Characterisation and biological responses of inhalable aerosols from carbon fibres

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Keywords: carbon fibres, WHO fibres, aerodynamic diameter,
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Carbon fibres (CF) and CF-reinforced plastics (CFRPs) are innovative materials, which are increasingly produced, recycled and disposed, possibly releasing particles and fibres. The BMBF project “Carbon Fibre Cycle – CFC” has the aim to identify respirable particles, fibres and fibre fragments after thermal and mechanical treatment of CF/CFRP, to analyse them and to assess pulmonary toxicity. The fibrous shape of treated CF could be similar to asbestos fibres, which raises serious concerns about potentially harmful effects in the lung.

Based on a material flow analysis identifying relevant release scenarios of respirable dusts investigations of CF/rCF/CFRP-materials under thermal and mechanical stress are carried out. Inhalable aerosols are provided and characterized, which are delivered to the air-liquid interface of human lung cells (ALI) in an exposure system, where toxicological investigations are carried out, i.e. directly on the apical surface of cell cultures, in order to simulate lung-like conditions. Lung epithelial, macrophage and fibroblast cell cultures in mono and co-culture are used for toxicological evaluation of respirable CF fragments focussing on determination of cytotoxicity, gene expression analyses and determination of proinflammatory, profibrotic and genotoxic potential.

Commercial short carbon fibres based on polyacrylnitrile (PAN) were investigated in pristine and thermally treated form, and the size distribution of the generated aerosol was measured by sampling parallel to the exposure station using a cascade low pressure impactor. The aerosol from the exposure system was on the one hand sampled on filters which were analysed by different microscopy methods and on the other hand the deposited dose on the cell surfaces was measured by the online dose measurement employing a quartz crystal microbalance.

All images from digital and scanning electron microscopy (SEM) (Figure 1) were evaluated using the image analysis software FibreShape (IST AG, Switzerland) in combination with own data post processing.

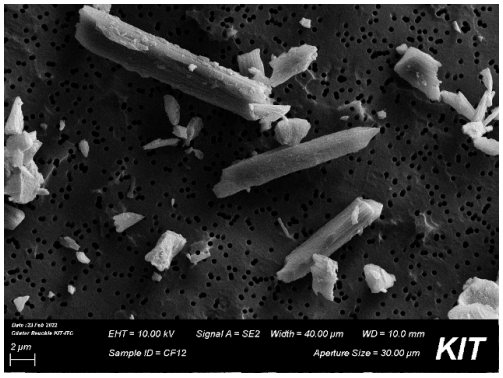

Figure 1. Scanning electron micrograph of carbon fibres deposited in the air-liquid interface.

The fibres were analysed regarding length, diameter (Figure 2) and in a further step the aerodynamic equivalent diameter was calculated.

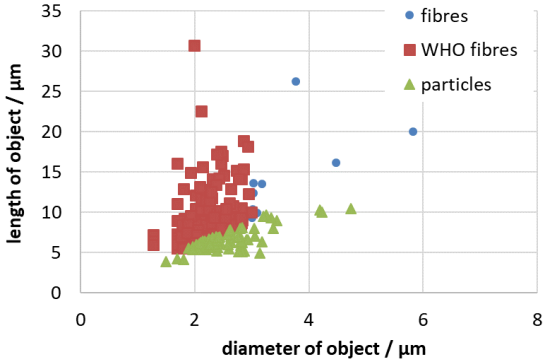

Figure 2. Single object evaluation of particles and fibres deposited on ALI exposed membranes in the exposure system.

Fibre characterisation and especially the generation of WHO fibres (critical aspect ratio > 3:1, length > 5 µm and diameter < 3µm) is discussed in the context with of biological responses caused by inhalable CF.

This project is financed by the Federal Ministry of Education and Research under project number FK03XP0195 which is greatly acknowledged.