27th ETH Nanoparticles Conference June 10-14, 2024, ETH Zurich
Topic: Toxicology

Traffic-related non-exhaust emission UFPs toxicological potentials

J. Becker[1,2], J. Pantzke[1,2], S. Offer[1,2], C. Neukirchen[3], M. Saraji-Bozorgzad[1], E. Kuhn[1], A. Mudan[3], A. Das[1,2], M. Sklorz[1], T. Adam[1,3], S. Di Bucchianico[1,2], R. Zimmermann[1,2] and the ULTRHAS consortium.

[1]Joint Mass Spectrometry Center (JMSC) at Comprehensive Molecular Analytics (CMA), Helmholtz Zentrum München, D-85764 Neuherberg, GER

[2] JMSC at Analytical Chemistry, Institute of Chemistry, University of Rostock, D-18051 Rostock, GER

[3]Universität der Bundeswehr MUC, Institute of Chemical and Environmental Engineering, Fakultät für Maschinenbau, D-85577 Neubiberg

Email of main speaker: Johannes.becker@helmholtz-munich.de

BACKGROUND: Traffic-related non-exhaust emissions (NEE) include ultrafine particles (UFPs) generated from vehicle brake wear and railway catenary systems, among others. NEE account for a substantial portion of particle matter (PM) emission from transportation, and therefore pose severe risks to human health. Brake wear contributes significantly to the release of NEE PM, but its characteristics and related toxicological potential may vary depending on the material formulation used, including metals. Like rail catenary sparking contributing to PM fractions with high metal content UFPs. As the nature of origin shape aerosol characteristics and hazard to human health a deeper understanding of toxicologic effects of NEE PM is needed.

METHODOLOGY: For this reason, we investigated the toxicological effects of relevant PM from brake wear and catenary sparking in a controlled laboratory environment. An automated brake dynamometer running a Worldwide Harmonized Light-Duty Vehicles Test Procedure (WLTP) was used to generate PM emissions from a non-asbestos organic (NAO) and a low-metallic (LM) brake pad. A spark discharge aerosol generator was applied to model copper containing UFPs emitted from catenary sparking. Two different lung cell models, a monoculture (MC) of A549 alveolar epithelial cells and a co-culture (CC) system consisting of Calu-3 bronchial epithelial cells, THP-1 differentiated M0 macrophages and EA.hy926 vascular endothelial cells were exposed to these aerosols at the air-liquid interface.

RESULTS: Dose-response assessments for NEE UFPs effects on cellular metabolic activity, barrier integrity and cytotoxicity, were performed. Brake wear and catenary sparking copper particles induced mild cytotoxicity, as measured by the release of lactate dehydrogenase. NAO-pad particles induced a decrease in metabolic activity in the CC system. Copper UFPs induced a less pregnant decrease of metabolic activity, whereas LM-pad particles did not affect metabolic activity. Epithelial barrier integrity was compromised by NAO-particles and copper UFPs, while LM particles did not weaken the epithelial layer. Further investigations will be conducted to determine biomarkers of pro-inflammatory activation and oxidative stress, as previous studies have linked brake wear emission to these events, accompanied by comprehensive genotoxicity, transcriptomic, and proteomic analysis.

This work was supported by the ULTRHAS project funded under the EU´s Research and Innovation programme Horizon 2020 (Grant agreement No. 955390).