

# ORGANIC SPECIATION OF NON-EXHAUST PARTICLES FROM WEAR BETWEEN PAVEMENTS AND TYRES

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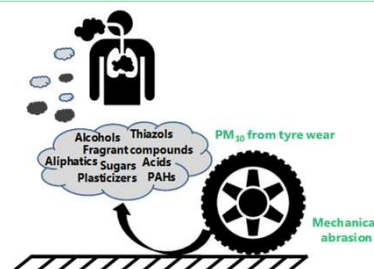
## Background

Road traffic emissions represent a large contribution to particulate matter concentrations in urban areas [1]. While stringent policies have led to sizeable reductions in exhaust emissions, currently, non-exhaust emissions from road vehicles, which include particles from brake and tyre wear and pavement abrasion, are still unabated. Improved information about particle emissions and their physico-chemical properties from tyre and pavement wear interaction is important

not only to infer the health effects, but also to devise source-oriented mitigation measures, and to model source contributions. This work aimed at characterising the organic composition of wear particles from the interaction between wheels and pavements, as well as the relationship with the chemical composition of the tyres.

Figure 1

Emission of inhalable particles from tyre wear of road pavements



## Design

A road simulator was used to generate wear particles from the interaction between 2 tyre brands and a composite pavement. Sampling of inhalable particles (PM<sub>10</sub>) was conducted with a high-volume sampler equipped with quartz filters. The organic carbon (OC) of PM<sub>10</sub> was determined by a thermo-optical system. Tyre rubber fragments and about 350 cm<sup>2</sup> of each filter were used to perform organic speciation by GC-MS. Samples were extracted with DCM and methanol. The total organic extracts were separated into 5 different organic fractions. The more polar organic compounds were silylated before chromatographic analysis [2].

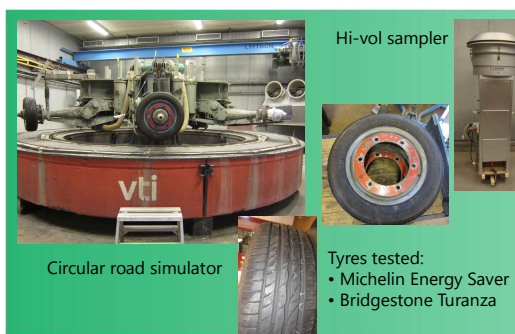


Figure 2

Sampling and analysis of tyre wear particles

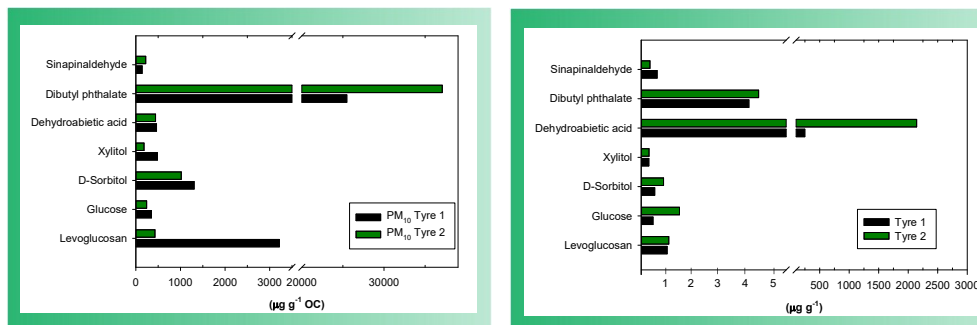
## Results

Table 1 Mass fractions of triaromatic steranes (m/z 231), monoaromatic steranes (m/z 253), steranes (m/z steranes), hopanes (m/z 191) and other classes of organic compounds

GROUPS OF ORGANIC COMPOUNDS	PM <sub>10</sub> from tyre type 1 (µg g <sup>-1</sup> OC)	PM <sub>10</sub> from tyre type 2 (µg g <sup>-1</sup> OC)	Tyre type 1 (µg g <sup>-1</sup> )	Tyre type 2 (µg g <sup>-1</sup> )
Σ alkanes	43,150	40,764	3,401	1,138
Σ triaromatic steranes	296	-	172	170
Σ monoaromatic steranes	158	270	66.4	60.2
Σ steranes	609	912	137	108
Σ hopanoids and triterpenoids	953	1392	356	266
Σ PAHs	1,237	933	131	169

*n*-Alkanes are added to the tyre stock solution as agents to protect the rubber material from oxidants and UV-light induced cracking. Hopanoids possibly derive from polymeric synthetic rubbers or some specific chemical fillers made from petroleum, which are nowadays added to the tyres. Monoaromatic, triaromatic steranes, and steranes are a group of biomarker compounds that have been used for oil source tracking. Almost all (92.3%) of the total extractable PAH content was ascribed to five compounds: benzo[ghi]perylene, coronene, indeno[1,2,3-cd]pyrene, benzo[e]pyrene, and benzo[a]pyrene. Retene was observed at comparable mass concentrations to those of other PAHs. It may originate from the natural waxes and resins (e.g. pine tars) added as softeners and extenders to the recipe of the rubber stock.

Figure 3 Mass fractions of some of the polar organic compounds detected in both the wear particles and the tyres



Although the mechanisms remain to be explained, it is likely that temperatures reached either in the vulcanisation process or in the friction between the tyre and the pavements during vehicle running can convert part of the cellulose fibres into sugars. Resin acids from pine-tree gum-resin, such as dehydroabietic, are used in the tyre manufacturing process as emulsifying agents. It should be noted that tyre rubber contains a huge number of components, such as reinforcing, activating and vulcanising agents, antioxidants, processing oils, and fragrance-emitting rubbers.

## Conclusions

Organic carbon represented about 10% of the PM<sub>10</sub> mass, encompassing a myriad of aliphatic compounds (*n*-alkanes, alkenes, hopanes, and steranes), PAHs, thiols, *n*-alkanols, polyols, some fragrant compounds, sugars, triterpenoids, sterols, phenolic constituents, phthalate plasticisers, several types of acids, among others.

The detection of compounds that have been extensively used as biomass burning tracers (e.g. retene, dehydroabietic acid and levoglucosan) in

both the tyre samples and the wear particles invalidates their uniqueness as markers of wood combustion.

Among the approximately 300 organic compounds analysed, the presence of some of them is documented, as far as we know, for the first time. The complex chemical composition of wear particles reflects the wide range of compounds employed in tyre manufacturing.

### Acknowledgements

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