High number concentration of sub-3 nm non-volatile aerosol particles emitted by gasoline direct injection engine

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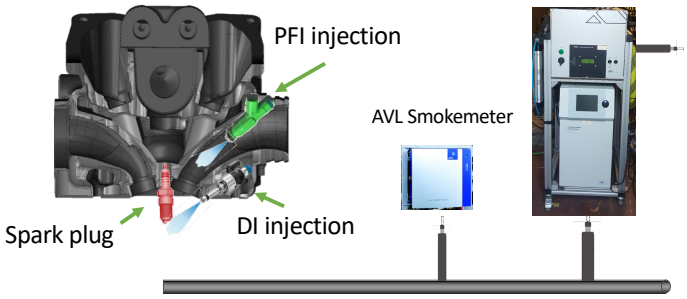
4-stroke single cylinder spark ignition engine emits sub – 3 nm particles both in GDI and GPFI mode

Small displacement SI engine

Engine type	4-stroke single cylinder
Displacement (cm^3)	250
Bore (mm)	72
Stroke (mm)	60
Bowl Volume (cm^3)	19.7
Maximum Torque [Nm]	20 Nm @ 5500 rpm
Maximum Power [kW]	16 kW @ 8000 rpm
Compression ratio	10.5:1
Injector Type	DI PFI
Number of Nozzle Holes	6 3



MEASUREMENT SETUP

A 4-stroke single cylinder spark ignition engine with a cylinder head of a naturally aspirated gasoline direct injection (GDI) engine.

The engine can be run in GDI and gasoline port fuel injection (GPFI) modes.

Two steady state engine speeds were used: 2000 and 4000 rpm.

A 1.5 m heated line and Dekati DEED dilution system with 1:79 dilution ratio was used to sample the exhaust. Dekati DEED has an evaporation tube between two dilution stages (on/off 400°C)

Airmodus A11 nano Condensation Nucleus Counter was used to measure particle number size distribution in the size range from 1.3 to 3.3 nm.

TSI Engine Exhaust Particle Sizer (EEPS) was used to measure particle size distribution from 5.6 to 560 nm.

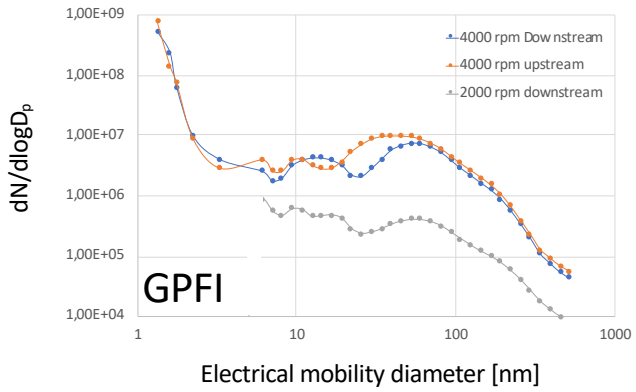


Figure 1. Size distribution measured up- and downstream of the 3 way catalyst while engine running in gasoline port fuel injection mode.

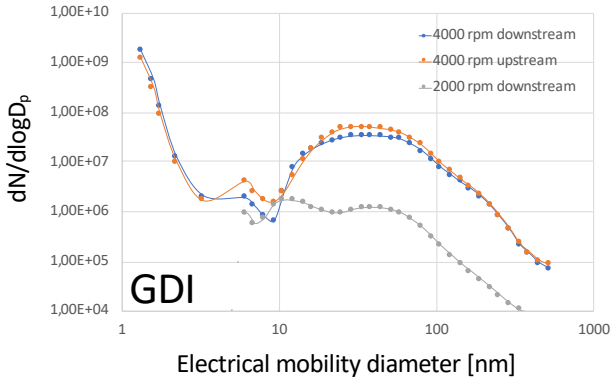


Figure 2. Size distribution measured up- and downstream of the 3 way catalyst while engine running in gasoline direct injection mode.

RESULTS AND CONCLUSIONS

2000 rpm -> no emission of sub 3 nm particles.

4000 rpm -> high emission of sub 3 nm particles both in GDI and PFI mode.

Sub - 3 nm particle number concentrations are higher than >3nm particle concentrations with 4000 rpm engine speed both in GPFI and GDI modes, upstream and downstream of the 3-way catalyst.

The 3 way catalyst doesn't have a clear effect on the particle emissions.

High concentrations of sub 10nm particles from GPFI, GDI and moped engines also measured by Giechaskiel et al. 2017.

References

B. Giechaskiel, J. Vanhanen, M. Väkevä & G. Martini (2017) Investigation ofvehicle exhaust sub-23 nm particle emissions, Aerosol Science and Technology, 51:5, 626-641

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