Assessment of particulate matter emission from Diesel vehicles equipped with DPF

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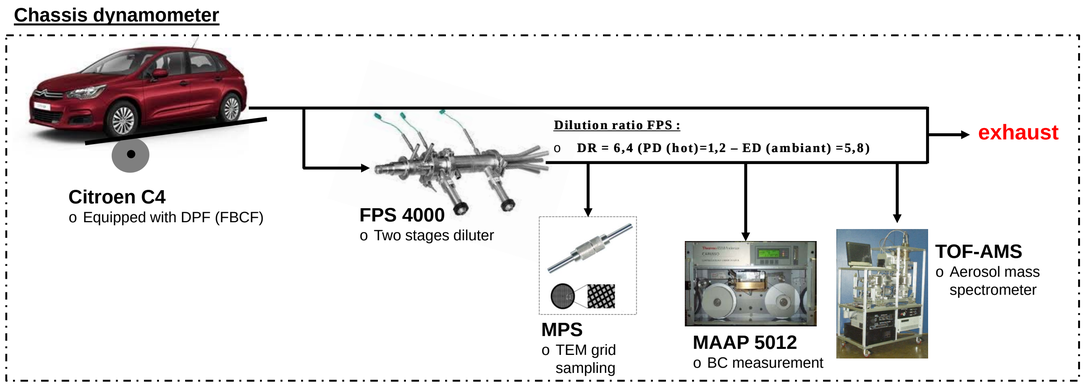
Introduction

Since 2011, all Diesel cars are equipped with a Diesel Particulate Filter (DPF) and respect European standards (Euro 6) for particulate matter emissions which combine a limit number (PN: 6.0×10^{11}part/km) with a limit mass (PM: 4.5 mg/km). However, vehicle emission during cold start and regeneration are known to be higher and not yet regulated. Otherwise, there is limited data concerning particle number, mass, morphology, chemical composition during these two phases.

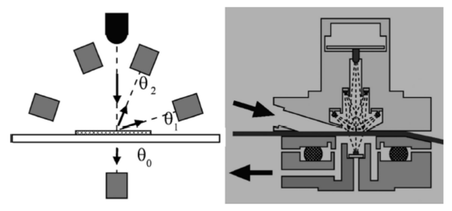
In this study we propose a new approach based on the combination of three technique namely, AMS, MAAP and MPS to characterize particles emitted from one Diesel Euro5 vehicles equipped with Fuel Born Catalyst Filter (FBCF). Collections were carried out during cold and hot start NEDC driving cycle and during regenerations phase.

Experimental set up

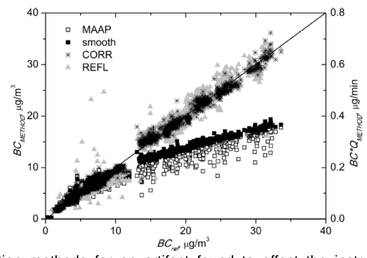


➢ Exhaust samples were analyzed during NEDC driving cycle as well as during regenerations phases

o **MAAP-multi-angle absorption photometry**
(A. Petzold et al. 2004, 2005)

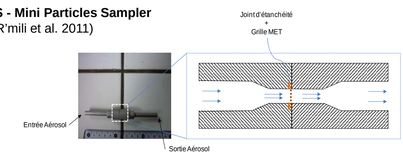


This method measure the black carbon mass concentration by measuring the aerosol light absorption from the simultaneous measurement of radiation passing through and scattered back from a particle-loaded fiber filter .



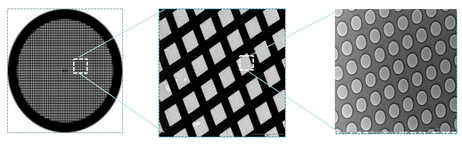
Correction methods for an artifact found to affect the instrument accuracy (A. P. Hyvärinen et al. (2012))

o **MPS - Mini Particles Sampler**
(B. R'mili et al. 2011)

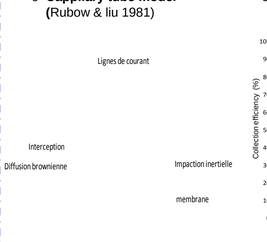


Particle collection technique based on filtration through on class of TEM dedicated technique support, namely porous TEM grids

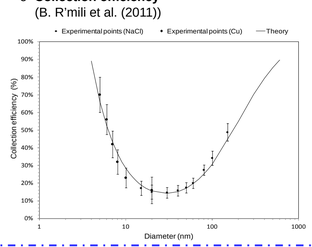
o **Porous TEM grid (Quantifoil)**



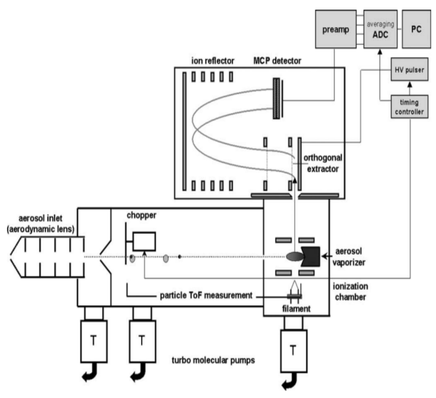
o **Cappilary tube model**
(Rubow & liu 1981)



o **Collection efficiency**
(B. R'mili et al. (2011))



o **Schematic of the Time-of-Flight Aerosol Mass Spectrometer (TOF-AMS).**

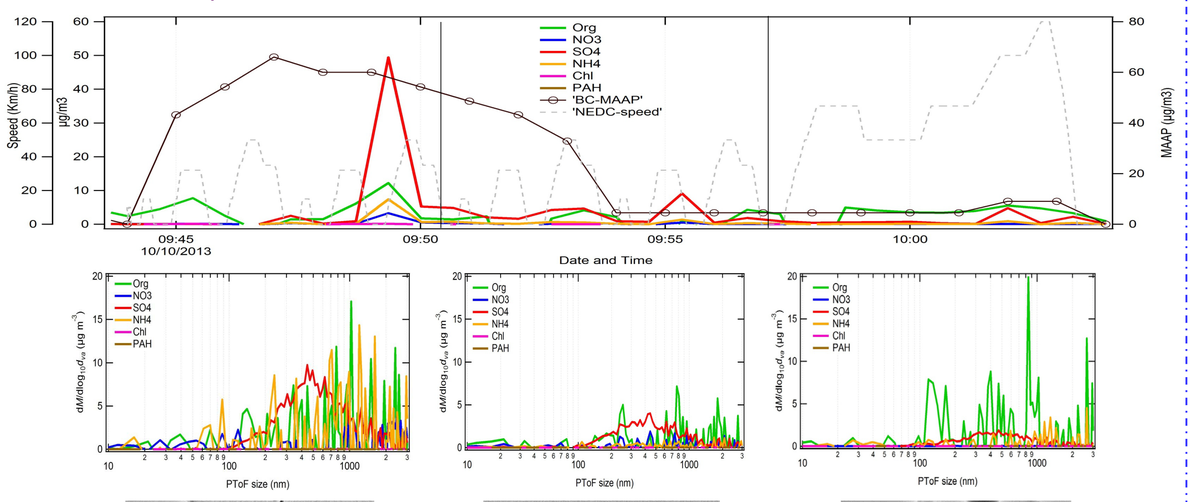


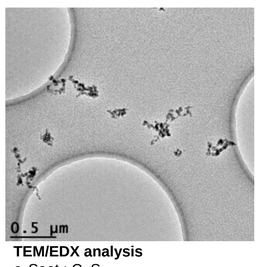
Aerosol is introduced into the instrument through an aerodynamic lens focusing the particles through a skimmer and an orifice onto the vaporizer. Particle vapor is ionized and the ions are guided into the TOF-MS, which generates mass spectra at ~ 83.3 kHz repetition rate. For particle size measurement the particle beam is chopped with a mechanical chopper and the detection is synchronized with the chopper opening time (F. Drewnick et al. (2005))

Results:

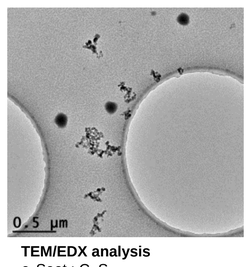
I: Transient test

o NEDC cycle : cold start

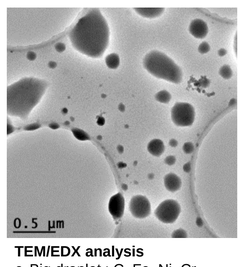




TEM/EDX analysis
o Soot : C, S



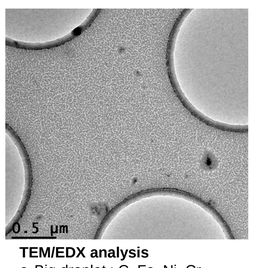
TEM/EDX analysis
o Soot : C, S
o Big droplet : C, Fe, Ni, Cr, S, Si, Ca, Mn, P, K, Na



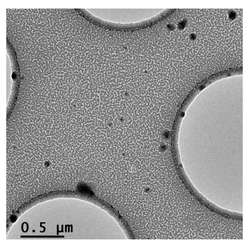
TEM/EDX analysis
o Big droplet : C, Fe, Ni, Cr, S, Si, Ca, Mn, P, K, Na

o NEDC cycle : Hot start

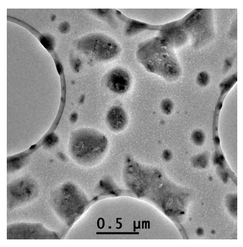
➢ Nothing was measured with the MAAP during the hot start



TEM/EDX analysis
o Big droplet : C, Fe, Ni, Cr, S, Si, Ca, Mn, P, K, Na

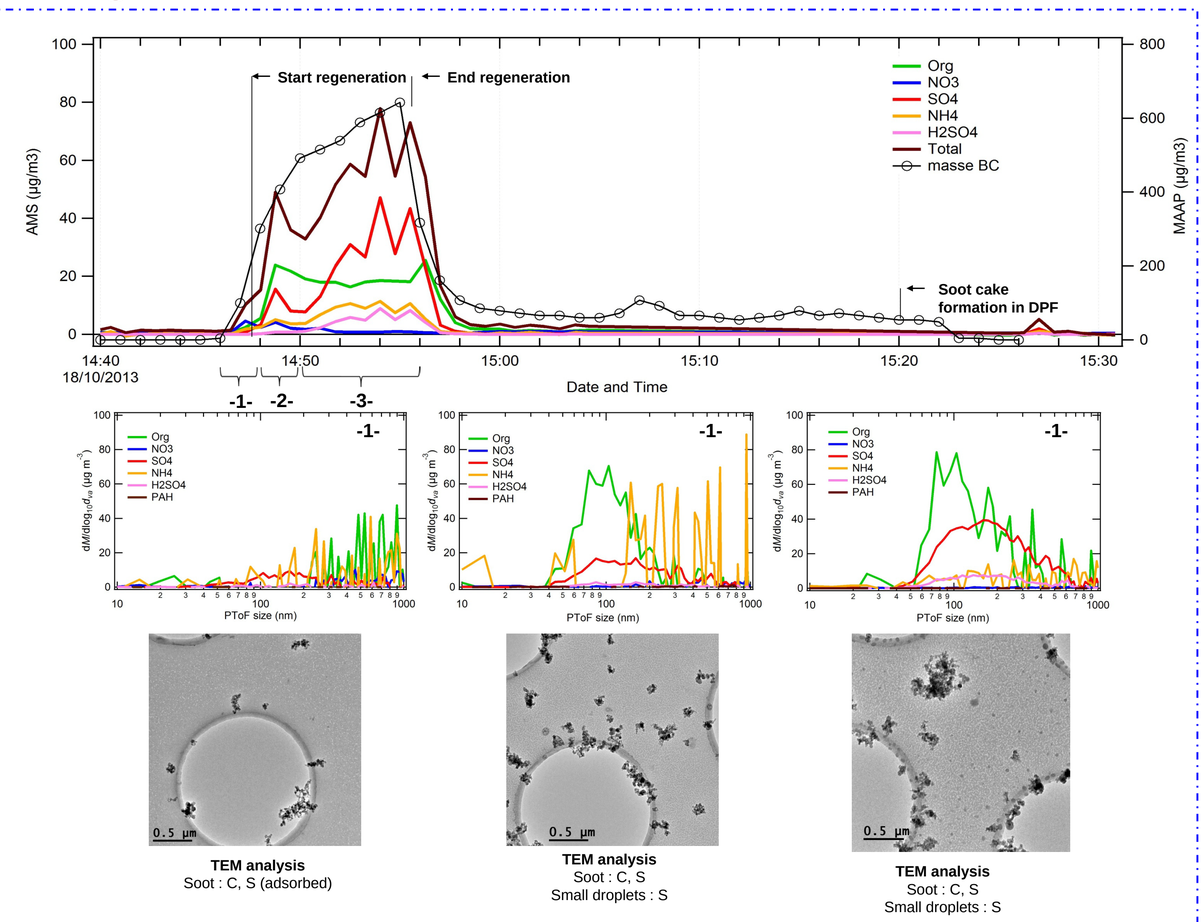


TEM/EDX analysis
o Big droplet : C, Fe, Ni, Cr, S, Si, Ca, Mn, P, K, Na



TEM/EDX analysis
o Big droplet : C, Fe, Ni, Cr, S, Si, Ca, Mn, P, K, Na

II: regeneration



TEM analysis
Soot : C, S (adsorbed)

TEM analysis
Soot : C, S
Small droplets : S

TEM analysis
Soot : C, S
Small droplets : S

Conclusions

Diesel engines equipped with DPF mainly emit particles during cold start and DPF regenerations.

o During cold start, in the first ten minutes, the particles emitted are mainly carbon soot. Later, big droplets with metal content appear especially during heavy acceleration

o During hot start, is observed only large droplets especially during heavy acceleration.
It seems that the increase of engine speeds during cycles resulted in increase of fractions of metal contents in particulate matters.

Sources of droplet and metal emissions :

➢ Abrasion from piston ring, cylinder liner, valves (abraded metal)
➢ Lubrication oil
➢ Trace metals in Fuel

o During the DPF regenerations, PM size distributions are classified as bimodal, mainly consisting of the nucleation and accumulation modes. Typically, these particles are composed of a complex mixture of soot and small droplet like particles.

These results are repeatable

Literature:

A.P. Hyvärinen et al. Atmos. Meas. Tech., (2013) 6, 81-90
A. Petzold & M. Schönlinner, Aerosol Science (2004) 421-441
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B. Rmili et al. Aerosol science and Technology, (2013) 47:7, 767-775
F. Drewnick et al. (2005) 36:637-658
K.L. Rubow and B.Y.H. Liu Gas. Vol. 1 ASTM (1986) p. 975

Acknowledgements

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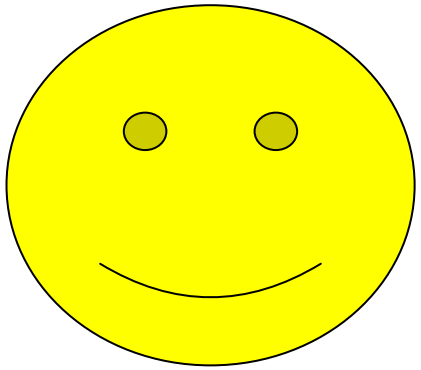

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