Monitoring Adsorption and Desorption of Volatile Material on Combustion Particles

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INTRODUCTION

Particles in the exhaust of combustion engines mainly consist of elemental carbon and a variety of volatile species, being either condensed on the particles or nucleating to form new particles, when the exhaust gas cools down. Mainly spark ignition engines produce a high fraction of volatile material. Already in the hot zone these particles start to coagulate and form chain or grapelike agglomerates. In many cases the condensation of volatile material only starts when the agglomeration process is already in an advanced state. In the experiments described here we studied the influence of condensation on the structure of the agglomerates by measuring the change in size of an agglomerate when condensing material on it and then removing this material in a following step. In addition, the condensation process was monitored by a photoelectric aerosol sensor (PAS).

METHODS

Particles are produced by a flame soot generator (Combustion Aerosol Standard, CAST, Jing, 2003.). One size class was then selected by a differential mobility analyser (DMA). The selected particles were guided through a Sinclair la Mere type condensation generator where DEHS was condensed on them. By varying the temperature in the generator the coating thickness could be varied. In the next step the DEHS could optionally be removed by a thermodesorber (Burtscher et al. 2001). Finally the resulting size distribution was measured by a second DMA and a condensation nucleus counter (CPC). Parallel to this size measurement a PAS was operated. Usually the PAS is applied to detect adsorbates of polycyclic aromatic hydrocarbons which significantly enhance the response of the sensor. In our experiments we do the opposite. By using DEHS we chose a species which suppresses emission of photoelectrons. The condensation process can then be monitored by the decrease in the signal of the PAS. Another CPC right after the exit of the first DMA is used for normalisation to correct variations of the particle production. The condensation generator and the thermodesorber can be bypassed.

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RESULTS and CONCLUSIONS

Experiments were done with particles of 60 nm and 100 nm initial diameter. The main results are:

- Adsorption of volatile material induces reconstruction process, leading to a decrease in diameter.
- This process starts at very thin coating and proceeds further, if more material adsorbed.
- Reconstruction is more pronounced for larger particles.
- PAS allows to monitor this process, it responds to extremely low coverage, which cannot be detected by a change in diameter.
- The adsorbent cannot be removed completely by thermodesorber.
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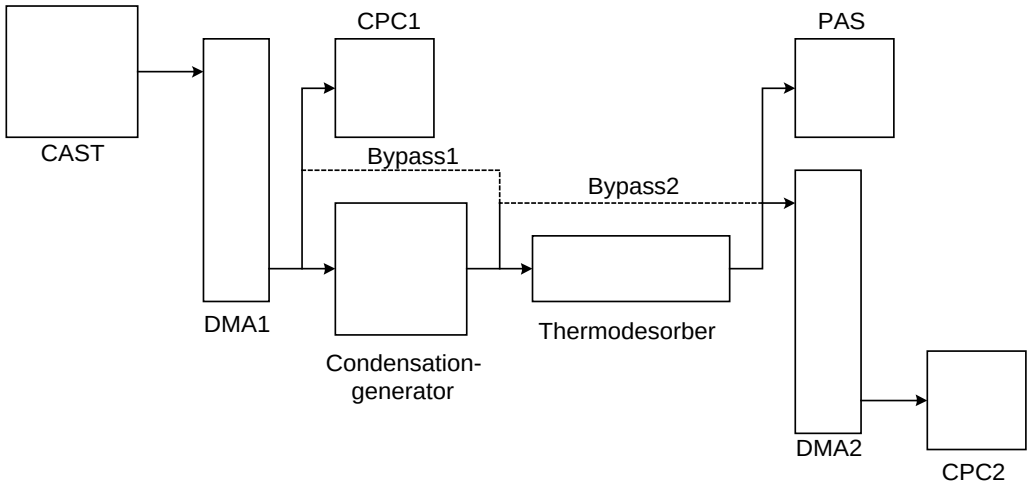
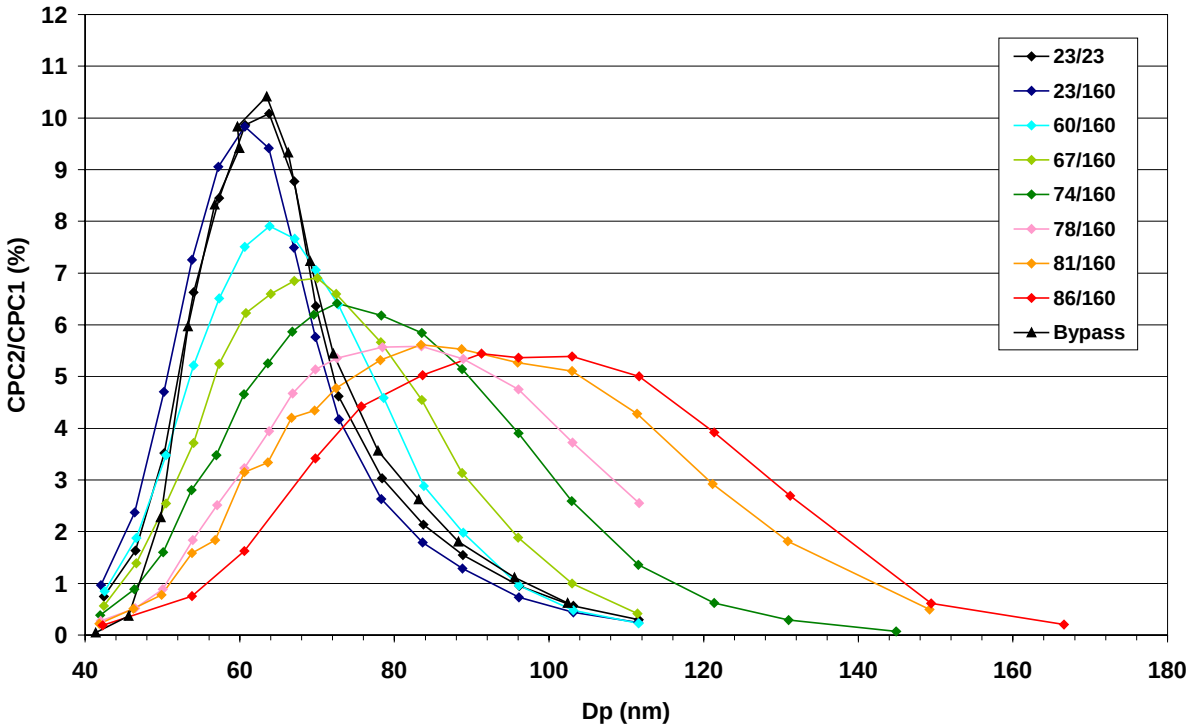
REFERENCES

Burtscher. H., U. Baltensperger, N. Bukowiecki, C. Hüglin, M. Mohr, U. Matter, S. Nyeki, V. Schmatloch, N. Streit, E. Weingartner (2001). Separation of Volatile and Non-volatile Aerosol Fractions by Thermodesorption: Instrumental Development and Applications, *J. Aerosol. Sci*, 32, 427-442.
Jing, L. (2003). www.sootgenerator.comT.

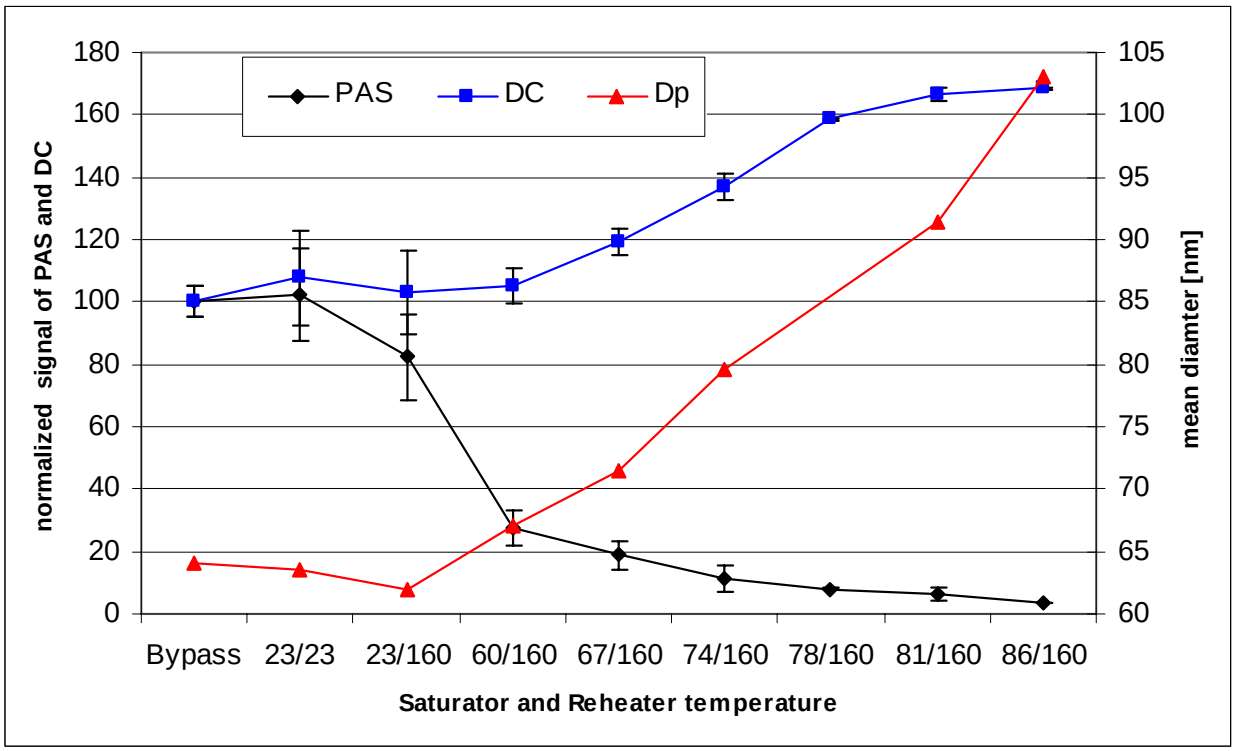
Figures:



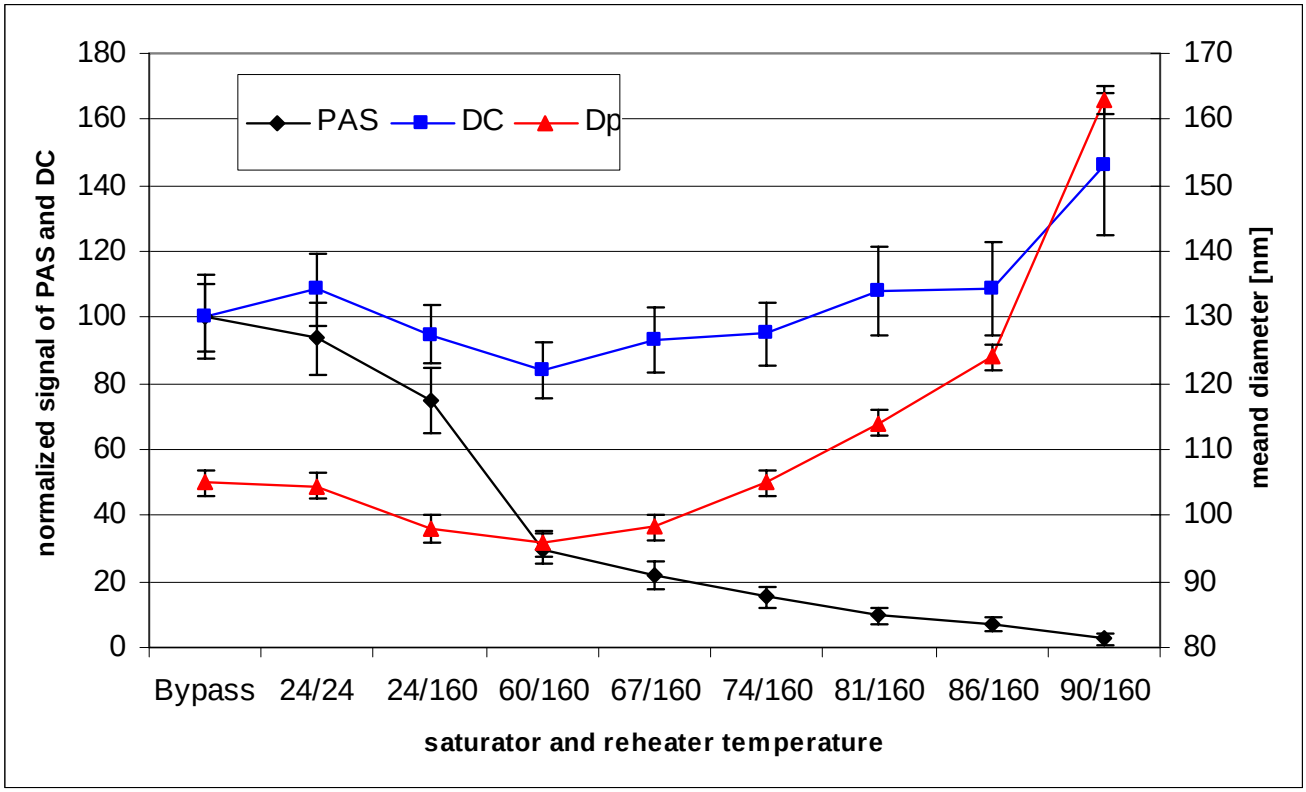
Experimental setup



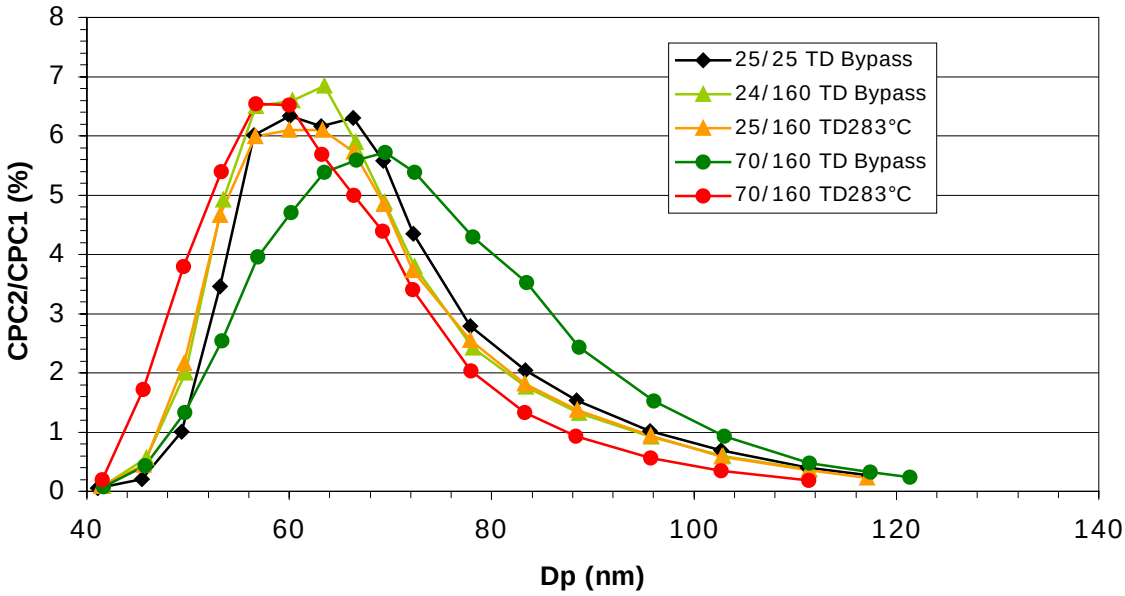
Change in size distribution of 60-nm particles, initial diameter 63 nm.



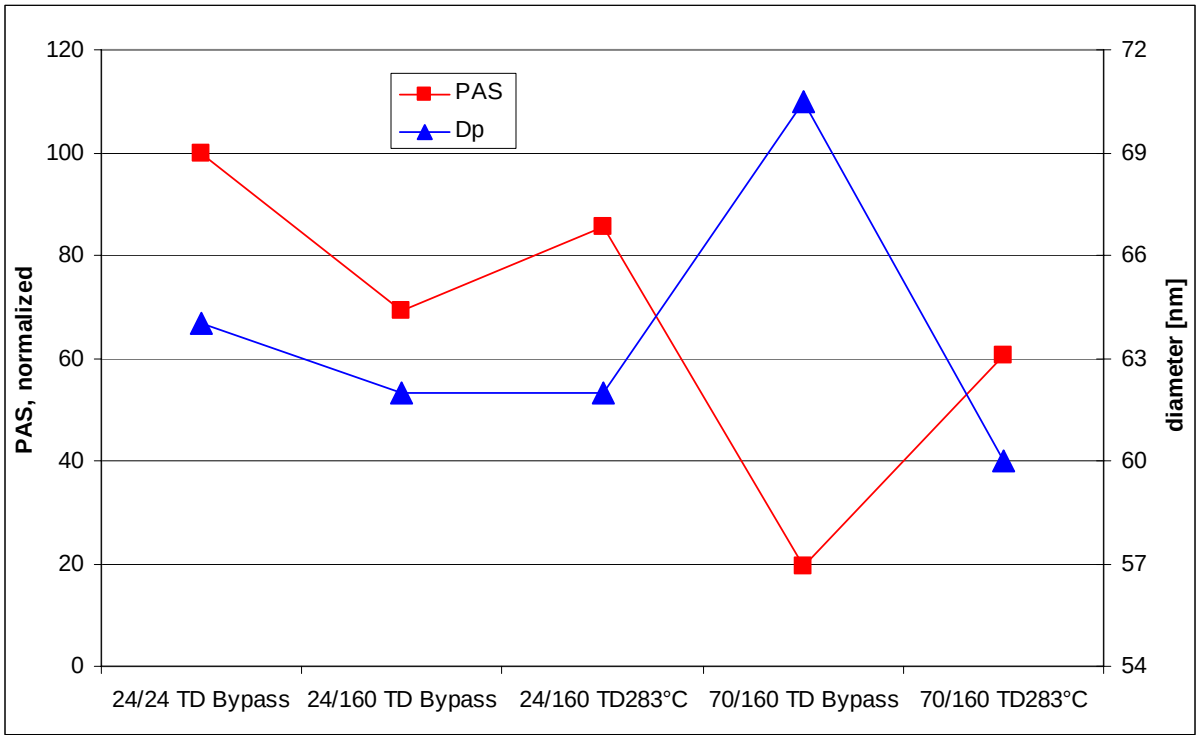
Change in diameter, DC-signal and PAS signal for different coating conditions for particles with 60 nm initial diameter.



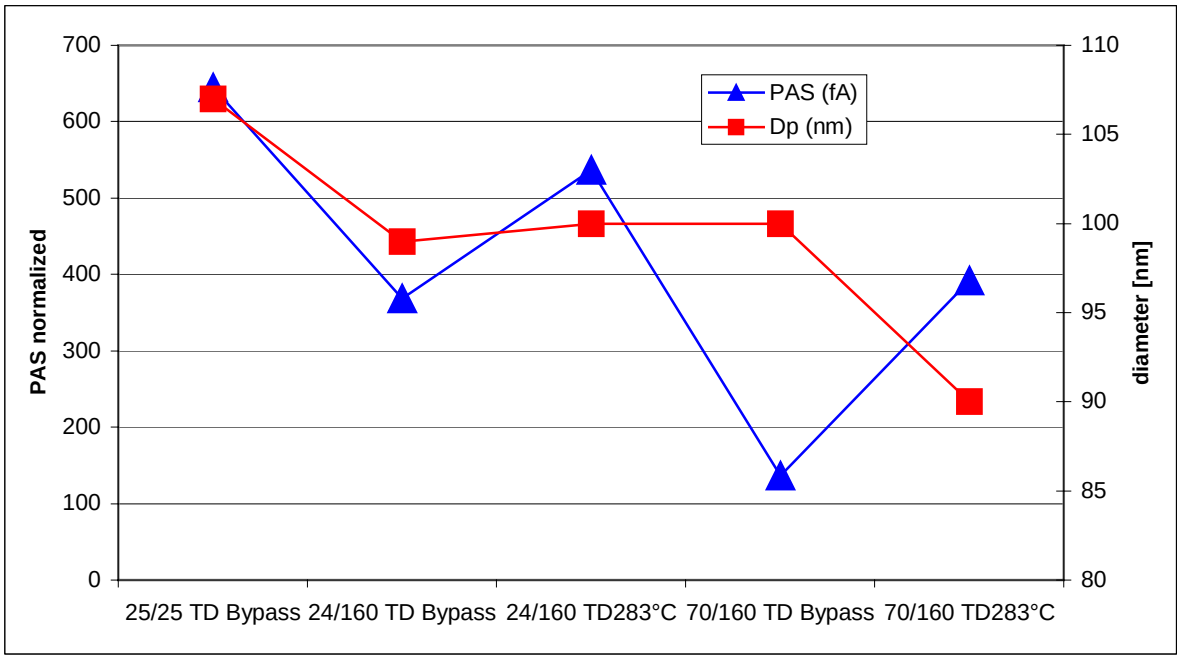
Change in diameter, DC-signal and PAS signal for different coating conditions for particles with 100 nm initial diameter



Adsorption and subsequent desorption by a thermodesorber: change in size distribution



Adsorption and subsequent desorption by a thermodesorber: change in mean diameter and PAS signal for 60 nm particles



Adsorption and subsequent desorption by a thermodesorber: change in mean diameter and PAS signal for 100 nm particles