Evaluation of the DiSCmini Personal Aerosol Monitor for Submicrometer Sodium Chloride and Metal Aerosols

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Background

Nanoparticles (particles < 100 nm) are an increasing exposure hazard in occupational settings. Robust, lightweight, and reliable direct reading instruments have been unavailable for nanoparticles. The DiSCmini (DM) operates by diffusion charging and an electrometer to enable nanoparticle detection which provides a direct reading of particle number concentration and mean particle diameter. However, the DM has not been evaluated for occupationally-relevant aerosols, such as welding fume.

Objective

Compare the performance of DM with two reference instruments: the condensation particle counter (CPC) and the scanning mobility particle sizer (SMPS).

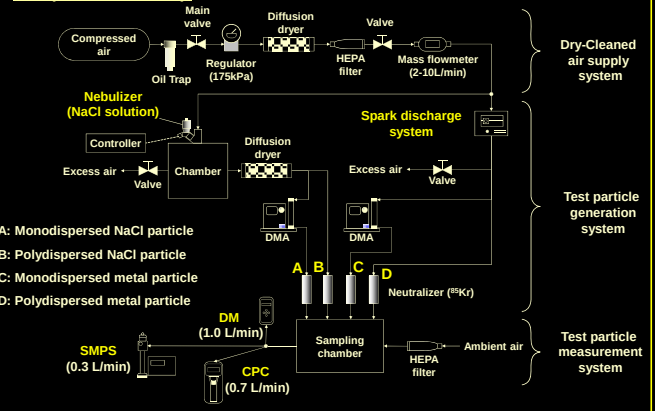
Methods

- Polydispersed particles were generated using sodium chloride (NaCl) particles nebulized from solution, and metal particles generated with a spark discharge system using welding rods
- For mono-dispersed particles, aerosols were classified into three sizes (30, 100, and 300 nm)
- Both mono- and polydispersed particles were controlled in three different steady-state concentration ranges (<10^3, 10^3-10^4, and >10^4 particles/cm^3) and particle number concentration and size were measured by the DM, CPC, and SMPS for a total of 24 test conditions

1. Test instruments

	Grimm SMPS 5.402	TSI CPC 3007	Matter Aerosol DiSCmini 1.1
Measurement principle	Electrical & Optical	Optical	Electrical
Size range (nm)	11-1083	10-1000	10-300
Concentration range (particles/cm^3)	0-10^7	0-10^5	20nm: 10^3-10^6 100nm: 5×10^2-5×10^5
Sampling flow rate (L/min)	0.3	0.7	1.0
Weight (kg)	DMA: 7.8 CPC: 11.5	1.7	0.7
Limitations	Large, bulky size & low resolution time	Too large for personal monitoring	Less accurate than reference instruments (±30%)
Cost (USD)	$40,000	$8,000	$ 15,000

2. Experimental setup



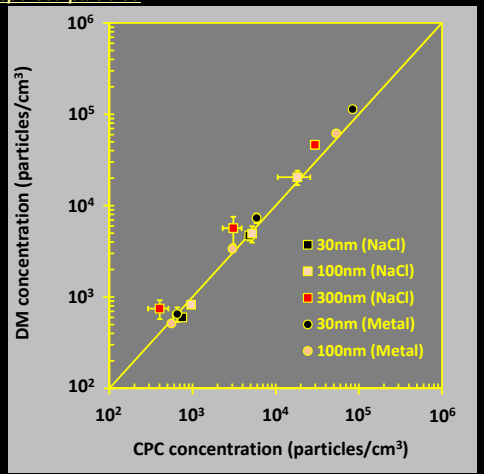
Results

1. Lung Deposited Surface Area

Test Aerosol	Conc. Range	$r_{LDSA} = \frac{LDSA_{DM}}{LDSA_{SMPS}}$ (Std. Dev.)
NaCl	L	1.09 (0.13)
	M	1.40 (0.03)
	H	1.55 (0.15)
Metal	L	1.00 (0.06)
	M	0.97 (0.10)
	H	1.10 (0.02)

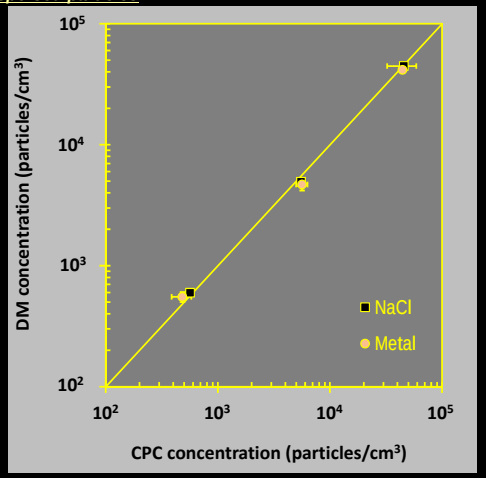
- LDSA Concentration was within 55% for NaCl and 10% for metal particles
- DM overestimated LDSA as the concentration of particles increased

2. Monodispersed particles



- Number concentrations from DM were similar to CPC (within 35%). Except for 300-nm NaCl aerosols (+101%)
- Mean particle size from DM slightly larger than that from SMPS (within 25%) Exception in high concentration of NaCl.

3. Polydispersed particles



- Number concentrations measured by DM compared to the CPC were favorable (within 11% for NaCl and 17% for metal).
- Mean particle size from DM was slightly larger than SMPS (within 25%). The exception was in the high concentration of NaCl (81%).

Conclusions

- The DiSCmini and CPC provided similar measurements to the SMPS (within 35% for most cases)
- Use with caution for aerosols that contain substantial concentrations of particles larger than 300 nm
- DiSCmini shows to be useful in the monitoring of polydispersed aerosols, particularly for this experiment, welding fume which is a common workplace exposure

Future Research

Deploy DiSCmini in ongoing welding fume study to monitor overall performance and long term usage.

Acknowledgements

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