In-vitro measurements of regional nasal deposition efficiency of particles ranging from 20 to 500 nm

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Many studies on the removal efficiency of inhaled particles in the nasal region have been performed in the past, either replicate casts or human volunteers. However, most of those studies were primarily based on a limited number of white male subjects (Kim and Hu, 2006). Kesavanathan and Swift (1998) pointed out that nasal anatomic and dimensional factor are important in determining the amount of deposition in the nasal passage. Studies indicated that Taiwanese have a shorter craniofacial depth and longer craniofacial width than Americans, and Chinese workers have shorter face length, longer face width and smaller nose protrusion than Americans (Yu et al., 1996). These facial differences are likely to affect the anatomical structure of the upper respiratory tract and, consequently, the characteristics of particle deposition in this region between the two ethnic groups. Thus, it is important to conduct particle deposition experiments to explore the possible difference between the two ethnic groups.

Three Taiwanese (subjects A~C) and two Caucasian adults (subjects D~E) were recruited to obtain the computed tomography (CT) scans of their respiratory tract extending from the nostril to trachea. The images of the CT scans were stored in DICOM file (Digital Imaging and COmmunications in Medicine) to build the 3D computer model using the Mimics and 3 Matic software package (Materialise, Leuven, Belgium). Then, based on the 3D computer models, the airway models were constructed with epoxy by a rapid prototyping machine. Figure 1 shows one of the models, which includes nasal cavity, nasopharyngeal and trachea, constructed and employed in the deposition experiments. The human respiratory flow rates of 5, 10, 15, and 20 LPM were used to represent different human workload. The particle sizes for the study ranged from 20 to 500 nm and a Scanning Mobility Particle Sizer (SMPS) (TSI Inc., Shoreview, MN, USA) was used to measure the particle sizes and number concentrations.

The results obtained from the respiratory flow rate of 15 LPM were shown as an example in Figure 2. As shown, the trend of deposition efficiency in nano-sized ranges conforms with the published data, i.e., deposition efficiency first decreases with the increasing particle sizes and, after 100 nm, increases with the increasing particle sizes. Additionally, deposition efficiency from Taiwanese is greater than that of from Caucasians for about 5%. Regarding regional deposition, all five models showed the same trend, i.e., nasal cavity

Figure 1. Replicate cast of the upper respiratory tract with separated nasal cavity, nasopharyngeal and trachea

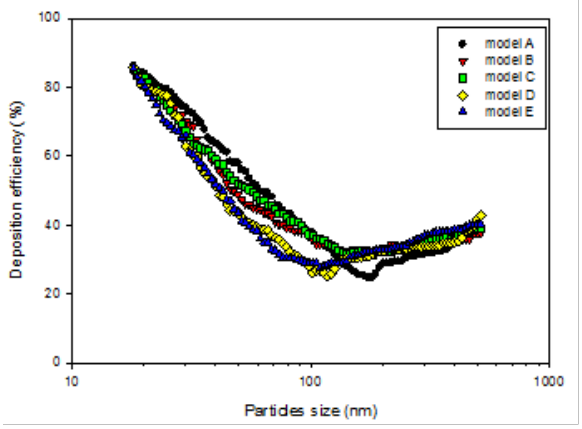

Figure 2. Particle deposition efficiency of Taiwanese (subjects A~C) and Caucasians (subjects D and E).

is with the highest deposition efficiency and trachea the lowest. The efficiency difference in the nasal cavity between Taiwanese and Caucasians can be as high as 7.1%. This constraint of this work is that the number of subjects is limited.

The work concludes that more subjects in both ethnic groups are needed and ICRP should be modified according to ethnic groups.

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