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Toxicological evaluation of carbon fibre dusts after air-liquid interface exposure of lung cell cultures

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The role of carbon fibres (CF) as an advanced material is growing in various sectors of the industry, for example in the automotive, aerospace or wind power industries. However, there are only few studies addressing the release of CF dusts and their toxicological impact after inhalation. To fill this gap, within the CarbonFibreCycle project air-liquid interface (ALI) cultures composed of bronchial epithelial cells (BEAS-2B) and macrophage-like cells (THP-1) were established and exposed to a single dose of differently processed CFs via the Vitrocell® Automated Exposure Station. A high modulus CF was either milled in a ball mill or heated in a tube furnace at 800°C and then milled. The CF fragments were aerosolized and fed into the exposure station. The deposition within the exposure chamber and the resulting doses were measured by digital microscopy as well as by quartz crystal microbalance. After different post-incubation periods, the cultures were assessed with regard to viability (LDH, cell count), genotoxic effects (alkaline unwinding), gene expression (high-throughput RT-qPCR) and cytokine release (IL-8).

Exposure towards mechanically processed CFs did not generate any cytotoxic response in mono- (BEAS-2B) or cocultures (BEAS-2B/dTHP-1). In monocultures, gene expression profiles revealed a time dependent response in the inflammation and apoptosis clusters, which peaked at 1 hour of exposure and decreased with increasing post-incubation time. The initial increase in pro-inflammatory gene expression was mirrored in the IL-8 ELISA; however, cytokine release further increased with longer post-incubation times. While differences between mono- and cocultured cells were minor at the level of gene expression, IL-8 release was higher in cocultures.

Exposure towards thermally-mechanically processed CFs also did not induce cytotoxic effects as assessed with the LDH assay. However, this treatment resulted in a reduced cell count. The underlying mechanisms are still to be investigated.

In conclusion, we generated ALI cultures that are stable, easy to use and suitable for the assessment of fibre toxicity. Although the fibres were not highly toxic in the applied cultures, a specific response was detected on the gene expression and protein level, especially with respect to inflammation. The distinct responses induced by mechanically and thermally-mechanically processed fibres show that toxicological effects are highly dependent on fibre treatment and properties.