

MONITORIZATION OF ALVEOLAR DEPOSITED SURFACE AREA OF NANOPARTICLES AND ULTRAFINE PARTICLES IN DIFFERENT ENVIRONMENTS

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INTRODUCTION

Current workplace exposure limits are based on particle mass, but this criteria could not be adequate in this case as nanoparticles are characterized by very large surface area, which has been pointed out as the distinctive characteristic that could even turn out an inert substance into another substance exhibiting very different interactions with biological fluids and cells. In fact, nanoparticles have far more surface area for the equivalent mass of larger particles, which increases the chance they may react with body tissues. Thus, it has been claimed that surface area should be used for nanoparticle exposure and dosing. As a result, assessing exposure based on the measurement of particle surface area is of increasing interest. It is well known that lung deposition is the most efficient way for airborne particles to enter the body and cause adverse health effects.

If nanoparticles can deposit in the lung and remain there, have an active surface chemistry and interact with the body, then, there is potential for exposure.

It was showed that surface area plays an important role in the toxicity of nanoparticles and this is the metric that best correlates with particle-induced adverse health effects. The potential for adverse health effects seems to be directly proportional to particle surface area. The objective of the study is to identify and validate methods and tools for measuring nanoparticles during production, manipulation and use of nanomaterials.

MATERIALS AND METHODS

A Nanoparticle Surface Area Monitor (TSI 3550 – Fig. 1), was used for assessing exposure to nano particles produced and manipulated in laboratory and industrial facilities. This equipment indicates the human lung-deposited surface area of particles expressed as square micrometers per cubic centimeter of air ($\mu\text{m}^2/\text{cm}^3$), corresponding to tracheobronchial (TB) and alveolar (A) regions of the lung.

Also, granulometry of particles was measured in the nano range using a Scanning Mobility Particle Size Spectrometer, (TSI 3034 - Fig. 2). Particles were sampled using a Nanometer Sampler Analyser, (TSI 3089 – Fig. 3) and observed further on using scanning electronic microscopy.

The obtained results clearly demonstrated the existence of airborne nanoparticles, as shown in figures 1 and 2, and also allowed the determination of lung-deposited surface area of nanoparticles, as well as the dose per unit lung mass and unit lung area, in the analyzed environments [1-4].



Fig. 1 - TSI Model 3550 - Nanoparticles Surface Area Monitor (NSAM) *, measures surface deposited area of nanoparticles in alveolar and tracheobronchial tracts of human lungs, based on diffusion charging.

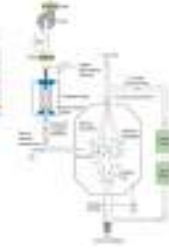
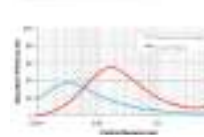


Fig. 2 - TSI Model 3034 - Scanning Mobility Particle Sizer Spectrometer (SMPS)**

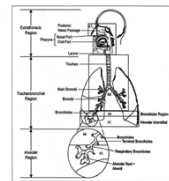


Fig. 3 - TSI Model 3089 - Nanometer Aerosol Sampler (NAS) *

RESULTS

Table 1. Measurement results over a typical week (May, 2011)

Sampling conditions	Average deposited area ($\mu\text{m}^2/\text{cm}^3$)	Range of values ($\mu\text{m}^2/\text{cm}^3$)	TWA for 8h ($\mu\text{m}^2/\text{cm}^3$)	Total deposited area (μm^2)	Dose per lung area ($\mu\text{m}^2/\text{m}^2$)
Baseline	34.1 ± 5.0	25.5 – 50.3	1.07	5.12 × 10 ⁵	6.40 × 10 ³
Monday	57.6 ± 5.7	14.7 – 343.3	172.8	8.29 × 10 ⁷	1.04 × 10 ⁶
Tuesday	89.2 ± 8.0	27.4 – 510.5	267.6	1.28 × 10 ⁸	1.61 × 10 ⁶
Wednesday	87.1 ± 7.5	31.1 – 421.1	261.4	1.25 × 10 ⁸	1.57 × 10 ⁶
Thursday	82.2 ± 7.2	23.2 – 245.7	165.2	4.72 × 10 ⁷	5.90 × 10 ⁵
Friday	75.0 ± 6.9	17.8 – 511.1	143.6	4.70 × 10 ⁷	4.60 × 10 ⁵
Saturday	35.0 ± 4.5	6.91 – 365.5	107.4	4.26 × 10 ⁷	3.40 × 10 ⁵
Sunday	34.9 ± 4.0	4.94 – 252.2	104.7	4.10 × 10 ⁷	3.20 × 10 ⁵

Fig. 4 – Size distribution of particles during a typical week day (May 2011)

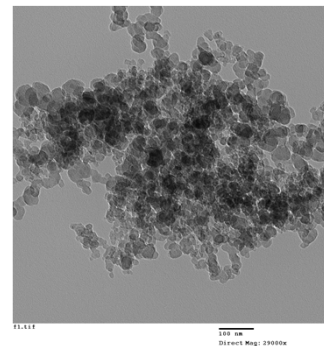
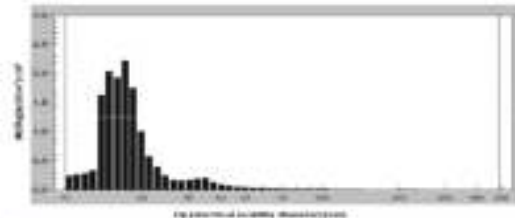


Fig. 5 – Observations on collected particles by transmission electron microscopy (TEM)

CONCLUSIONS

Previous studies (Fissan et al., 2007; Kuhlisch et al., 2000; Ntziachristos et al., 2007) confirmed evidence that diffusion chargers are useful and reliable instruments for measuring ambient aerosol concentrations in different environments and that their signal can be combined with the number concentration of particles to provide an estimate of the mean diameter in real time.

The study clearly demonstrated the existence of ultrafine particles due to automobile traffic, which could be confirmed by the measurements of size distribution and morphology of sampled particles. Also, this seems to be consistent with observations of ultrafine particles concentrations in other major towns. Mainly during week days, observed concentrations can be as high as 2,6 times the measured baseline level.

It should be noted that, although measured parameters such as the deposited area and the dose per lung area, are elevated when compared with baseline values, mainly for week days where automobile traffic is more intense, they cannot, at this stage, be ascertained as toxicity indicators. Nevertheless, they point out for important contamination of potentially hazardous particles released from automobile traffic in urban environments. Data obtained in this study is a basic information allowing to understand the relationship between exposure to ultrafine particles in urban atmospheres and health affections, which can be taken as the basis for epidemiologic studies.

As ultrafine particles can have a significant lifetime in urban air, possible effects on health cannot be neglected.

References:

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