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Benefit-Risk Assessment of Diesel Particle Filters (DPFs): An Analytical and a Toxicological Challenge

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Filter or no filter is not the question anymore, except perhaps in the Swiss parliament which voted against a retrofit program for heavy duty vehicles in May 2014. In R&D, one asks if catalyzed or non-catalyzed filters are the best available technology for detoxification of diesel exhaust. Assessing the impact of filters on exhaust composition and toxicity is challenging for analytical chemists and toxicologists (see the Highlight of Bisig *et al.*, *Chimia* **2015**, *69*, 68). Are toxic compounds reactive species triggering oxidative stress and inflammation, are they genotoxic inducing cancer or do they provoke other cell responses?

The endeavor 'NEAT' (Neue Alpentransversale, the new transalpine rail link) triggered various activities, among them the VERT project (Verminderung der Emissionen von Realmaschinen im Tunnelbau) – a joint effort from SUVA, BAFU, filter and catalyst manufacturers, TTM, and EMPA – to evaluate suitable filter technology for construction machinery to fulfill air quality standards in these long tunnels (Fig. 1).

Fig. 1. Construction machinery in Switzerland has to be equipped with filters since 2009, but most trucks on roads are not.

By now all construction machinery in Switzerland has to be equipped with efficient filters fulfilling the VERT standards (efficiencies >98%). Approved filters must convert genotoxic compounds such as polycyclic aromatic hydrocarbons (PAHs) but must not support a *de novo* formation of other pollutants such as nitro-PAHs and polychlorinated dibenzodioxins/furans (PCDD/Fs). Fig. 2 displays sampling filters, exposed to 7 m^3 exhaust (3 min operation) of a heavy duty engine (6.1 L). A VERT-approved diesel particle filter was used in one case. The other sample represents untreated heavy duty vehicle exhaust (94% of the Swiss HDV fleet).

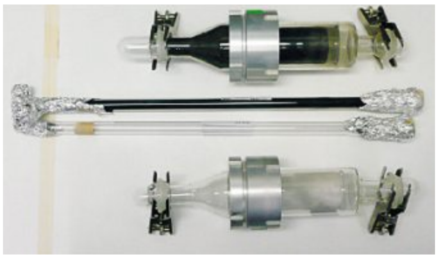

Fig. 2. Glass sampling devices exposed to 7 m^3 exhausts of a heavy duty engine (3 min operation) with and without filter.

Obviously, particles are removed with filters, but semi-volatile compounds including genotoxic PAHs and nitro-PAHs are not necessarily converted. An assessment of filters, now described in the Swiss Norm 277206, also includes an evaluation of genotoxic compounds. EMPA has contributed congener-specific PAH, nitro-PAH and PCDD/F analyses for >40 diesel particle filters with GC-HRMS.

Fig. 3 compares pyrene and 1-nitro pyrene penetration of filters with high, low and no oxidation potential. Catalyzed filters convert pyrene (75–97%). The non-catalyzed filter stored pyrene when new, but released it when soot-loaded. Such storage-release phenomena may occur when changing from cold to hot conditions (*e.g.* urban vs. highway driving). Emissions of 1-nitropyrene even increased for the non-catalyzed filter. A secondary formation of nitro-PAHs affects the exhaust genotoxicity. **We conclude that filtration *per se* is not sufficient to lower genotoxicity. Genotoxic compounds must be combusted in filters with efficient catalysts.**

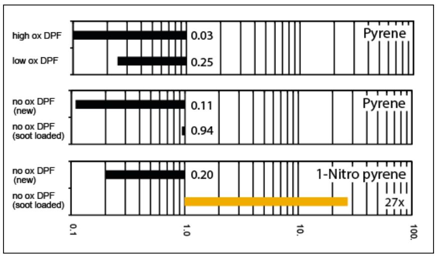

Fig. 3. Pyrene and 1-nitro pyrene penetration of filters with high, low and no oxidation potential (new and soot loaded) are compared.

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