Intercomparability study of electrical mobility particle sizers with NaCl and Diesel soot

Christof Asbach[1], Heinz Kaminski[1], Burkhard Stahlmecke[1], Heinz Fissan[1], Christian Monz[2], Dirk Dahmann[2], Sonja Mülhopt[3], Hanns-R. Paur[3], Heinz J. Kiesling[4], Friedhelm Herrmann[4], Matthias Voetz[4], Thomas A.J. Kuhlbusch[1]

[1] Institute of Energy and Environmental Technology (IUTA) e. V., Duisburg, Germany
[2] Institut für Gefahrstoffforschung (IGF), Bochum, Germany
[3] Forschungszentrum Karlsruhe, Eggenstein-Leopoldshafen, Germany
[4] Bayer Technology Services, Leverkusen, Germany

Abstract

Human exposure to nanoparticles has raised increasing interest, since recent studies have indicated that adverse health effects can be associated with inhaled nanoparticles. Different instruments exist to measure airborne particle concentrations and size distributions. For nanoparticles, these devices comprise e.g. condensation particle counters (CPC's) for the determination of the total number concentration and electrical mobility analyzers, such as scanning (SMPS's) or fast mobility particle sizers (FMPS's) that measure the number size distribution of airborne particles. These instruments can provide useful means to assess the human exposure to nanoparticles, e.g. in nanotechnology workplaces, where nanoparticles are produced, handled, or processed. In this study, we challenged altogether four instruments with intentionally produced particles. These particles included sodium chloride and Diesel soot that were sampled from a 25 m³ sedimentation chamber. Mode and median diameter, geometric standard deviation, and peak concentration of the size distributions, as well as the size resolved ratios of the concentration values were subject to a detailed intercomparison study.

Instrumentation and Experimental Conditions

- Particles were generated with Collison atomizer (NaCl) or Diesel engine (soot)
- Diesel soot and NaCl used as test material for comparison only because they exhibit very different morphologies
- Diluted with dilution air in wind tunnel to obtain homogenously distributed aerosol
- Sampled through sampling lines, measured data corrected for diffusion losses in tubes and in instruments (where possible)
- Measured data mathematically fitted with lognormal size distributions to facilitate comparison between different instruments

Table 1: Instruments used in intercomparability study

	ID	Manufacturer/ Model	Flow Rate Settings	Other Settings	Size Range	Particle Counter
SMPS	SMPS-T1	TSI/3080	0.3 lpm aerosol, 3 lpm sheath	long DMA	14.1 - 736.5 nm	TSI W-CPC 3786
	SMPS-T2	TSI/3080	0.3 lpm aerosol, 3 lpm sheath	long DMA	14.1 - 736.5 nm	TSI CPC 3010
			0.6 lpm aerosol, 6 lpm sheath	long DMA	9.47 - 429 nm	TSI CPC 3010
	SMPS-G1	Grimm/SMPS+C	0.3 lpm aerosol, 3 lpm sheath	M-DMA	5.5 - 350.4 nm	Grimm CPC 5.404
			0.3 lpm aerosol, 3 lpm sheath	L-DMA	11.1 - 1083.3 nm	Grimm CPC 5.404
FMPS	FMPS	TSI/3091	10 lpm aerosol, 40 lpm sheath		5.6 - 560 nm	22 electrometers

Sodium Chloride

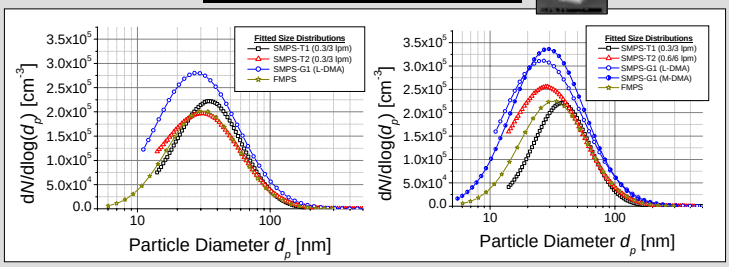

Fig. 1: NaCl number size distributions measured with different instruments with largely equal settings (left) and different settings (right)

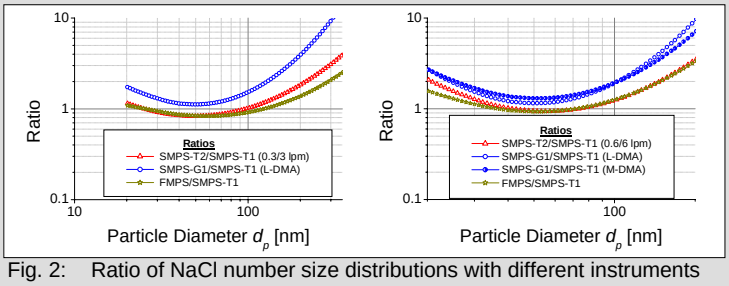

Fig. 2: Ratio of NaCl number size distributions with different instruments with largely equal settings (left) and different settings (right) with respect to SMPS-T1

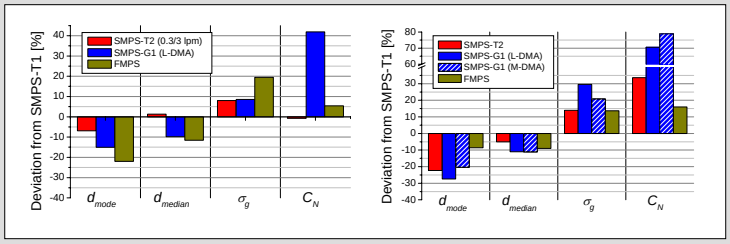

Fig. 3: Deviation of NaCl size distribution parameters of different instruments from SMPS-T1 with largely equal settings (left) and different settings (right)

Diesel Soot

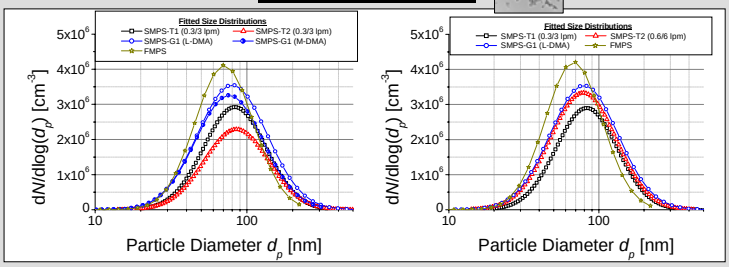

Fig. 4: Diesel number size distributions measured with different instruments with largely equal settings (left) and different settings (right)

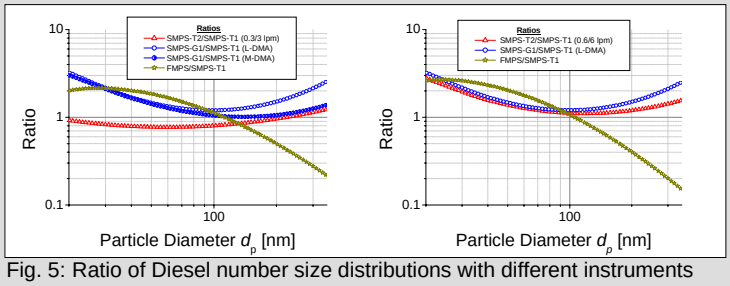

Fig. 5: Ratio of Diesel number size distributions with different instruments with largely equal settings (left) and different settings (right) with respect to SMPS-T1

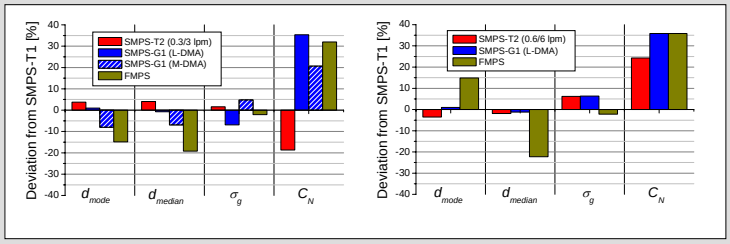

Fig. 6: Deviation of Diesel size distribution parameters of different instruments from SMPS-T1 with largely equal settings (left) and different settings (right)

Conclusions

- All instruments in the test agreed well concerning sizing of the particles
- SMPS-G1 showed consistently higher concentrations and wider distributions than TSI-SMPS's
- SMPS-T2 showed higher concentrations with higher operating flow rates
- SMPS-G1 showed very comparable results with L-DMA and M-DMA
- FMPS and SMPS's reacted differently to NaCl (compact particles) and Diesel soot (agglomerates), maybe due to different charging

This work has been funded by the German Federal Ministry of Education and Research (BMBF) as part of the NanoCare project.

Final Conference NanoCare
16. – 17.06.2009, Berlin

Reference:
C. Asbach *et al.* (2009): Comparison of four mobility particle sizers with different time resolution for stationary exposure measurement, *J. Nanoparticle Res.* (accepted for publication)