

Prolonged retention of ultrafine carbon particles from human airways and the lung periphery

W. Möller¹, K. Felten¹, K. Sommerer³, G. Scheuch³, G. Meyer², K. Häussinger², and W.G. Kreyling¹

¹GSF National Research Center for Environment and Health – Clinical Research Group ‘Inflammatory Lung Diseases’ and Institute for Inhalation Biology, Gauting and Neuherberg, Germany

²Asklepios Hospital for Respiratory Diseases, Gauting, Germany

³Inamed Research GmbH, Gauting, Germany

Keywords: Air pollution, ultrafine particles, bolus technique, clearance, translocation

Introduction: A growing body of epidemiological studies have shown consistent associations between the exposure to particulate air pollution and increases in morbidity and mortality rates, especially for persons with obstructive pulmonary and cardiovascular diseases (Samet, J.M. *et al.*, 2000). The causality of the exposure by inhalation and the noxious effects on the cardiovascular system is still under debate. Ultrafine particles may play a specific role in this causality, because they contribute little to the mass concentration (PM₁₀ or PM_{2.5}), but are dominant in the number of airborne particles.

In this study we report on deposition, clearance and translocation of 100 nm radiolabeled carbon particles in healthy human volunteers and in patients with chronic obstructive pulmonary disease (COPD). Because the conducting airways and the alveoli are anatomically different structures with different clearance mechanisms, we targeted the ultrafine test particles to either of these regions by using the aerosol bolus technique.

Methods: 99m-Tc radiolabeled 100 nm diameter carbon particles (Technegas (Möller, W. *et al.*, 2006)) were inhaled by healthy non-smokers, asymptomatic smokers and by patients with chronic obstructive pulmonary disease (COPD). Using a bolus inhalation technique particle deposition was targeted either to the airways or to the lung periphery, and retention, clearance and translocation were measured using retained radiotracer imaging (shielded lung counter and gamma camera).

Results and discussion: In vitro leaching of the 99mTc-radiotracer after 24 hours was 4.10±2.6%, and 24-hour cumulative urine 99mTc-activity excretion was 1.09±1.25% of deposited activity. Activity in the blood after 1 h and after 5 hours was 0.22±0.17 % and 0.23±0.25 % of the deposited activity, respectively. In the lung periphery particle retention was not affected by smoking or disease; retention was 96.0±2.8 % after 24h (see Figure 1). The inverse correlation of retention with in vitro leaching, blood activity and 24-h urine activity excretion suggests negligible clearance of particles deposited in the lung periphery. In the airways

particle retention and clearance show two phases. Fast mucociliary clearance removes particles within the first 24 hours. In non-smokers retention of particles targeted to the airways was 89.3±5.7 % and 74.8±10.2 % after 1.5 h and 24 h, respectively. There was no further clearance between 24 hours and 48 hours, indicating that the remaining fraction (75 %) is persistent. Retention was significantly increased in smokers (after 1.5 h) and in COPD patients (at all measurement points).

Particle translocation to the liver could not be identified above the detection limit of the gamma camera (0.5 % of deposited activity).

Conclusions: Ultrafine carbon particles are prolonged retained in the lung periphery and in the conducting airways (only about 25 % were cleared within 24 hours), and may accumulate after chronic exposure. This may imply increased risks for susceptible individuals, such as patients with chronic diseases

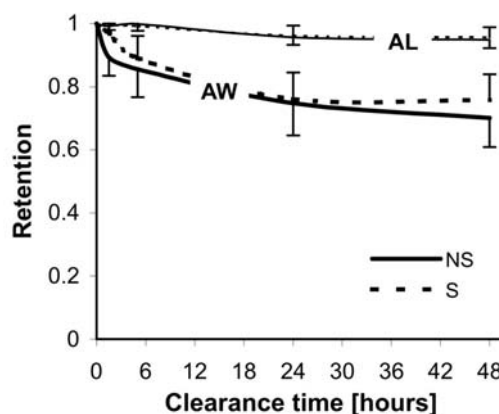


Figure 1. Clearance of 100 nm carbon particles after shallow (AW) and after deep (AL) bolus inhalation in non-smokers (NS) and in asymptomatic smokers (S) during a 48-h post inhalation period..

This study was supported in part by the CEC (FIGD-CT-2000-00053).

Möller, W., et al. 2006. *J. Aerosol Sci.* 35, 631-644.
Samet, J. M., et al. 2000. *Research report / HEI* 94, 5-70; discussion 71-9.