Aerosol Deposition Study of Subject-specific Upper Respiratory Model

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EXTENDED ABSTRACT

Inhaled aerosol deposition studies with an accurate model of the human respiratory system allow health professionals to gain insight into the interactions between particulate matter and the exposed surfaces of the lung airways. Pharmaceutical companies and pulmonologists find these studies useful in evaluating the efficacy of inhaled medicinal aerosols and devising new patient treatment regimens. The purpose of this study was to investigate inhaled micron size particle deposition within a subject-specific 3D model of the oral cavity, pharynx, and trachea.

Image processing software, ScanIP (SimpleWare, UK), was applied to process two-dimensional computed tomography (CT) images and to reconstruct a subject-specific 3D model of the upper respiratory system including oral cavity, pharynx, and trachea. The reconstructed 3D model was printed out of ABS plastic and then used for the experimental measurement of regional aerosol deposition. The Oleic acid droplets with florescent (i.e., liquid droplets) were generated by a vibrating orifice aerosol generator (TSI Inc) which fed into a steady air flow. These droplets then passed through a Kr-85 charge neutralizer before the delivery to the model. The airflow rates through the upper respiratory system were 25, 40, and 57 LPM. Particles that passed through the model were collected on a 47 mm diameter Millipore filter with 1.0 μm pore size. Each section of the model was dipped into deionized water for several seconds to dissolve deposited florescent. This process was repeated 4 to 5 times to ensure the complete removal of droplets deposited in the region. The florescent in the washed solution was measured with a Flurometer (Model 110, Turner Associates). Regional aerosol deposition was calculated by regional florescent deposition concentration.

The aerosol deposition in the oral cavity was higher than the aerosol deposition in the oropharynx region, the middle section of the 90 degree bend of the upper respiratory system. Oropharynx deposition was lower than the laryngopharynx and oral cavity depositions. Variation of flow rate reduced deposition in the oral cavity and oropharynx when the flow rate was increased from 25 to 40 LPM. However, higher deposition was measured at 57 LPM. Statistically only the laryngopharynx deposition trend shows increasing deposition as flow rate increases. Total DF, deposition fraction, for each flow rate corresponds to 4.94% at 25 LPM, 4.38% at 40 LPM, and 9.48% at 57 LPM.