Using polydisperse SMPS samples for fast determination of respiratory deposition in humans – influence of small size-shifts between the inhaled and exhaled sample

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METHODS

The influence of a small shift in the size-distribution on the determined respiratory deposition fraction was investigated. A data-set collected on roof-level near a busy road (Hornsgatan in Stockholm) was used (figure 1). The exhaled concentration (idealised experiment) was calculated by using respiratory deposition fractions from the ICRP 66 model. The exhaled size-distribution was shifted 15% (corresponding to 1 channel in the size-spectra) and 1% respectively towards smaller particle sizes.

A model-experiment has been performed in order to investigate whether the particles are brought back to the same mobility diameter after the humidification in the lungs and subsequent re-drying. A H-TDMA system was used. Two cases were considered representing the sampling from inhaled and exhaled air, respectively. Dry-Dry-Dry where the RH after the aerosol humidifier was set to 20% and Dry-Wet-Dry with RH after the Aerosol Humidifier set to 90%. The system was modified by adding a 24” Nafion-drier in the aerosol line after the aerosol humidifier. The RH in DMA2 was 22-25% in both cases. Particles of 6 dry sizes between 30 and 400 nm were extracted with the first DMA at an RH of 4%. In addition conventional H-TDMA measurements at RH=90% were performed.

RESULTS AND DISCUSSION

The influence of a small size-shift on the determined respiratory deposition is given in figure 2. It can be seen that the recovered respiratory deposition fractions are totally obscured when the size shift is 15% in diameter. However when the shift is only 1%, the error is almost negligible in the range below 200 nm. It can also be noted that the regions where the gradient in the original size-distribution data is highest gives the largest errors.
Figure 3. Ambient size distribution from roof-level in Stockholm (inhaled) and calculated exhaled concentration.

Figure 4. Effect of a 1% and a 15% size-shift in the exhaled size-distribution on the calculated respiratory deposition.

Figure 5. Size-changes for ambient particles when comparing dry-wet-dry and dry-dry-dry experiments. Ambient particles sampled from campus in Lund, Sweden January 31, 2003.

The result of the model experiment with the modified H-TDMA is given in figure 3. Each point is the ratio of a single dry-wet-dry experiment divided by the mean value of the diameter from the dry-dry-dry experiments. During the measurement day, the size-shift was within 1% on average for all sizes. These results are in contrast to the experiments performed on fresh combustion particles where considerable particle shrinking occurred. One likely explanation is that the particles studied by Weingartner et al. (1997) and Rissler et al. (2003), where diluted using artificial heated dilution and did not experience the transient supersaturation after the stack or the tail-pipe.

In the conventional hygroscopic growth measurements it was found that the 30 nm particles were dominated by less hygroscopic particles. Particles of 60, 100 and 200 nm had a bimodal hygroscopic growth spectra.

REFERENCES