Chemical characterization and evolution of tire wear emissions: from source signatures to transformation and hygroscopic properties (TWEET)

Abstract

Road transport remains a major contributor to air pollution. While exhaust emissions have been significantly reduced through technological advances and the progressive electrification of vehicles, non-exhaust emissions—including brake, road, and tire wear—are increasingly recognized as dominant and still poorly characterized sources of pollutants. Among these, tire wear particles (TWPs) constitute a complex mixture of organic compounds, additives, and metals, emitted both in the particulate and semi-volatile phases. TWPs accumulate in many environments (air, stormwater runoff or through bioaccumulation in vegetation and animals) and can be a major source of microplastics and heavy metals that are toxic to human and animal health. Despite growing attention, important uncertainties remain regarding the chemical composition, atmospheric transformation, and environmental behavior of tire-derived emissions. In particular, the impact of atmospheric aging on their physicochemical properties—such as oxidation state, surface reactivity, and interaction with water—remains insufficiently understood.

This collaborative PhD project between IMT Nord Europe and the Université de Lille (LASIRE UMR 8516 CNRS) aims to characterize tire wear particulate emissions from primary release to atmospheric evolution. The objectives are to (i) develop a method to quantify TWP and their selected additives using pyrolysis-GC-MS,

(ii) identify chemical tracers of TWPs in controlled and real-world samples,

(iii) investigate compositional and surface changes induced by aging, and

(iii) assess their hygroscopic properties.

At IMT Nord Europe, emissions from new and aged tires (summer, winter, and all-season) will be analyzed using complementary techniques including microchambers, TD-GC-MS, pyrolysis-GC-MS, and FTIR spectroscopy to determine molecular composition and functional groups. Samples collected in traffic-influenced environments will be studied to evaluate the relevance of identified tracers under realistic conditions. TWP's metal content and distribution in the particles will be investigated using ICP-MS and surface-sensitive approaches. At LASIRE, particle morphology, elemental composition, degree of encrustation and surface characteristics will be examined using electron microscopy (MEB/EDX), while electron paramagnetic resonance (EPR) will be employed to identify persistent radical species

formed during aging and assess their potential role in particle reactivity. The project will also examine how simulated and real environmental aging modifies the interaction of TWPs with water, providing insight into their evolving physicochemical properties in the atmosphere. Overall, this work will improve the mechanistic understanding of tire wear as an emerging source of urban air pollution and support its consideration in air quality studies.

Candidate Profile

We are seeking a highly motivated candidate with a strong background in **atmospheric chemistry, physical chemistry, or a related field**.

The ideal candidate should have:

- A Master's degree (or equivalent) in atmospheric chemistry, physical chemistry, environmental science, or a closely related discipline
- Knowledge of analytical techniques, particularly spectrometric and/or spectroscopic methods (e.g., GC-MS, FTIR, or similar)
- Interest in experimental laboratory work and physicochemical characterization of complex systems
- Ability to work in a multidisciplinary and international research environment
- Strong organizational skills, scientific rigor and autonomy
- Good communication skills in English (written and spoken)

Previous experience with atmospheric simulation chambers, aerosol analysis, or advanced analytical instrumentation will be considered an asset. The candidate will be involved in a collaborative research project at the interface of atmospheric chemistry, materials science, and environmental analysis, with opportunities for interaction between IMT Nord Europe and the Université de Lille, within the laboratories from the cross-disciplinary project "Aerosols at the heart of the atmosphere" (CDP AREA) research consortium.

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