On-site ALI versus Submerged Culture: Toxicological and Chemical Characterization of Brake Wear Nanoparticles

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27th ETH-Nanoparticles Conference (NPC-24) and Aerosols-24, June 10-14, ETH Zurich, Switzerland

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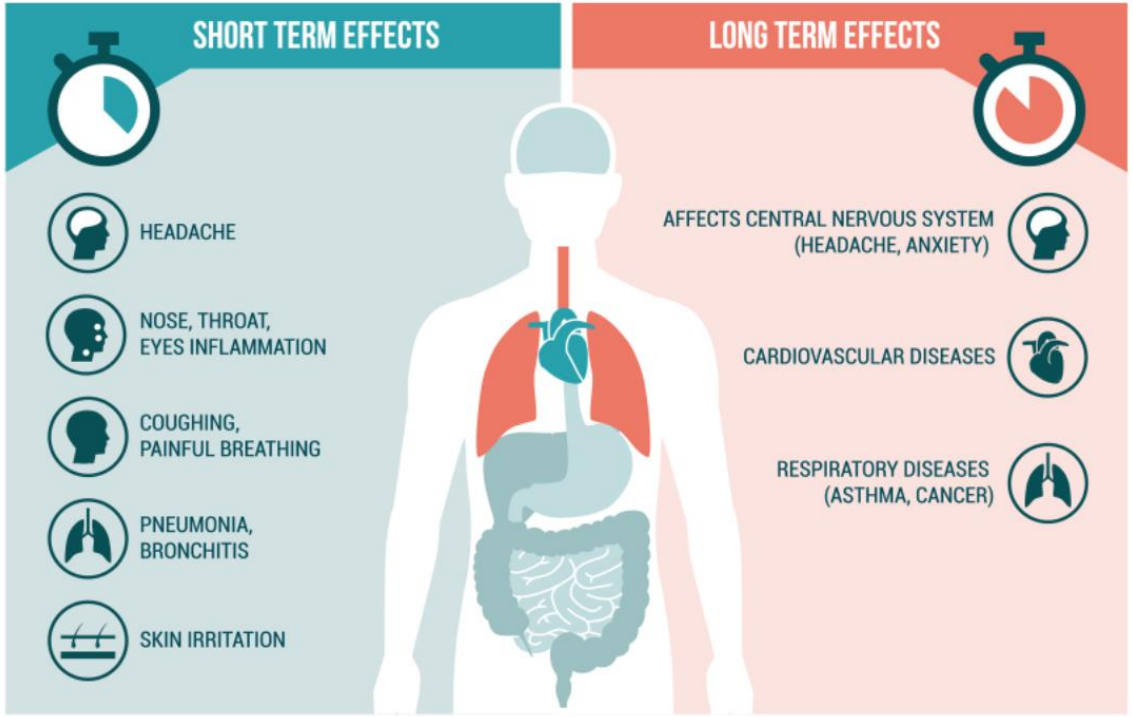
Framework

Air pollution is one of the major environmental risks to health

Almost every organ in the body can be affected by air pollution

- Air pollution is associated with generation of oxidative stress and inflammation in human cells, which may lead to chronic diseases

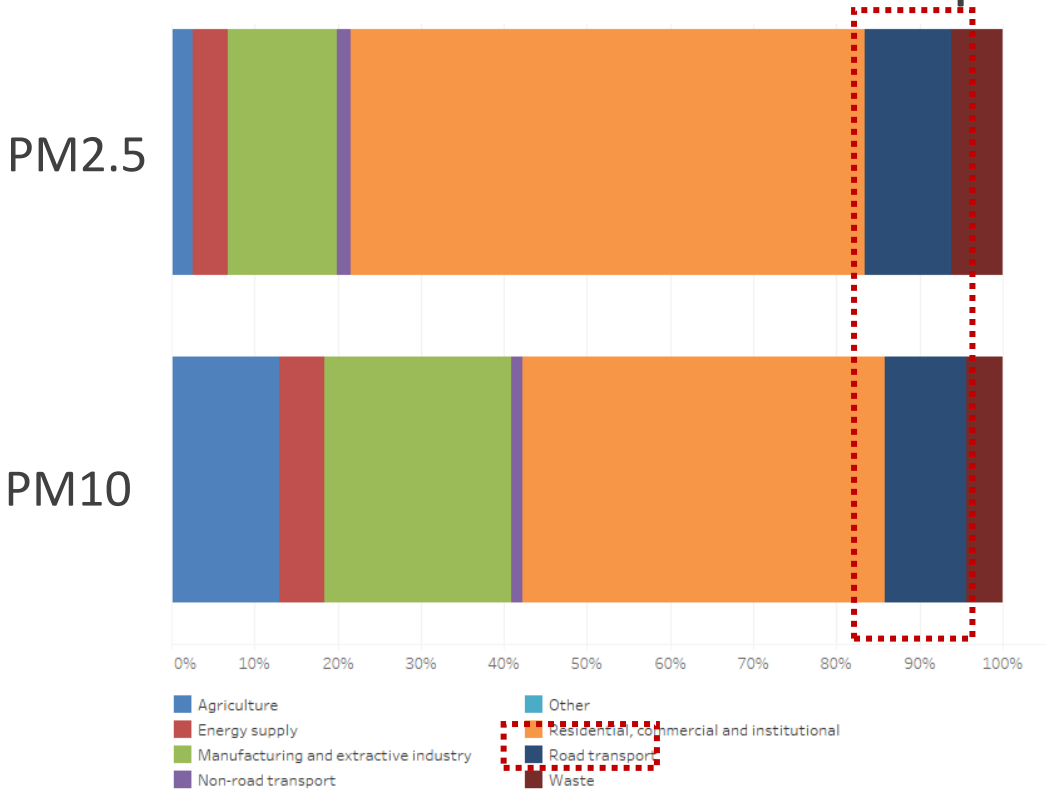
- Respiratory tract is the main system affected by air pollution



World Health Organization (2021). WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide.

Framework

Air pollutants with the strongest evidence for public health include particulate matters (PMs)



- Respetively 10.4 % and 9.7 % of total $PM_{2.5}$ and PM_{10} are related to the road transport
- PMs from the road transport are divided in Exhaust and Non-Exhaust emissions

Air pollution in Europe: 2023 reporting status under the National Emission reduction Commitments Directive. doi: 10.2800/149724

nPETS Project

- **Aim** - Characterization of nano-emissions generated by the trasport sector
- **WP3:** collection of nano-particulates generated by brakes during laboratory tests
- **WP6:** physico-chemical and toxicological characterization of nano-emissions from different traffic sources (inorganic fraction)

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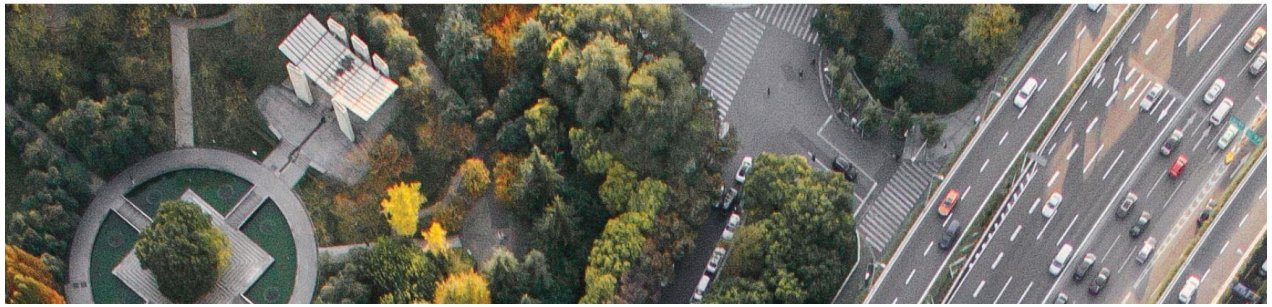
Nanoparticle Emissions From The Transport Sector: Health And Policy Impacts

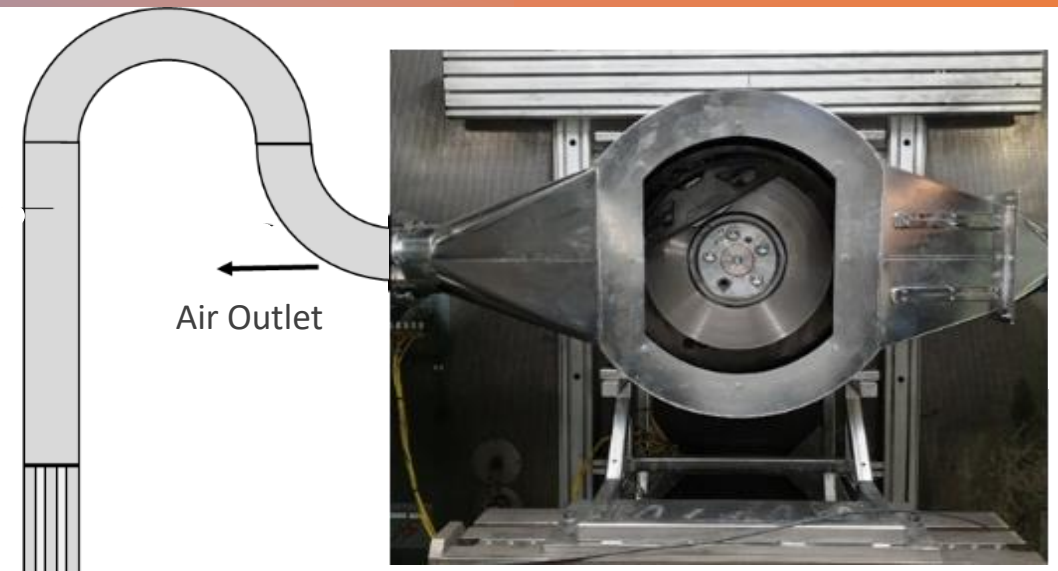


Horizon 2020 – Grant n°954377

Aim of the Work

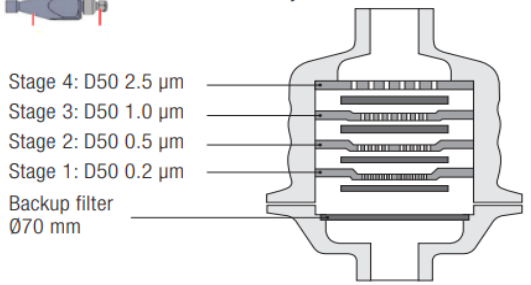
- Perform reliable physico-chemical characterization of non-exhaust nano-emissions produced by brakes
- Compare the toxicity response, of A549 cells exposed to nano-emissions, in submerged and on-site ALI conditions

Instrumentation



Dynamometric Bench
(almost GTR compliant)

Vertical, coaxial and isokinetic sampling



DGI-S2 WLTP Cycle (8h)

On-site ALI Trip 10 of WLTP Cycle (2h)

Materials & Methods

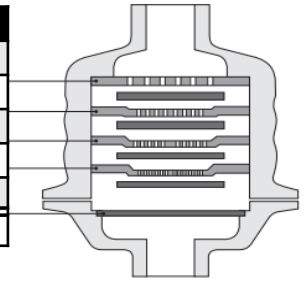
Materials

Grey Cast-Iron Braking Disc

+

M1a & M1b (Low Steel)

DGI	
Stage	d50 / µm
S4	2.10-2.20
S3	0.80-0.90
S2	0.40-0.45
S1	0.13-0.15
Back-up	-



S2

Chemical Characterization

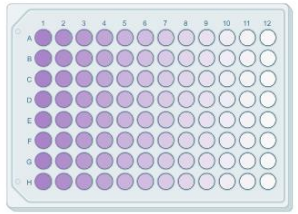
SEM/EDS

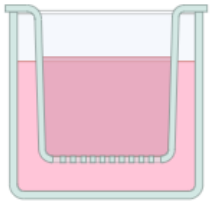
Raman Spectroscopy

XRD

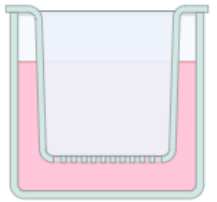
Toxicological Characterization

Alamar Blue Assay





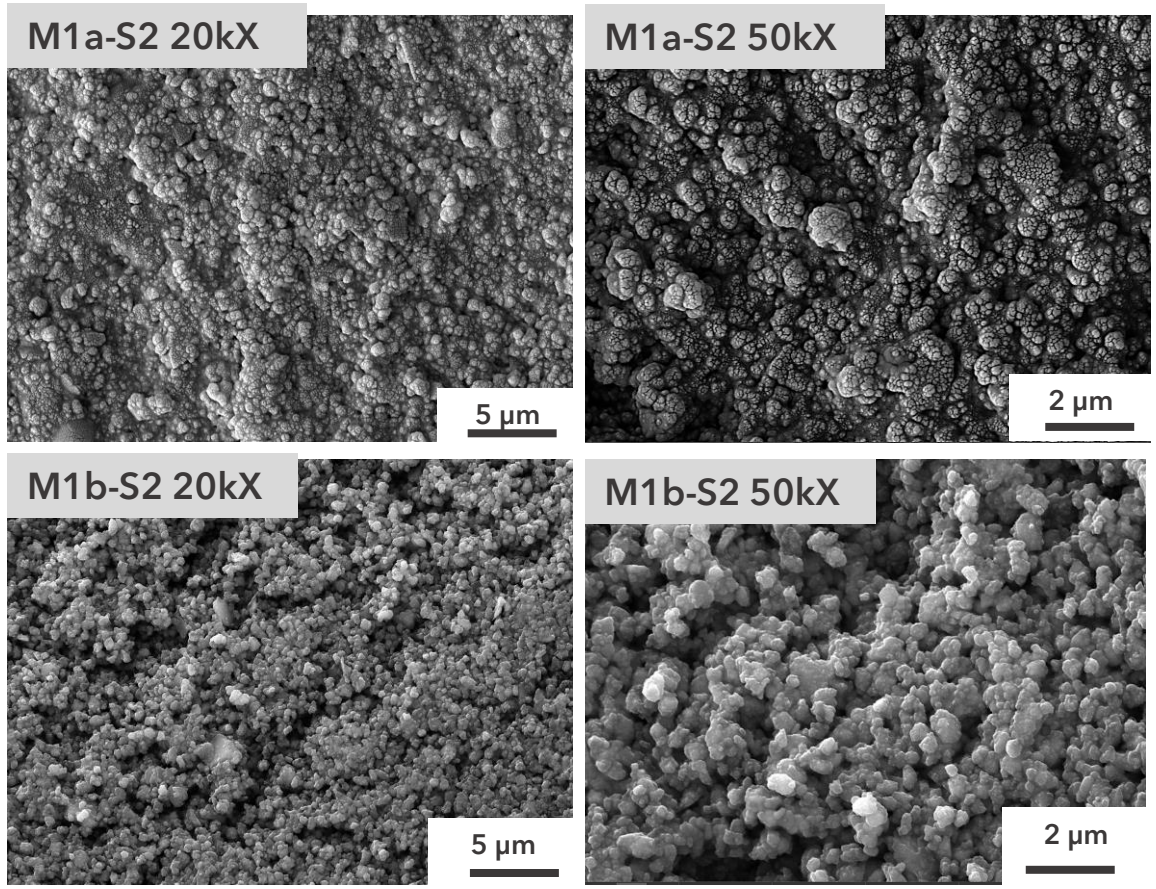
Submerged Conditions (A549 & dTHP-1)

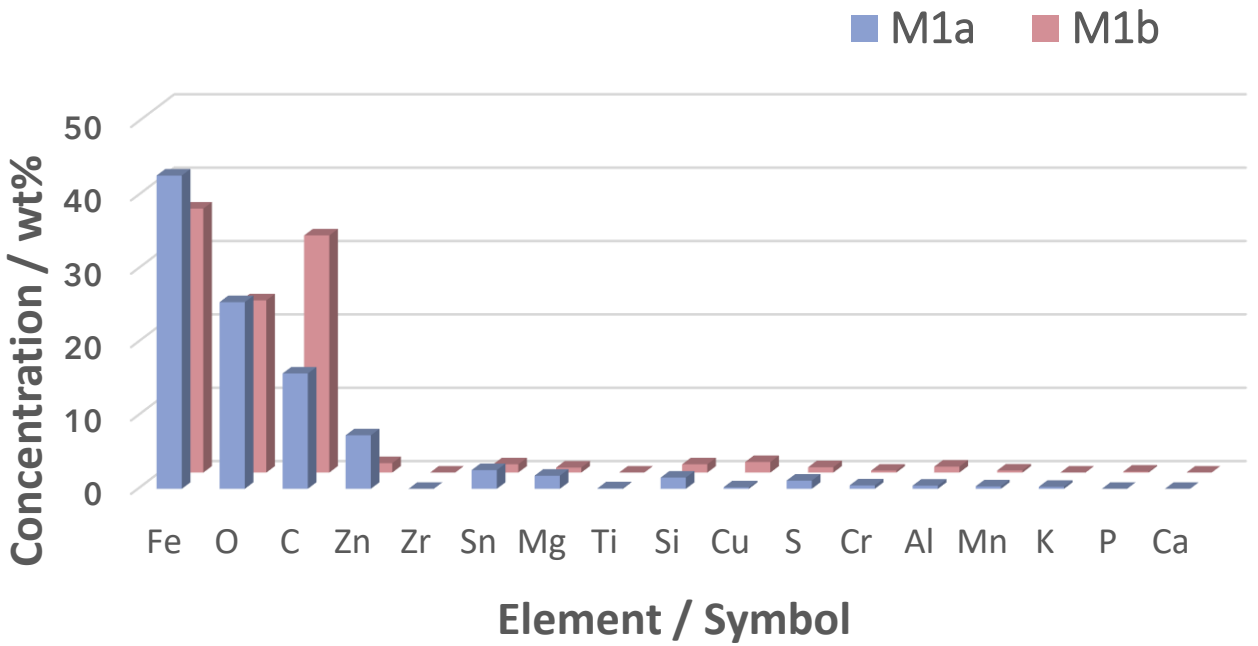


On-site ALI Conditions (A549)

ALI PMs exposure	2 hours
Incubation	24 hours
Alamar Incubation	3 hours
Replicates	3 test for each friction material

SEM/EDS Characterization





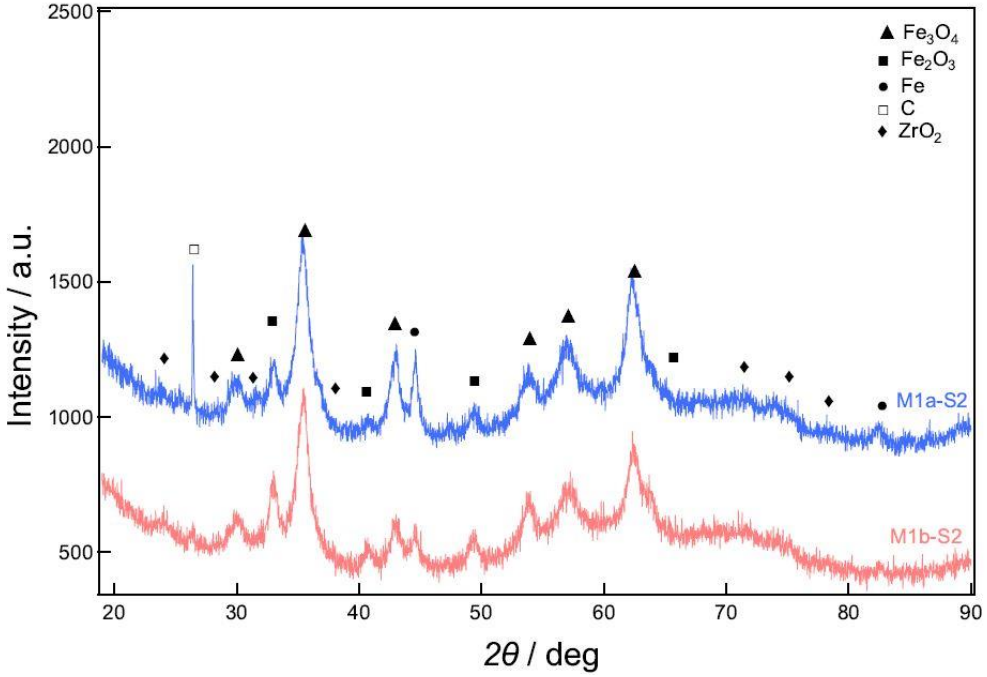
Distribution of elements as measured for the **M1a** and **M1b** samples of DGI S2.

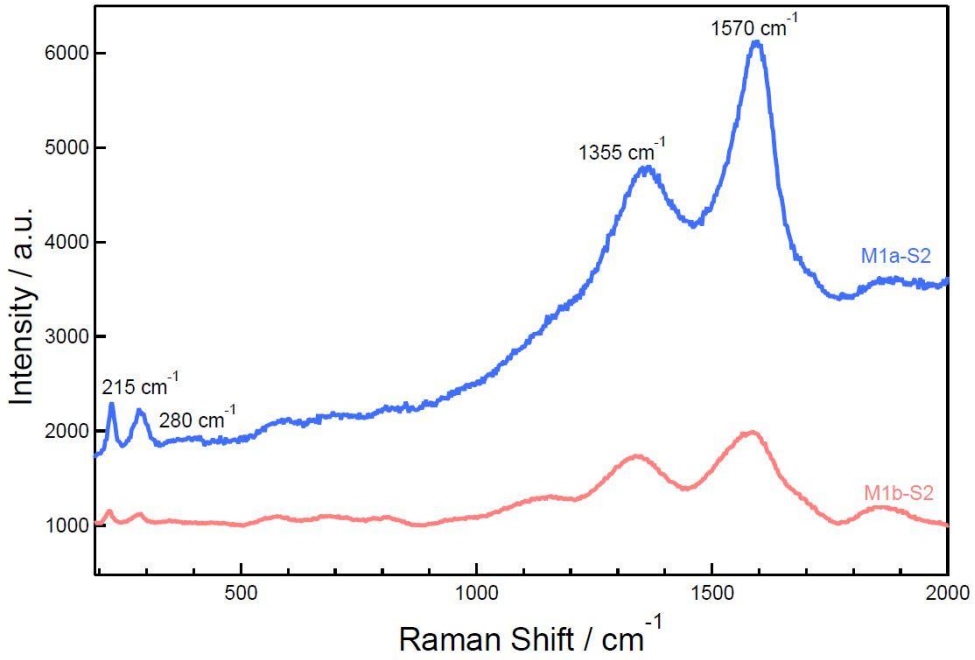
The elemental composition of NPs emission is dominated by three main elements, **Iron**, **Carbon** and **Oxygen**.

XRD & Raman Characterization

X-Ray Patterns

- **Fe_3O_4** Magnetite **M1b > M1a**
- **Fe_2O_3** Hematite **M1a > M1b**
- **Fe** Iron **M1b > M1a**
- **C** Graphite **M1a > M1b**



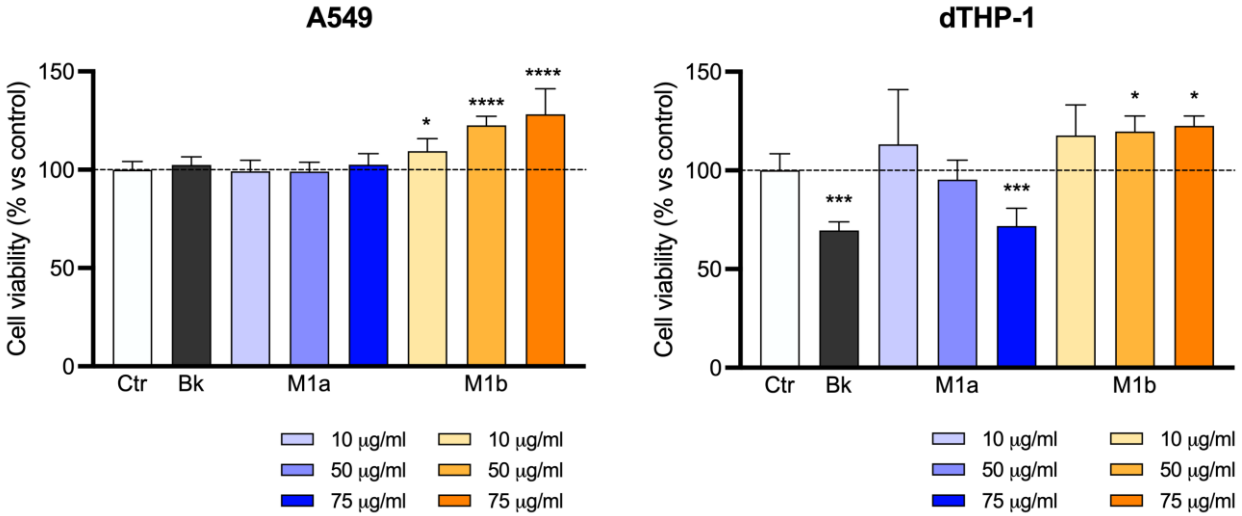


Raman Spectra (confirms XRD findigs)

- **50** to **700 cm^{-1}** signals related to **Iron oxides**
- **1200** to **2000 cm^{-1}** signals related to **elemental Carbon**

Toxicological Characterization

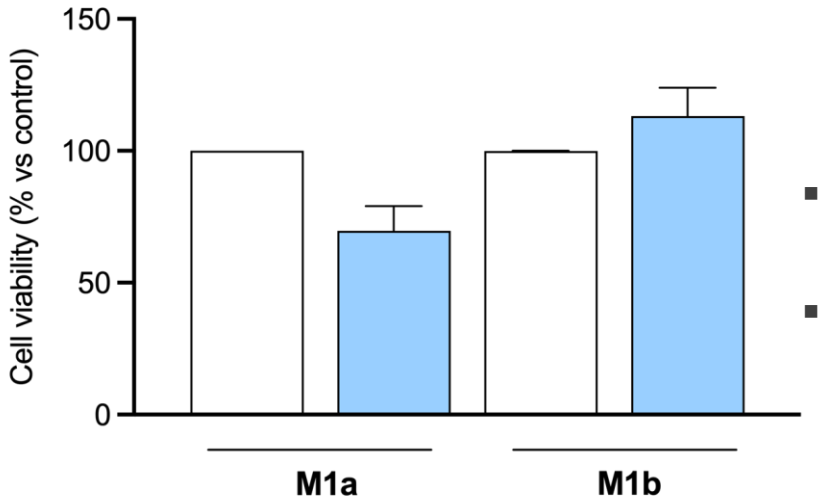
Submerged Conditions



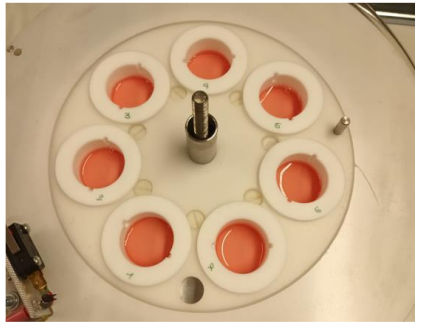
- **A549** cell viability is not affected by M1a and M1b emissions
- For **dTHP-1** a dose dependent behaviour was observed for M1a emission

Statistical analysis: differences were established using a two-way ANOVA and considering significant at *p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001, ****p ≤ 0.0001

On-site ALI



- **M1a – 0.009 µg/cm²**
- **M1b – 0.04 µg/cm²**



There are no statistical differences in the **A549** cell viability of M1a and M1b emissions

Conclusions

- M1a and M1b non-exhaust nano-emissions (<450 nm) were collected and analysed
- In spite of the observed differences in chemical composition between M1a and M1b, the cell viability of A549 was not affected for both in submerged and on-site ALI conditions
- M1a emission exhibit a dose-dependent effect in cell viability in dTHP-1. This might be related to the higher amount of metals compared to the M1b emission

Acknowledgments
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Thank You!

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