Effect of flow rate on fiber deposition in the model of human lungs

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Keywords: fiber deposition, respiratory airways, optical microscopy, image analysis
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Long exposure and inhalation of fibers can have very harmful effects on human health, because they resist the pulmonary clearance mechanisms, penetrate deep into the human lungs and retain there. The toxicity of fibers depends on their size characteristics, e.g. length and diameter, and on their biopersistence. Asbestos were definitely banned in 2005 and after that they were replaced mainly by man-made vitreous fibers (MMVF). MMVF include glass, rock, wool or ceramic fibers. They are widely used nowadays, which motivates comprehensive research on this topic.

Glass wool fibers with diameter of 1 μm were used in this study. Generated fibers were classified in a classifier, their average length was 10 μm. Classified fibers were mixed with air in a dilutor and delivered into a realistic model of the human lungs (Figure 1.). The model consisted of oral cavity and respiratory airways up to the 7th generation of branching. Different flow rates were tested (30 and 50 LPM). Glass fibers, which passed through the model, deposited on the output filters. The model has 10 outputs therefore there were 10 output filters. Ten flow meters were situated behind the output filters to regulate the air flow generated by the air pump. More details about experimental setup were published by Wang et al (2005).

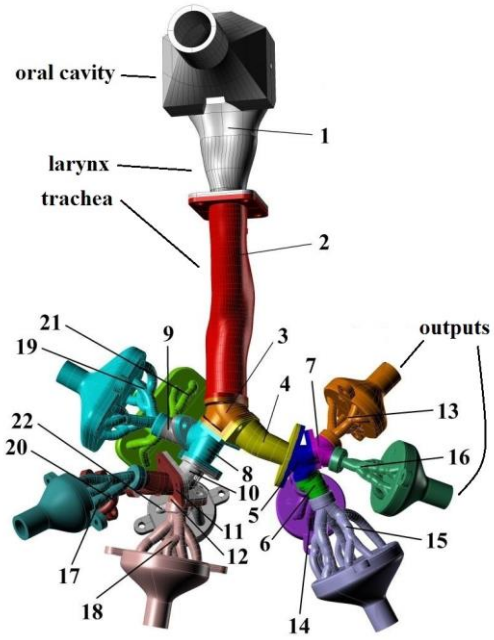

Figure 1. Realistic model of the human lungs with the segment labels

The experiment was run for four hours and the output filters were changed every 30 min. The model was disassembled after the experiment. Every segment of the model was rinsed with isopropanol and resulting solution was filtered using vacuum filtration unit. The filters were then dried and both the filters from the model and output filters were made transparent by acetone vapours.

New method was developed to analyse the filters with fibers, which replaced the method following the NIOSH 7400 methodology. Our method is based on an image analysis. Images of the filters are captured by high definition camera attached to an optical microscope. Images are analysed and fibers are counted by in-house software. Unfortunately, filters from the model could not have been analysed automatically as they contained too many impurities.

Deposition efficiency was calculated afterwards. It is the ratio of number of fibers entering the segment and number of fibers deposited in the segment. The results of the experiment are represented in Figure 2. The deposition efficiency increased with decreasing airway diameter, but over 95 % of fibres got through the model and deposited on the output filters anyway. This agrees with the theory, that fibres can follow the air flow in the lungs and penetrate into lower respiratory airways and therefore induce some health hazards. Deposition efficiency increases with increase in flow rate.

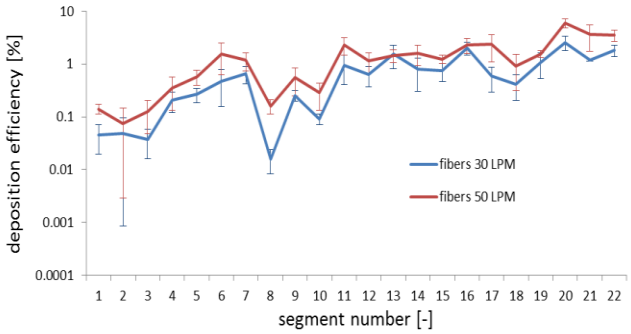

Figure 2. Deposition efficiency in the model

The authors are grateful to Philip K. Hopke from CARES, Clarkson University, NY, USA for his support and kind help. This work was supported by Czech Grant Agency under the grant P105/11/1339 and by the project FSI-S-11-6.

Wang Z., Hopke P. K., Baron P. A. et al (2005), *Aerosol Science and Technology* **39**(11), 1056-1063