Size-selective sampling and chemical characterization of ultra-fine particulate matter emitted by a direct injection single cylinder gasoline engine

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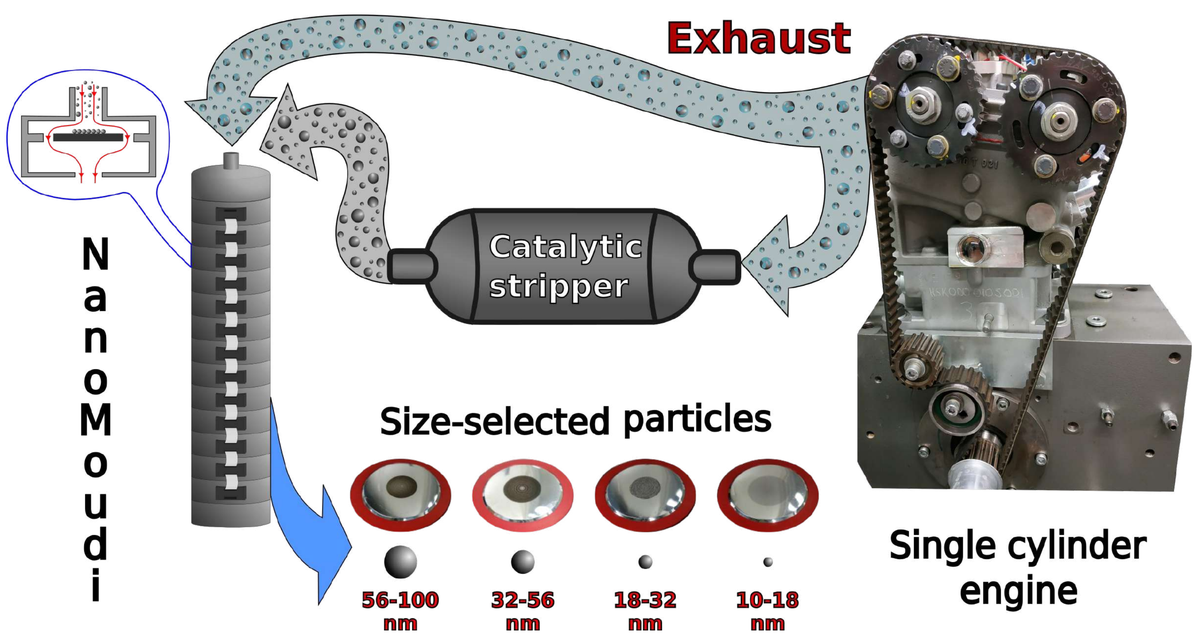
Context

- Particle emissions from on-road vehicles represent an acknowledged health risk and significant societal concern due to their high toxicity and climate impact.
- There is a critical lack of certification procedures under **real driving** conditions and for the smallest particles, **down to 10 nm**.
- The goal of the H2020 PEMs4Nano project (**www.pems4nano.eu**) is the development of a measurement procedure down to 10 nm and to further contribute to future regulation on particle emissions in real driving conditions.
- The development of a precise and reliable measurement procedure requires a deep understanding of emitted particle characteristics, in particular the **size variation of the chemical composition and volatility**.
- Chemical characterization of size-selected particles emitted by a direct injection single cylinder gasoline engine is presented.

Experimental setup



Size-selective sampling

- Investigated particles (*i.e.* soot) were generated by a single cylinder engine operated in different regimes.
- Particles were sampled with and without a catalytic stripper (CS) by a cascade impactor (NanoMoudi-II, TSI) enabling size-selective sampling.
- Chemical characterization was performed using a two-step laser mass spectrometer (**L2MS**) allowing an in-depth molecular analysis of chemical classes of critical interest (*Faccinetto et al., 2015*).

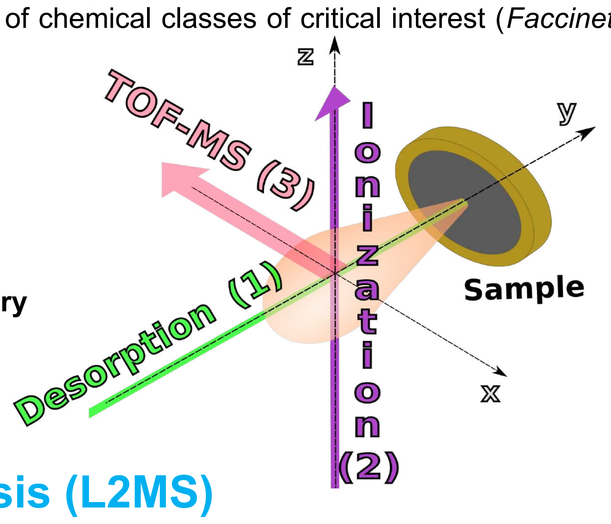
Offline analysis (L2MS)

L2MS consists of three key stages:

1) Laser desorption (532 nm)

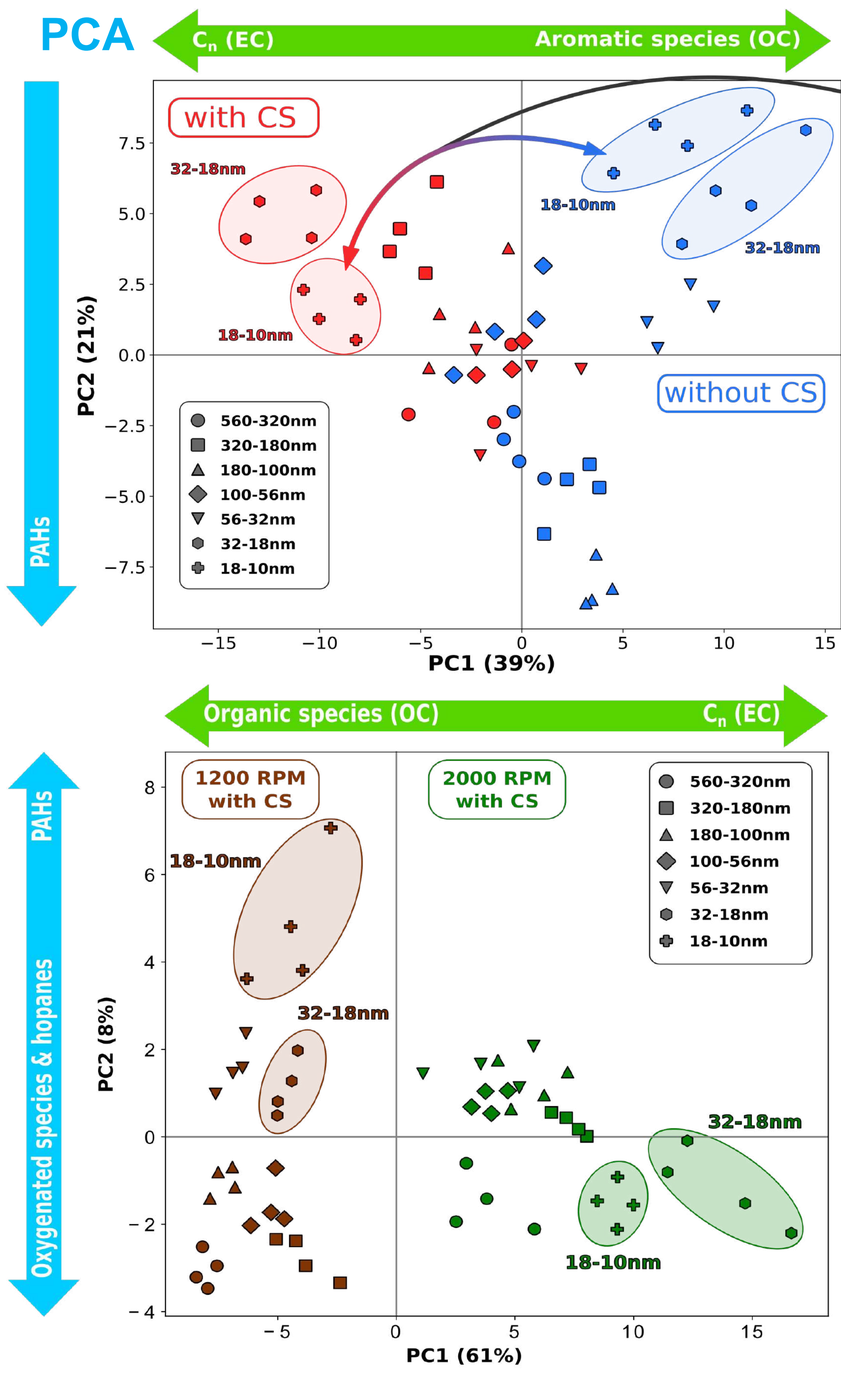
2) Laser ionization (266 nm)

3) Time-Of-Flight Mass Spectrometry

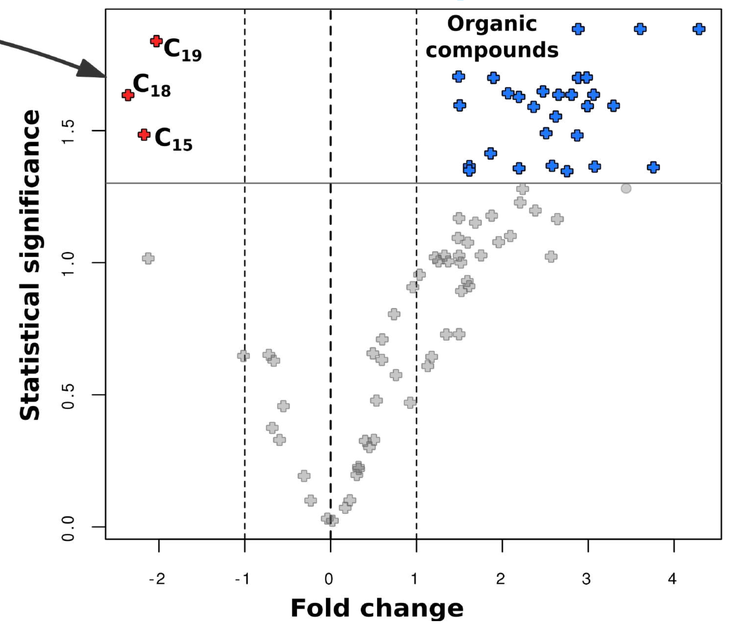


Chemical analysis

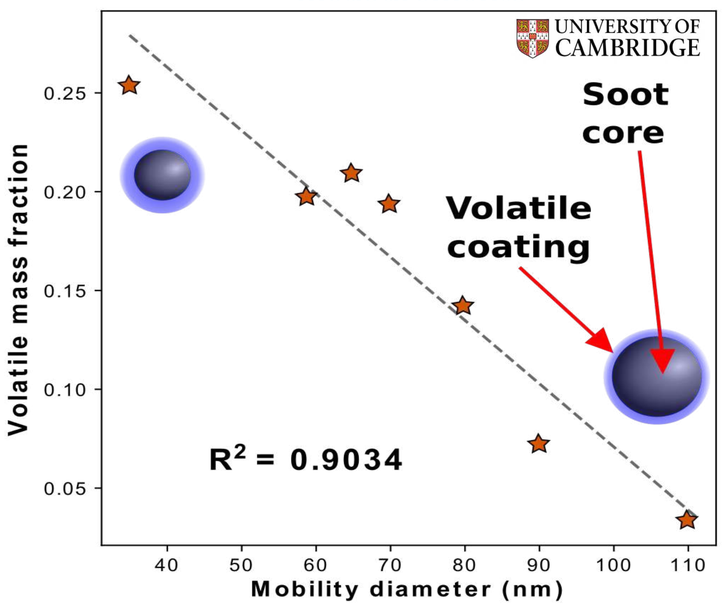
PCA



Volcano plot



Online aerodynamic-mass-mobility measurements



Conclusions

- The combination of mass spectroscopic measurements and advanced statistical procedures allows the determination of a **detailed molecular level** surface chemical composition of soot particles.
- The use of **size-selective sampling** enabled the characterization of surface chemistries on particles down to 10 nm.
- The **impact of the catalytic stripper** on particles of different sizes and from different engine regimes was determined.
- The **smallest particles hold the highest surface organic fraction** and therefore are the most affected by the catalytic stripper (confirmed by online and offline measurements).

Acknowledgements

This work was supported by European Union's Horizon2020 Programme for research, technological development and demonstration under Grant Agreement no. 724145 (H2020-GV-2016)(PEMS4Nano project).

A. Faccinetto et al. *Progress toward the Quantitative Analysis of PAHs Adsorbed on Soot by Laser Desorption/Laser Ionization/Time-of-Flight Mass Spectrometry,* Environmental Science and Technology 49, pp. 10510 –10520, 2015.

PCA – Principal Component Analysis **PAH** – Polycyclic Aromatic Compounds **OC** – Organic Carbon **EC** – Elemental Carbon