In vivo measurements of nanometer-sized particle deposition in the nasal cavities of Taiwanese adults

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Numerous studies on the removal efficiency of inhaled particles in the nasal region have been performed in the past decades, by using either replicate casts or human volunteers (Hsu and Chuang, 2012). Many empirical equations were also developed to characterize the deposition efficiency in this region. 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 and that particle deposition data from a demographically diverse group is important. An anthropometric study in Taiwan indicated that Taiwanese have a shorter craniofacial depth (i.e., distance between glabella and occiput) and longer craniofacial width (i.e., distance between two tragi) than Americans (Yu et al., 1996). Another US study suggested that Chinese workers have shorter face length, longer face width and smaller nose protrusion than Americans (Du et al., 2008). These differences in facial features 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, the experimental data of particle deposition in the respiratory tract reported previously will be less applicable to the Asians if the nasal particle deposition is different between two ethnic groups.

15 Taiwanese adults (subjects A~O, 9 males and 6 females) were recruited to participate in the measurements of nasal deposition efficiency of particles ranging from 14 to 500 nm. The human respiratory flow rates of 5, 10, 15, and 20 LPM were used to represent different human workload. Particle size and number concentrations were measured by a Scanning Mobility Particle Sizer (SMPS) (TSI Inc., Shoreview, MN, USA). The nasal passage cross-sectional area as a function of distance from the nostril of each subject was measured by an otolaryngologist using an acoustic rhinometer (Eccovision, Hood Laboratories, Pembroke, MA, USA). The minimum cross-sectional area (A_{min}) and volume of nasal cavity were determined from the measurements.

The results showed the deposition efficiency decreased with the increasing flow rate, and this trend conforms with the published data. No significant difference was found in the deposition efficiency of male and female subjects. The efficiency obtained from the Taiwanese adults was higher than the current available data which were mainly obtained from the white male subjects. This trend between the two ethnic groups is opposite to that found in the micrometer-sized particles (Hsu and Chuang, 2012). Additionally, subjects A and N were found to have a relatively large difference in the minimum nasal cross-sectional area, while subjects D and K had the smallest difference in this parameter. Figure 1 shows the deposition efficiency as a function of particle size for the subjects A, D, K and N at respiratory flow rate of 10 liters per minute . As shown in the figure, the data from subjects D and K collapse into a single curve, while subjects A and N had apparently different efficiencies. This supports what was noted by Cheng (2003): that the minimum cross-sectional area is the critical dimension in determining the nasal deposition efficiency.

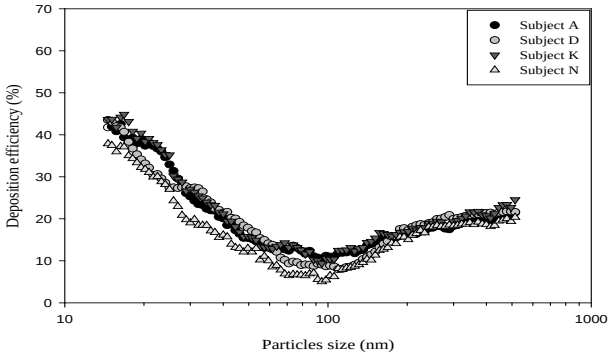

Figure 1. Comparison of nasal particle deposition efficiency of subjects A, D, K and N.

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