FINNISH METEOROLOGICAL INSTITUTE

AGING OF DIESEL ENGINE EXHAUST, PELLET BOILER EXHAUST, AND THEIR MIXTURE

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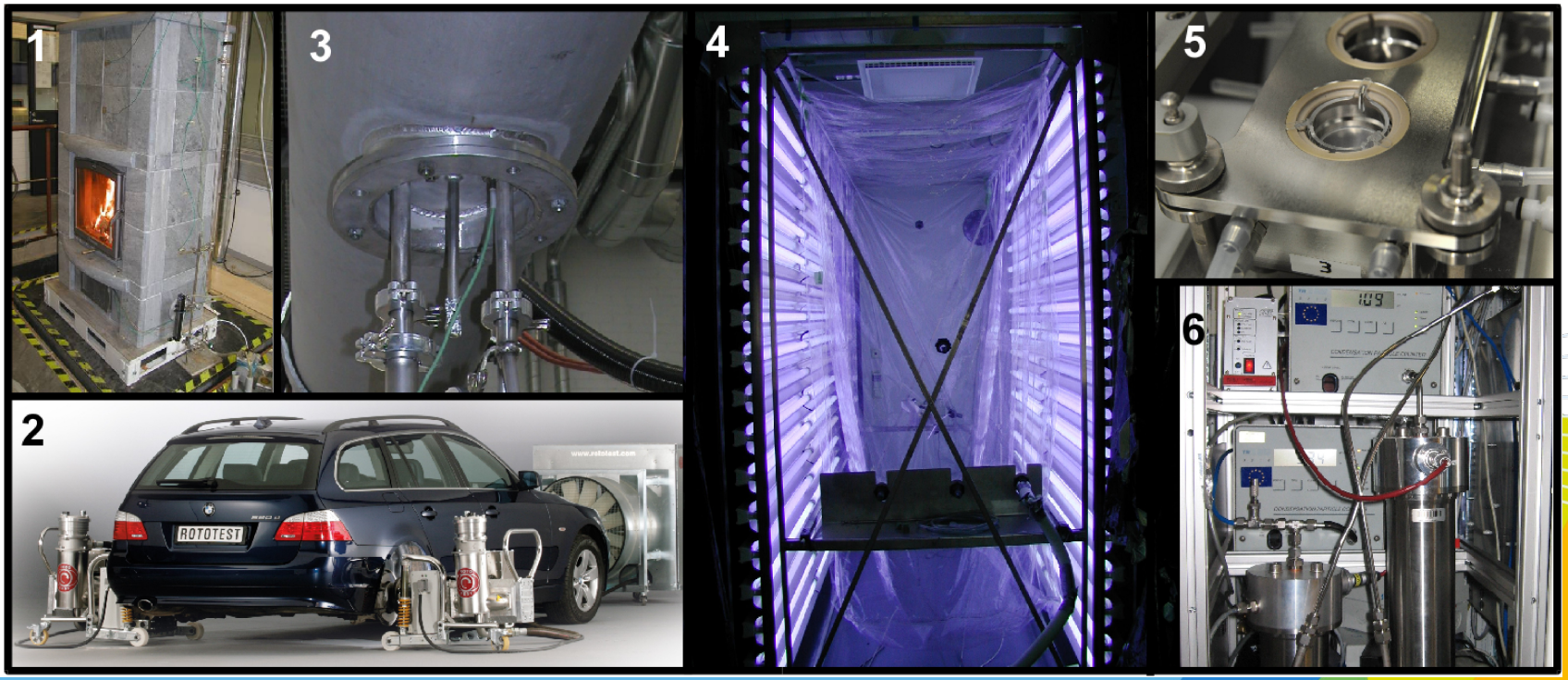
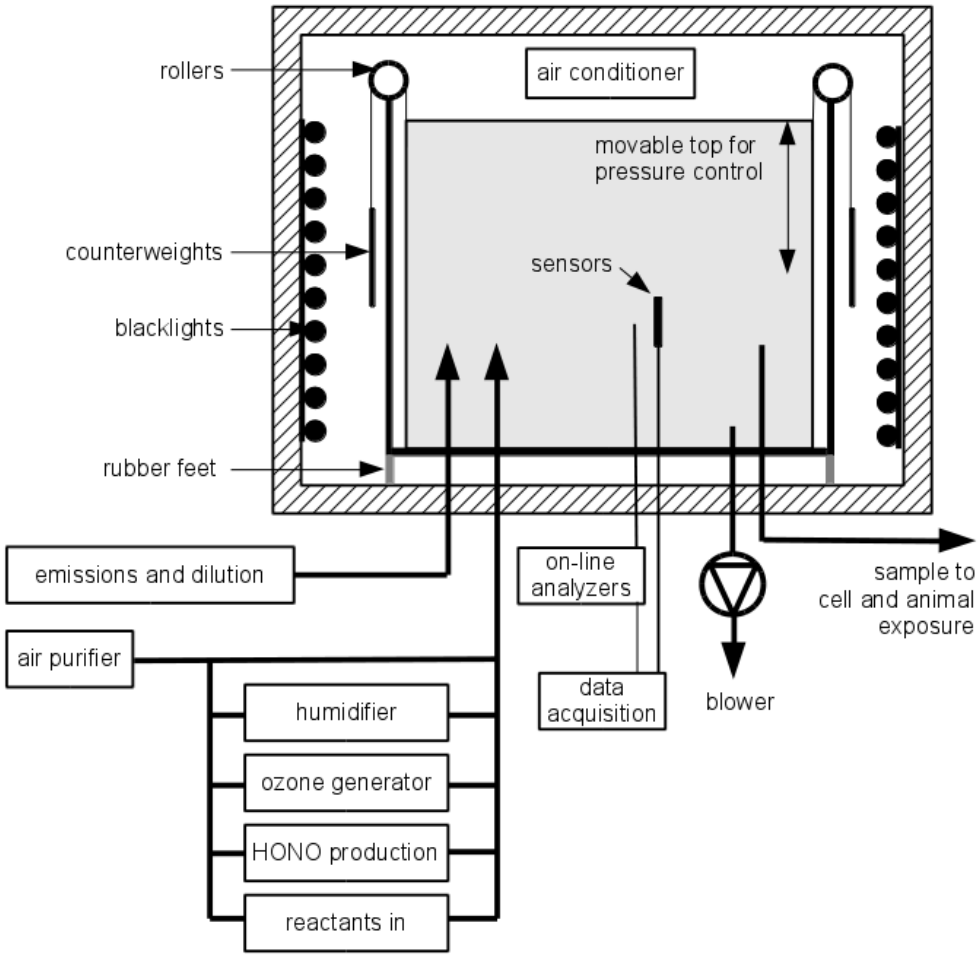
The research unit “ILMARI” at UEF

- emission sources (stoves, burners, vehicles) and dilution
- environmental chamber
- on-line cell exposure (air-liquid interface) and animal whole body exposure units



The transformation chamber at ILMARI

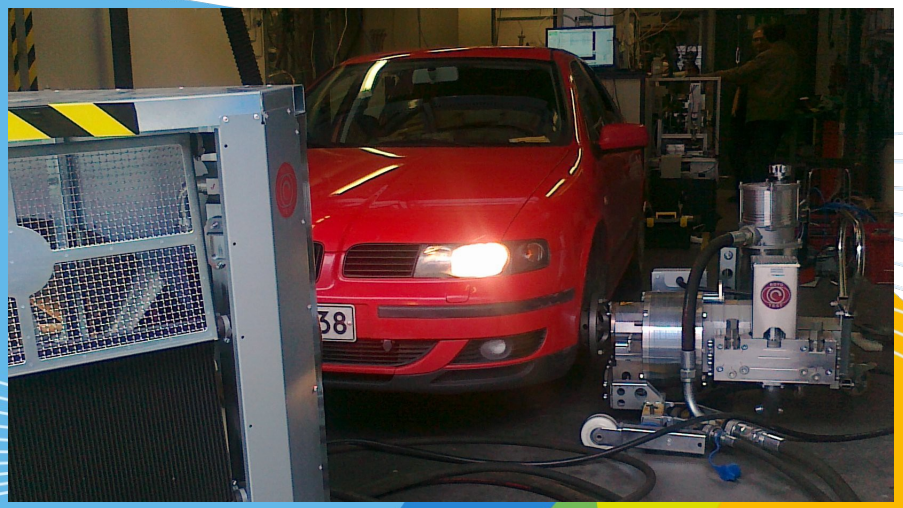


- 125 µm FEP Teflon
- 3.5 m × 3.5 m × 2.4 m (29 m^3)
- movable top, lines and cables through the floor, maintenance hatch
- purified air source ~170 lpm
- blacklight lamps @ 365 nm
- an air-conditioned enclosure with reflective walls

Leskinen et al., AMTD, 7, 5921–5951, 2014

The emission sources

- Biotech PZ25RL, model 2007, 25 kW, top-feed fuel input, logic-controlled fans for combustion air distribution, secondary air reduced (by 17 %), commercial pellets (mostly pinewood).
- Seat Toledo 1.9 TDI, model 2002, mileage 370 tkm, oxy-cat, no DPF, commercial diesel, on 2WD dyno 50 km/h, ~20 % load.
- Dilution: porous tube (DR 2.9), ejector (9.7), chamber (10.7), total DR ~300.



Experiments in the first campaign

- pellet boiler exhaust (2 runs: either with or without HONO)
- diesel engine exhaust (3 runs: either with or without HONO)
- mixture of pellet burner and diesel engine exhausts (2 runs: both runs with HONO, 1 with and 1 without alphapinene)
- in each experiment O_3 and UV radiation present, chamber temperature 294–299 K, relative humidity 45–60 %
- HONO was injected before the lights were switched on, the resulting in initial [OH] of ~2 × 10^7 molecules/cm^3

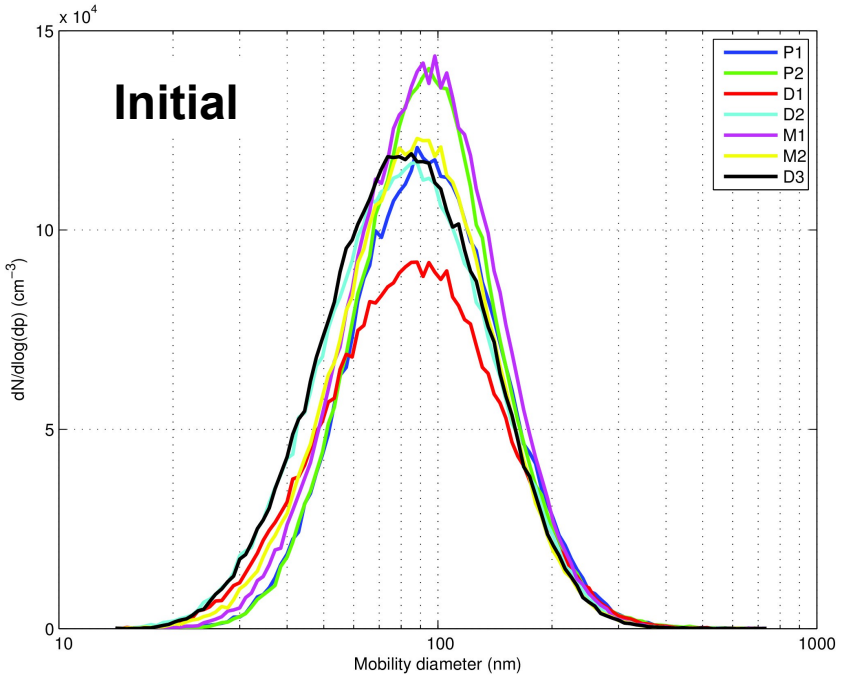
Measured properties (and instruments)

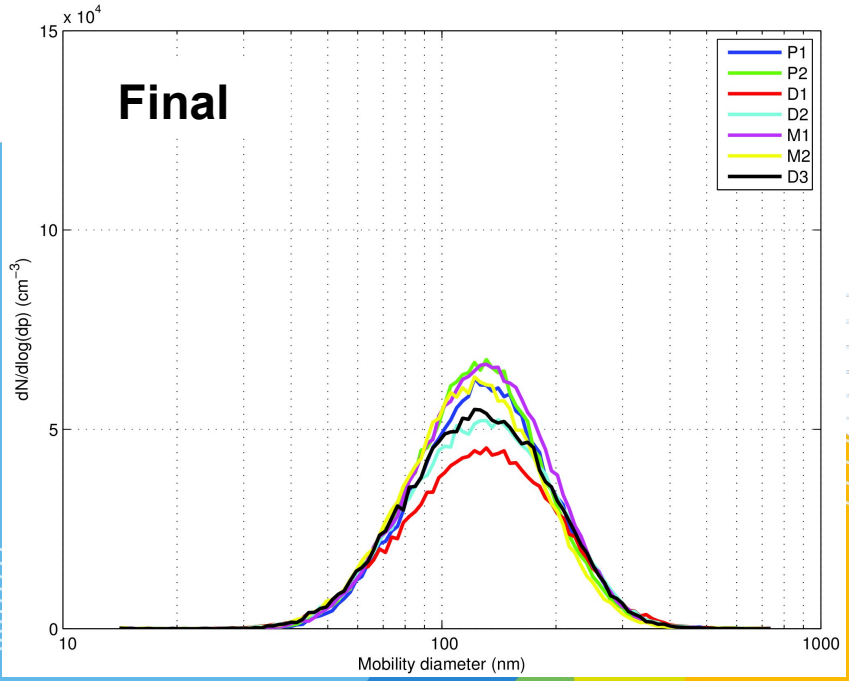
- particle size distribution (SMPS) and morphology (TEM)
- particle hygroscopicity (H-TDMA) and chemical composition (HR-ToF-AMS)
- light absorption by particles (7-wavelength Aethalometer) and absorption Ångström exponent

SMPS: Scanning mobility particle sizer, TEM: Transmission electron microscopy,
H-TDMA: Hygro-scopicity tandem differential mobility analyzer,
HR-ToF-AMS: High resolution - time-of-flight - aerosol mass spectrometry

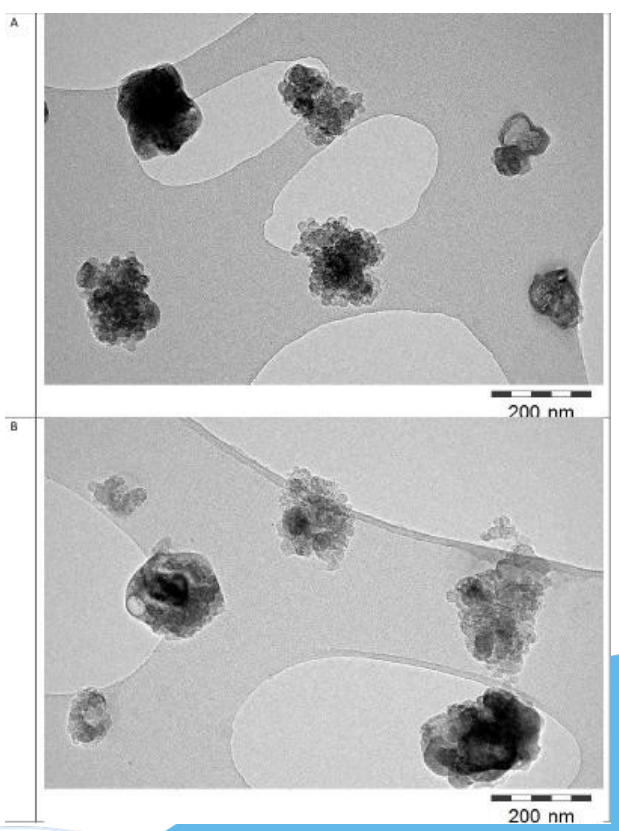
The size distributions

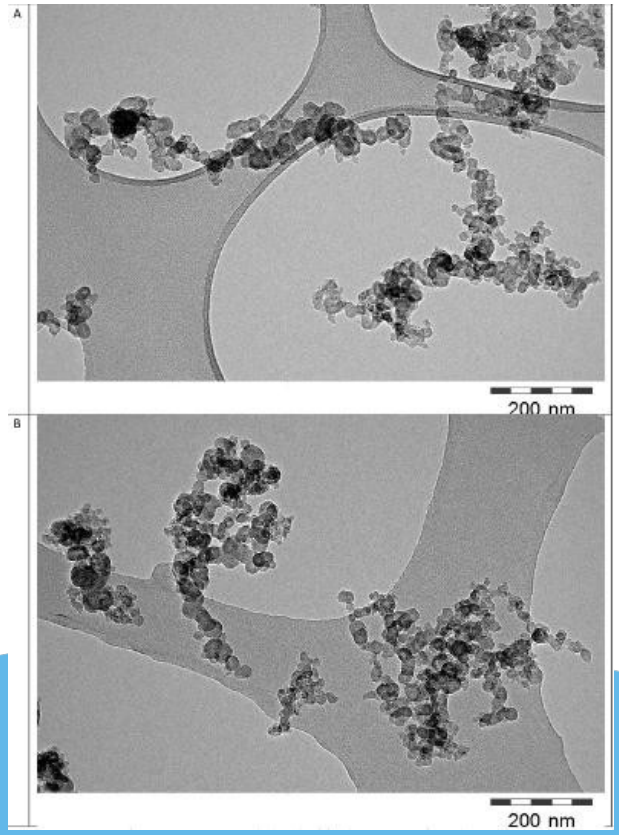
- number median diameter from 80–90 to 120–130 nm
- calculated volume change (spherical particles, wall loss corrected)
  - pellet: 62.4...71.6 $\mu m^3/cm^3$ (+15 %)
  - diesel: 50.8...68.4 $\mu m^3/cm^3$ (+35 %)
  - mix: 56.2...68.1 $\mu m^3/cm^3$ (+21 %)
- calculation for the diesel exhaust particles and the mixture fails due to the non-spherical form of the diesel particles (see the next slide)

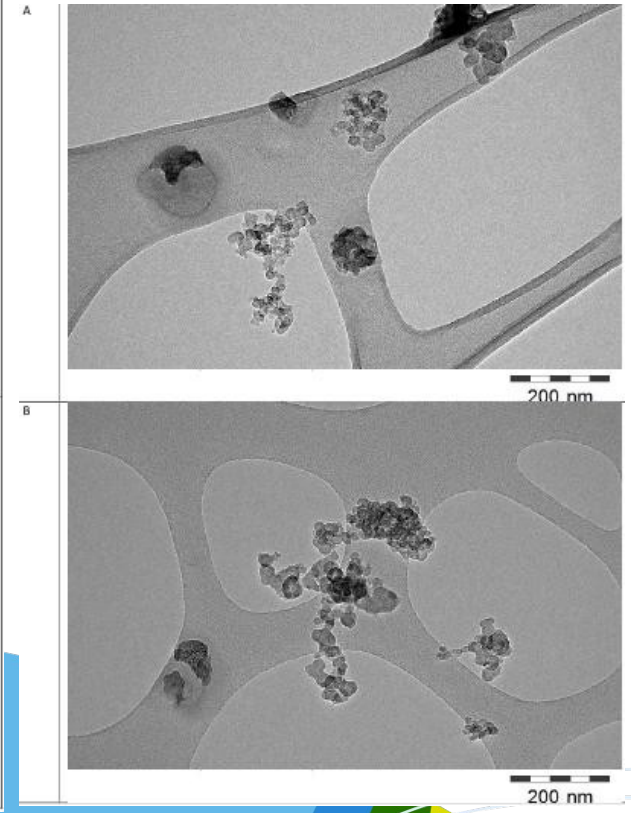




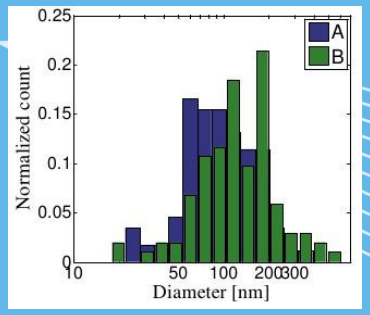
Morphology



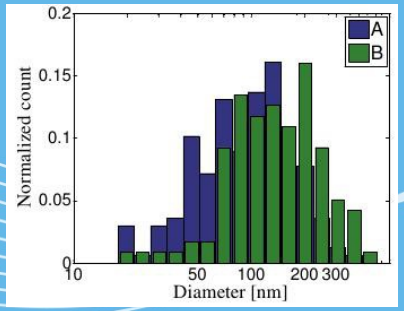




Pellet



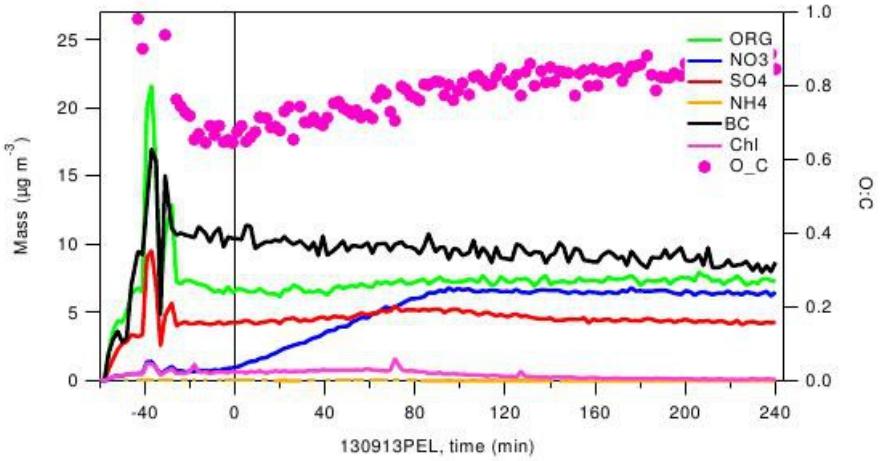
Diesel

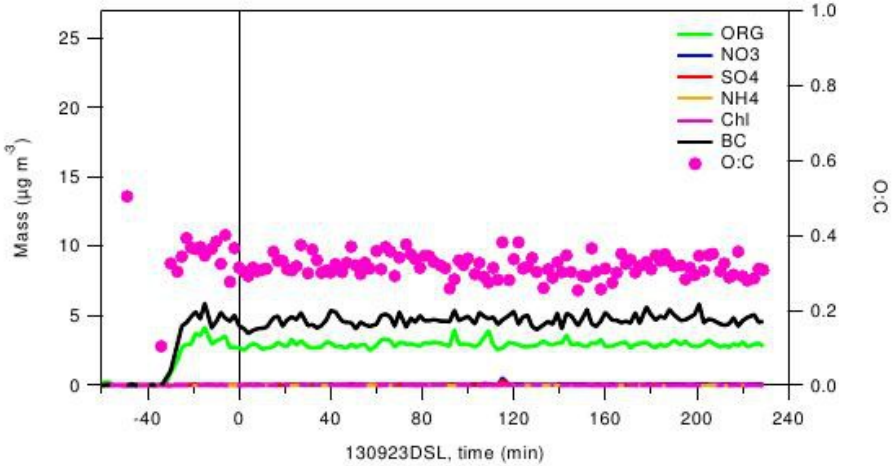


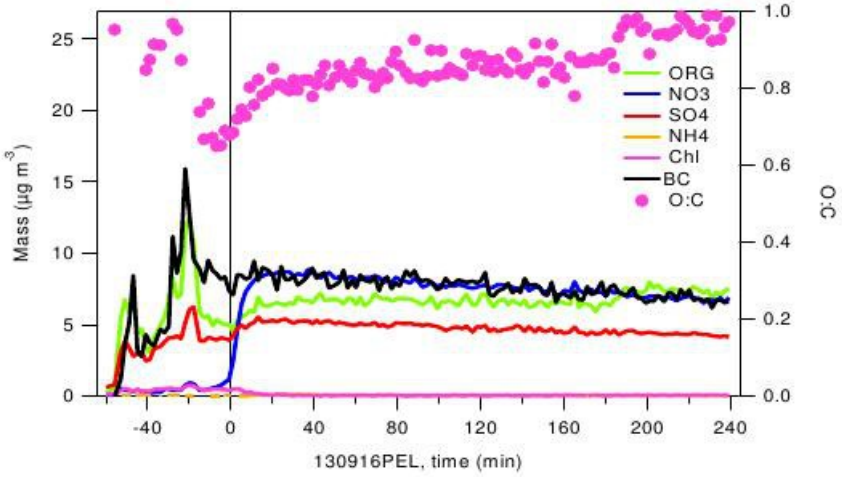
Mixture (with a-pinene)

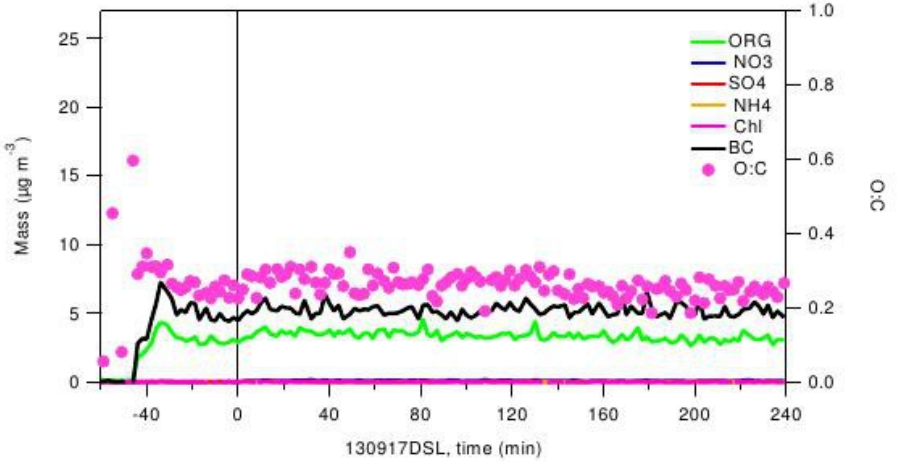
Particle chemical composition

upper: without HONO, lower: with HONO









Pellet, initial [NO_x] 16–46 ppb

Diesel, initial [NO_x] 81–143 ppb

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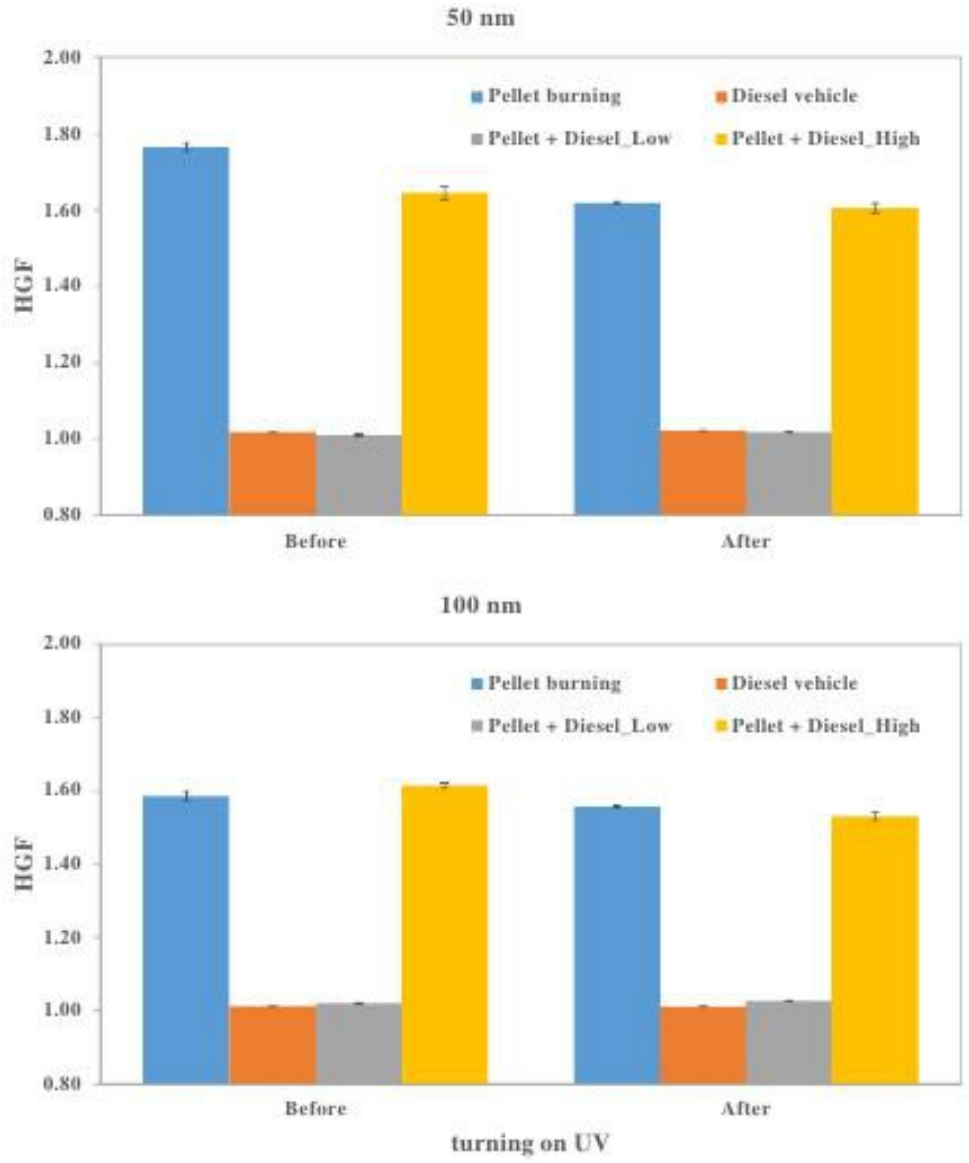
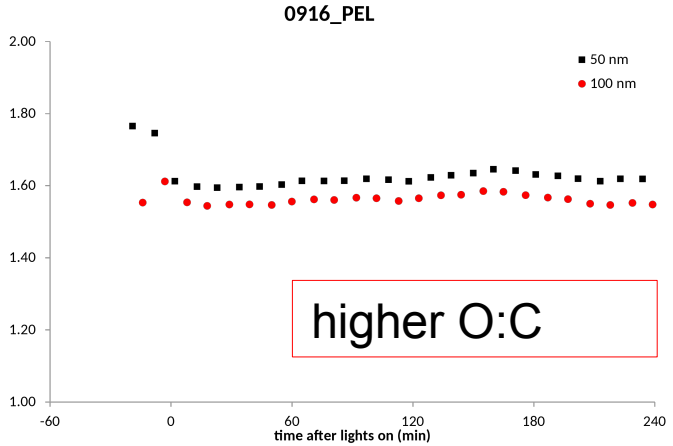
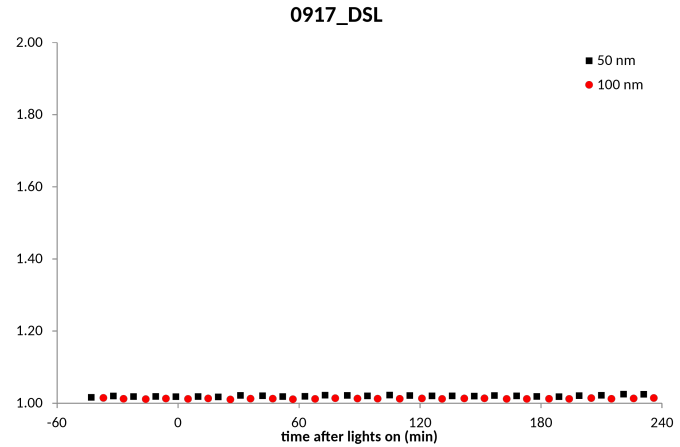
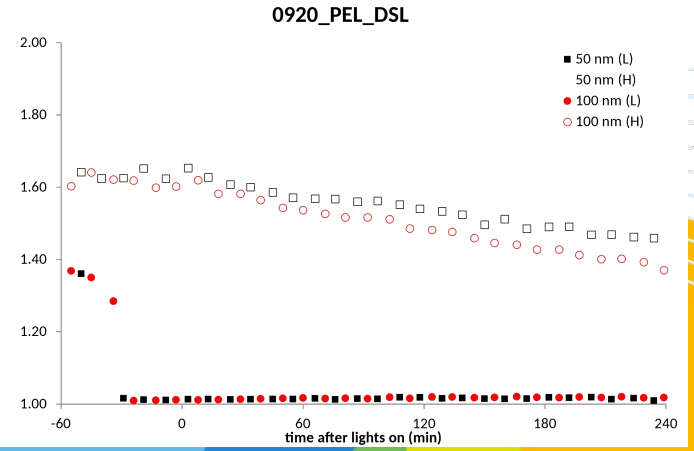
Hygroscopicity



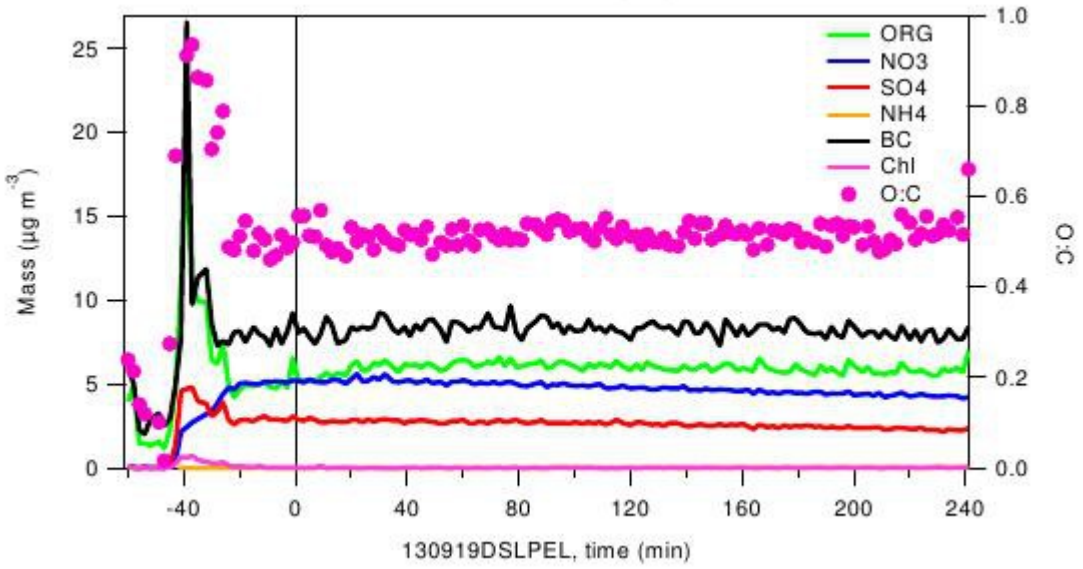


higher O:C

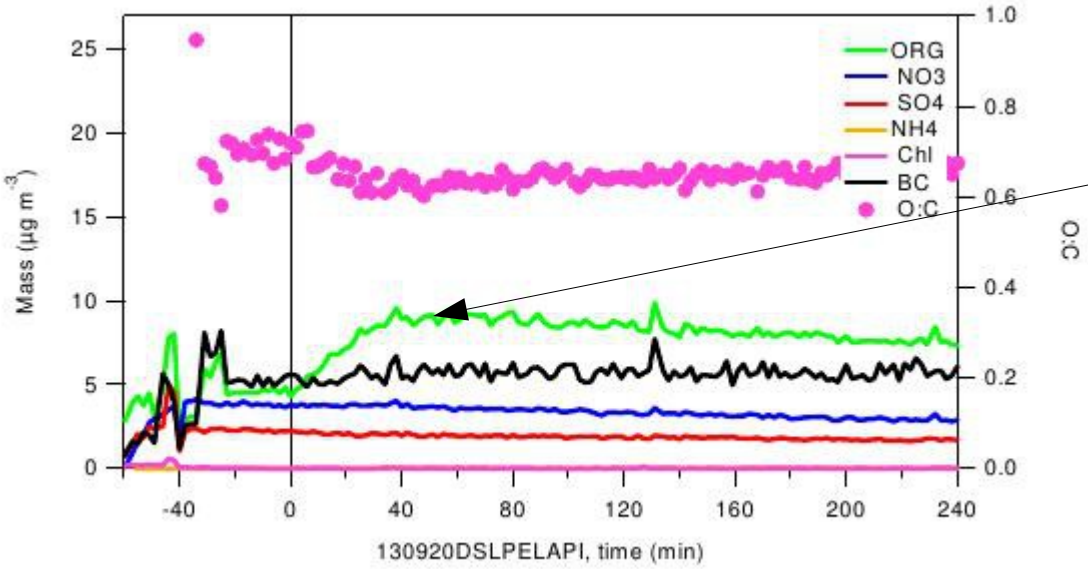




The effect of alphapinene



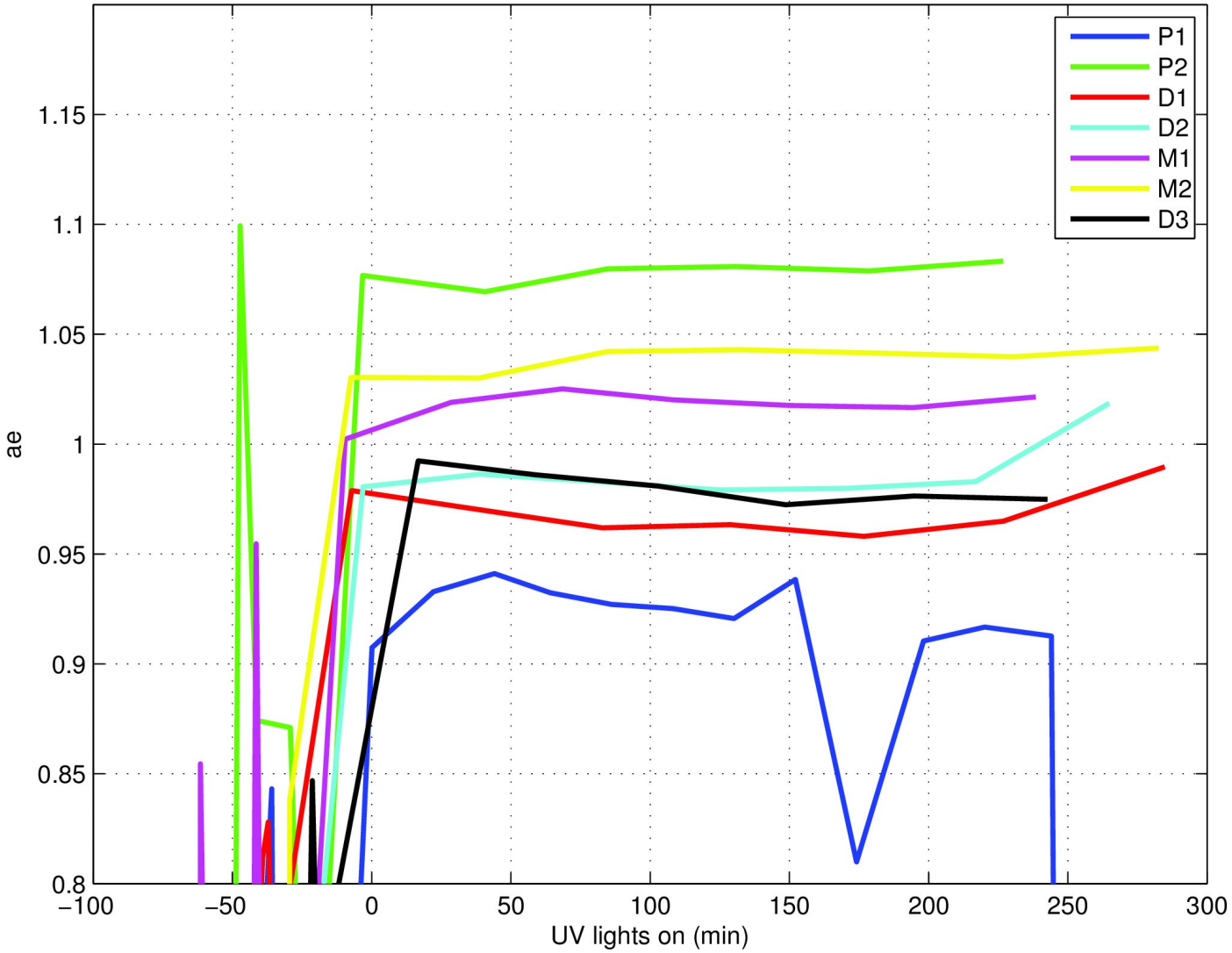
upper: without a-pinene



lower: with a-pinene

the organics increase

Optical properties (preliminary)



Summary

- no remarkable changes in the properties of the diesel engine exhaust during aging
- in the pellet boiler exhaust the particulate mass increased due to formed particulate nitrogen compounds during aging (no such increase in organics as mentioned in my abstract!)
- in the mixture the particle phases were externally mixed but the gas phases mixed well
- the hygroscopicity of the pellet boiler exhaust particles was different in the mixture than when alone
- more SOA formed when alphapinene was present

Conclusion

- more aging experiments for mixtures are needed

Thank you for your attention !

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