CAQ III - Cabin air quality assessment of long-term effects of contaminants

WP2: CAC-Event Simulation & Chemical Characterization

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WP2: CAC-Event Simulation & Chemical Characterization

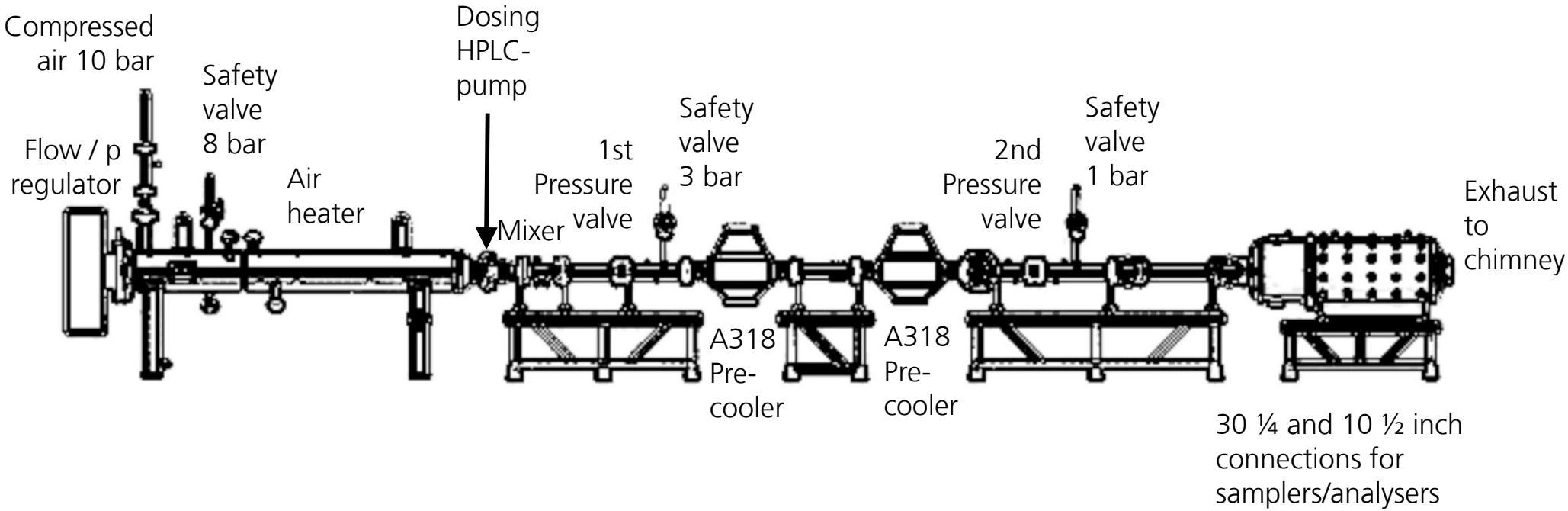
Objectives within WP 2

CABIN AIR QUALITY III

- Generation of controlled and worst-case bleed air oil-contamination events
- Use of a Bleed Air Contamination Simulator BACS (aircraft oil fume events too rare)
- Thorough characterization of fume composition by on-line monitors and off-line analyses
- Transfer of fumes from BACS to mobile toxicological laboratory (MAPCEL) without alteration (pre-tests)
- Exposure tests for neuro-toxicological assessment: dose range finding & main exposure study (➔ WP 3)
- Defined loading of HEPA filters with an oil fume event (➔ WP 4)
- Comparison with HEPA filters from real aircraft with / without reported fume event (➔ WP 4)

WP2: CAC-Event Simulation & Chemical Characterization

Bleed Air Contamination Simulator BACS



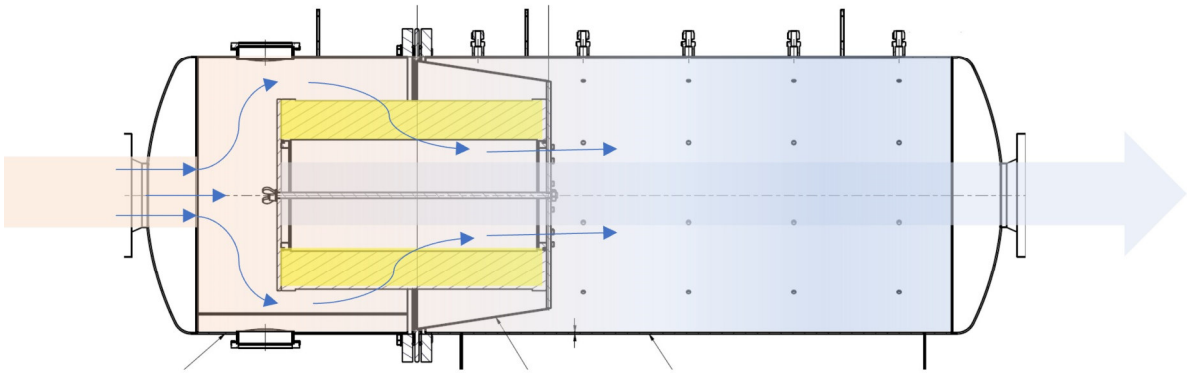
WP2: CAC-Event Simulation & Chemical Characterization

Bleed Air Contamination Simulator BACS

CABIN AIR QUALITY III

Use of BACS for filter loading in WP 4

A320 cylindrical
HEPA filter



BACS: Sampling Vessel

WP2: CAC-Event Simulation & Chemical Characterization

Bleed Air Contamination Simulator BACS

CABIN AIR QUALITY III

- Set points:
- T = 350°C
- p = 6 bar
- Mobil Jet Oil II (most used)
- ACER/VIPR: 6 mg/m³
- Range finding: starting point 50-100 mg/m³

WP2: CAC-Event Simulation & Chemical Characterization

On-line monitors

CABIN AIR QUALITY III

Parameter	BACS	Exposure Unit
Carbon monoxide (CO)	X	X
Carbon dioxide (CO_2)	X	X
Nitrogen oxides (NO_x)	X	X
O_3 / UV absorbing compounds	X	-
TVOC (FID)	X	-
Particle number	X	X
Particle size	X	X
Particle mass	-	X
Black Carbon (C)	-	X
Oxygen (O_2)	-	X

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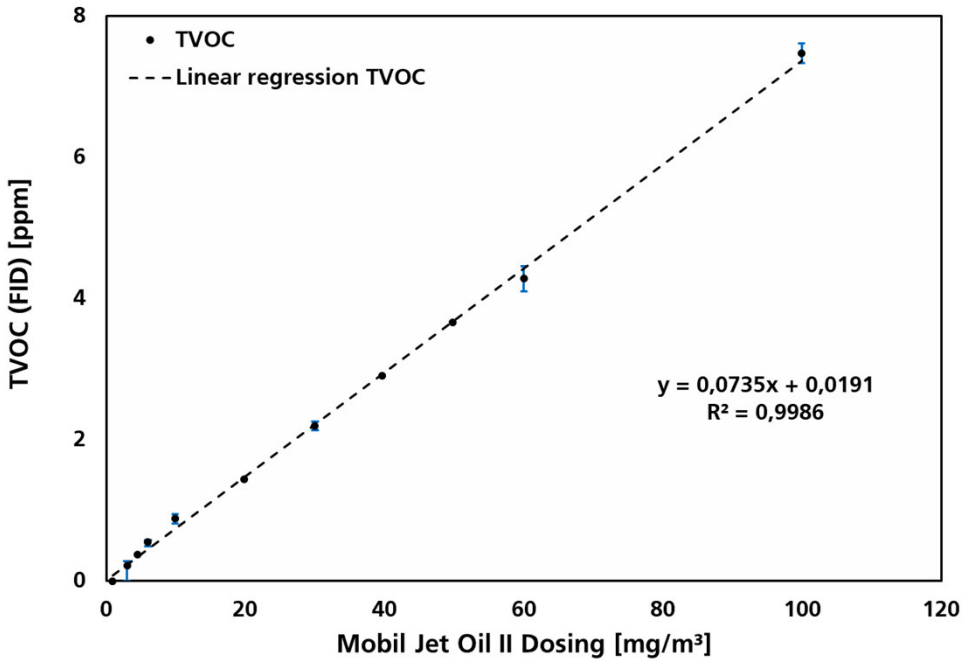
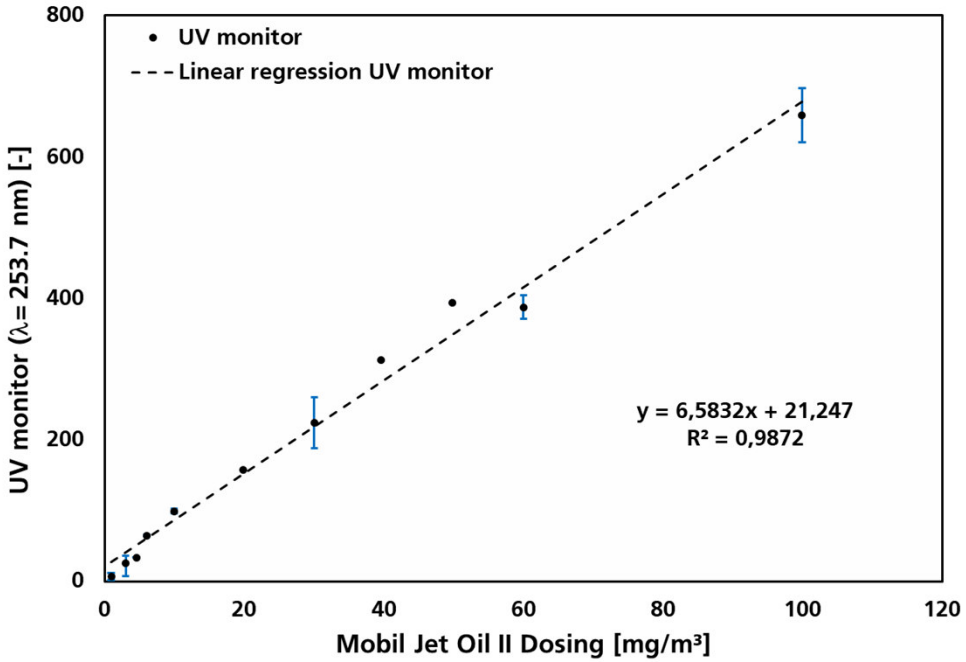
Monitor signal in dependence of dosed oil amount – FID and UV



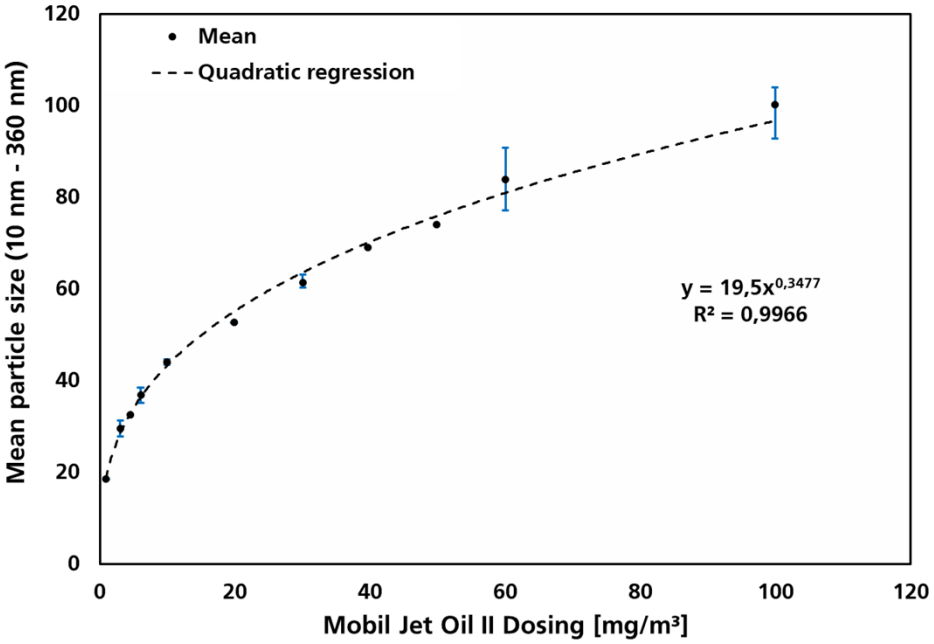


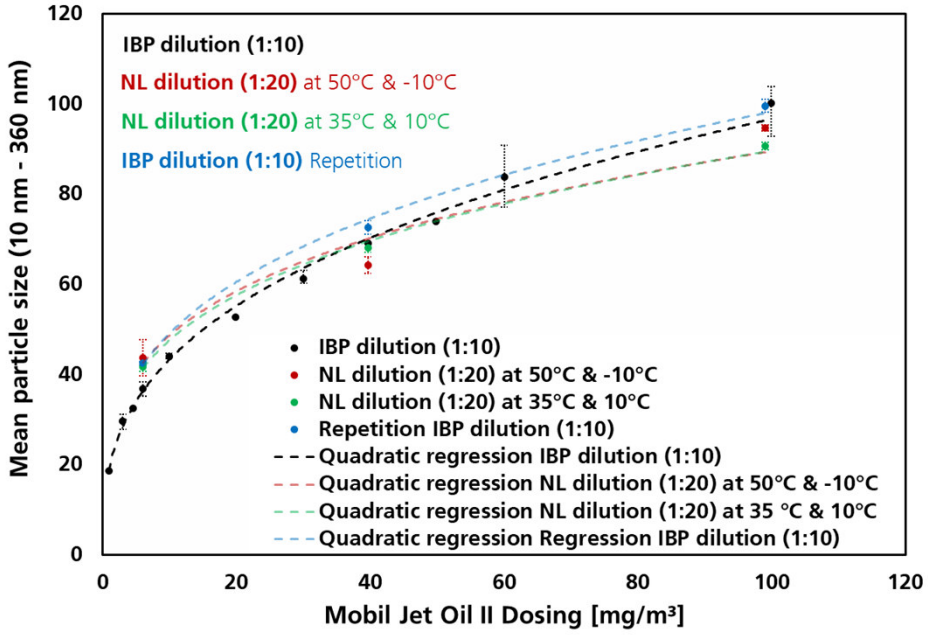
WP2: CAC-Event Simulation & Chemical Characterization

Mean particle size in dependence of dosed oil amount

CABIN AIR QUALITY III

Different conditions





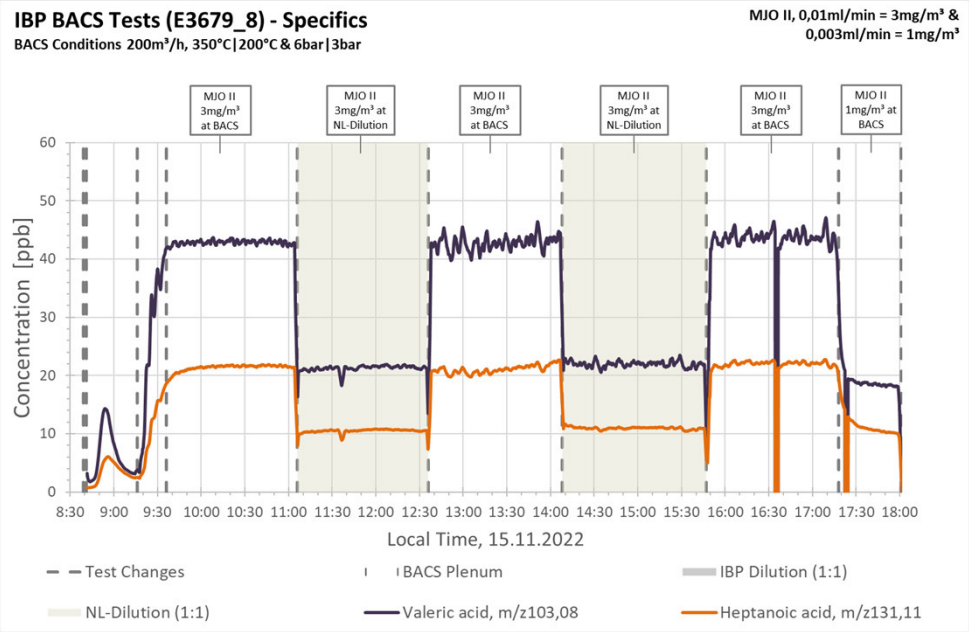
Fraunhofer IBP

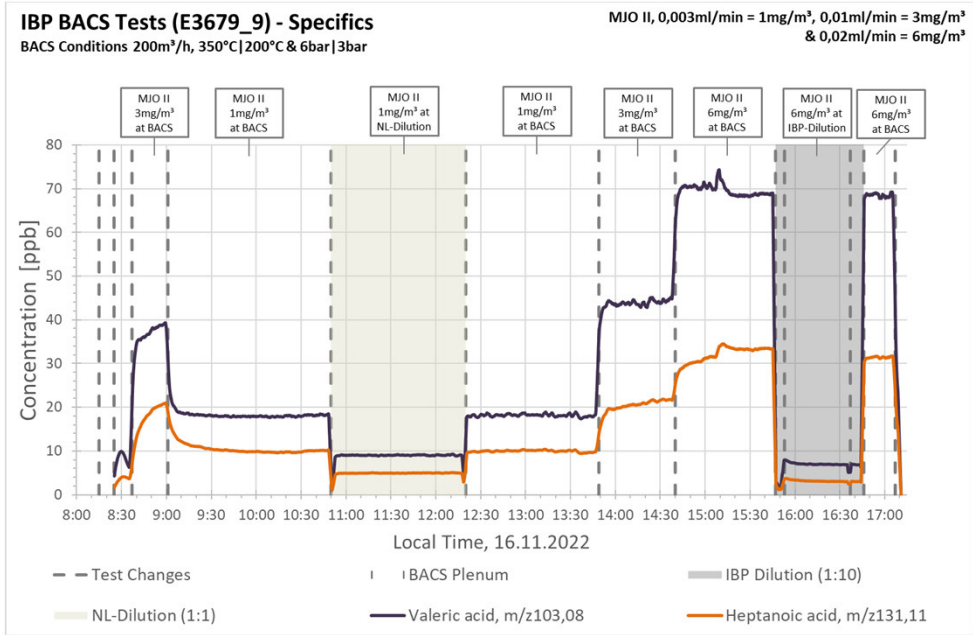
WP2: CAC-Event Simulation & Chemical Characterization

PTR-MS measurements of typical oil breakdown products

CABIN AIR QUALITY III

Concentration before and after transfer-line (cooling + 1:1 dilution) - low concentrations



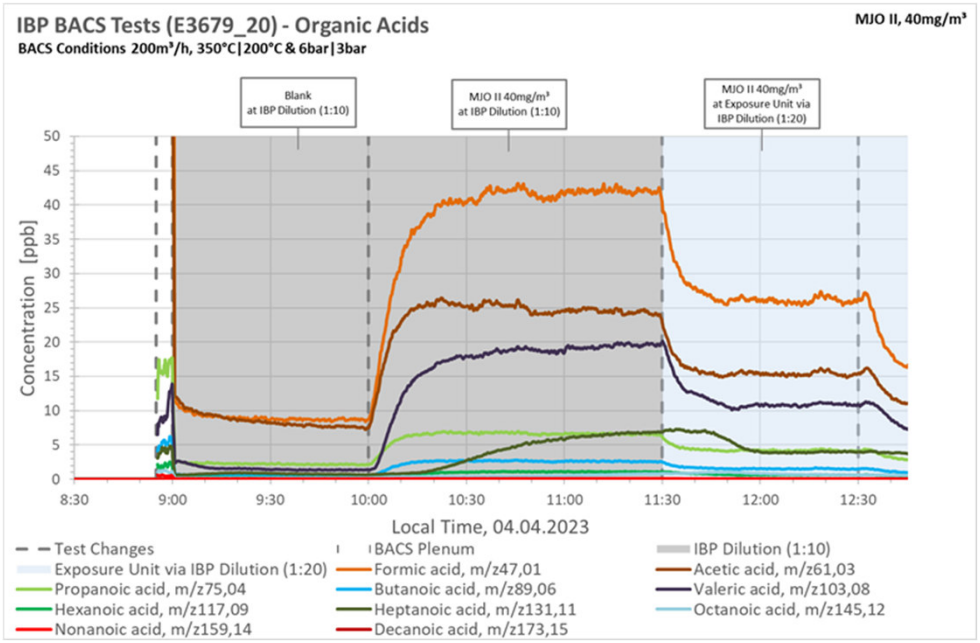


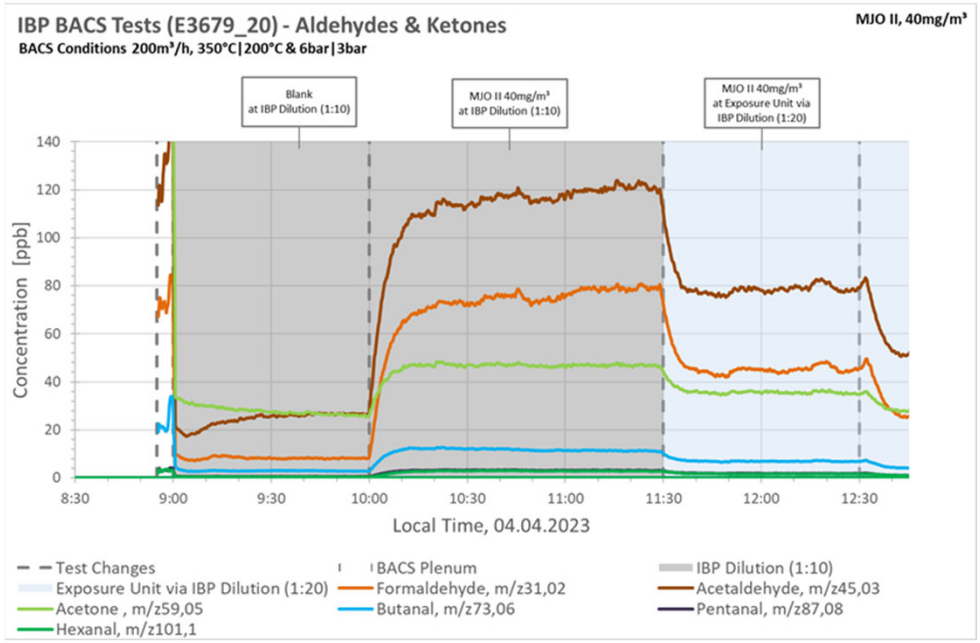
WP2: CAC-Event Simulation & Chemical Characterization

PTR-MS measurements of typical oil breakdown products

CABIN AIR QUALITY III

Concentration before and after transfer-line (cooling + 1:1 dilution) - high concentrations





WP2: CAC-Event Simulation & Chemical Characterization

PTR-MS measurements of typical oil breakdown products

CABIN AIR QUALITY III

Dilution factors

Before transfer-line and

after transfer-line and 1:1 dilution

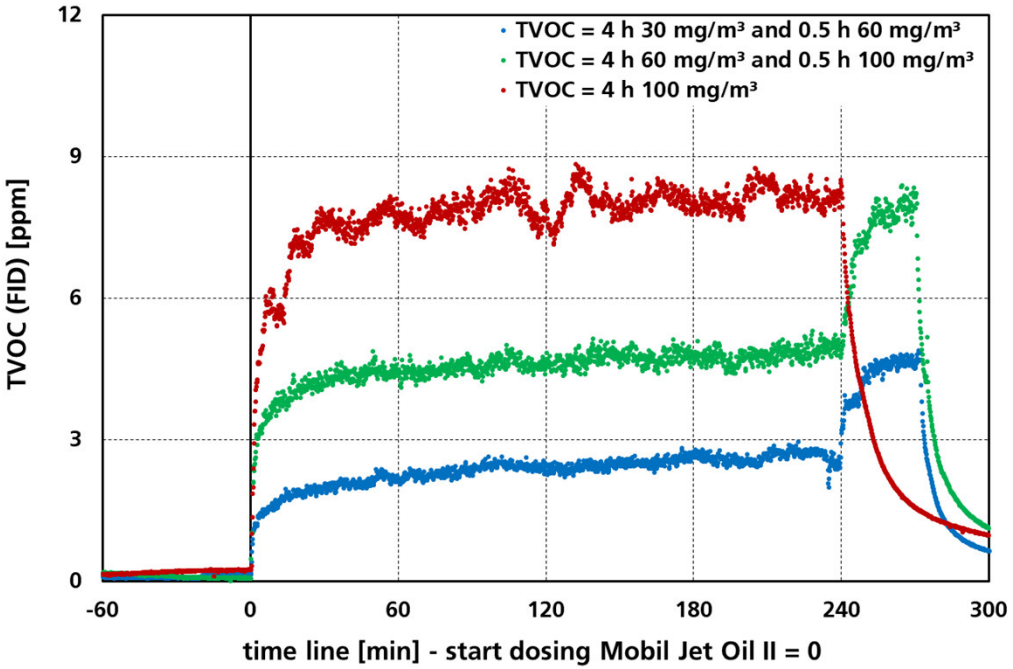
Compound	Average dilution factor	Range
Formic Acid	**1.8**	1.6 – 1.9
Acetic Acid	**1.9**	1.7 – 2.0
Propanoic Acid	**1.7**	1.6 – 2.0
Butanoic Acid	**2.0**	2.0
Pentanoic Acid	**2.0**	1.8 – 2.0
Hexanoic Acid	**2.0**	2.0
Heptanoic Acid	**1.9**	1.8 – 2.2
Octanoic Acid	**2.0**	2.0
Nonanoic Acid	-	-
Decanoic Acid	-	-
Formaldehyde	**1.9**	1.6 – 2.1
Acetaldehyde	**1.7**	1.6 – 1.8
Acetone	**1.4**	1.2 – 1.6 (without background subtract!)
Butanal	**1.9**	1.6 – 2.0
Pentanal	-	-
Hexanal	**2.0**	2.0

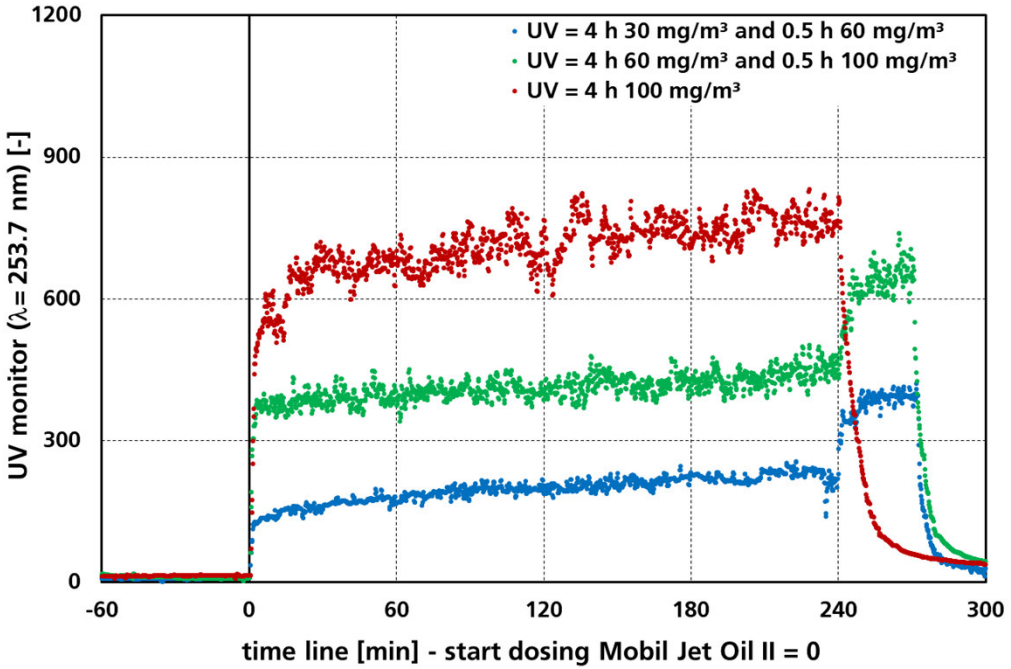
➔ **Oil vapour composition remains the same!**

WP2: CAC-Event Simulation & Chemical Characterization

Monitor signal stability over hours of dosing – FID and UV

CABIN AIR QUALITY III

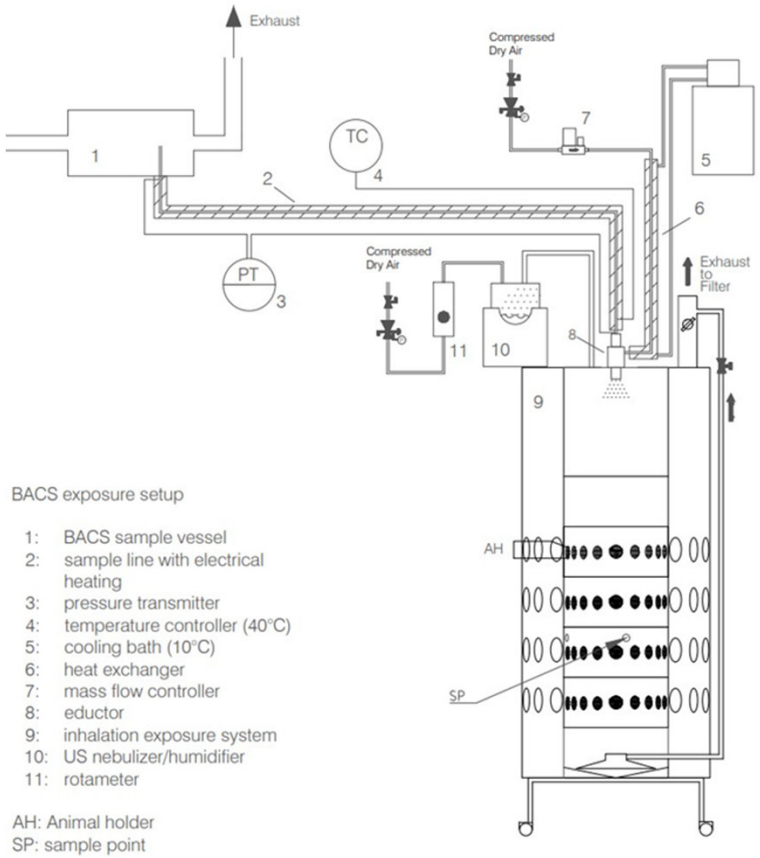




WP2: CAC-Event Simulation & Chemical Characterization

Experimental set up

CABIN AIR QUALITY III



BACS exposure setup

1: BACS sample vessel
2: sample line with electrical heating
3: pressure transmitter
4: temperature controller (40°C)
5: cooling bath (10°C)
6: heat exchanger
7: mass flow controller
8: eductor
9: inhalation exposure system
10: US nebulizer/humidifier
11: rotameter

AH: Animal holder
SP: sample point

WP2: CAC-Event Simulation & Chemical Characterization

Range finding study

CABIN AIR QUALITY III

Dosing of 100 and 30 mg/m³ MJO II into BACS

➔ Toxicological results, acute effects? (Helmholtz, WP 3)

- **➔ Dosing of 100 mg/m³ of MJO II into BACS (exposure concentration 50 mg/m³) puts too much burden on the animals**
- **➔ Dosing of 30 mg/m³ of MJO II oil into BACS shows no acute effects**
- **➔ Result: exposure concentration for main study (20 working days exposure) is**

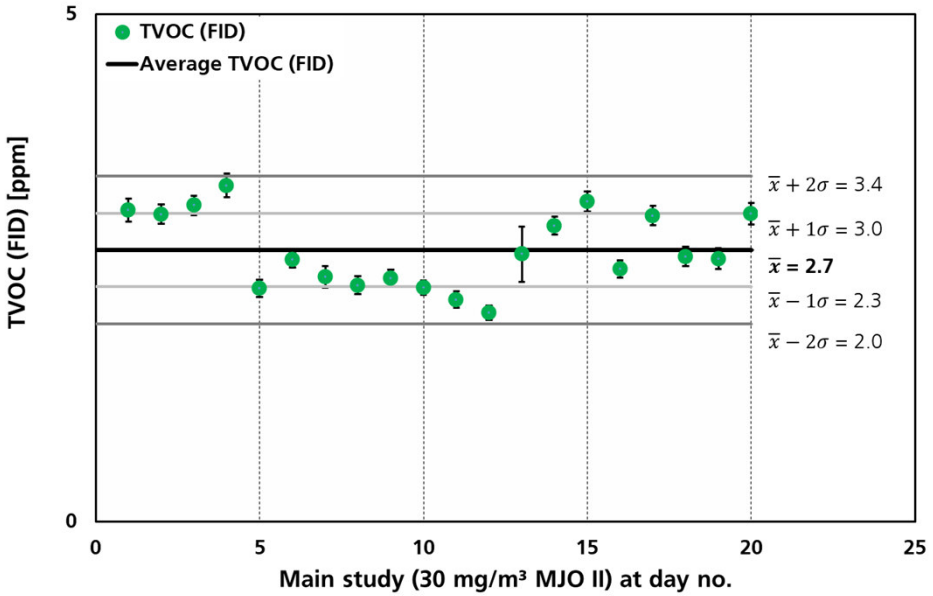
15 mg/m³ MJO II fume

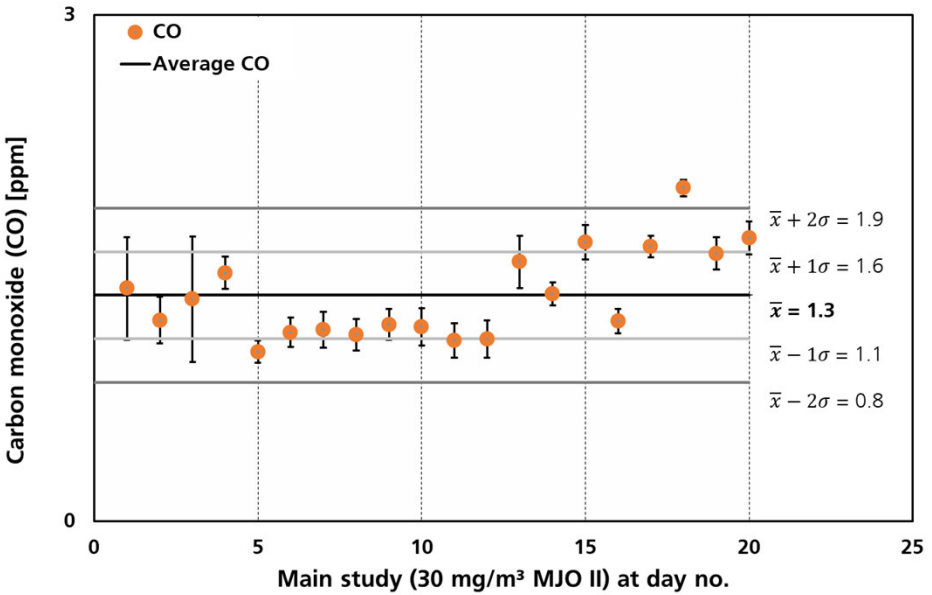
WP2: CAC-Event Simulation & Chemical Characterization

Main study – exposure to 15 mg/m³ MJO II fume for 20 working days

CABIN AIR QUALITY III

Dosing of 30 mg/m³ MJO II into BACS



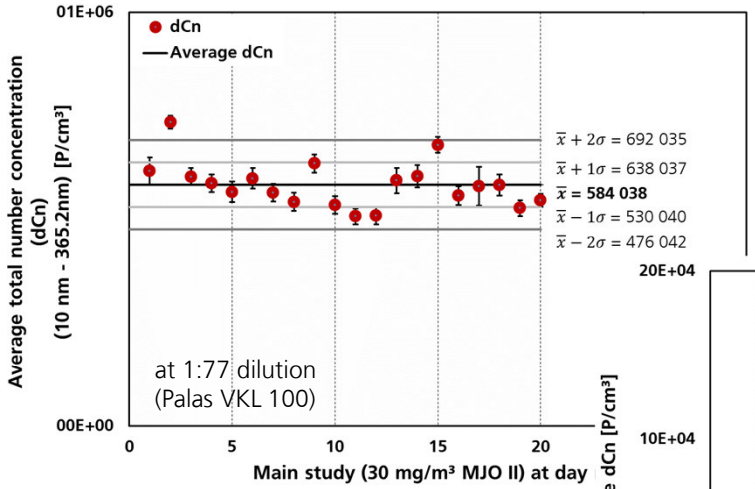


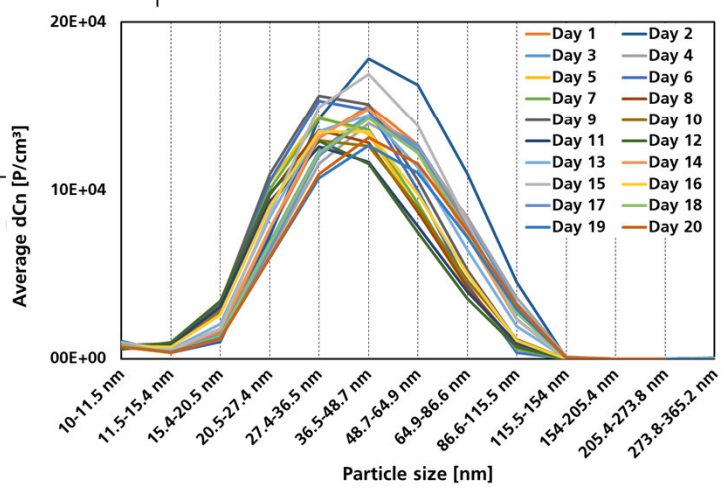
WP2: CAC-Event Simulation & Chemical Characterization

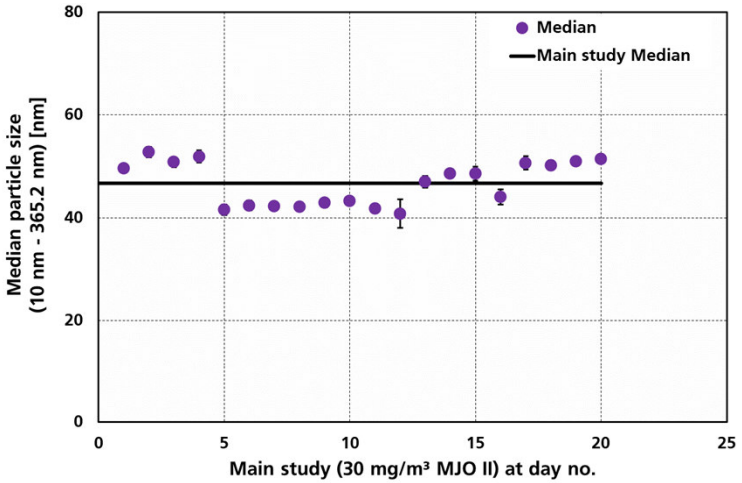
Main study – exposure to 15 mg/m³ MJO II fume for 20 working days

CABIN AIR QUALITY III

Dosing of 30 mg/m³ MJO II into BACS







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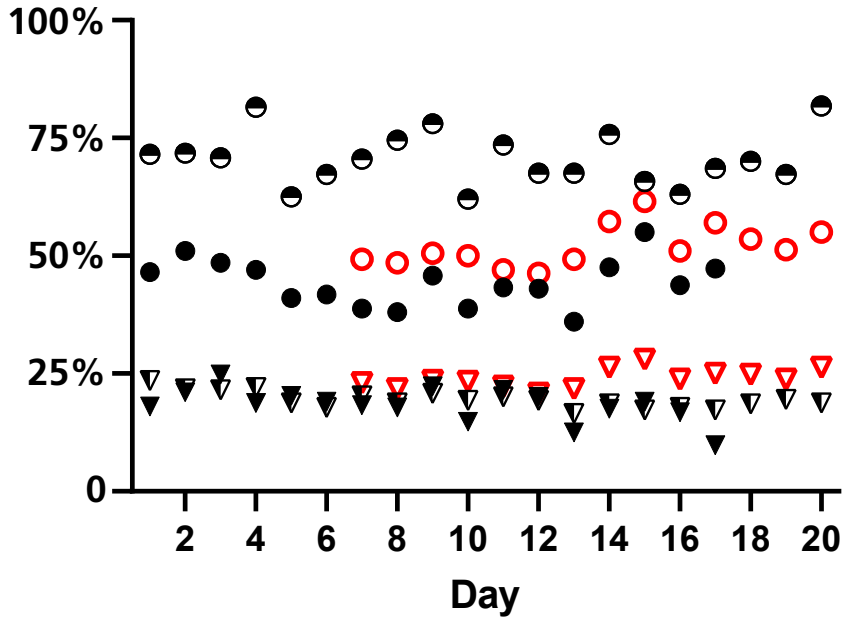
WP2: CAC-Event Simulation & Chemical Characterization

20 Days Exposure Study: Dosing stability for online and offline sampling



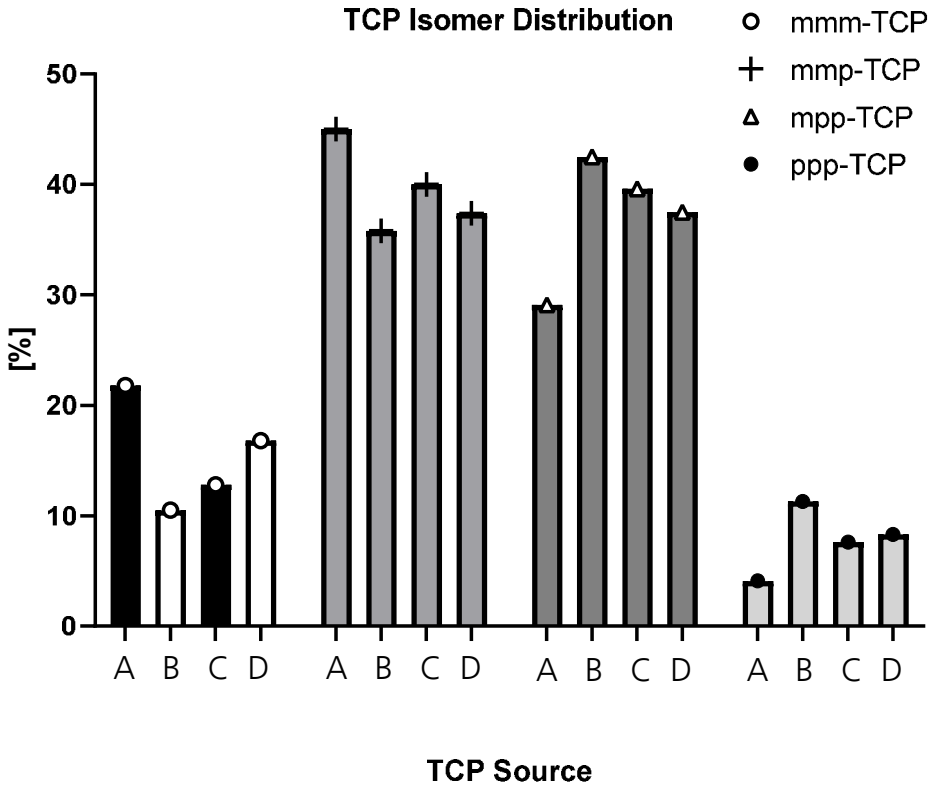
- C5-Acid Tenax
- C5-Acid Silica
- C5-Acid PTR
- C7-Acid Tenax
- C7-Acid Silica
- C7-Acid PTR

Mean concentrations in the exposure unit measured by PTR-MS [µg/m³]

…	
Pentanoic acid	**2.2x**
…	
Heptanoic acid	**x**
…	
…	

WP2: CAC-Event Simulation & Chemical Characterization

20 Days Exposure Study: Typical Isomer Distribution of technical TCP (offline)

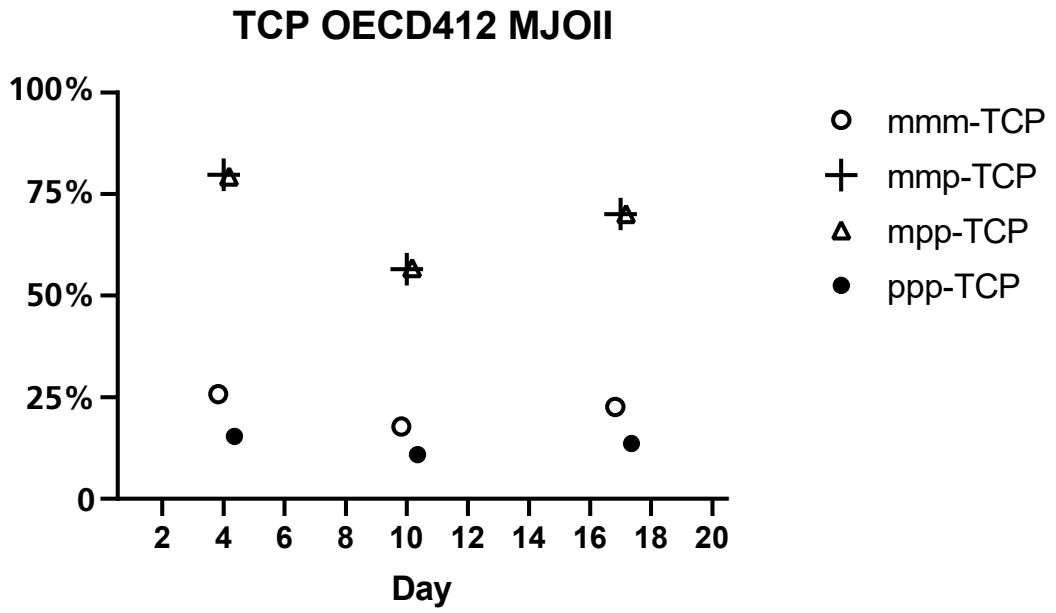


TCP Source

A TCP-Mix (TCI)
B MJO II
C Day 4
D HEPA-Filter

WP2: CAC-Event Simulation & Chemical Characterization

20 Days Exposure Study: Dosing stability for TCP (offline)

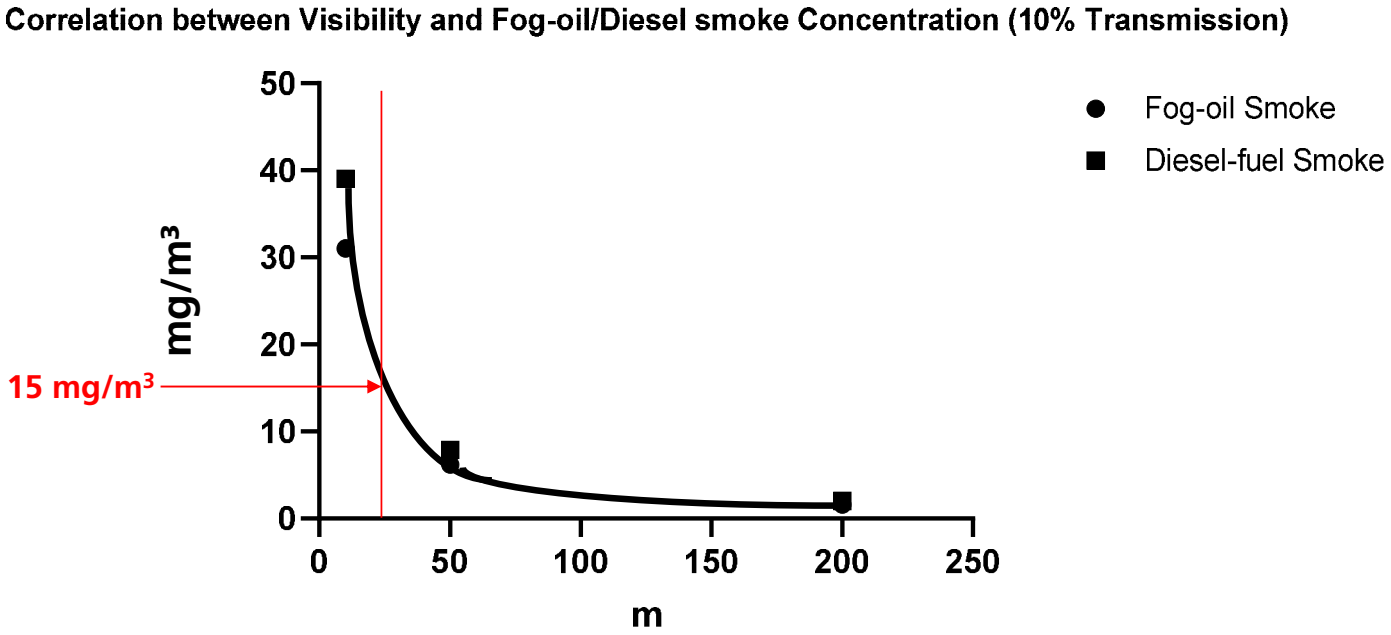


With an exposure concentration of 15 mg/m³ oil fume:

sum TCP > OEL

WP2: CAC-Event Simulation & Chemical Characterization

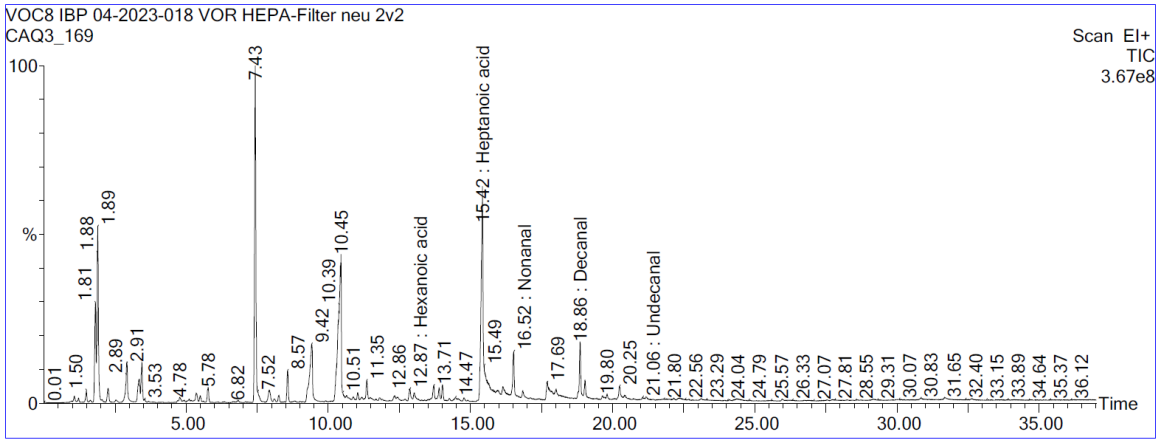
Transferability of BACS to cabin air: Visibility of Oil Fumes/Mist

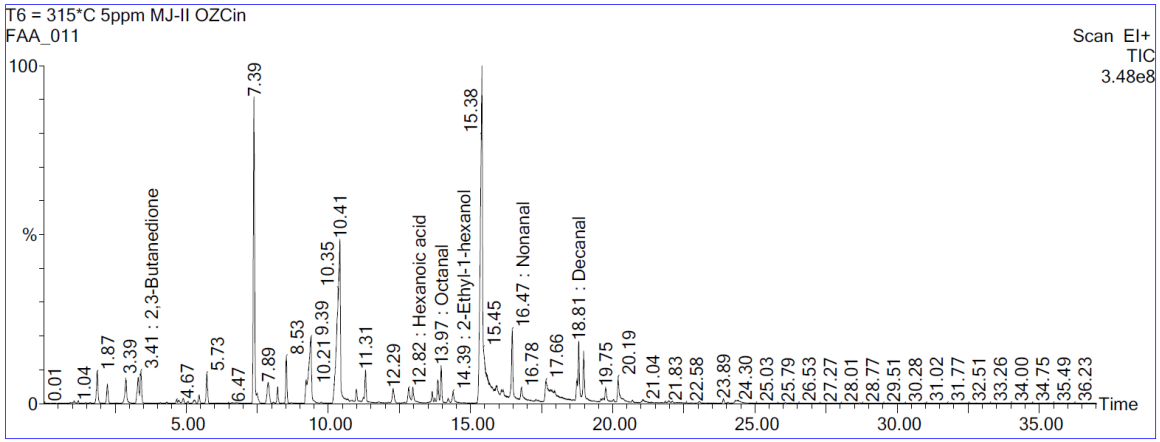


Source: Toxicity of Military Smokes and Obscurants: Volume 1 (1997)

WP2: CAC-Event Simulation & Chemical Characterization

Transferability of BACS to cabin air: Mobil Jet Oil II





BACS, IBP, Holzkirchen

Germany

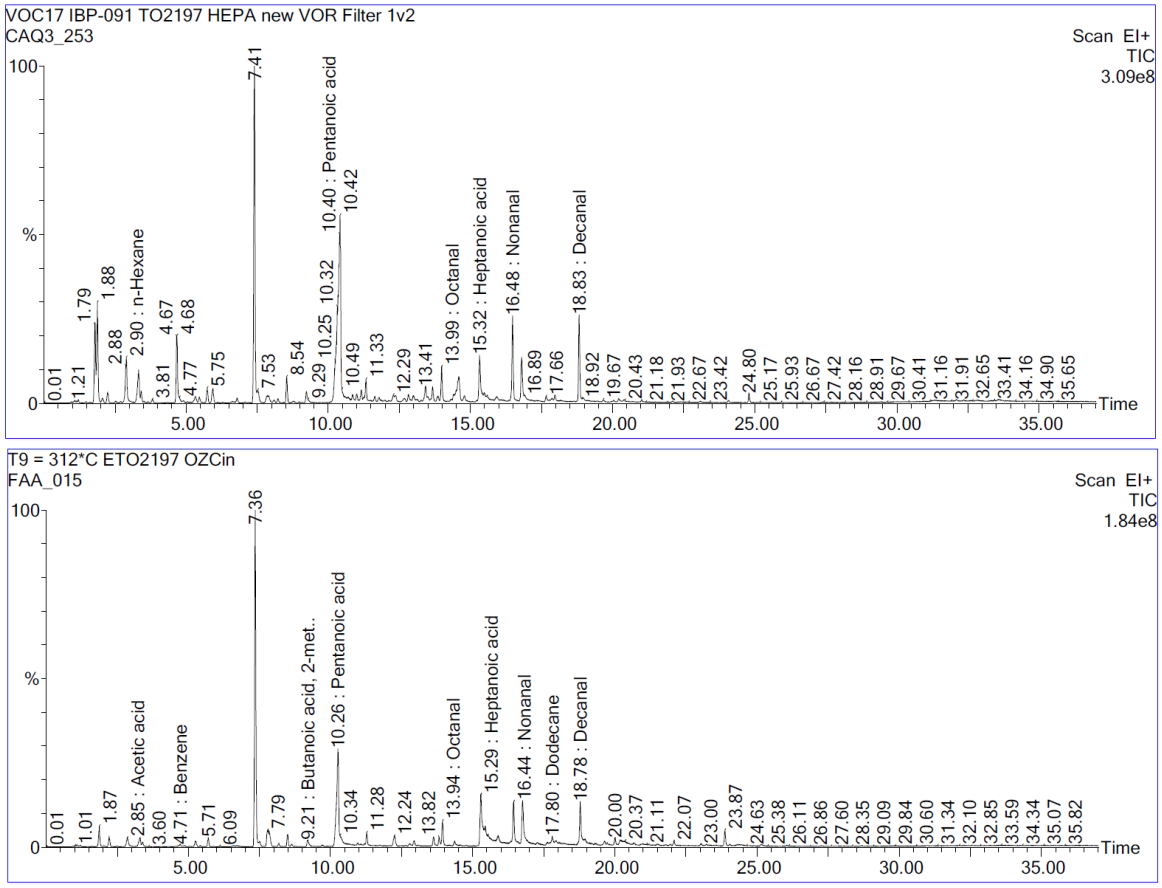
B747, FAA Atlantic City

USA

➔ very similar GC-MS peak pattern (fingerprint)!

WP2: CAC-Event Simulation & Chemical Characterization

Transferability of BACS to cabin air: ETO2197



BACS, IBP, Holzkirchen

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B747, FAA Atlantic City

USA

➔ very similar GC-MS peak pattern (fingerprint)!

CAC-Event Simulation & Chemical Characterization

Main study – exposure to 15 mg/m³ MJO II fume for 20 working days

CABIN AIR QUALITY III

➔ **Oil breakdown concentrations were stable over the 20 exposure days**

➔ **PTR-MS results correlate with off-line analyses of breakdown products**

➔ **BACS oil fume composition represents a provoked cabin fume event very well**

WP2: CAC-Event Simulation & Chemical Characterization

Transferability of BACS to cabin air

CABIN AIR QUALITY III

We will repeat cabin air sampling during a provoked fume event at Airbus TLS for verification of

- **FACTS ground test**
- **FAA Atlantic City B747 test**

Some details about the planned ground test in TLS will be given later

Thank you for your attention!