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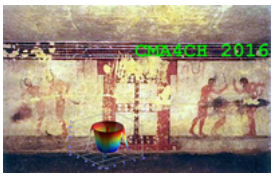

Particles in Domestic Environments: Levels, Behavior and Doses Deposited in the Human Respiratory Tract

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Abstract

The health effects of Ultra Fine Particles (UFPs < 100 nm) have been associated to their high number concentrations and surface areas, together with their high penetration efficiency into the respiratory system and capability of translocation from the airways into the blood circulation. Therefore, it is important to characterize the aerosols deriving from the operations currently performed in an indoor environment and also to estimate the relevant particle respiratory doses. To this purpose, a study has been carried out on aerosol sources currently encountered in indoor environments. Both combustion (conventional cigarette smoke, cooking, incense, citronella candles and mosquito coils burning) and no-combustion sources (spray air fresheners, hair dryers, hot flat iron, vacuum cleaner and drills) have been considered. Aerosol number size distributions have been measured with 1 s time resolution and the relevant doses deposited in the respiratory system have been estimated with the MPPD model.

Introduction

Exposure to particulate matter (PM) is an issue of great concern for public health, because scientific evidences highlight significant associations between the increase of the levels of airborne fine and Ultra Fine Particles (UFPs < 100 nm aerodynamic diameter) and the increase of morbidity and mortality rates [1]. PM indeed, independently of its chemical composition, has been linked to many adverse effects on human health, such as major adverse cardiovascular events (acute myocardial infarction, ischemic stroke, hemorrhagic stroke, or death due to cardiovascular cause) and respiratory disorders (lung inflammation, asthma, and fibrosis). Aerosol doses deriving from outdoor sources represent only a part of the daily dose deposited into the human respiratory system. The contribution deriving from indoor sources can be comparatively important considering that people spend more than approximately 80% of their time indoors, in confined environments favorable to contaminant accumulation. For these reasons, the purpose of this work is to study the aerosol concentration and size distribution in a residential indoor environment during a typical day. Such data have been used to estimate the dose of particles deposited in the human respiratory system as a function of time, particle diameter and airway generation number

Materials & Methods

Aerosol number-size distributions were measured by means of a Fast Mobility Particle Sizer (FMPS, model 3091, TSI, Shoreview, MN, USA). The instrument counts and classifies particles, according to their electrical mobility, in 32 size channels, in the range from 5.6 to 560 nm, with a 1 s time resolution.

Particle deposition in the human respiratory system was evaluated using the multiple-path particle dosimetry model (MPPD v2.1, ARA 2009), which calculates the deposition and clearance of mono- and poly-disperse aerosols, from ultrafine to coarse particles, in the respiratory system of humans and rats [2].

Results

Figure 1a shows the background particle size number distribution together with the aerosol size distributions for vacuum cleaning and for meat grilling. For the background size distributions, a tri-modal curve was observed with modes that in order of importance were at about 80 nm, 10 nm and 19 nm (almost negligible). The same modes were observed for vacuum cleaning, but their relative importance was opposite: the mode at 10 nm increased by 16-fold and was more intense than the one at 80 nm (almost the same intensity as the background size distribution). Moreover, the mode at 19 nm was no longer negligible and increased by 34-fold. Such behaviour was due to the electric arc discharge between the copper windings in the rotor and the graphite electrodes (brushes) in the stator of the brush electric motor of the vacuum cleaner [3, 4].

Higher particle number concentrations were measured for meat grilling, with a broad intense mode at about 60 nm.

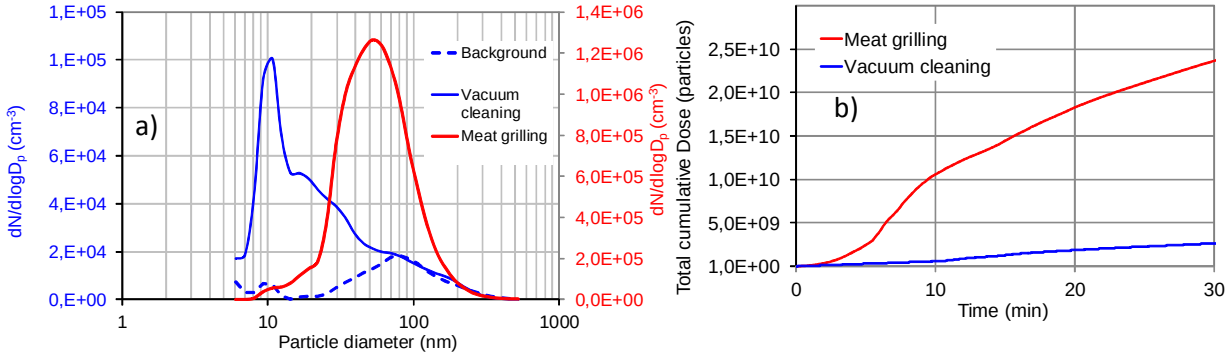

Fig. 1 aerosol number size distribution (a) and temporal trend of cumulative particle doses deposited in the respiratory tree for vacuum cleaning and meat grilling

Figure 1 b shows the temporal trends of the total cumulative particle doses deposited in the respiratory tree during vacuum cleaning and meat grilling. After 30 minutes, about 2.8×10^{9} and 2.4×10^{10} particles were deposited in the respiratory tree, respectively for vacuum cleaning and for meat grilling.

Conclusions

Indoor activities considered in this work generate aerosols that cause significant increments of the particle concentrations above the indoor. The most intense aerosol emissions have been measured when indoor combustion sources are active. It is therefore important to control such emissions (e.g., through the use of exhaust ventilation) and whenever possible to completely eliminate them by changing one's lifestyle (e.g. environmental tobacco smoke). Overall, the indoor activities considered represent a relevant contribution (27%) to the total daily dose. The cumulative doses estimated vary from 2.8×10^{9} particles for vacuuming to about ten-fold higher for meat grilling.

References

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