On-site ALI versus Submerged Culture: Toxicological and Chemical Investigation of Brake Wear Nanoparticles

Bozhena Tsyupa[1,3*], Chiara Emma Campiglio[4], Elena Carrara[2], Alessandro Mancini[3], Karine Elihn[5], Georgios Tsakonas, Andrea Remuzzi[4], Manuela Teresa Raimondi[1],

[1]*Department of Chemistry, Materials and Chemical Engineering "G. Natta", Politecnico di Milano, Italy*

[2]*Department of Biomedical Engineering, Istituto di Ricerche Farmacologiche Mario Negri IRCCS, Bergamo, Italy*

[3] *Materials Engineering & Laboratories, GCF Research & Development, Brembo S.p.A, Stezzano, Italy*

[4]*Department of Management, Information and Production Engineering, University of Bergamo, Italy*

[5]*Department of Environmental Science, Stockholm University, Sweden*

** bozhena.tsyupa@polimi.it, bozhena_tsyupa@brembo.it*

Poor air quality represents one of the biggest risk, both for the human health and for the environment. It has been proven, that polluted air has a direct correlation with respiratory diseases and, in the worst cases, can lead to premature death [1]. Specifically, nanoparticles present in the atmosphere play an important role in determining hazardous effects on human health. Generally, environmental particulate matter originates from various sources, including e.g. non-exhaust PMs (particulate matters) from road transport, which contributes to the progressive worsening of air quality [2].

In this work, toxicological response of A549 cell line (lung epithelial adenocarcinoma cells) was evaluated, both in submerged and on-site ALI (Air-Liquid Interface) conditions. These two systems were exposed to nanometric PMs (<450 nm) resulting from wear process of car brakes. Toxicity was assessed via two different toxicity tests; cell viability (Alamar Blue) and cytokine assays.

The nanoparticle emissions were collected using dynamometric bench, a set-up that simulates standard driving and braking conditions. For submerged condition, nanoparticles were collected on filters, detached and subsequently exposed to cells. Considering ALI conditions, a mobile ALI system was directly connected to the dynamometric bench and freshly emitted nanoparticles were directly exposed onto the cells. For both sampling campaigns, the WLTP (Worldwide harmonized Light vehicle Test Procedure) cycle was used. In this study, two friction materials were examined, labeled as M1a and M1b, both falling into the category of friction couples composed by grey-cast-iron brake discs and ECE R90 Low Metallic brake pads, but with different behavior in terms of chemical composition and braking performance. The morphology and chemical composition of emitted nanoparticles were evaluated through SEM/EDS and Raman Spectroscopy measurements.

A reduction in the cell viability was observed only with the M1a material and only in ALI condition. Further research is needed to understand better the differences obtained between two materials.

Acknowledgments

This research was supported by the European Commision's Horizon 2020 research and innovation programme: nPETS (grant agreement No 954377, https://www.npets-project.eu)

[1] Status of air quality in Europe, **2023,** Europe's air quality status 2023 — European Environment Agency (europa.eu)

[2] N. V. S. Vallabani, O. Gruzieva, K. Elihn et al, *Environmental Research*, **2023**, *231 (Pt.2)*, 116186