Sensitivity of regional deposition of inhaled atmospheric aerosols in human respiratory tract to their size distribution and hygroscopicity: A case study

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Aerosols, which inhaled to human respiratory tract, can cause various diseases that threaten one's health. In order to estimate aerosol's health risk, it is significant to elucidate the sensitivity of regional deposition of inhaled aerosols.

In this study, by applying size distribution and hygroscopic growth factor data of aerosol (measured by a scanning mobility particle sizer in September 2009 and July-August 2010) to an MPPD (Multiple-Path Particle Dosimetry) model, we calculated the regional deposition differentiated by size diameter/hygroscopicity for a resting/light exercising adult male. As a result, regional deposition ratio in intrathoracic region (both tracheobronchial airway and alveolar interstitium) showed a bimodal distribution among particle size diameter ranging between 24.1~359.0 nm, in which the maximum value was 50.1%/50.0% at 24.1 nm (during light exercise). In general, there was a decreasing trend in deposition ratio when particle size diameter increased. For mode particles (dry diameter $d_{p,dry} < 100$ nm), the regional deposition of particles that have low hygroscopicity parameter (κ) tent to be larger than those with higher κ. However, for larger particles (especially when $d_{p,dry} > 200$ nm), this trend became reversed.

In 2009 the measurement was continuous for 10 days, while daily variation was found in aerosol number-size distribution and regional deposition. Therefore, we analyzed the meteorological data of the measurement period in 2009, comparing daytime (12:00-18:00 LST) and nighttime (00:00-06:00 LST) in order to indicate meteorological matters that affect the temporal variation of regional deposition. The result showed that the relative humidity (RH) during daytime was basically lower than 50% except September 15 and September 22~23 due to continuous rain, and the distribution of regional deposition was maximum for relatively hydrophobic mode particles ($d_{p,dry} < 100$ nm, hygroscopic growth factor g ranges between 1.0~1.2). On the other hand, RH during nighttime was mostly higher than 60%, and a bimodal distribution of both hydrophobic and hydrophilic (g ranges between 1.2~1.4) particles was found. Meanwhile, on September 23 RH was high (over 75%) during whole day, we found a monomodal distribution of regional deposition with a maximum value for hydrophilic particles that last about 6 hours in the afternoon.

According to our results we suggested that along with the temporal variation of artificial emission, changes in ambient humidity could also influence the composition of inhaled aerosol particles to a great extent, and therefore affected the regional deposition.

Keywords: Aerosol, size distribution, hygroscopicity, regional deposition

