

MASS MEDIAN DIAMETER (MMD) OF AEROSOL SUBSTANCES IN DEPENDENCE OF TEMPERATURE

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INTRODUCTION

The deposition velocity of an aerosol substance depends on its MMD (1, 4) which is a function of the specific vapour pressure (2). This also determines the penetration and deposition in the human respiratory tract. Ambient air temperature usually is lower than our body temperature.

Therefore, aerosol particles may shrink after inhalation. Consequently, this shrinkage induces higher deposition rates in the respiratory tract. Quantitative knowledge about this effect is indispensable.

METHOD AND RESULTS

The deposition velocity v (cm/s) is a function of the MMD (μm):

$$(1) \quad v = \frac{v_o}{2} \left[\left(\frac{MMD}{0,6 \mu\text{m}} \right)^2 + \left(\frac{0,6}{MMD} \right)^2 \right]$$

v_o (μm) is the calibration factor.

Impactor measurements within the last two decades revealed that the MMD of a particulate substance can be related to its specific vapour pressure p_s (Pa):

$$(2) \quad MMD = 0,1 \left(1 - \lg p_s \right) \mu\text{m}; \quad p_s < 10 \text{ Pa}$$

It was also found that the p_s of a considered substance can be assessed by use of the freezing point T_F and boiling point T_B (2):

$$(3) \quad \lg p_s = -c \frac{T_m}{T} \lg T + 14 \qquad T_m = \frac{T_F + T_B}{2}; \quad T_m \text{ and } T \text{ in Kelvin}$$

Inserting equation (3) in (2) we get.

$$(4) \quad MMD = 0,1 \left[c \frac{T_m}{T} \lg T - 13 \right] \mu m \qquad c \frac{T_m}{T} \lg T > 13$$

c is a specific factor, for organic compounds varying between 3,7 and 4,2. By use of equation (4) is seen that the MMD is shrinking with increasing temperature. In the case of inhaled organic particulate substances which have vapour pressures between 10 Pa and 10^{-15} Pa the change of ambient air temperature to higher body temperature enlarges the deposition. This effect was observed for total deposition of combustion aerosols in the human respiratory tract (5). Shrinking particle size due to increased temperature enlarged the deposition by more than 25 %.

For semi-volatile compounds gas/particle partitioning is also related to temperature (3):

$$(5) \quad x_p = \tan h \left[\frac{1}{6} \left(c \frac{T_m}{T} \lg T - 13 \right) \right]^2 \qquad x_p = \frac{m_p}{m_p + m_g} \quad \text{particulate mass fraction}$$

$$x_g = \frac{m_g}{m_g + m_p} \quad \text{gaseous mass fraction} \qquad c \frac{T_m}{T} \lg T > 13$$

Varying x_p also influences the deposition rates.

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