Styler Research Group

HEI

Atmospheric reactivity of brake wear: implications for predicting and improving air quality

Laura Matchett, Maya Abou-Ghanem, Kristyna Stix and Sarah A. Styler

McMaster University | Department of Chemistry & Chemical Biology

UNIVERSITY OF ALBERTA
DEPARTMENT OF CHEMISTRY

Traffic particulate matter

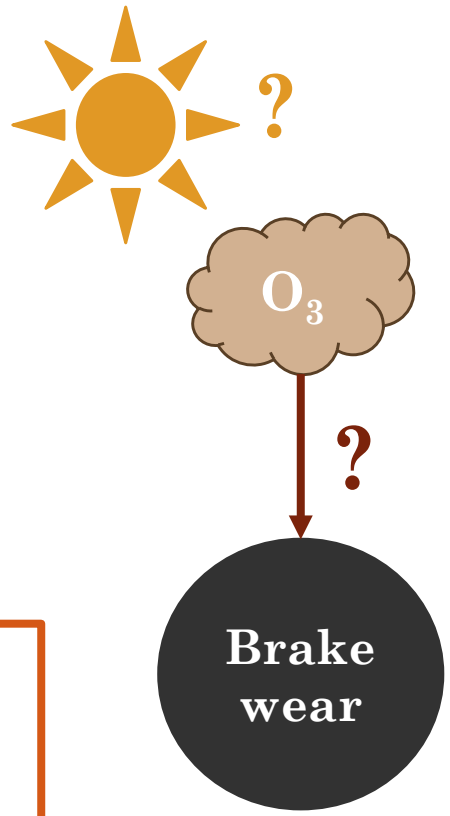
- Particulate matter (PM) is linked to adverse health effects, including cardiovascular and respiratory illnesses [1]
- Globally 25% of urban $PM_{2.5}$ and PM_{10} is from traffic [2]

- Exhaust emissions are decreasing
- Non-exhaust emissions are starting to dominate traffic PM
- Brake wear = 16-55% of non-exhaust PM_{10} mass loadings [3]

1. Samet, J. M.; Zeger, S. L. The New England Journal of Medicine 2000, 8.
2. Karagulian, F et al.. Atmospheric Environment 2015, 120, 475–483.
3. Grigoratos, T.; Martini, G. Environmental Science and Pollution Research 2015, 22 (4), 2491–2504.

Reactivity of brake wear

- Studies have examined the amount, size, chemical composition, and health impacts of emitted brake wear [1]
- However, little is known about the fate of brake wear in the atmosphere
- One process that can occur is the uptake of gases by the particle [2]
- Can change the concentration of the gas, form new gaseous products, or change the properties of the particle [2]



Objectives:

1. Use ozone as a probe molecule to investigate brake wear reactivity
2. Illuminate the samples to determine possible photoreactivity
3. Investigate which brake pad components contribute to the reactivity

1. Grigoratos, T.; Martini, G. Environmental Science and Pollution Research 2015, 22 (4), 2491–2504.
2. Kolb, C E, et al. Atmos. Chem. Phys. 2010, 10, 10561–10605.

Sample selection

Ceramic (NAPA)

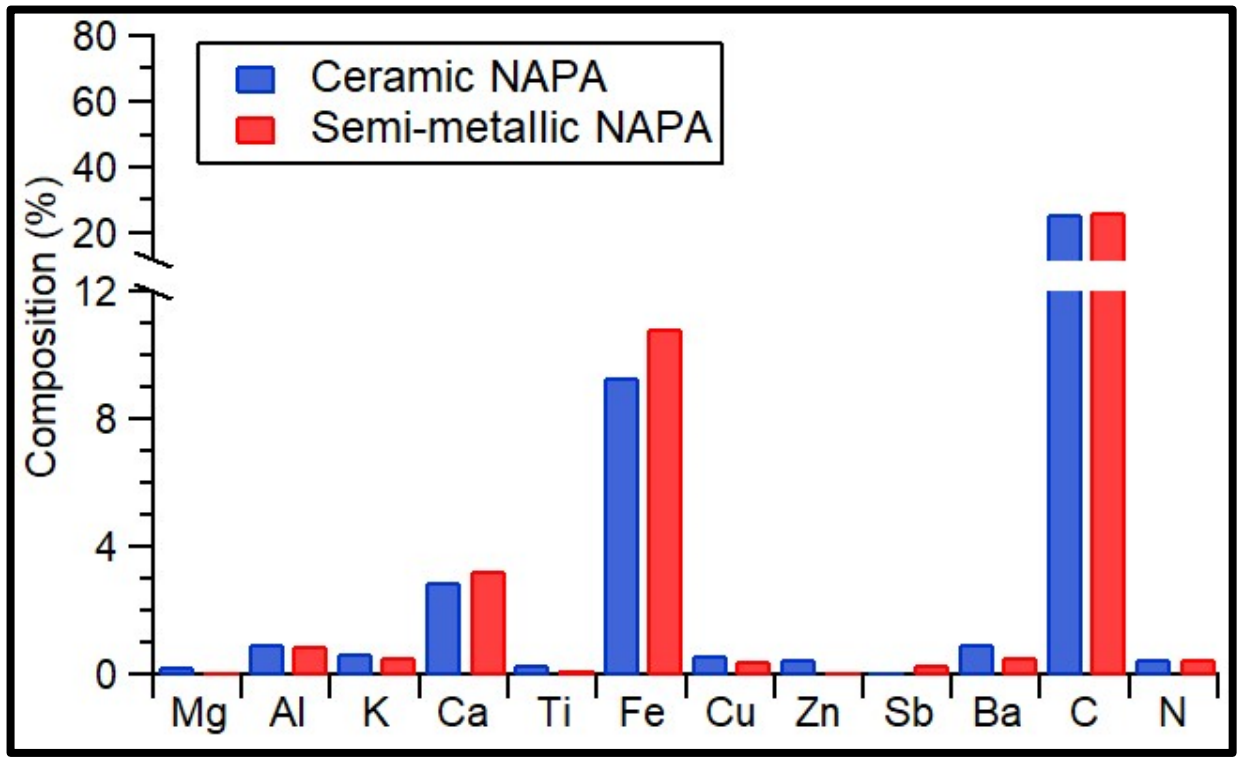
Semi-metallic (NAPA)

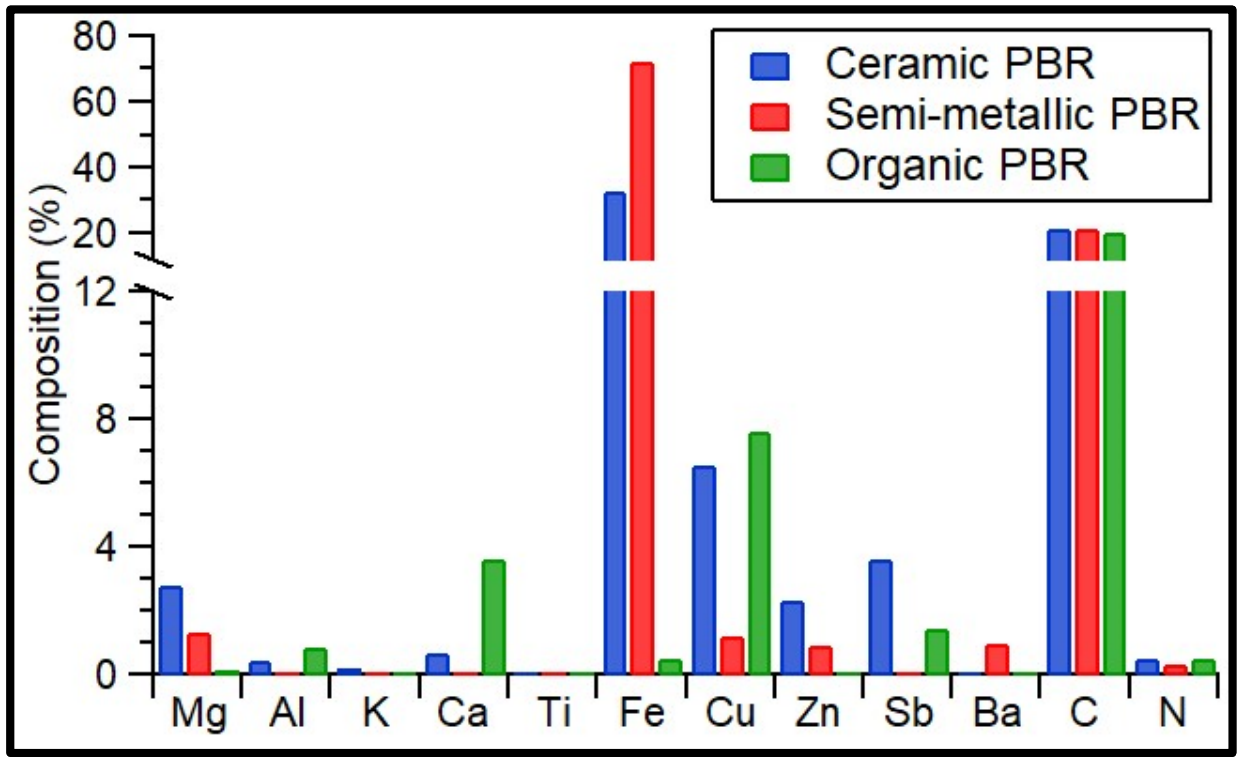
Ceramic (PBR)

Semi-metallic (PBR)

Organic (PBR)

Characterization of brake pads

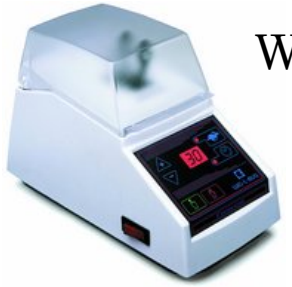




- Determined using ICP-MS and total carbon/total nitrogen combustion analysis
- Metal composition differs between types and between manufacturers
- Carbon and nitrogen is similar for all samples

Experimental procedure

1. Grinding

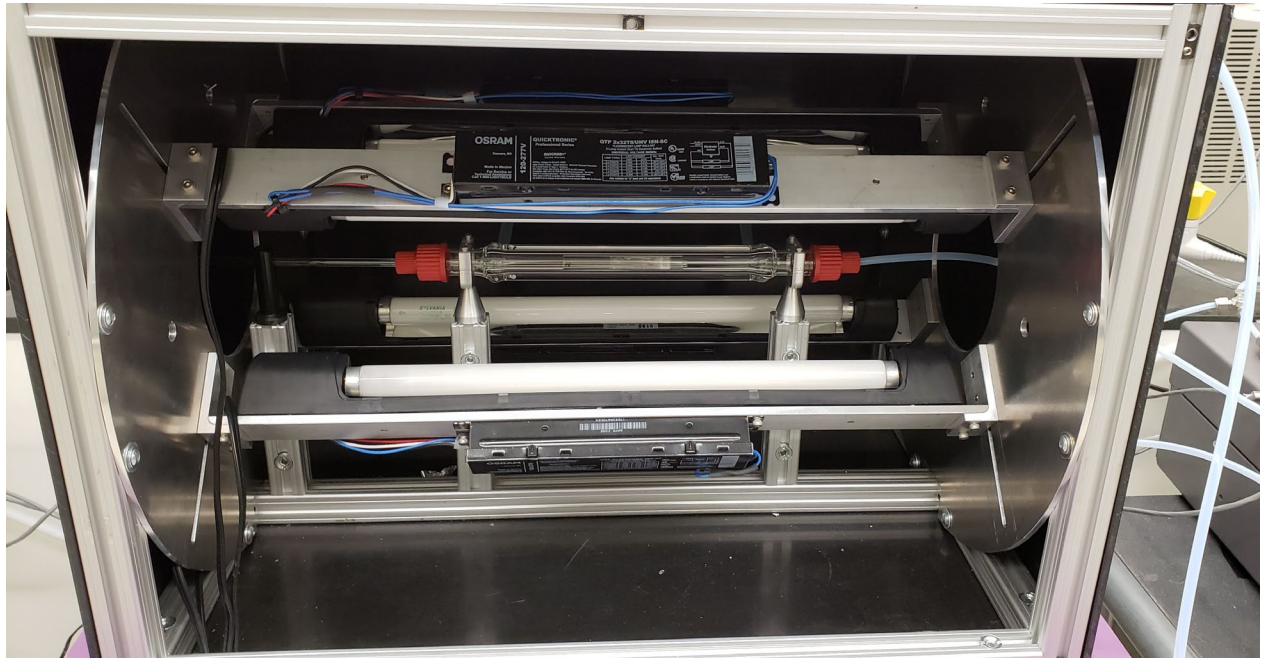


Wig-L-Bug

2. Coating on Pyrex tubes

3. Coated-wall flow tube experiments

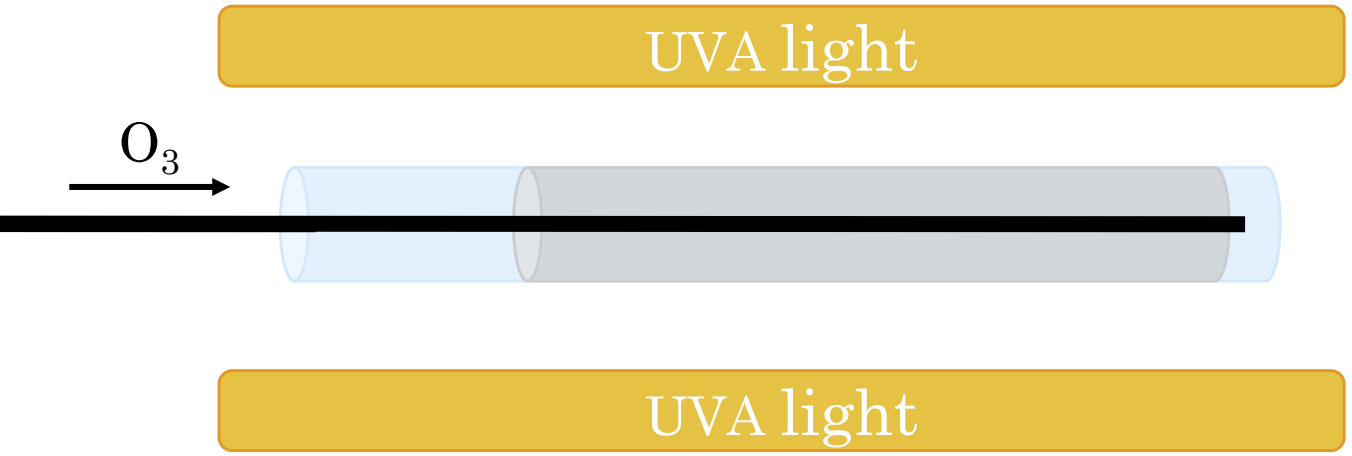
RH = 25%
$[O_3]$ = 50 ppb



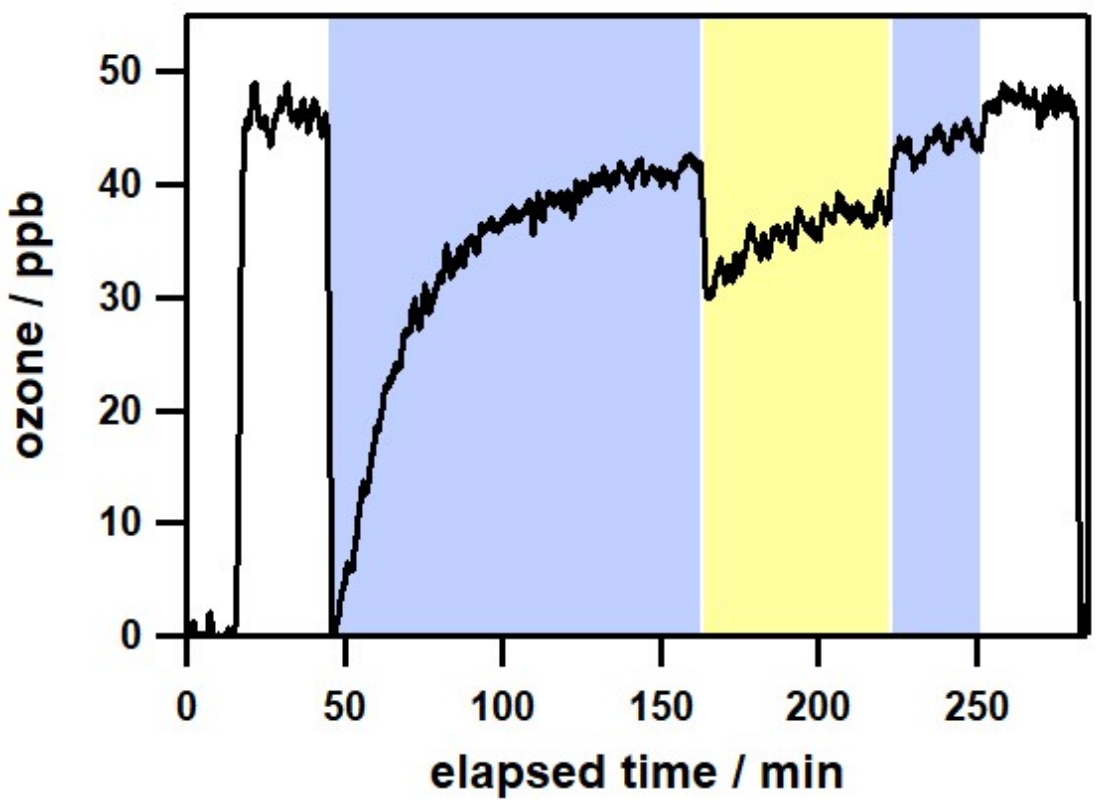
O_3 analyzer

Coated-wall flow tube protocol

30 min Baseline → 2 hour Dark → 1 hour Light → 30 min Dark → 30 min Baseline

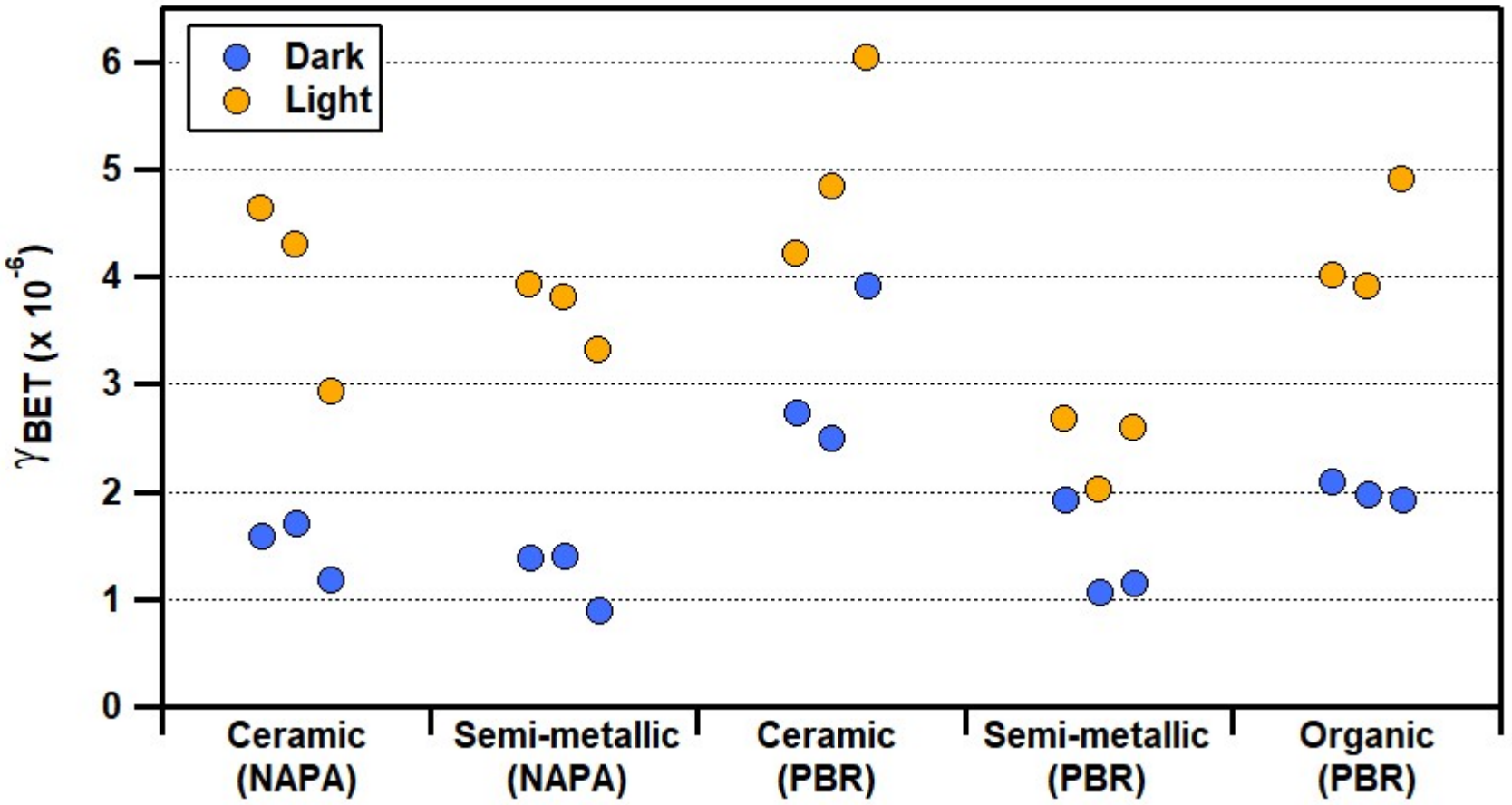


Semi-metallic (NAPA)



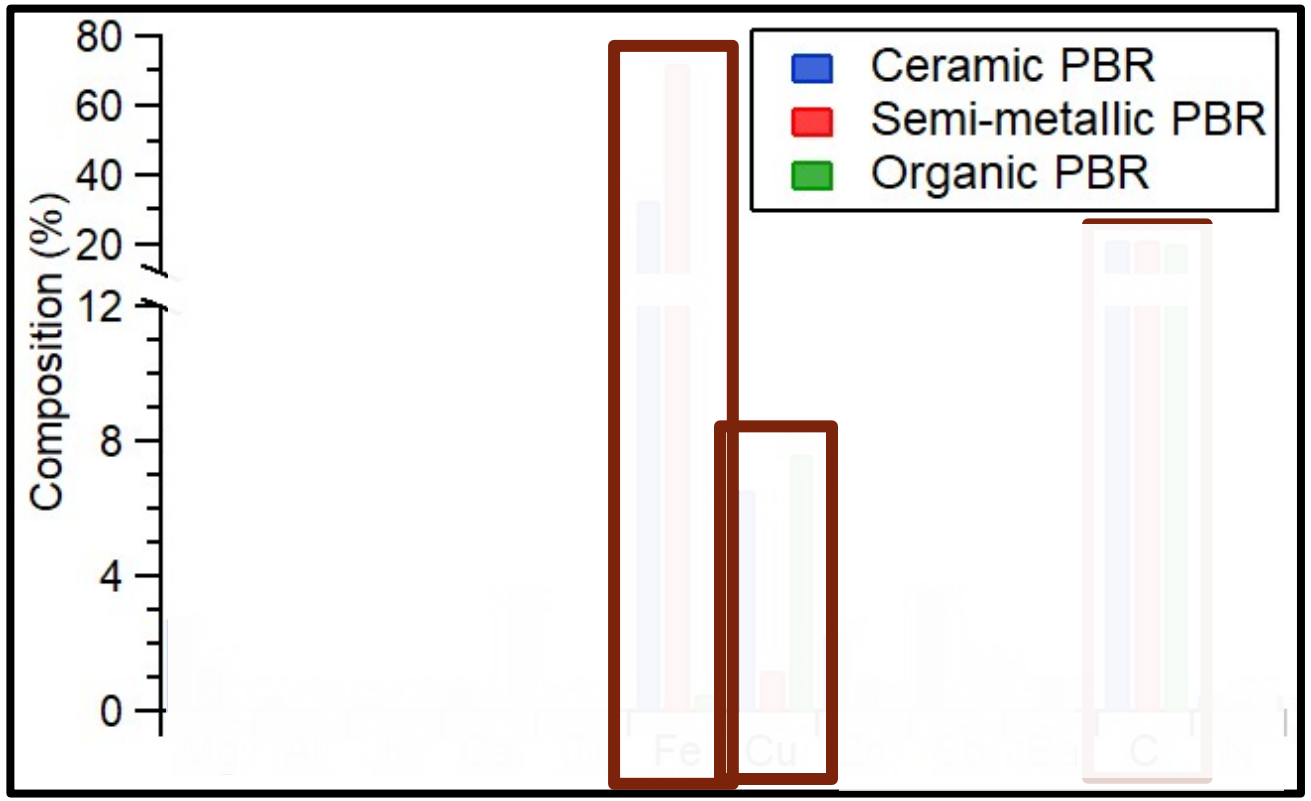
Uptake of O_3 on brake wear

Uptake coefficient (γ) = fraction of successful collisions of O_3 with brake wear



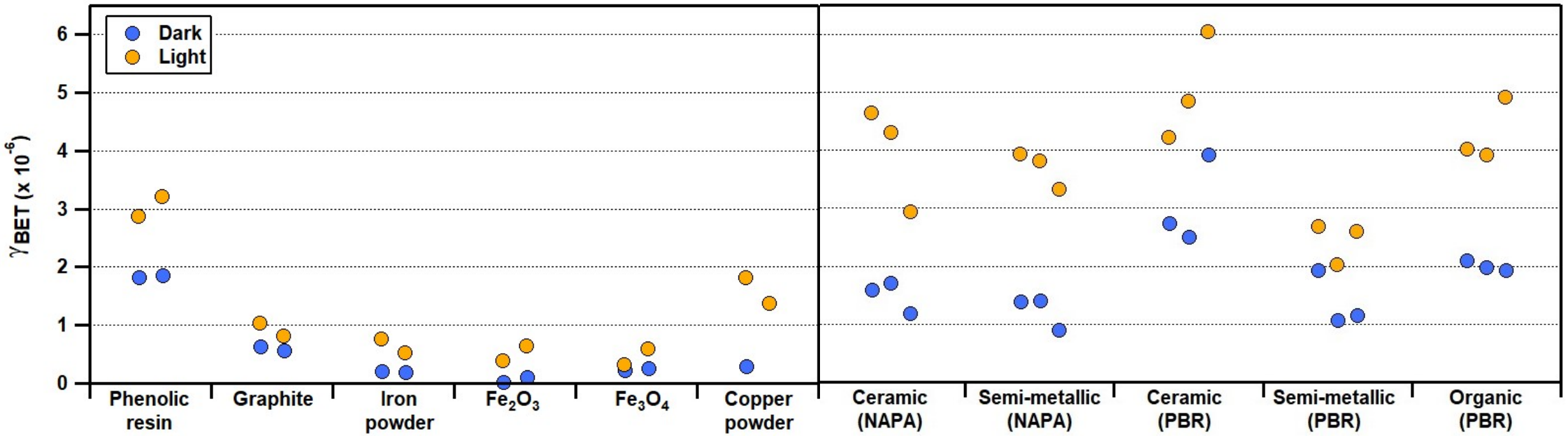
- Enhancement in the light
- Uptake coefficients within the same order of magnitude
- One order of magnitude larger than for road dust

Exploring components of brake pads



- Phenolic resin
- Graphite
- Iron powder
- Fe_2O_3 / Fe_3O_4
- Copper powder

Uptake of O_3 on brake pad components



- All components tested are reactive with enhancement in the light
- Brake wear reactivity is a combination of many components
- Phenolic resin was the most reactive component

Conclusions

- Uptake coefficients for O_3 on the five brake wear samples are within an order of magnitude
- This may simplify the implementation of this process into models
- We don't expect brake wear to impact modeled ozone concentrations
- Brake wear particles could be oxidized in the atmosphere, which may have implications when investigating their impact on health
- These results are for mechanically generated brake wear
- During braking also have oxidative wear due to high temperature and pressure

Acknowledgements

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Characterization

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Coated-wall flow tube construction

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- Dr. Manolis Romanias and Dr. Jason Olfert

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Questions?