

## Analyses of size distribution and related lung deposition in the *SELSONICS* Ultrasonic Nebulization Chamber

P. Madl and W. Hofmann

Department of Materials Engineering & Physics, University of Salzburg, 5020 Salzburg, Austria

Keywords: health aspects of aerosols, inhalation, lung deposition, particle formation, size distribution.

Vitamin-C enriched sodium-chloride (15% NaCl solution) from the Dead Sea and organically grown and extracted olive-oil samples with traces of supplemented Vitamin-D (5mL each) were separately nebulized by ultrasound atomizers in a therapeutic aerosol cabin constructed by Selsonics GmbH. Particle growth dynamics from aerosol processing reactions were measured with a Scanning Mobility Particle Sizer (SMPS) immediately after a 3 minutes long sample injection sequence. Scanning times with the SMPS covered a potential exposure window of at least 10 minutes in the size range of 0.01 to 1.1  $\mu\text{m}$ . Based on the data obtained from the SMPS measurements, the stochastic lung particle deposition model IDEAL-2 (Koblinger & Hofmann, 1990; Hofmann & Koblinger, 1990) was applied. As expected, two very different particle deposition patterns were obtained based on the hydrophilic / hydrophobic nature of the aerosol samples involved.

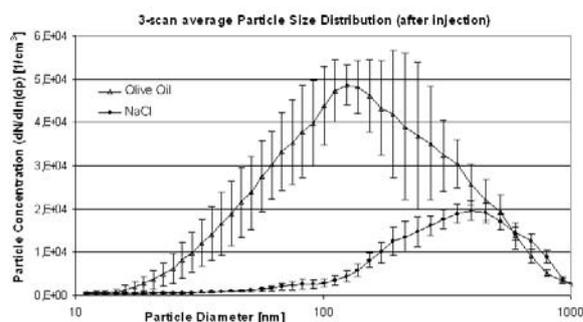


Figure 1. Size distributions of olive-oil and NaCl aerosols.

Figure 1 reveals a polydisperse distribution with the geometric mean located at around 140 nm. Particle concentrations of the olive-oil (NaCl) peaked at around  $103 \times 10^3 \pm 26 \times 10^3$  ( $30 \times 10^3 \pm 4.8 \times 10^3$ ) particles  $\text{cm}^{-3}$  and gradually decreased afterwards due to agglomeration to larger clusters.

To investigate the fate of inhaled olive-oil and NaCl particles with unit density, we used the stochastic lung deposition model to predict particle deposition patterns. For the deposition calculations, the 44 size classes of the SMPS were grouped into 20 size classes to facilitate the computations. Considering the elevated humidity level within the pulmonary region, an equilibrium hygroscopic growth factor (HGF) of 5 was assigned to the NaCl aerosol (Heyder et al. 2004). Predicted deposition

patterns of the samples within the human lung are exhibited in figure 2. The generation-numbers plotted on the abscissa correspond to the different lung regions (trachea: generation 0), where generations 1 to 15 are associated with the bronchial region, and generation numbers greater than 15 correspond to the alveolar region (Yeh & Schum, 1980).

In conclusion, deposition from both olive-oil and NaCl particles is higher in the alveolar region, and to a lesser extent within the bronchial region, where ciliary motion would promptly translocate deposited particles (clearance). Hence, from a therapeutic perspective, alveolar deposition may be associated with an increased immuno-response activity by alveolar macrophages (Donaldson et al., 1998).

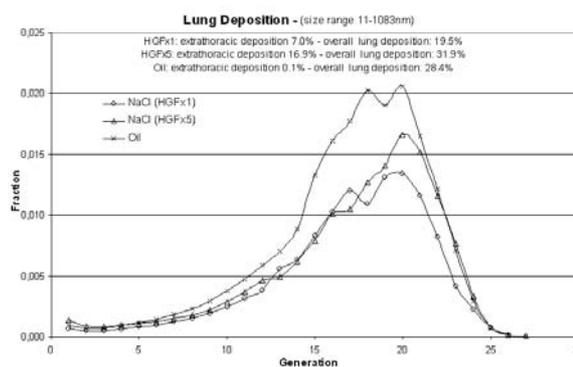


Figure 2. Particle deposition of the nebulized oil and NaCl samples in the various lung generations.

The authors wish to thank the Selsonics GmbH for their kind assistance, in particular to *P. Huber*, Technical Officer and to *P. Richter*, Managing Director of Selsonics GmbH.

- Donaldson, K., Li, X.Y., & MacNee, W. (1998). *J. Aerosol Science*, 29, 553-560.
- Heyder, J., Gebhart, J., Roth, C., & Ferron, G. (2004). in Gradon L., Marijnissen, J.C. (eds.). *Optimization of Aerosol Drug Delivery*. Heidelberg, FRG: Springer Verlag, 139-147.
- Hofmann, W., & Koblinger, L. (1990). *J. Aerosol Science*, 21, 675-688.
- Koblinger, L., & Hofmann, W. (1990). *J. Aerosol Science*, 21, 661-674.
- Yeh, H. C. & Schum, G. M. (1980). *Bull Math Biol.*, 42, 461-480.