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

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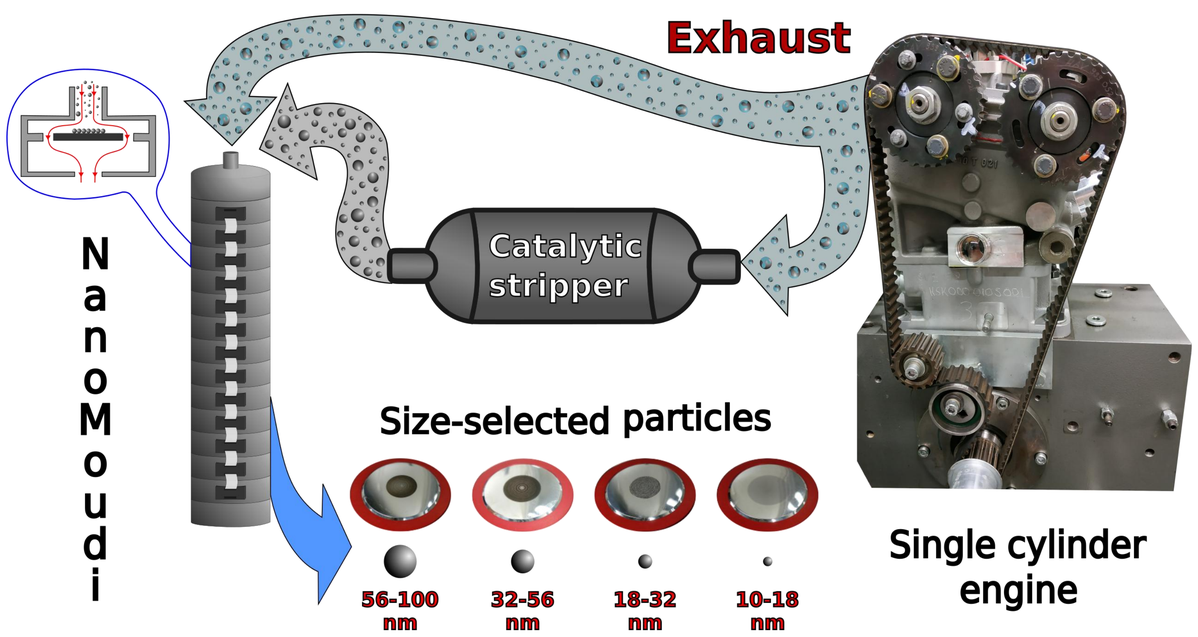
Context

- 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

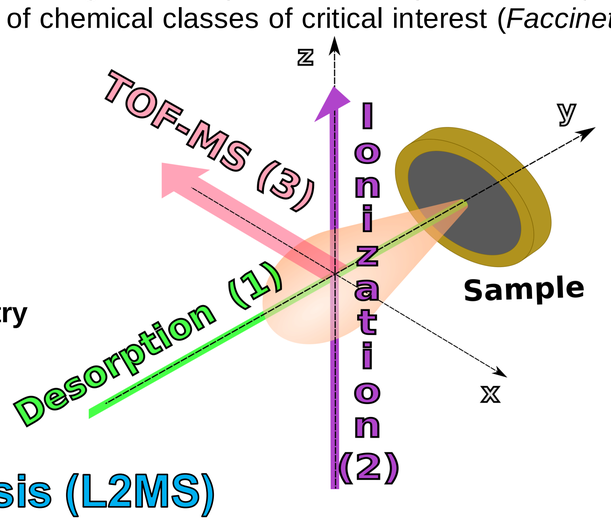
- Investigated particles (*i.e.* soot) were generated by a single cylinder engine operated in different regimes.
- Particles were sampled with and without a catalytic stripper (CS) by a cascade impactor (NanoMoudi-II, TSI) enabling size-selective sampling.
- Chemical characterization was performed using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

L2MS consists of three key stages:

1) Laser desorption (532 nm)

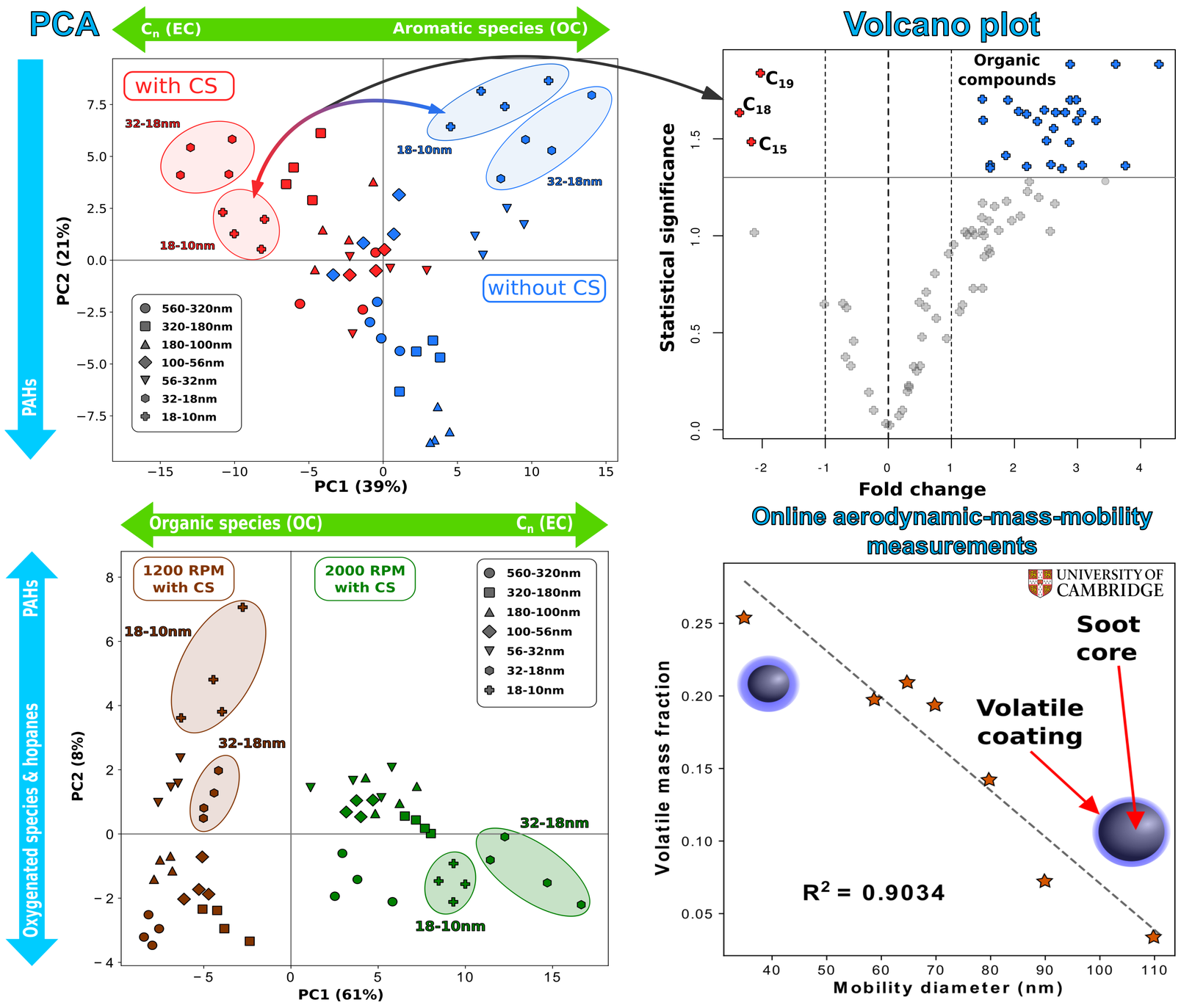
2) Laser ionization (266 nm)

3) Time-Of-Flight Mass Spectrometry



Offline analysis (L2MS)

Chemical analysis



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

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

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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.