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# Absorption and chemical properties of combustion cycle resolved in-cylinder diesel soot

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## INTRODUCTION

Soot or black carbon (BC) emissions reduce air quality and increase the absorption of solar radiation in the atmosphere. Diesel engines contribute to approximately 20% of the global BC emissions (Bond et al., 2013).

Engine operating conditions alter the magnitude of particle emissions and may drastically change soot characteristics, such as light absorbance and scattering. The mechanisms and time scales of soot formation, oxidation and the transformation of soot properties in the cylinder are poorly understood.

In this project, in-cylinder particle properties are analyzed with the aim to improve soot emission modelling and to reduce toxic and climate relevant particle emissions from combustion engines.

## METHOD

A heavy duty diesel engine was operated at a low load, 1200 rpm and at three levels of exhaust gas recirculation (EGR) corresponding to 21%, 15% and 13% inlet oxygen concentration ( $C(O_2)$ ). A method based on a fast sampling valve was used to extract a small semi-continuous aerosol flow (11pm) from the in-cylinder gas mixture.

The aerosols were extracted at well-defined stages of the combustion cycle, measured as the crank angle (CA) position after the piston top dead center (ATDC) at 0°CA. The sampling resolution depends on the in-cylinder pressure, with a 1°CA sampling window near 10°CA (ATDC).

The diluted sample was analyzed with three on-line techniques: a Soot-Particle Aerosol Mass Spectrometer (SP-AMS), an SMPS and a 7-wavelength Aethalometer.

## CONCLUSIONS

The observed in-cylinder BC mass concentration was found to be heavily dependent on the combustion cycle and EGR level (figure 1, main-graph). At lower EGR, i.e. 21% and 15% inlet  $C(O_2)$ , the soot concentration varies more than two orders of magnitude over the combustion cycle.

Furthermore, the oxidation of soot is very fast at low EGR resulting in low net soot emissions.

The absorption Ångström exponent ( $\alpha_{\text{abs}}$ ) was determined at each sampled point of the combustion cycle. Late in the cycle, the  $\alpha_{\text{abs}}$  is low and the particles are “black” or graphite-like. At an early stage of combustion, there is an increase in particle “brownness” with high  $\alpha_{\text{abs}}$ , possibly due to absorbing organic carbon. Increasing the EGR also tends to result in more “brown” particles throughout the combustion cycle.

The SP-AMS analysis indicates that the increased particle brownness is associated with an increased polyaromatic hydrocarbon (PAH) to BC ratio (figure 1, sub-graph).

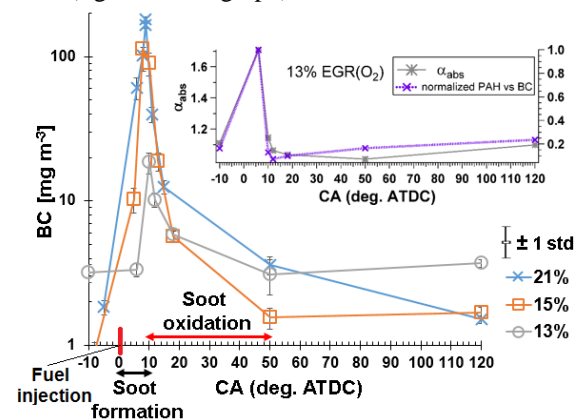


Figure 1: Aethalometer BC (880nm and 950nm average) at three levels of EGR ( $C(O_2)$ ) against the combustion cycle (in CA). Sub-graph: Absorption Ångström exponents and PAH fraction normalized to BC (and peak) at 13% inlet  $C(O_2)$  against CA.

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## REFERENCES

Bond, Tami C., et al. Journal of Geophysical Research: Atmospheres 118.11 (2013): 5380-5552.