



Towards real-world TRWP quantification: Combining a novel enclosed collection system with optical sensors to mitigate particle loss in tire emission measurements

Miriam Chacón-Mateos¹, Manuel Löber¹, Nina Reijrink¹, Sven Reiland², Michael Eßl², Fabius Epple², Nina Gaiser¹, Franz Philipps², and Markus Köhler¹

¹German Aerospace Center (DLR), Institute of Combustion Technology, Stuttgart, Germany

²German Aerospace Center (DLR), Institute of Vehicle Concepts, Stuttgart, Germany

The significant impacts of tire and road wear particles (TRWP) on human health and the environment are increasingly being recognized. As a major source of microplastics, tire abrasion presents a pressing challenge, especially with the introduction of the Euro 7 standard, which will regulate brake and tire wear emissions for the first time. However, the absence of standardized methods for airborne TRWP measurements remains a critical barrier. Accurate quantification of airborne TRWP emissions requires complex measurement systems, which are often susceptible to particle loss during sampling.

As part of the “Models and Data for Future Mobility_Supporting Services (MoDa)” project, we aim to develop customer-oriented solutions to support the transformation of the transport sector. One such solution is AirQualityLive (AQL), designed to generate actionable insights from air quality data and enable evidence-based decision-making for cleaner and more sustainable mobility.

This study aimed to enhance measurement precision and mitigate particle loss during tire emission assessments conducted on a chassis dynamometer test bench during Worldwide Harmonized Light Vehicles Test Cycles (WLTCs) applied to a electric car. To achieve this, we designed an enclosed tire system (patent pending) and tested the integration of low-cost optical particle counters (OPCs) to measure airborne tire emissions. Two isokinetic particle collection systems were compared: (1) a closed collection system encapsulating the tire, isolating it from brake and environmental interferences, and (2) an open collection system. For that purpose, two parallel set-ups were mounted behind the back tires including for each system gravimetric measurements of PM₁₀ and PM_{2.5}, a cascade impactor with four particle size stages (>PM₁₀, PM_{2.5-10}, PM_{2.5}, and <PM₁), continuous particle number measurements using a mixing condensation particle counter (Brechtel Model 1720; 7 nm–2 µm), and an optical particle sizer (TSI Model 3330; 0.3–10 µm). The background concentration was monitored using an additional optical particle sizer. Furthermore, four low-cost optical particle counters (Alphasense Model OPC-N3; 0.35 - 40 µm) were deployed: one in each of the sampling set-ups, one for background monitoring, and one for optimal measurement placement studies.

The enclosed collection system demonstrated superior performance for UPF and PM

measurements, collecting up to 10 times more particles in the 7 nm–2 μm size range and up to 3 times more particles in the 0.3–10 μm size range compared to the open system. Moreover, preliminary results indicate that calibrated sensors can effectively measure highly time-resolved PM coarse concentrations if placed in close proximity to the tire, being a cost-effective complement to the gravimetric and PM measurements. The results underscore the importance of the measurement system and how the combination of a closed collection system with direct PM sensor measurements can enhance the quantification of real-world tire emissions.