Organic analysis of aircraft engine smoke number filter samples with thermal-optical carbon analysis and thermal desorption–gas chromatography/mass spectrometry

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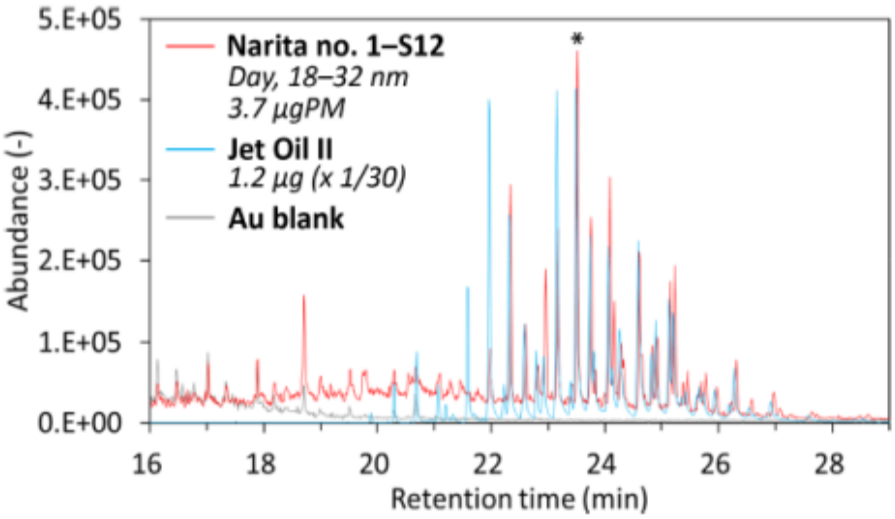
- **Jet lubrication oil** is a dominant component of **aircraft** exhaust **nanoparticles** (*Fushimi et al., ACP, 2019*)
- **Where** are **oil nanoparticles** emitted or formed?



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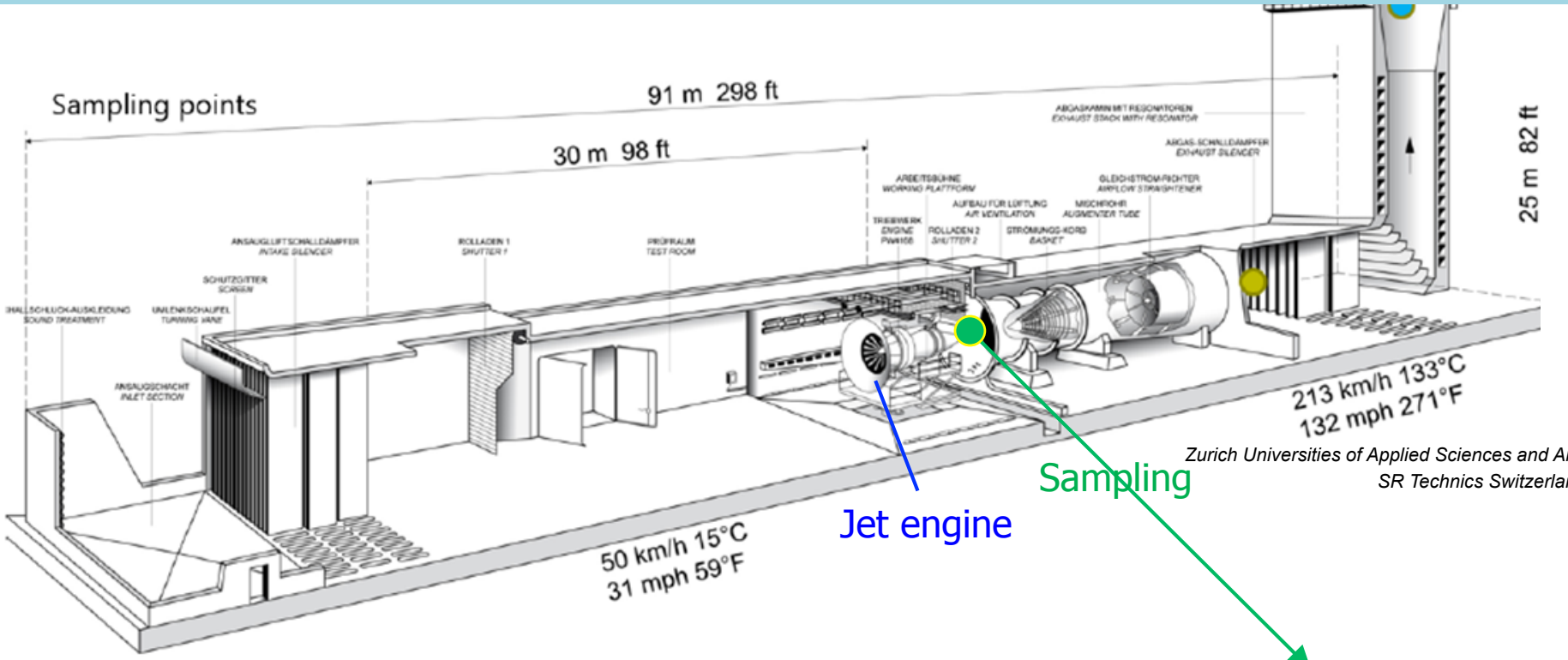
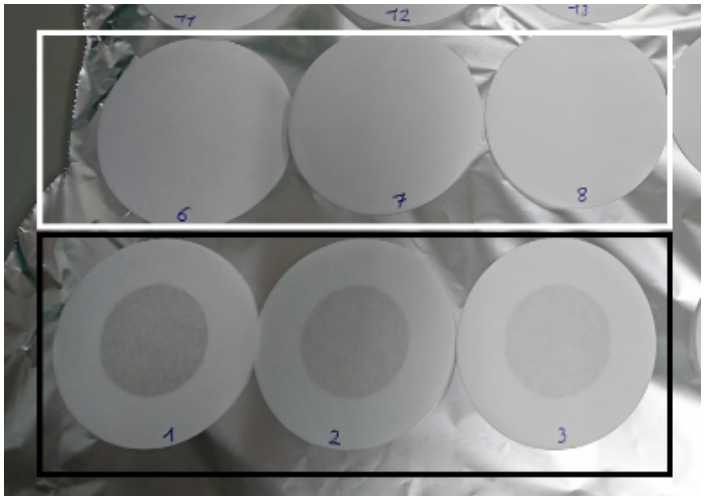
Smoke number paper filter samples collected at SR Technics (Zürich Airport, Switzerland) in 2019-2020



Zurich Universities of Applied Sciences and Arts
SR Technics Switzerland

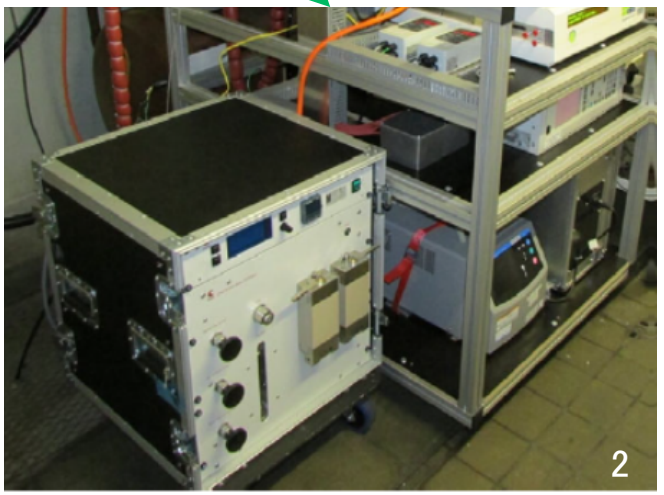
White

Gray



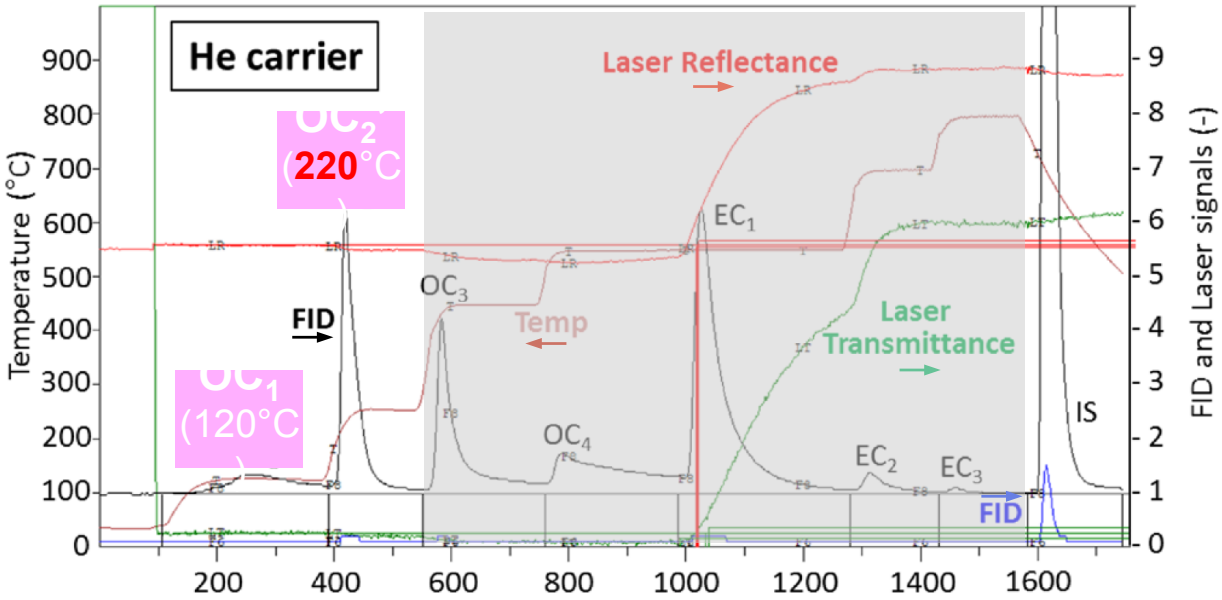
Smoke meter

Undiluted exhaust @160 °C, Chell, CSM2000, filter paper (Whatman, No.4, 55 mm)@ 70 °C, 14 L min^{-1}



Volatile organic carbon (OC) clearly detected from the smoke number paper filters

DRI Model 2001
Carbon Analyzer



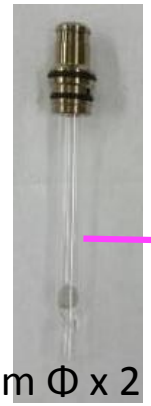
Original IMPROVE protocol (*Fushimi et al., 2015*)

	Gray filters (*n* = 5)	White filters (*n* = 5)
OC_1 (μgC/cm²)	0.26±0.16	ND
OC_2' (μgC/cm²)	1.76±0.39	0.11±0.24
OC_1+OC_2' (μgC/cm²)	**2.1±0.5**	**0.11±0.24**
OC_1+OC_2' (μgC/m³)*	**1,200±300**	**60±140**

Filter-blank (OC_1+OC_2' = 2.04±0.70 μgC/cm², *n* = 3)-subtracted values.
* Estimated using the sampling volume of 11 L.

Major components of jet lubrication oil clearly detected from the smoke number paper filters with TD-GC/MS*

* Thermal-Desorption Gas Chromatography /Mass Spectrometry



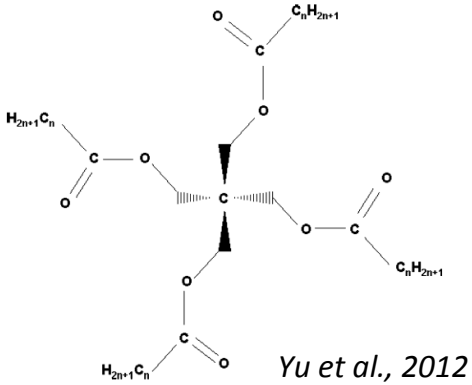
5 mm Φ x 2
(or 8 mm Φ)

Thermal desorption: 40°C (0.5 min) →
50°C min^{-1} → **220**°C (3 min)

Mobil Jet Oil II

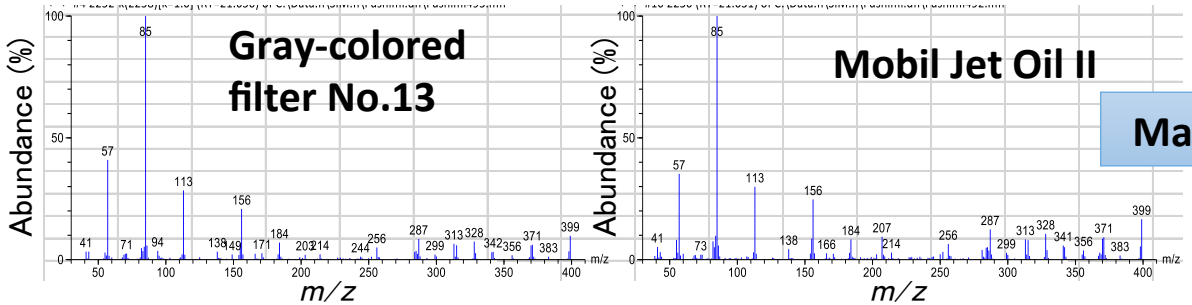
Gray-colored filter No.13
(Filter blank-subtracted)

Mass chromatograms (*m/z* 85)



Yu et al., 2012

C_5–C_{10} fatty acid esters of pentaerythritol



Mass spectra

Conclusions

- **Smoke number paper filters** can be used for measuring PM volatile organic compounds
- OC and **lubrication oil components** clearly detected

→ **Oil consisted in the jet engine exhaust**

Future plan

- Filter sampling (bulk and size-resolved) at room temperature at engine exit and 30-m downwind
- Detailed chemical analysis

→ **Where are oil nanoparticles emitted or formed in jet engine exhaust?**

Related poster presentation

2P-036 Saitoh et al., Elements and ions.