Toxicity of Dust - Relevant Parameters of Health Hazard

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Ambient airborne particulate matter of varying size and composition is known to produce respiratory and cardiovascular diseases in humans as well as adverse effects on reproductive functions. Cancer incidence is related to a high burden of particles in ambient air. Epidemiological studies correlated adverse health effects to the amounts of particles with an aerodynamic diameter below 10 µm (PM10). However, nano-sized particles with a diameter below 100 nm came recently into the focus of attention. Their high surface/mass ratios resulted in a higher toxic potential. Relevant exposure to nano-sized dust in urban areas originates from diesel soot and in the working place environment from toner particles or welding fumes. Nano-sized dusts are predominant in terms of particle numbers, but do not contribute markedly to the total mass.

The number of particles and the particle mass are usually measured and used for correlation of exposure and risk of adverse outcome. Additional toxicologically relevant parameters are the dust volume and the surface area. In animal studies the risk assessment is predominantly based on the installed dose or the dust volume.

Nano-sized particles generally occur in agglomerates, thus pretending a smaller particle number. The agglomeration/aggregation behaviour of nano-sized particles can be summarized as follows: Primary particles characteristically agglomerate forming larger units (agglomerates) by adhesion due to weak physical interactions. Consequently, agglomerates are not fixed units, but can change size and shape. Altering conditions such as temperature, pressure, pH values, or viscosity of the surrounding medium result in strongly diversified kinds of agglomerates. Aggregates develop when primary particles begin to form a common crystalline structure. When crystal growth begins, the agglomerate is converted into a new, larger particle (aggregate). Although the original geometry of the primary particles is still visible in the aggregate, the particles are firmly fused together. As a consequence, the surface area of the new particle (aggregate) compared with the sum of the surface areas of the former primary particles is decreased.

A differentiation between compact particles, agglomerates, and aggregates is relevant, because the biological effect depends on the solubility of the particles in pulmonary fluids. Agglomerates can re-decay into their primary particles with diameters less than 100 nm which may enhance their adverse effects. On the other hand, the toxic effect of larger particles in the lung is predominantly related to their size because the clearance from the respiratory tract is reduced in a lung with an overload situation. For smaller (nano-sized) particles, the surface properties, *i.e.* the larger active specific surface area and the number of particles, are much more important.

In order to elucidate the influences of volume, mass, particle number, and surface area on the carcinogenicity, the particle characterization has to be focused on the distinction between primary particles, agglomerates, and aggregates [1].

[1] J. Schneider, D. Walter, B. Brückel, K. Rödelsperger,
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