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Ultrafine Brake Wear Particles in Real-World Scenarios: Morphology and Composition

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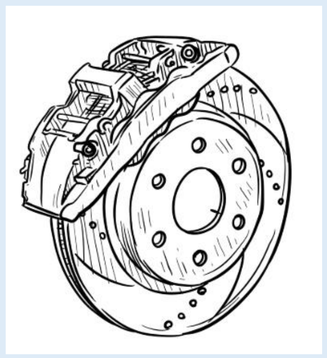
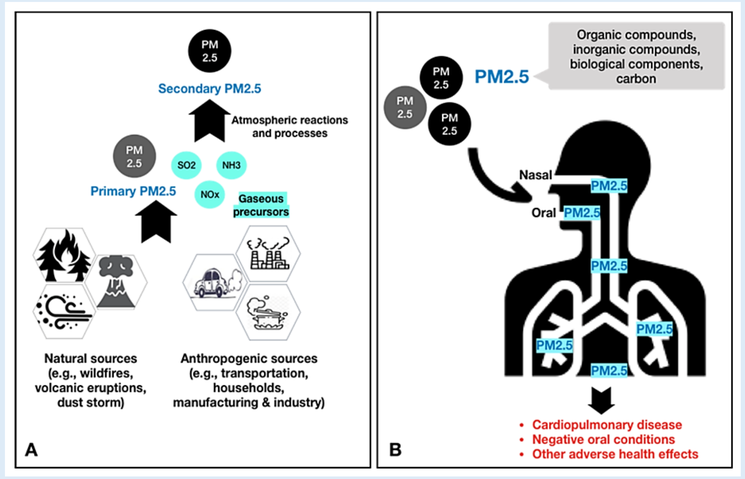
Introduction & Objectives

Brake wear is an important source of non-exhaust particles in urban air. Ultrafine particles (<100 nm) are of particular concern due to their potential to penetrate deep into the lungs and carry toxic metals (Oberdörster et al., 2005). While brake particle emissions have been studied under controlled conditions, there is limited knowledge on their morphology and chemical composition in real-world scenarios. This work investigates the structure and elemental content of brake particles emitted during high-temperature braking events using on-road sampling and electron microscopy techniques.

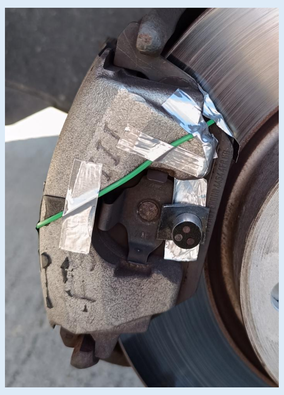


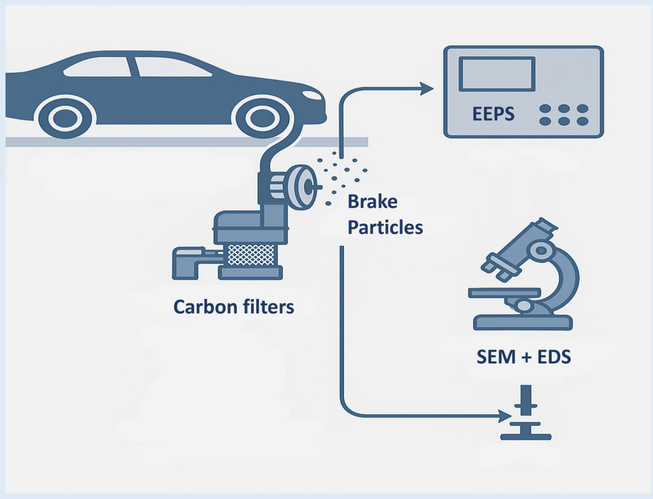


Vo et al. (2020). *Biochem. Pharmacol.*

Materials & Methods

Brake particles were collected during on-road tests using a custom sampling system positioned near the front brake caliper of a passenger car. The vehicle underwent repeated decelerations from 120 to 0 km/h, reaching brake disk temperatures of up to 200 °C. Ultrafine particles were sampled onto carbon-coated TEM grids and analysed off-line using Scanning Electron Microscopy (SEM), and Energy-Dispersive X-ray Spectroscopy (EDS) to assess particle morphology and elemental composition.





Results

Figure 1

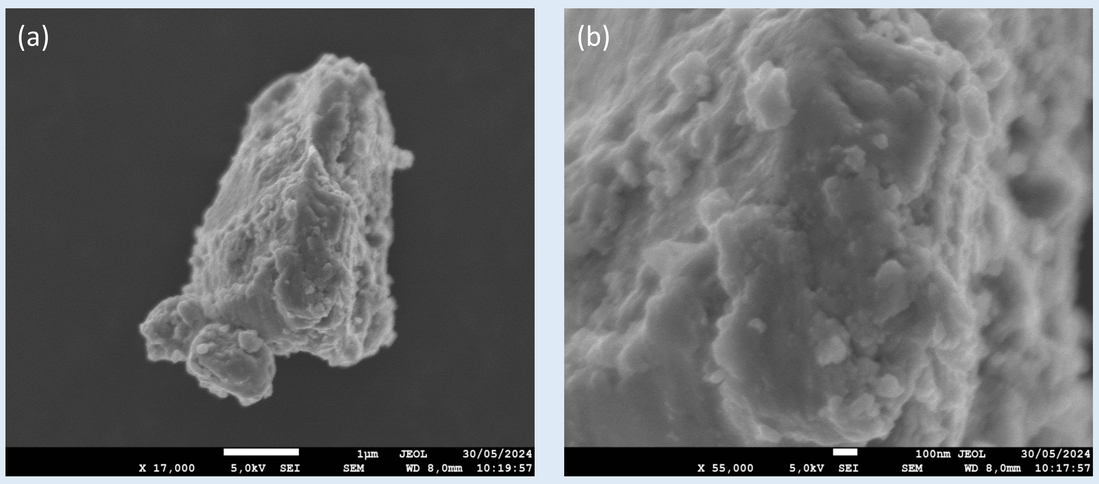


Figure 2

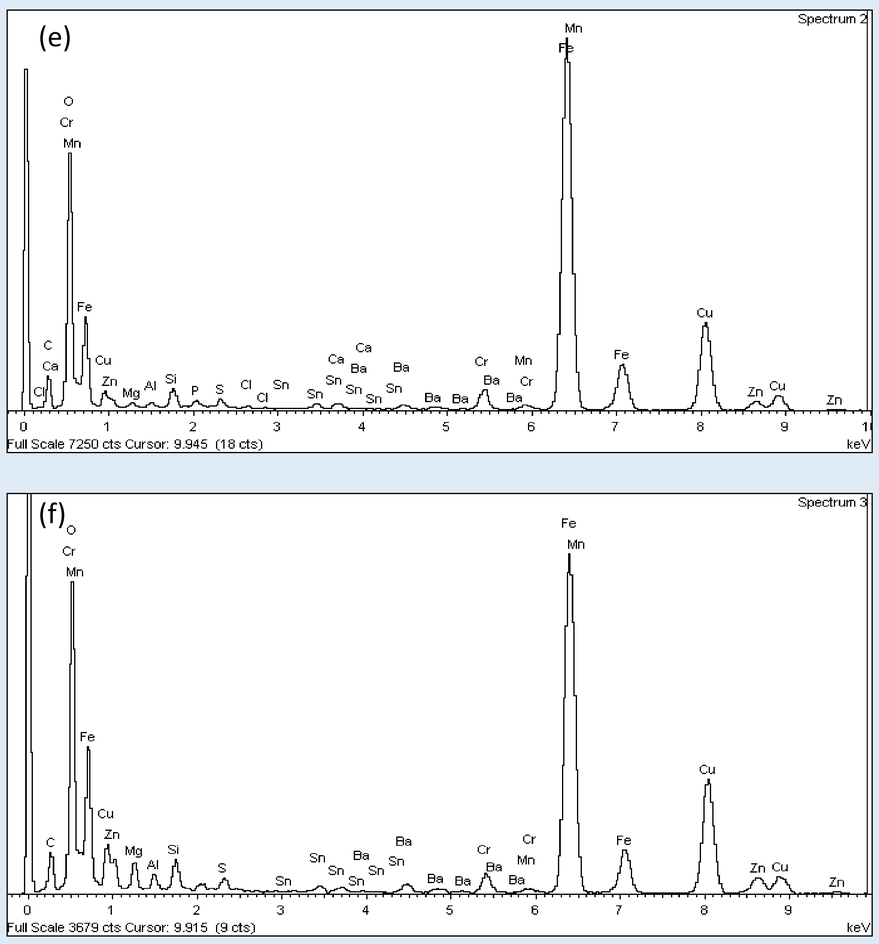


Figure 1. SEM images of particles under the two Tdisk conditions examined. Images (a) and (b) correspond to a final Tdisk of 257 °C, and images (c) and (d) correspond to a final Tdisk of 307 °C. **Figure 2.** EDS spectra of representative particles for each condition. Spectrum (e) corresponds to a particle collected at a final Tdisk of 257 °C, while spectrum (f) corresponds to a particle collected at a final Tdisk of 307 °C.

Conclusions

- **Brake disk temperature** strongly influences particle formation mechanisms.
- At ~250 °C, particles are **rough and irregular**, indicating mechanical abrasion.
- At ~307 °C, particles become **smoother and spherical**, suggesting thermal degradation.
- **Elemental analysis** shows Fe as dominant, with Sn, Zn, Ba, Si, and trace metals also present.
- **Real-world sampling + electron microscopy** is key to understanding the particles chemical composition and hence, the potential health and environmental impact of non-exhaust emissions.

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