Nanoparticles From Combustion Processes in Situ, in the Ambient Air and in the Respiratory System

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Background

Significant particle emission reduction in the past due to measures from stationary and mobile sources regarding the particle mass led to the fact that emissions are near the detection limit of gravimetrical methods. Some improvements are still possible but EU working groups consider for the future the measurement of number distributions as a helpful tool to judge health effects of those low particle levels. Combustion processes generally produce particles in the size range from 50nm to 500 nm more or less independent from the source. These particles change in the atmosphere with time, temperature, pressure, radiation and humidity in size and chemical composition. Regarding health effects the character of inhaled aerosols has to be examined in greater depth as currently usual.

Size distribution and Morphology

Size distribution of in situ particles is bimodal. The nucleation mode is volatile and diminish with heating, see figure 1.

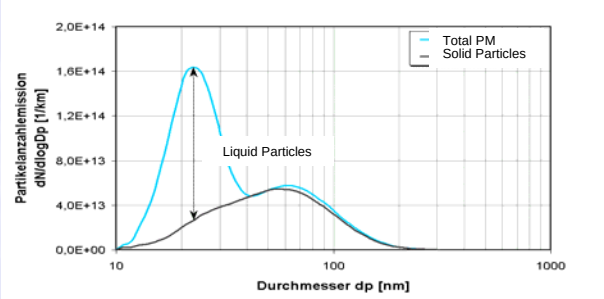

Fig. 1: Bimodal size distribution of diesel aggregate particles

In ambient air the size distribution has solid and liquid parts, see figure 2 for particle size classes with 80 nm and 150 nm.

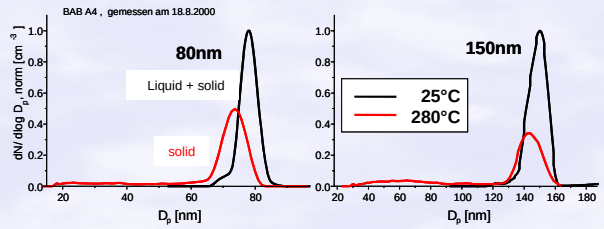

Figure 2: Size distribution on one Highway A4 near Aachen

During the day numbers in a tunnel get smaller, see fig.3, due to the elevated boundary layer, increased dilution and decreased humidity.

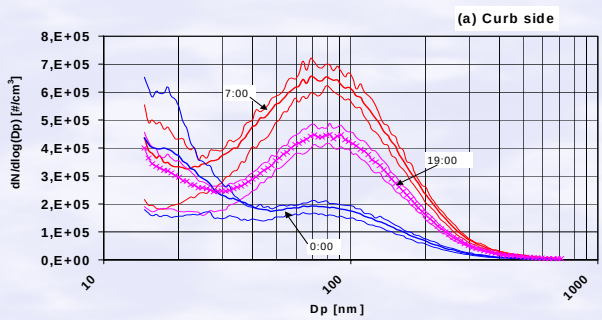

Figure 3: Size distribution of diesel particles in a tunnel (Plabutsch)

At midnight nucleation takes place due to increased humidity with higher numbers < 40 nm. Solid particles are low due to less traffic.

Diesel particles from passenger cars and duty vehicles look similar in transmission electroscopy, see fig.4 and 5. In the ambient air further aggregation took place, even more in the respiratory system (fig. 6+7).

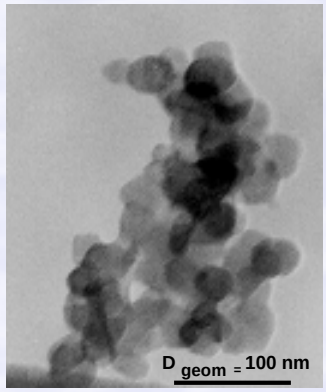

Fig. 4: Diesel Engine with Common-rail High Pressure Direct Injection BMW 530d/3.0l, 120 km/h

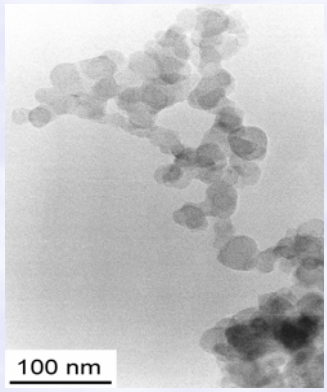

Fig. 5: Diesel Engine with Common-rail High Pressure Direct Injection MAN D2876LF-4V /12.8l, 1600 bar

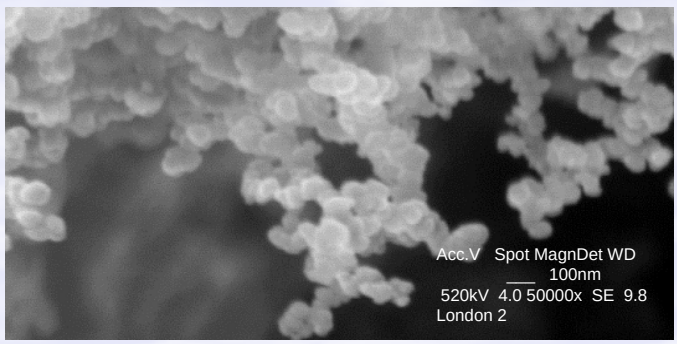

Figure 6: Diesel Aggregate Particle in Ambient Air in London

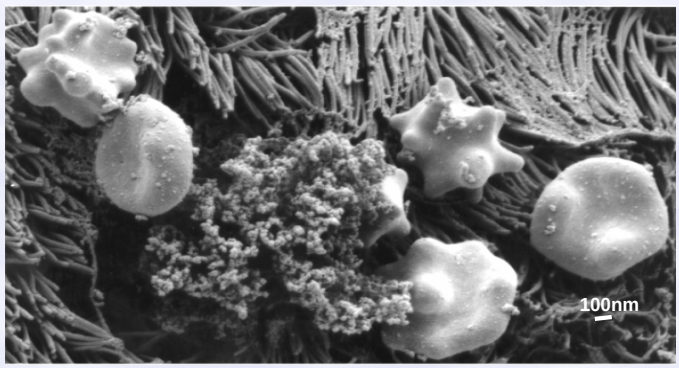

Figure 7: Diesel Aggregate Particle in the Trachea

On the way to the respiratory deposition particles tend to increase their Diameter. Therefore most of them will be eliminated by macrophages.

Findings and Conclusions

Diesel particles are small enough to penetrate into the respiratory system. Direct after the exhaust gas pipe typical sizes are about 80 nm, in the ambient air the size, dependent from the residual time, is between 70 nm and 140nm, in the respiratory system after additional aggregation the size is larger, mostly around 1000 nm. Therefore Diesel particles does not belong to the group of ultrafine or nano particles.
PM mass and number emission reduction have an ongoing trend in the future. The contribution of road transport is declining and therefore PM_{10} air quality is slowly improving until today and also in the next years.

References: Sorsche P., FVV-Report 640, Partikelkenngrößen, Frankfurt, 1997
Wehner B., Wiedensohler A., 5th ETH-Nanoparticle Conference, Zürich, 8.8.2001
Metz N., Resch G., Steinparzer F., MTZ 61 (2000),
Größenvert., Charakterisierung der Rußpartikeln moderner Dieselmotoren
Richards et al., Pers. Communication, 7. 2003, Cardiff University, UK
Sturm P. et al., J.Atm. Environm.,8.5.2003, Roadside PM size distribution measurements

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