Beyond Emission Factors: Brembo's Protocol for Physico-Chemical and Environmental Assessement of Brake Wear Particles

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Outline

Context

Non-Exhaust Emissions (NEE)

Physico-chemical Characterization

Environmental & Health Impact

Conclusions

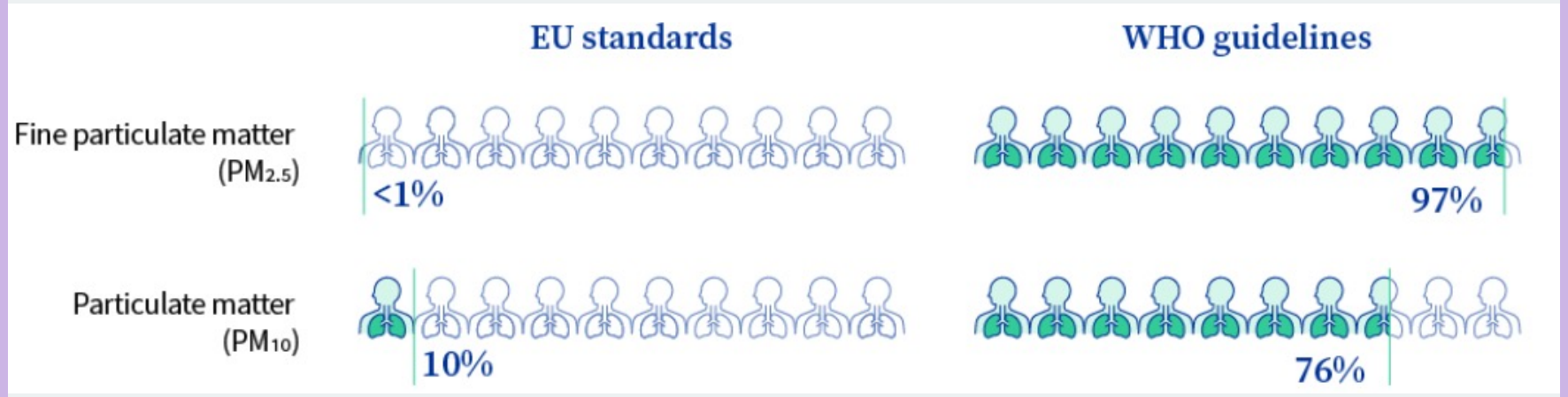
Contest – EURO7

- Up to 70% of particulates in urban environment due to road transport sector
- Progressive decrease in exhaust emissions led to increasing attention on non-exhaust emissions (brakes, tyres, clutches)
- EURO7 regulation: first time limitation on PM10 generated by brakes (7 mg/km)

Non-Exhaust Emissions (NEE)

- Emission factors (EF) provide valuable, but limited insight into air pollution (quantity matter)

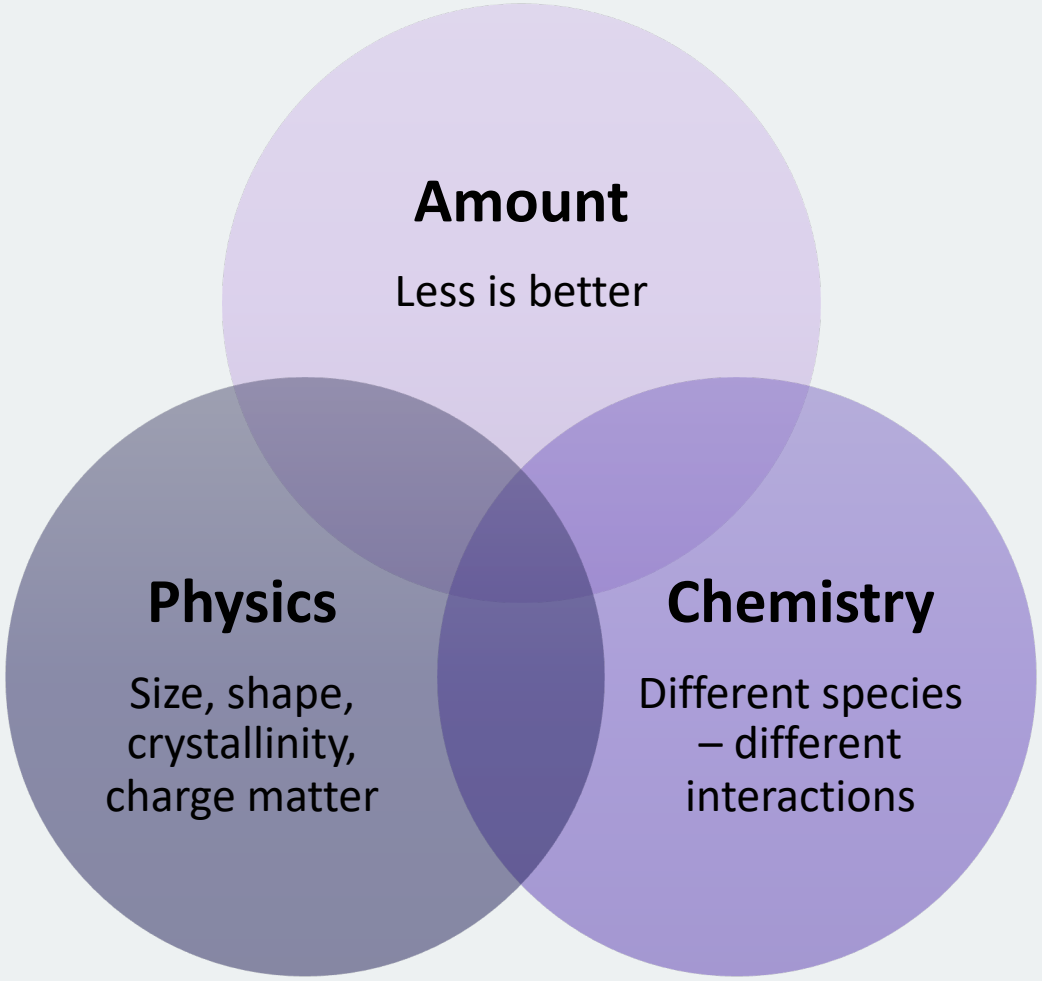
- Understanding physicochemical composition is crucial for risk assessment (quality matter)



- Investigating environmental responses offers deeper insights (quality matter)

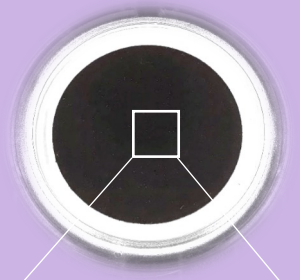
Beyond EF: Quality of Emissions

Reduce emissions (**quantity**) AND improve environmental compatibility (**quality**)

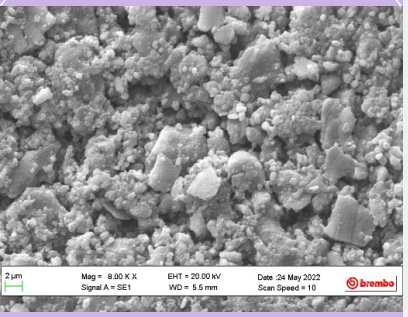


Physico-Chemical Characterization

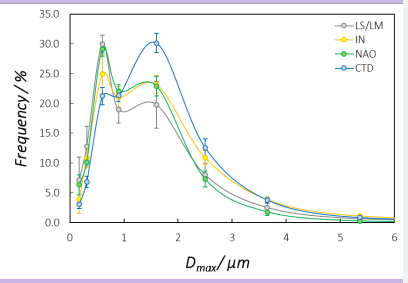
Particulate (PM10, PM2.5)



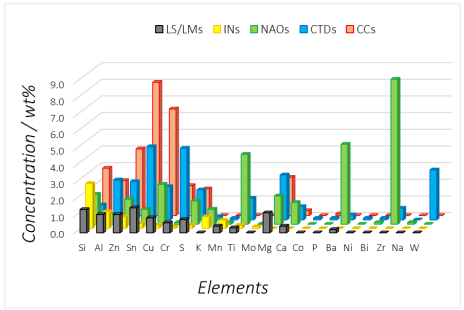
Morphology



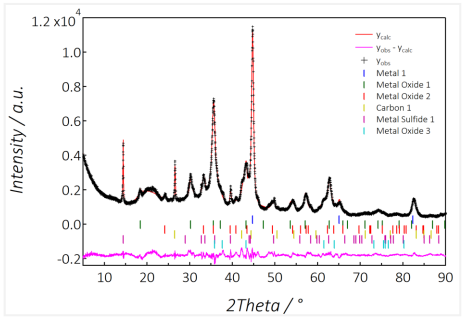
Size Distribution



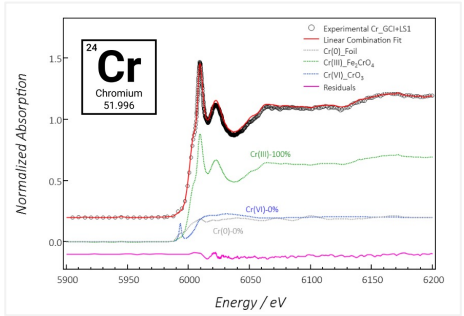
Elemental Composition (Z > 6)



Phase Composition (Crystalline compounds)

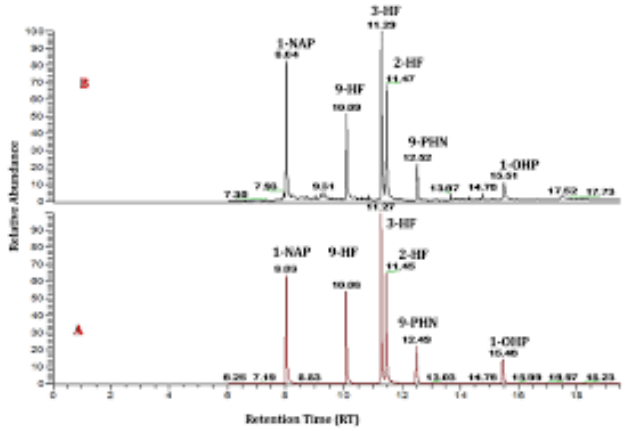


Speciation (*d*-block metals)



Inorganic Fraction

Organic Compounds

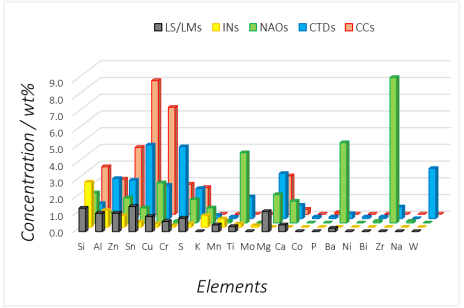


- PAHs/ NPAHs / OPAHs
- PCBs
- Phenols
- Aldehydes
- Alkanes

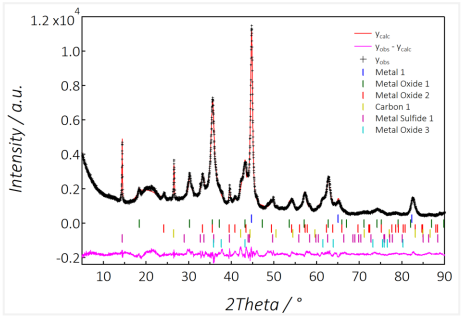
Organic Fraction

Inorganic Fraction

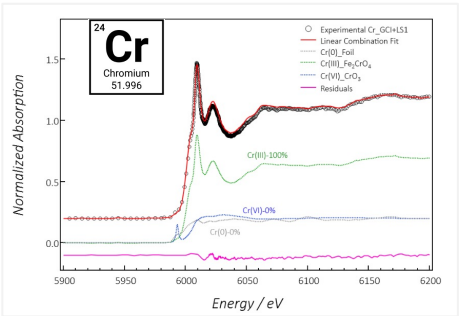
Elemental Composition



Phase Composition



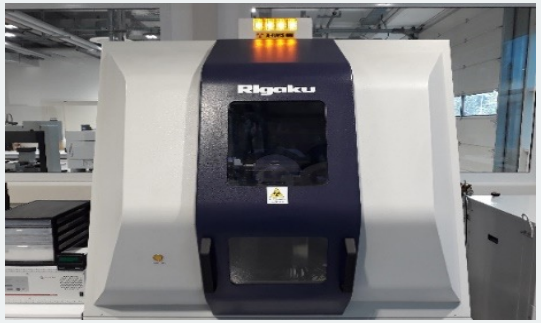
Speciation



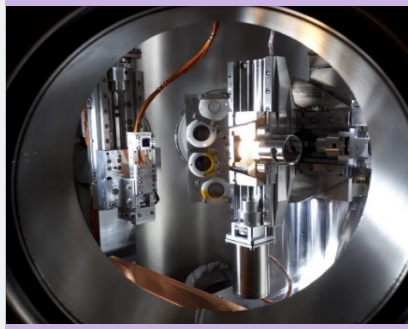
Particulate (PM10, PM2.5)

SEM/EDXS
Morphology & Semi-quantitative composition

Raman Spectroscopy
Phase Composition UFP



XRD
Crystalline Fraction



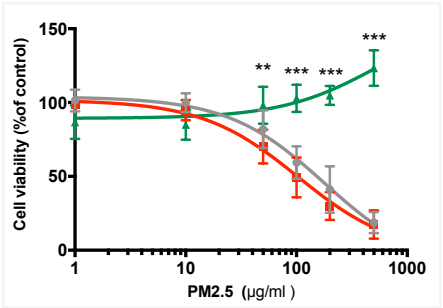
XANES
Speciation of d-block Metals

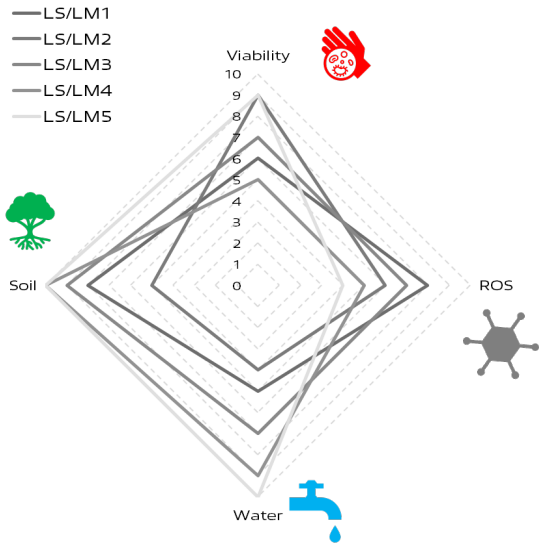
Environmental & Health Impact

Model Powders

Real Emissions

Interaction Mechanisms



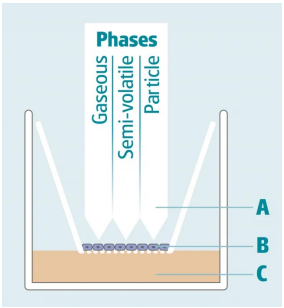


- **Maps of effects**
- **Comparative impact ranking**
- **Input for cost & benefit analysis**

A – Direct and controlled exposure of test atmosphere to cells

B – Cells on transwell membrane

C – Media below cells



- **Simulating more realistic particulate dispersion (ALI – Air Liquid Interface)**
- **Simulating more realistic cells growth and exposure conditions**

Simplified models

Who triggers what

Test standardization

Effects of specific emissions

Correlative toxicological maps

Improved exposure and cell colture systems

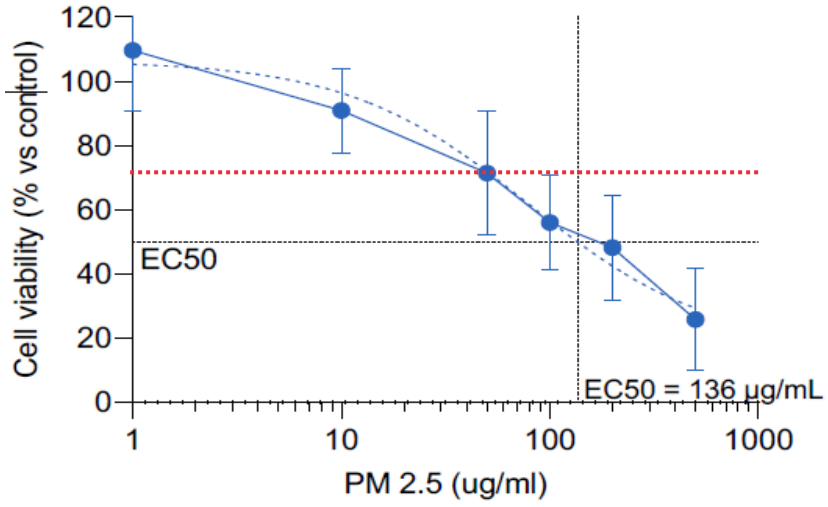
Health Impact

A549 epithelial cells

Dispersion of PM in cell colture (24-48 hours)

Detection of responses

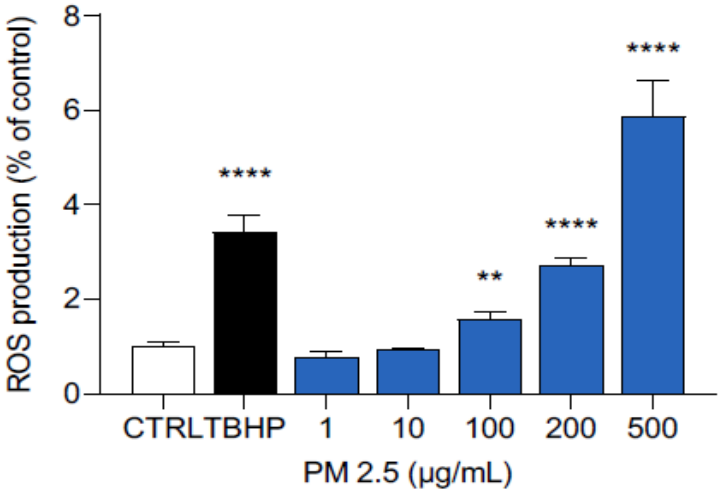
Cell Viability
(Alamar Blue Assay)



Unexposed cells → **100% Cell Viability**

Cells Exposed to PM2.5 → **Critical PM, cell viability < 70%**

ROS Production
(Reactive Oxygen Species Assay)

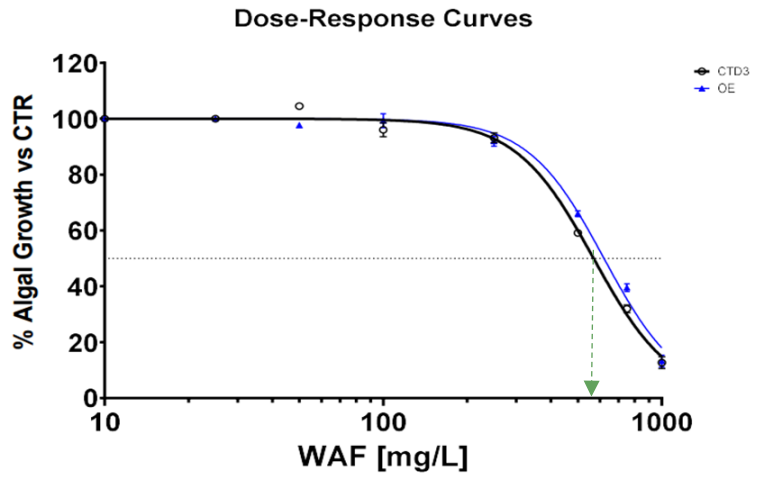


High ↑ **ROS Production** → **Cells are suffering**

Low ↓ **ROS Production** → **Cells are doing fine**

Environmental Impact

Terrestrial response



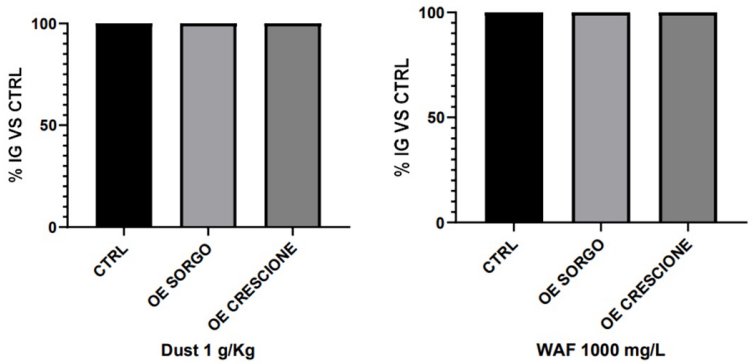
Dust

- Lephidium Sativum (plant)

WAF

- Lephidium Sativum (plant)

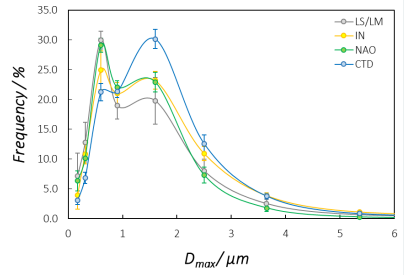
Aquatic response



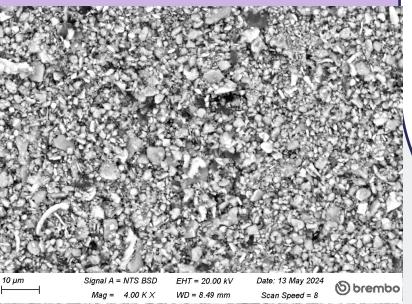
WAF

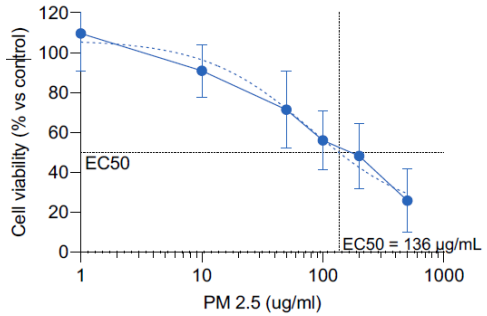
- Raphidocelis subcapitata (alga)
- Daphnia Magna (crustacean)

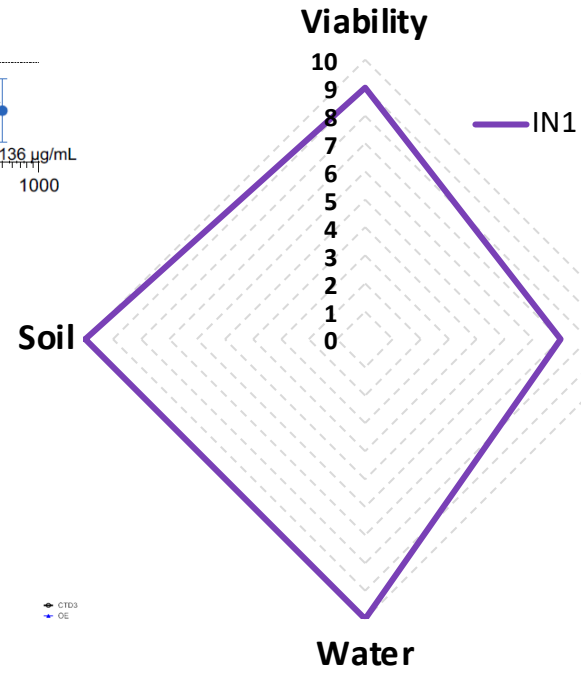
Output – Example

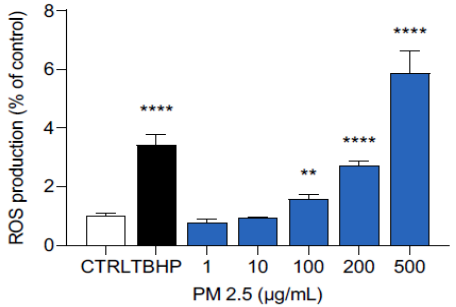


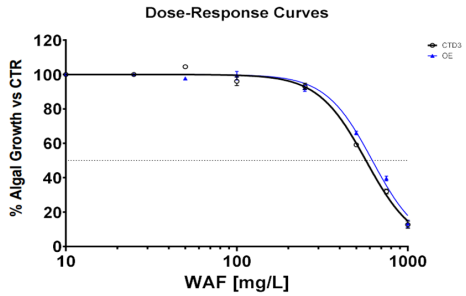
PM10		
	wt%	SD
Fe	57.2	0.5
O	21.9	0.1
C	13.1	0.6
Sn	1.5	<0.1
Mg	1.4	<0.1
Si	1.2	<0.1
Zn	0.8	<0.1
Al	0.7	<0.1
Ti	0.6	<0.1
S	0.5	<0.1
Cr	0.5	<0.1
Ca	0.3	<0.1
Cu	0.3	<0.1
K	0.2	<0.1
P	-	-

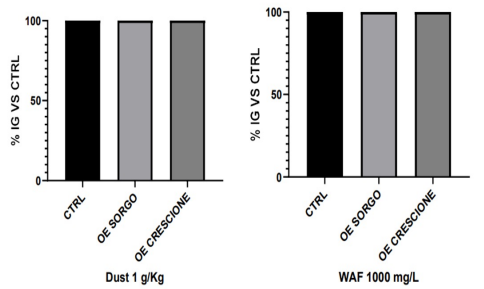












Conclusions

- Brembo's protocol focuses on the physico-chemical and environmental assessment of brake wear particles
- The aim is to enhance understanding and mitigation of non-exhaust emissions
- The goal is to reduce emissions and improve environmental compatibility

Thank you

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