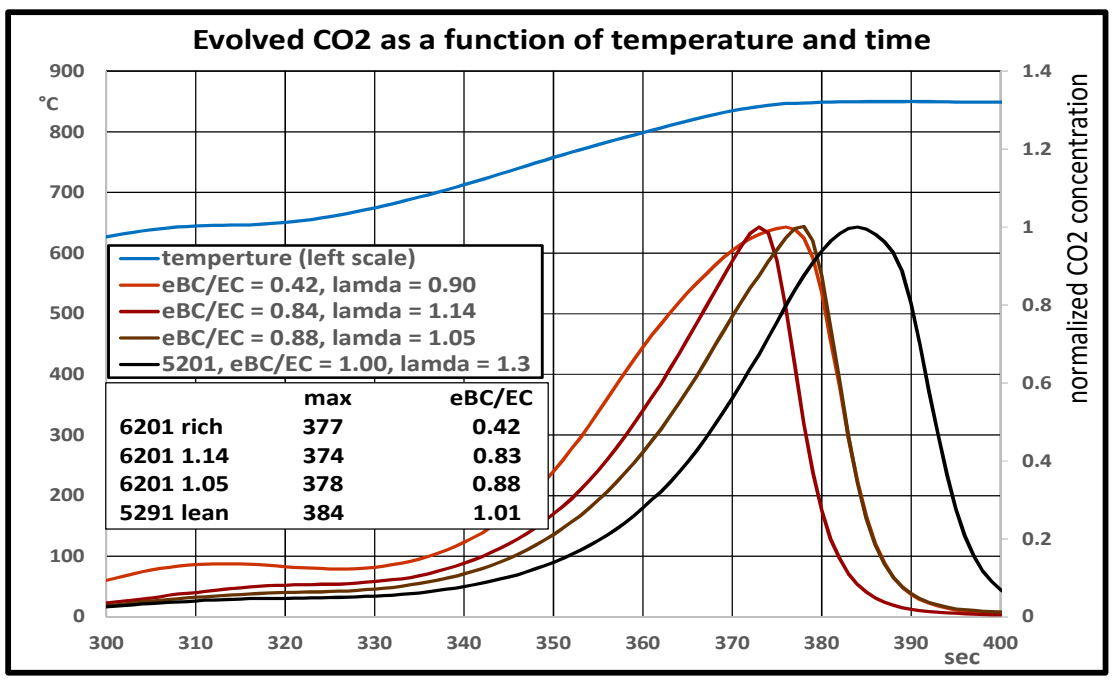


The relation between EC and eBC

Particles consisting of more than 50% EC were generated in a CAST propane burner, varying the fuel and oxidation air flow [11].

The ratio eBC / EC is directly proportional to the MAC, with eBC / EC = 1 corresponding to the MAC of the calibration particles.

Our experiments showed a trend of increasing oxidizing temperature with increasing eBC / EC ratio, although not necessarily with the peak temperature T_{max}.



Qualitatively, this is expected because the MAC is related to structural changes of EC [9].

A quantitative prediction of the MAC from T_{max}, however, was not possible: in some tests a difference in T_{max} of only 1°C for a 10% change in the MAC was found, while in other tests 2°C change in T_{max} was found for a change of <5% in the MAC.

⇨ **More detailed investigations are required**

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