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Universität Rostock Traditio et Innovatio

CMA Comprehensive Molecular Analytics

Generation and characterization of ultrafine soot particles with similar physical but varying chemical properties enabling differential toxicological assessment in human lung cells

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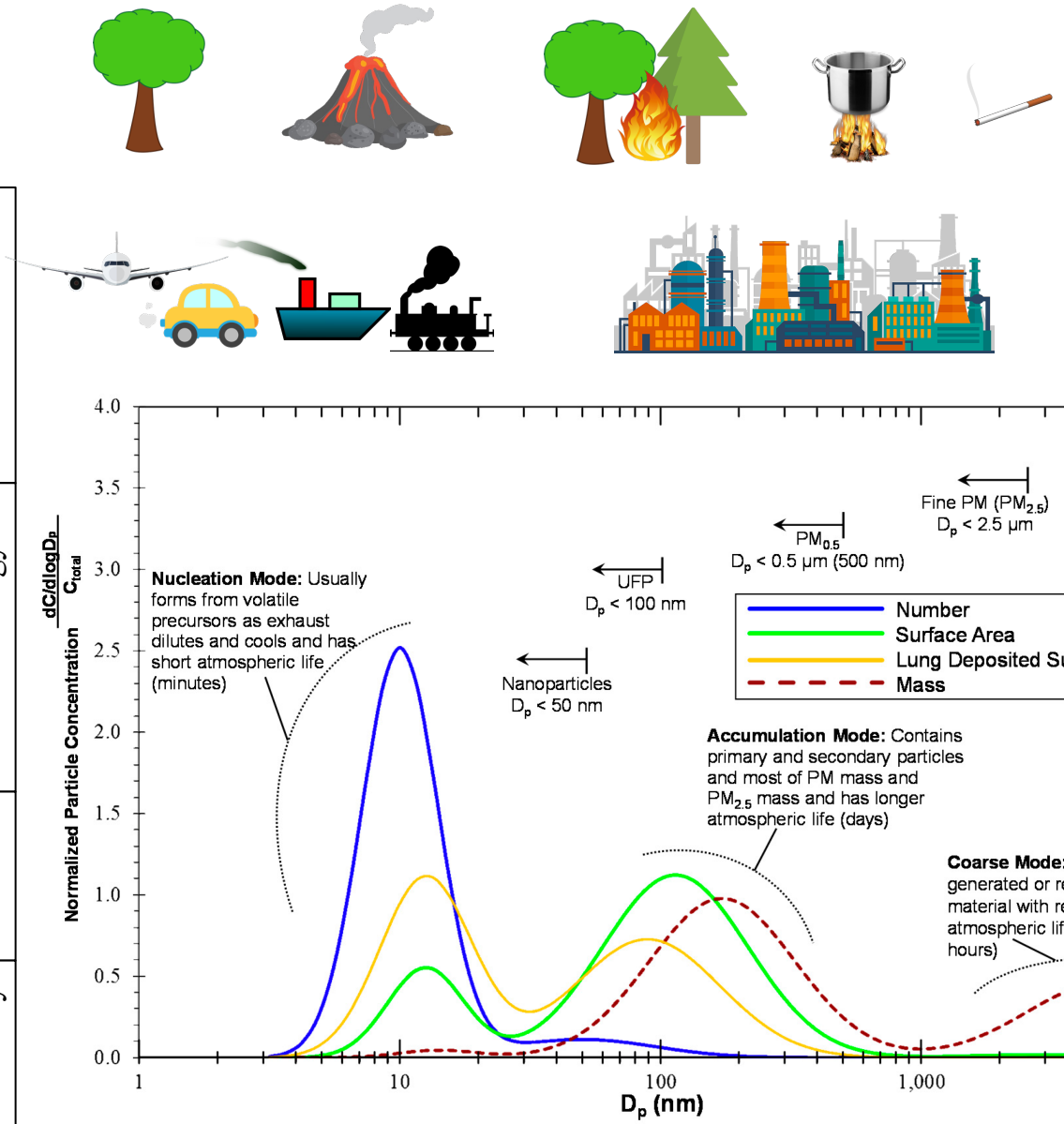
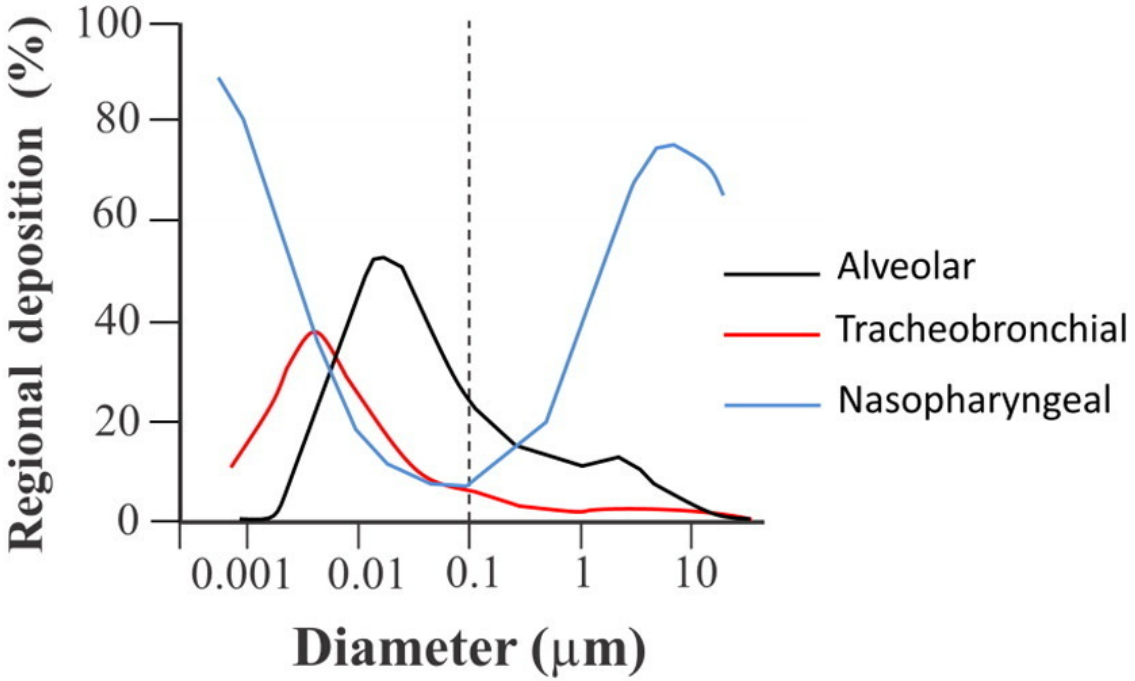
Ultrafine particles: Atmosphere and Exposure





Predicted fractional deposition of inhaled particles in the human respiratory tract during nose breathing based on the data from the International Commission on Radiological Protection (ICRP 1994)

- H.-S. Kwon, M. H. Ryu, C. Carlsten, Experimental & Molecular Medicine 2020, 52, 318–328.
- Lee CW, Vo TTT, Wu CZ, Chi MC, Lin CM, Fang ML, Lee IT. Cancers (Basel). 2020 Sep 3;12(9):2505
- G. Oberdorster, E. Oberdorster and J. Oberdorster Environ. Health Perspect., 113 (2005), pp. 823-839

Objectives

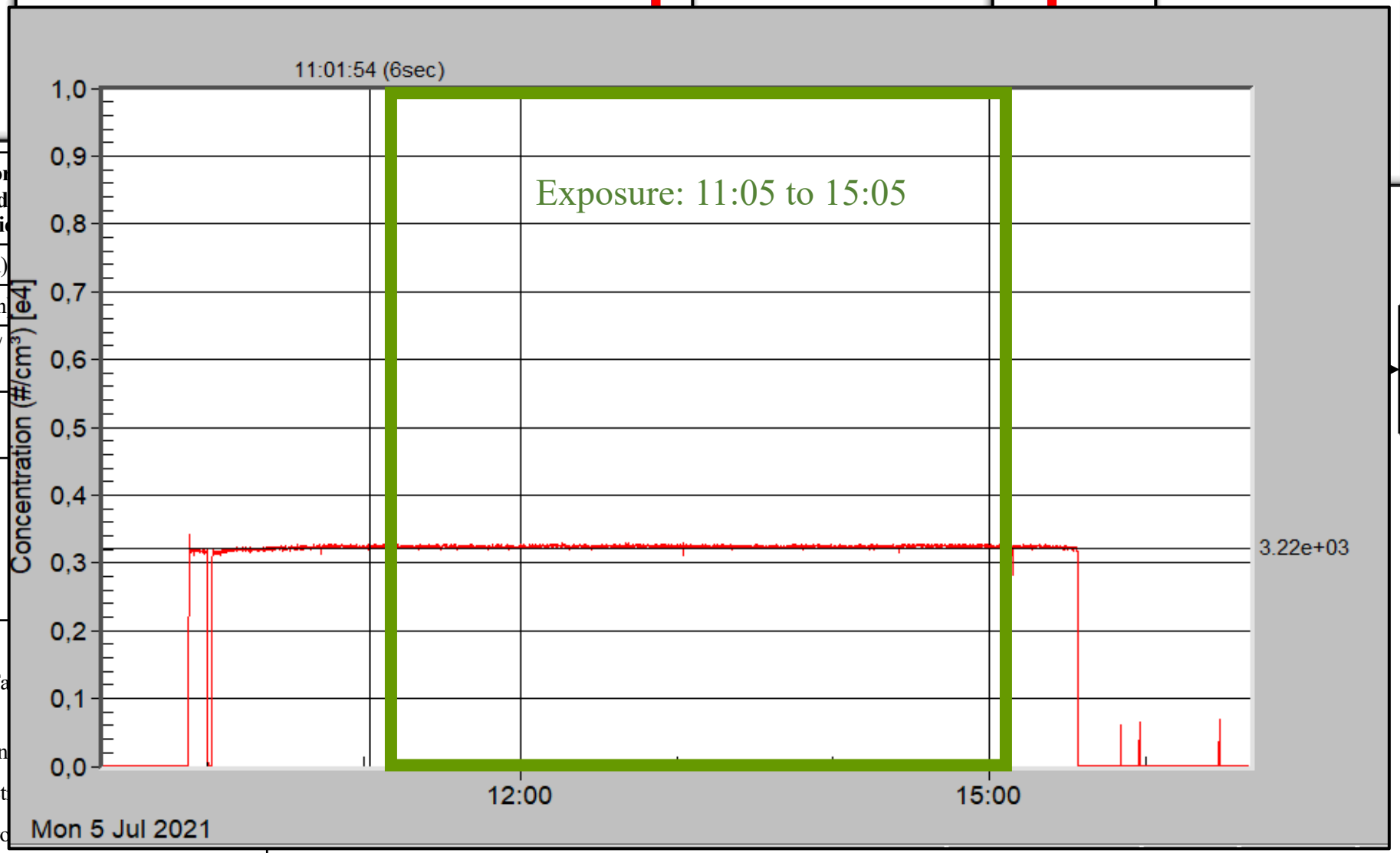
- **To understand if physical characteristics are the real drivers for biological responses or it is the chemistry:**
- **Constant physical properties**
- **Different chemical properties**
- **Reproducible production of UFPs of defined properties for biological responses**

Schematic Diagram: UFP campaign 2021

Mini Cast

Flow rates for operating cond studied (Mini
Propane (ml/ min)
Nitrogen (ml/ min
Oxidation air (L/ min)
Dilution air (L/ min)

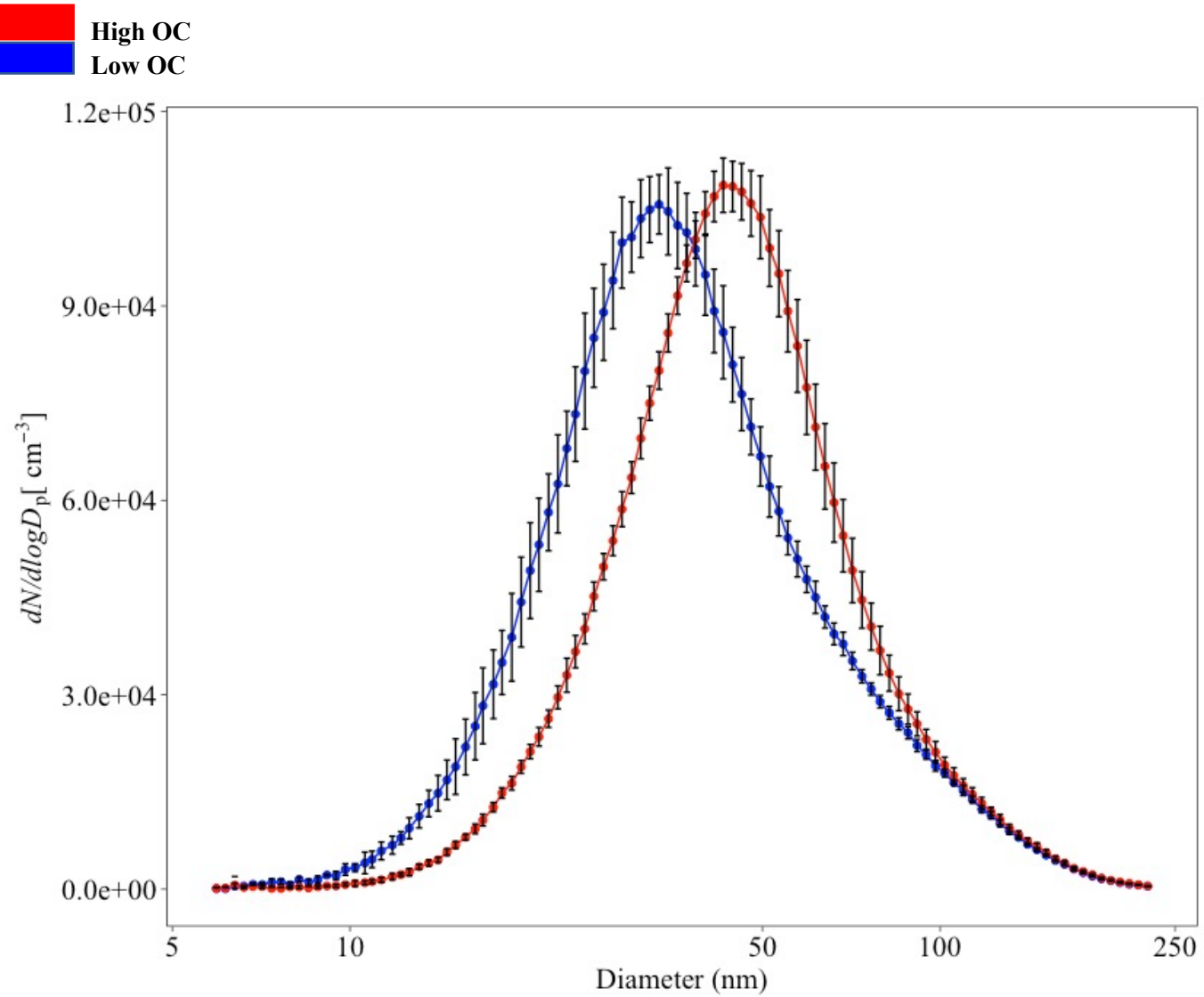
ALI	
TEOM	Ta
SMPS	Scan
ELPI	Elect
AAC	Aero
CPC	Condensation particle counter



Collection

ALI

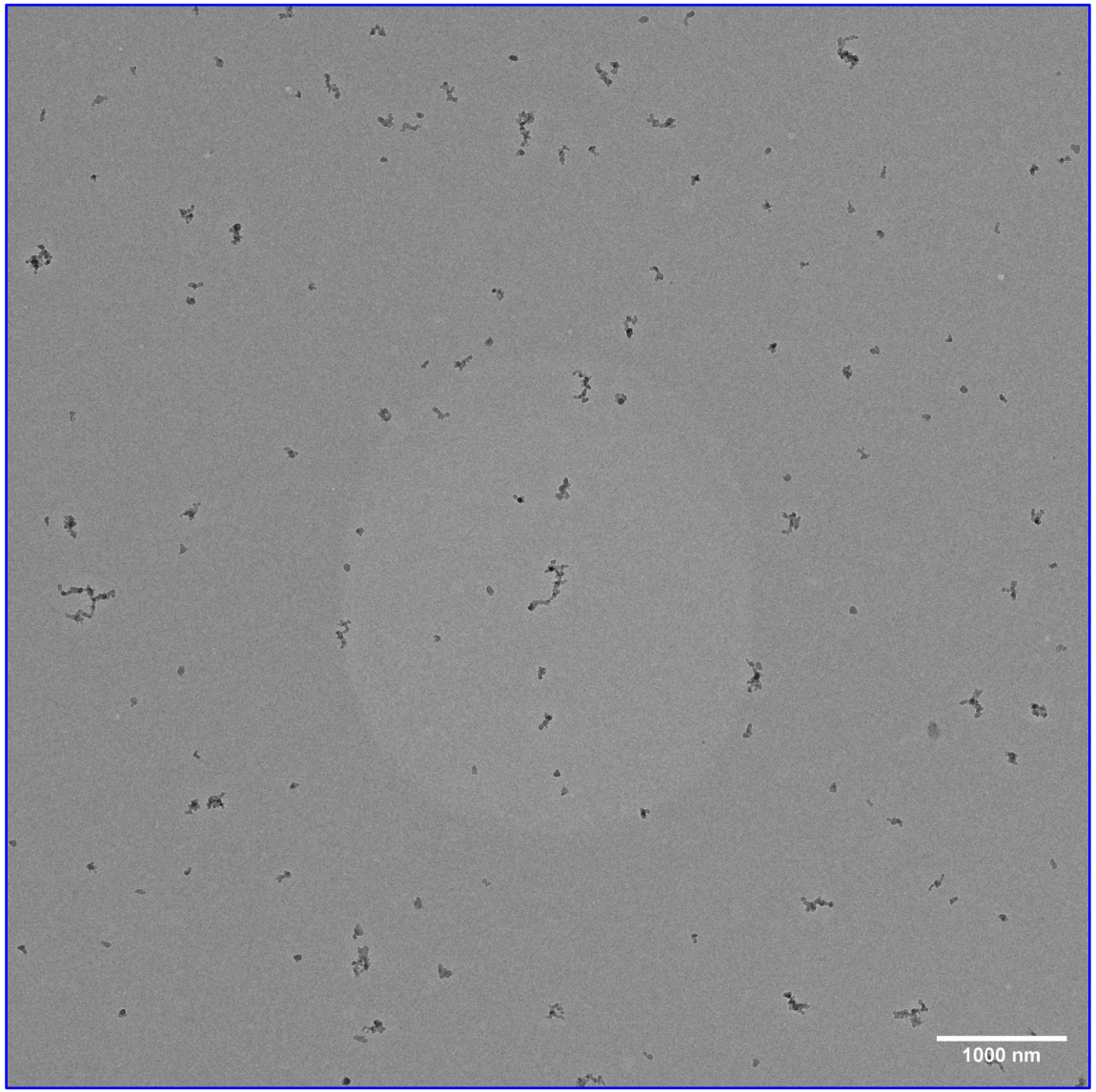
Comparing High and Low OC: Physical Characterization

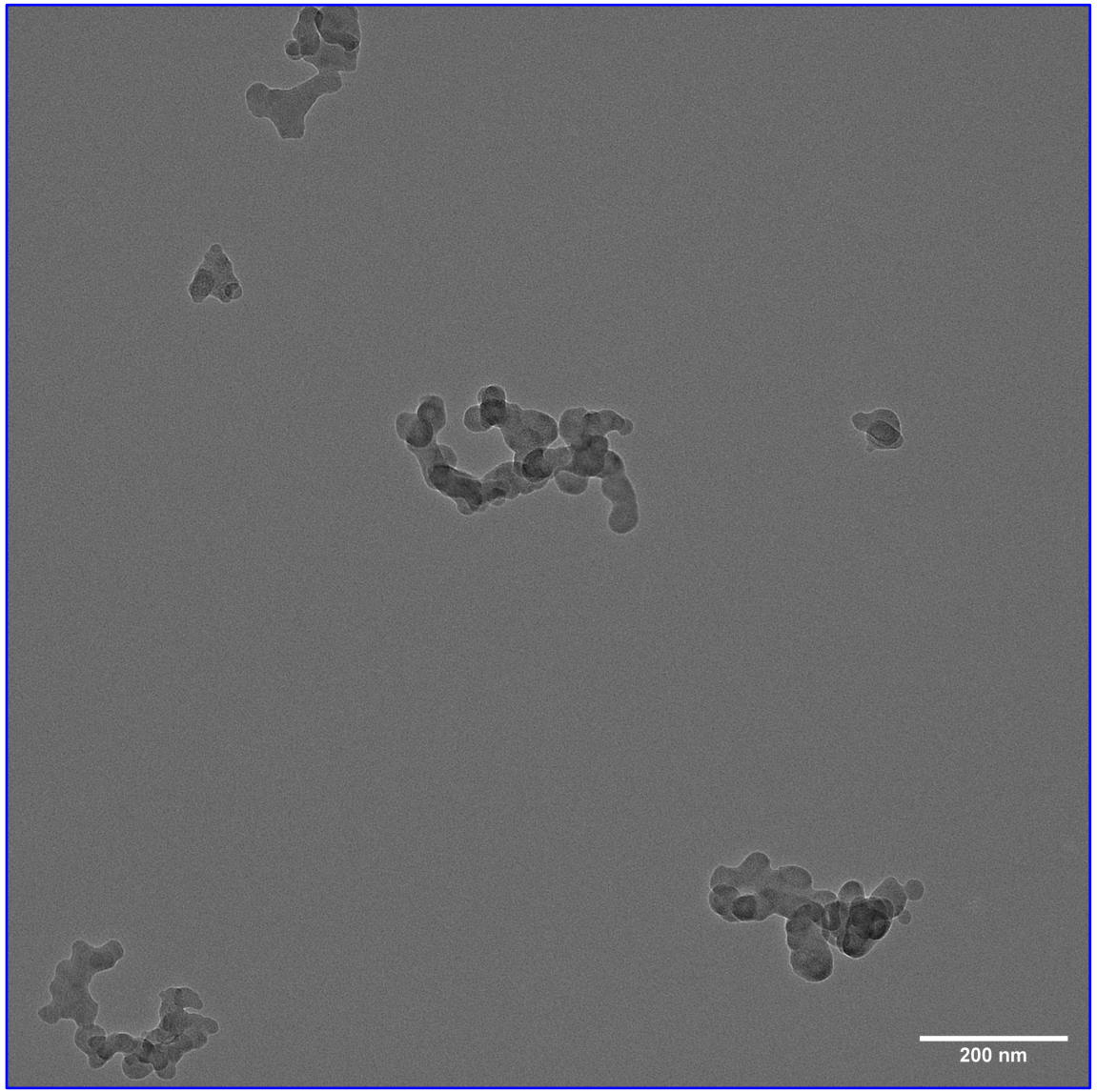


High OC: AT ALI for seven 4 h exposures
Mobility diameter: 44.3 [nm] **(±0.7)**
Number: 5.0e05 [#/cm³] **(± 2.0e03)**
Mass concentration: 82.4 [µg/m³] **(±3.1)**
ALI Dose (calculated): 1.5 [ng/cm²] **(±0.2)**

Low OC: AT ALI for three 4 h exposures
Mobility diameter: 35.5 [nm] **(±1.0)**
Number: 5.3e05 [#/cm³] **(± 2.0e03)**
Mass concentration: 68.0 [µg/m³] **(±6.4)**
ALI Dose (calculated): 1.35 [ng/cm²] **(±0.2)**

Morphology: TEM analyses: Low OC



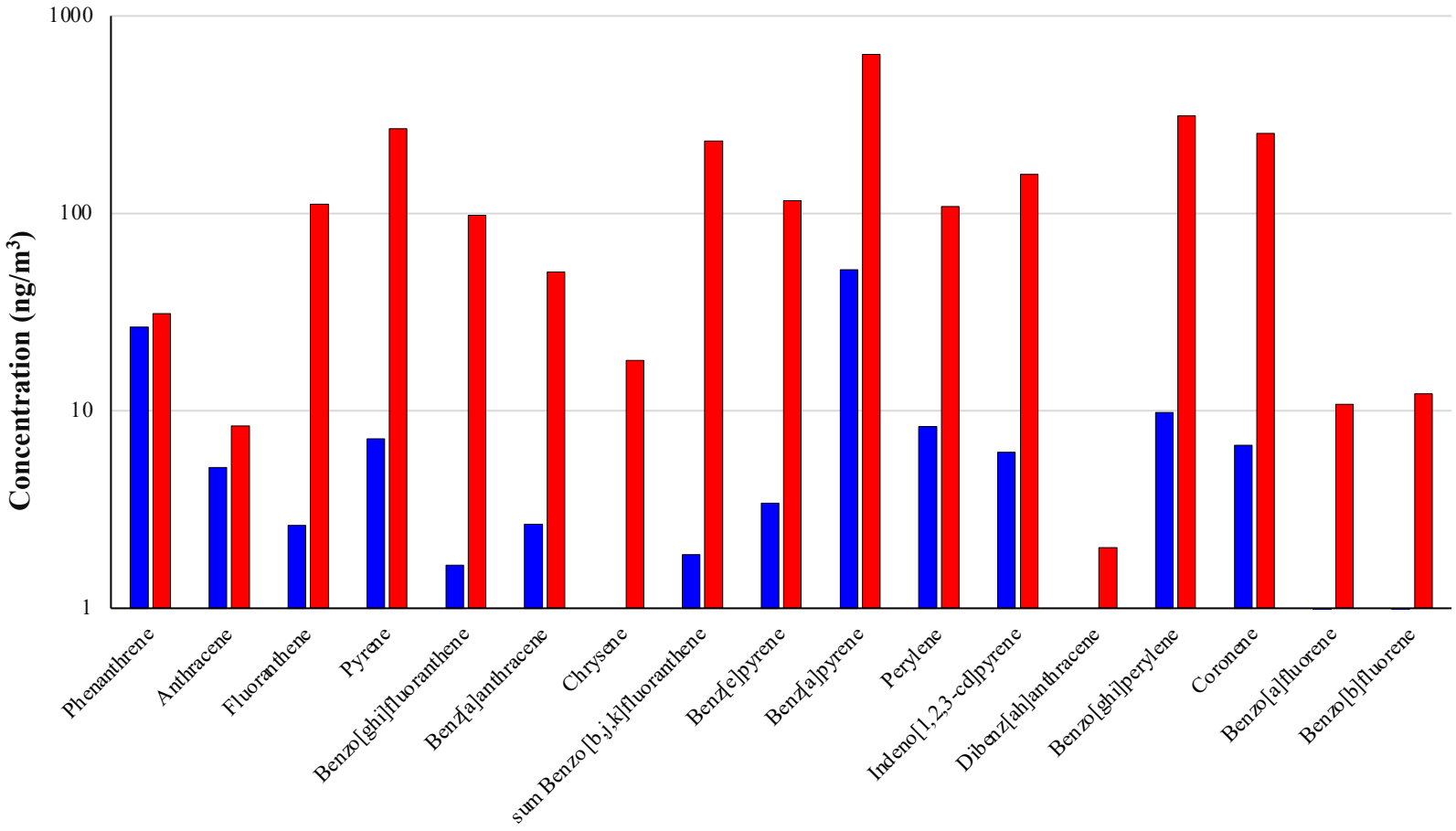


Courtesy: Dr. Mircea-Ioan Iacovache
University of Bern

Comparing High and Low OC: Chemical Characterization

High OC
Low OC

Log Scale!!

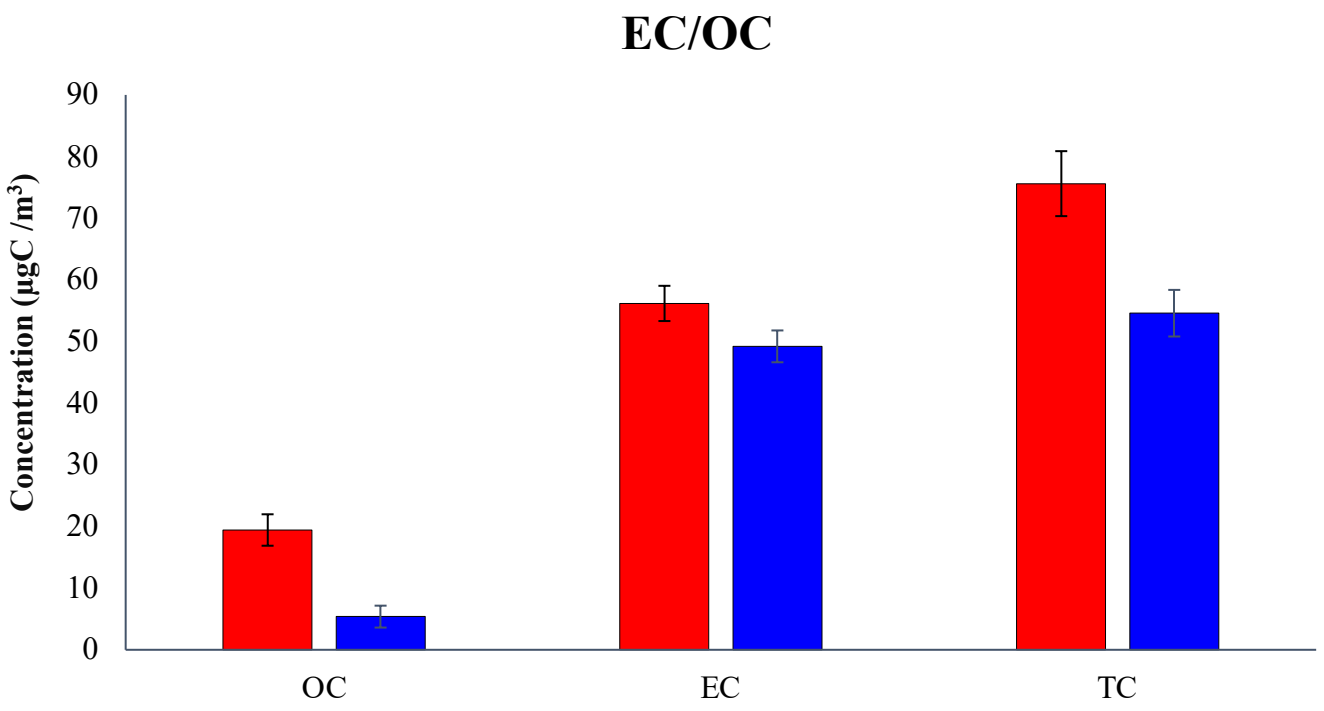


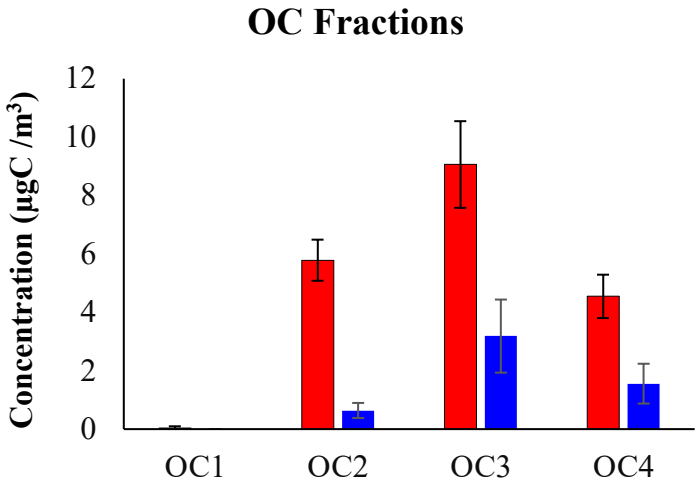
Due to the reduction of organics, PAHs were depleted

Comparing High and Low OC: Chemical Characterization

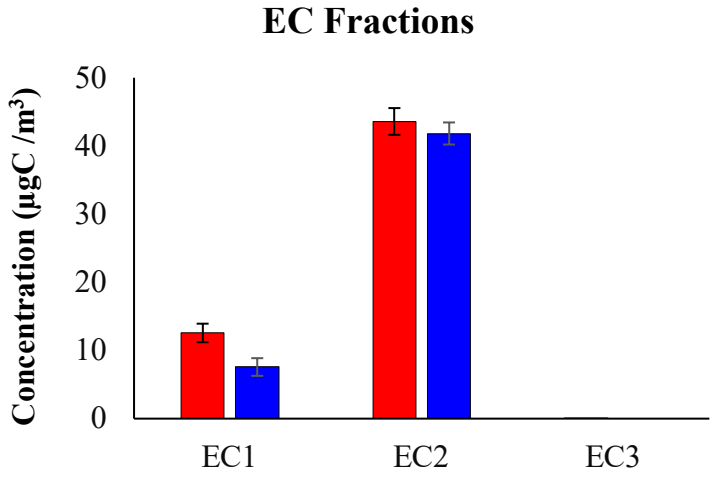
High OC
Low OC

N= 4





Distinct reduction of organic carbon compounds (OC); Stronger decrease of SVOCs compared to LVOCs



Comparisons

	High OC (2021)	Low OC (2021)
Median (nm)	44.3 (±0.7)	35.5 (±1.0)
Number concentration (#/cm³)	5.0e05 (± 2.0e03)	5.3e05 (± 2.0e03)
Mass concentration (µg/m³)	82.4 (±3.1)	68.0 (±6.4)
Carbon concentration: OC (µg/m³)	19.4 (±2.5)	5.4 (±1.8)
Carbon concentration: EC (µg/m³)	56.2 (±2.9)	49.2 (±2.6)
Carbon concentration: TC (µg/m³)	75.6 (±5.3)	54.6 (±3.8)

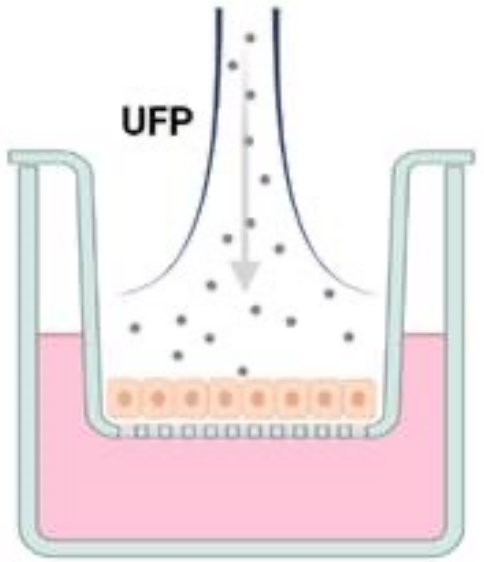
Reproducibility/ Repeatability: July 2021 and May 2022

	High OC (2021)	High OC (2022)	Low OC (2021)	Low OC (2022)
Median (nm)	44.3 (±0.7)	41.2 (±1.4)	35.5 (±1.0)	37.4 (±0.5)
Number concentration (#/cm³)	5.0e05 (± 2.0e03)	5.8e05 (± 4.4e03)	5.3e05 (± 2.0e03)	4.1e05 (± 5.6e03)
Mass concentration (µg/m³)	82.4 (±3.1)	89.0 (±20.1)	68.0 (±6.4)	74.0 (±10.1)

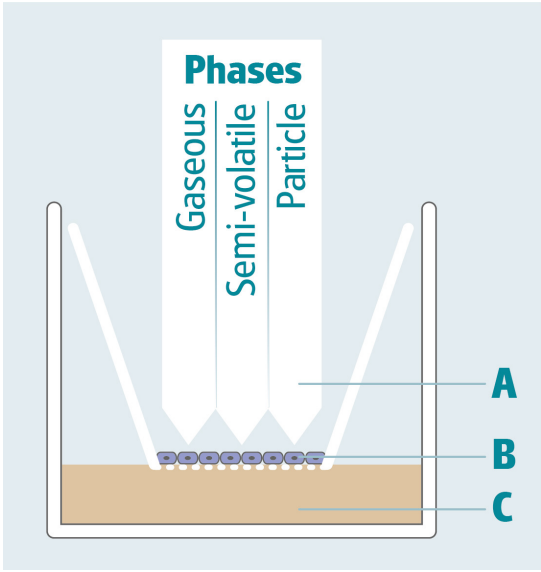
Biological exposures

Duration: 4 hours

- ✓ A549 cells
- ✓ Cell Integrity
- ✓ Cell Viability
- ✓ Xenobiotic Metabolism
- ✓ DNA Damage



ALI

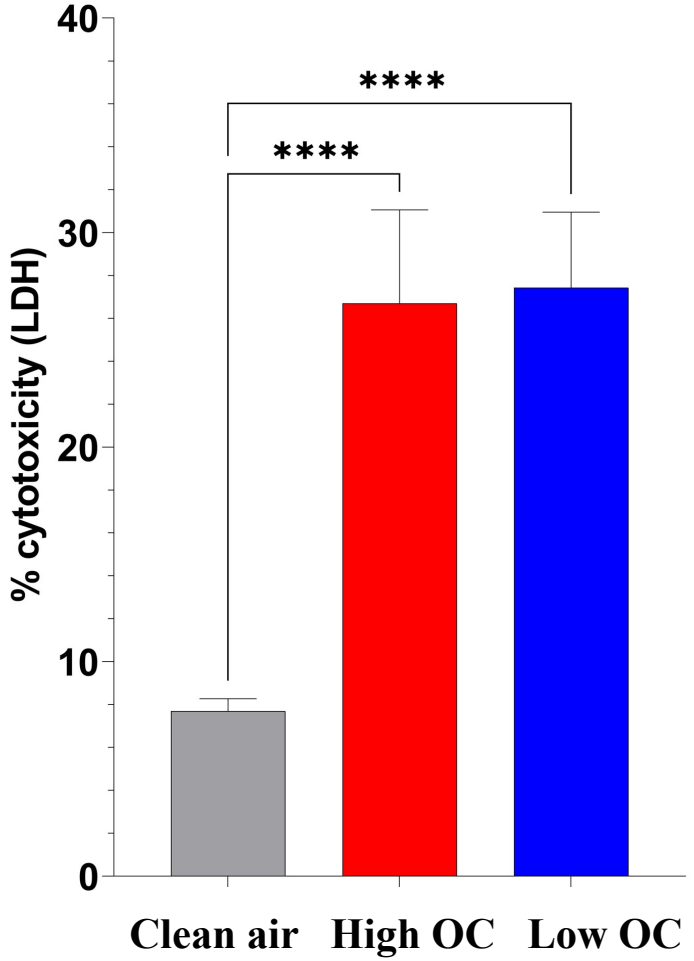


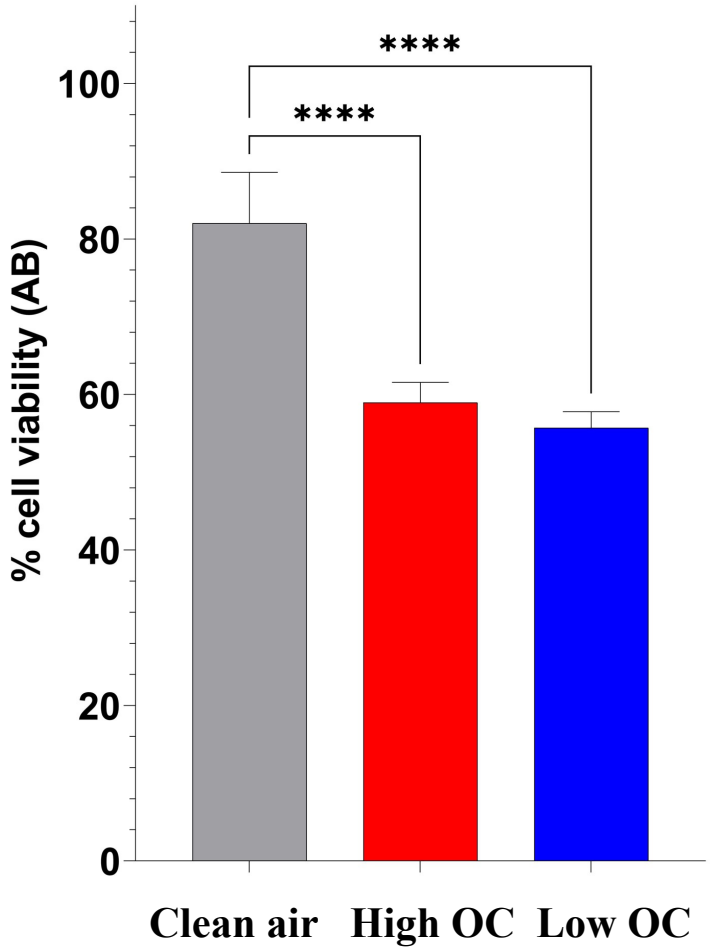
A. Direct and controlled exposure of test atmosphere to cells
B. Cells on membrane
C. Medium below cells

Cytotoxicity

High OC
Low OC

N= 3





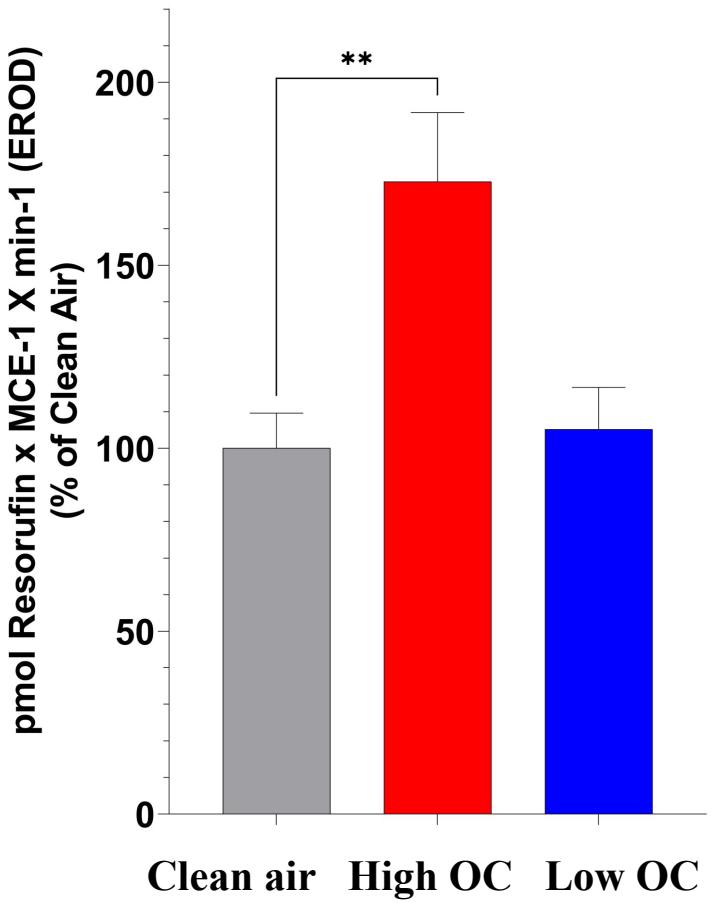
Both UFP types affect cell viability and cell integrity to a similar extent

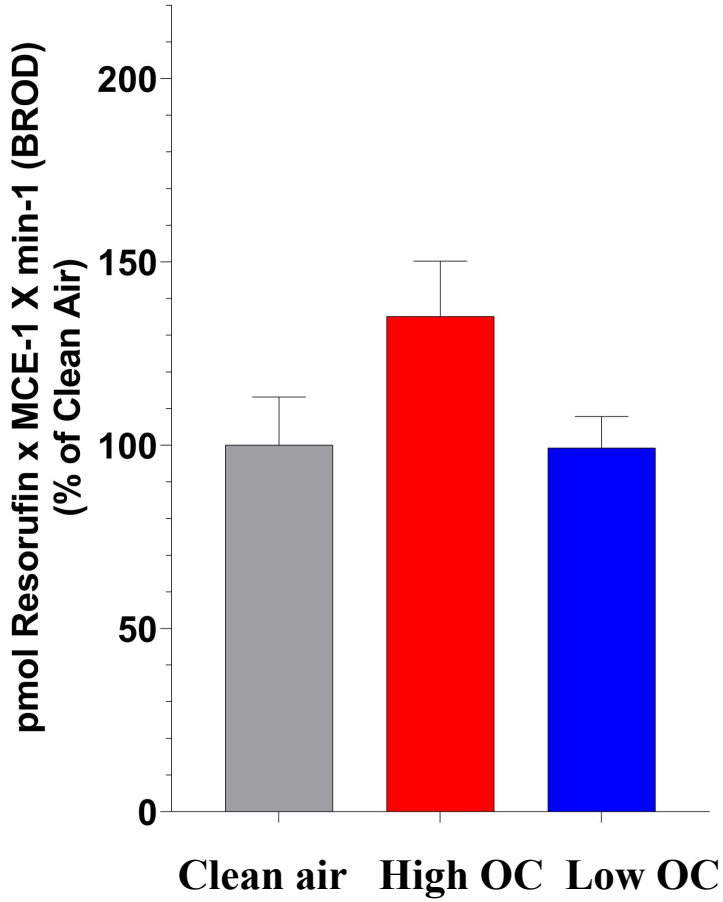
*One way Anova with Dunnett's Multiple Comparison Test (**** $p \leq 0.0001$)*

Xenobiotic Metabolism

High OC
Low OC

N= 3





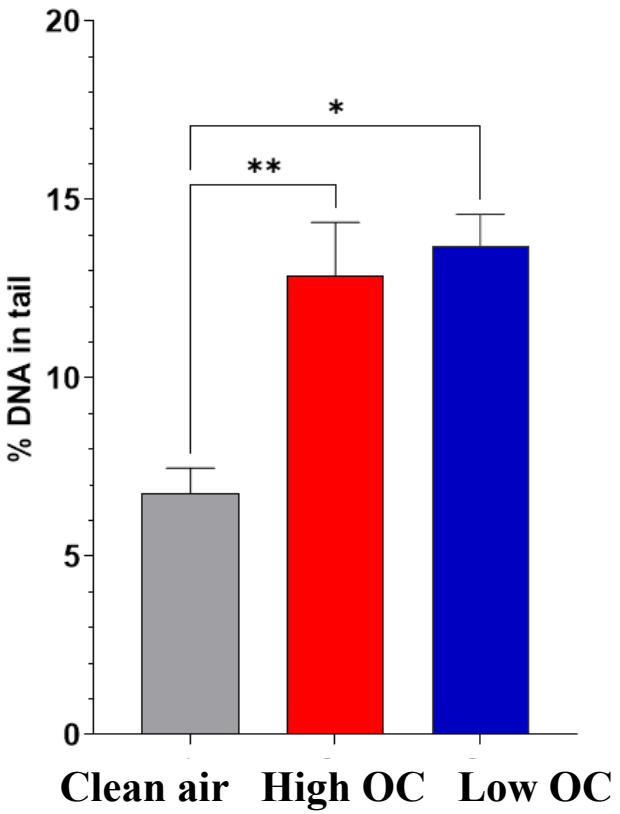
In particular, High OC leads to an increase in the xenobiotic metabolism of polycyclic aromatic hydrocarbons.

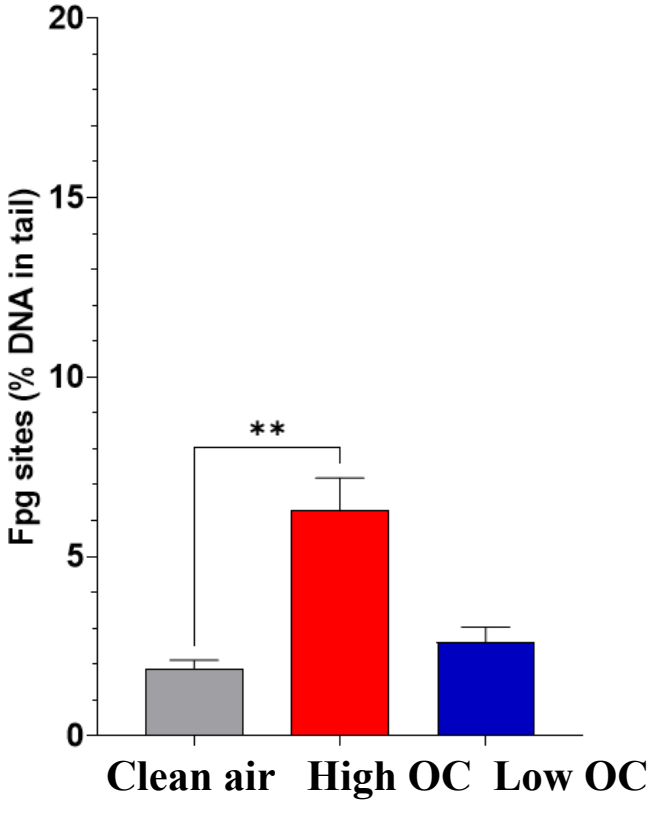
One way Anova with Dunnett's Multiple Comparison Test
*(** $p \leq 0.001$)*

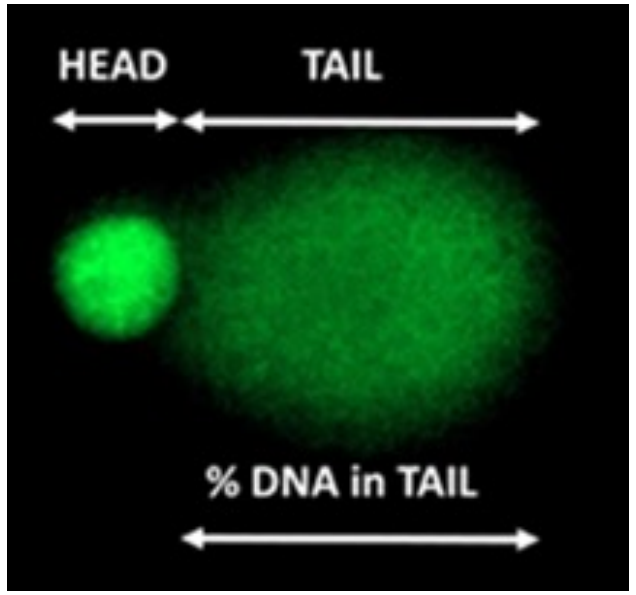
DNA Damage

High OC
Low OC

N= 3







Both UFP types induce DNA single and double strand breaks. However, High OC UFPS alters the potential to induce DNA oxidation and DNA alkylation

One way Anova with Dunnett's Multiple Comparison Test
($p \leq 0.05$, * * $p \leq 0.01$)*

Summary

- **Constant generation of UFP particles** ✓
- **Constant physical properties** ✓
- **Different chemical properties** ✓
- **Reproducible Setup** ✓
- **Toxicological Endpoints: Cytotoxicity, DNA Damage, etc.** ✓

The chemical composition of UFP cannot be neglected for toxic and genotoxic effects

Wayforwards

- **Constant chemical properties**
- **Different physical properties**
- **More physicochemical characterizations**
- **More Toxicological Endpoints**
- **Different cell Models**

Acknowledgements

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Many Regards to:

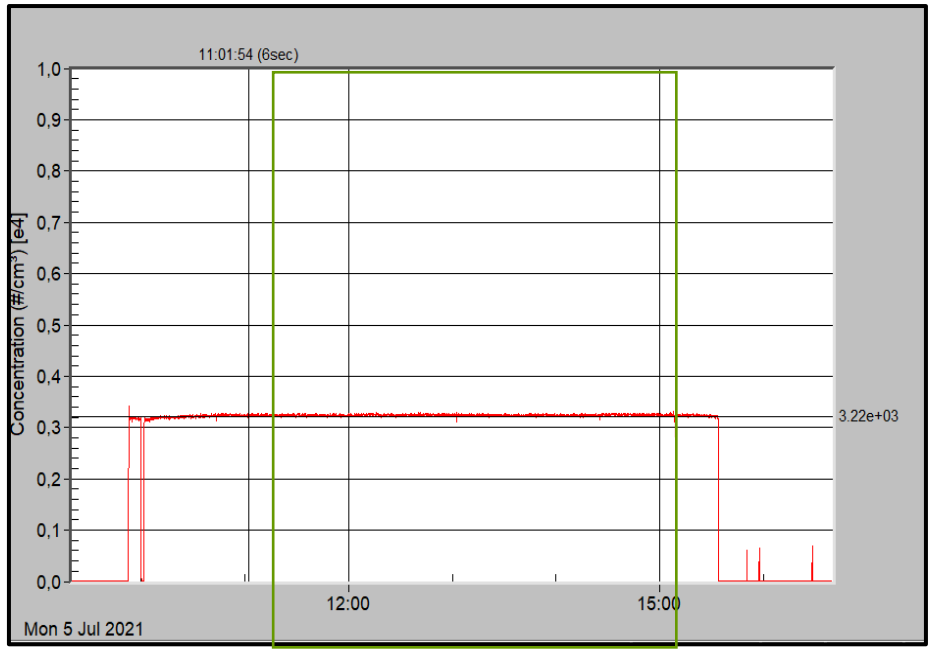
The CMA team
University of Rostock
Ultrafine Particle Project Partners

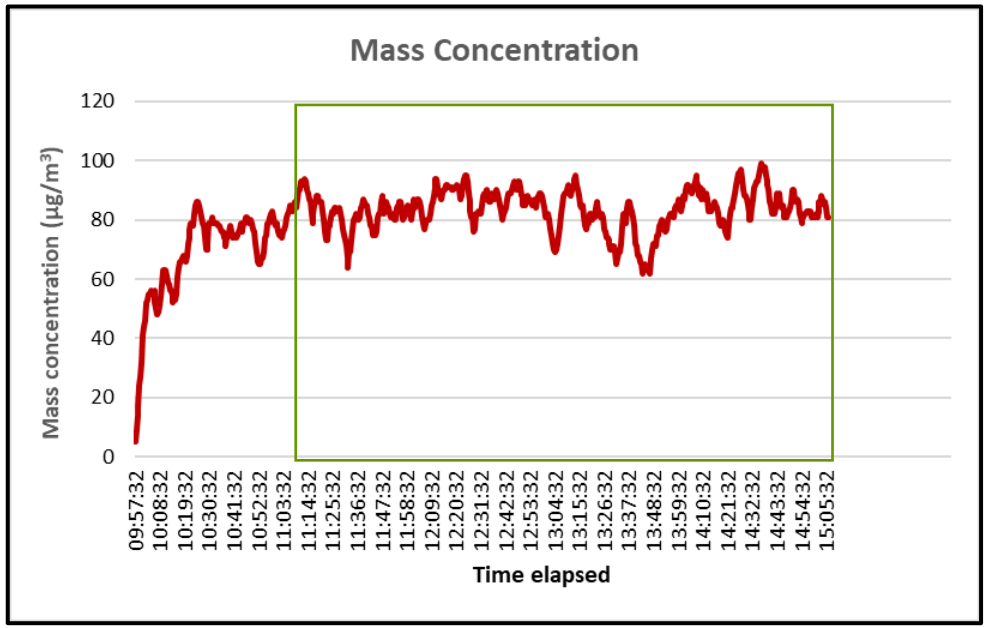
Thank you.

https://www.ultrafeinepartikel.de/

Supplementals

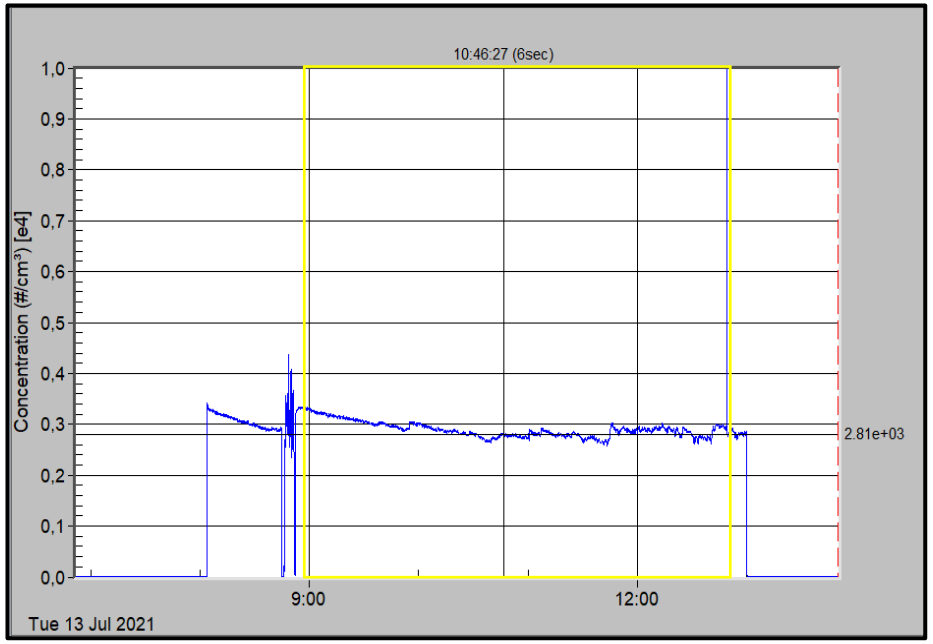
High OC: B01: UFP Campaign 2021

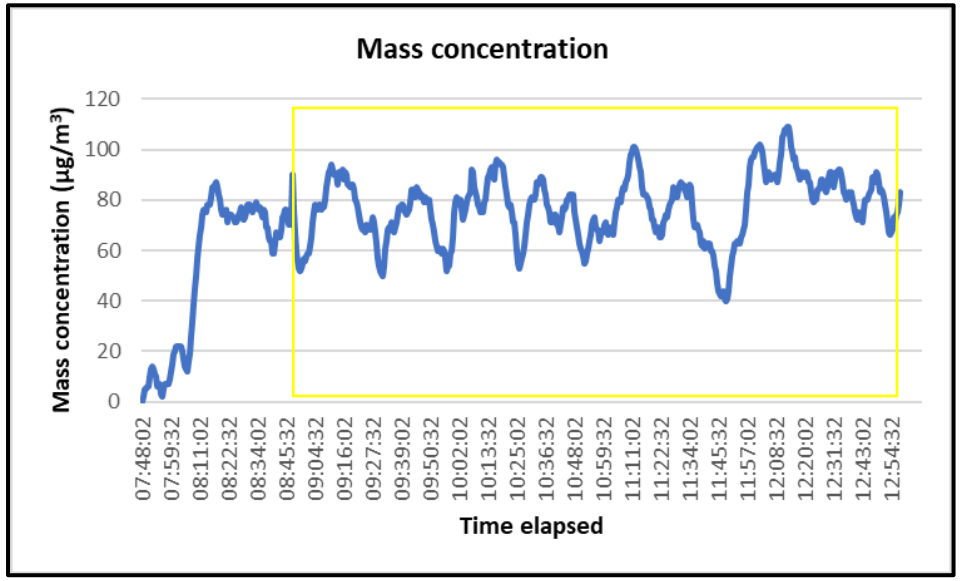




No.	Start time	End time	TEOM (µg/m³)	CPC (Total (#/cc))	SMPS (Median (nm))	SMPS(Total (#/cc))	AAC (Median (nm))	AAC (Total (#/cc))	UVPM (TC_{aeth})	BC	BrC (%)
BO 1	11:05	15:05	83.1±6.8	3.2e05 ± 1.7e03	44.1 ± 0.3	4.8e05 ± 5.7e03	58.4 ± 0.3	3.3e05 ± 9.0e03	111.3	46.0	59.0

High OC: B01: UFP Campaign 2021

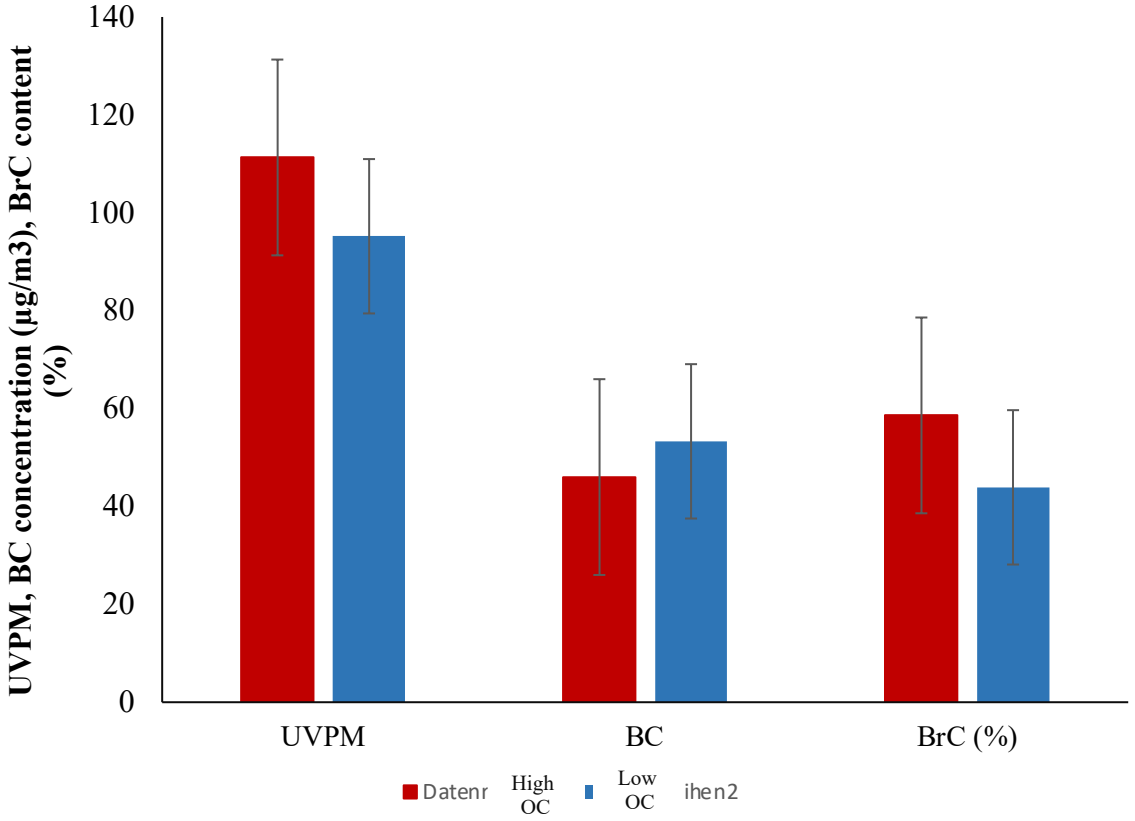




No.	Start time	End time	TEOM (µg/m³)	CPC (Total (#/cc))	SMPS (Median (nm))	SMPS(Total (#/cc))	AAC (Median (nm))	AAC (Total (#/cc))	UVPM (TC_{aeth})	BC	BrC (%)
B07	08:58	12:58	77.0±13.0	2.8e05 ± 1.5e04	36.0 ± 0.2	5.6e05 ± 3.0e03	56.0 ± 1.0	3.0e05 ± 3.0e04	95.2	53.3	44.0

Aethalometer

UVPM: Sum of carbon species
BC: black carbon (elemental carbon)
BrC: organic carbon compounds



Using the catalytic stripper renders to a reduction in the amount of SVOC- organics in UFP low (BrC) with steady elemental carbon concentration (BC)