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CALIBRATION OF AERODYNAMIC AND OPTICAL PARTICLE SIZING INSTRUMENTS WITH THE ELECTRICAL MOBILITY SIZER

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Keywords

Calibration, Particle size distribution, Low Pressure Impactor, Scanning Mobility Particle Sizer, Optical Particle Counter.

Introduction

Particle sizing instruments are based on various principles which segregates the aerosol particles according to their size. Based on the classification technique, each instrument has a specified and limited size range. This study is aimed at comparing the size distributions obtained from various instruments in the overlapping size ranges so as to assess their ability to generate continuous distributions in the entire particle size range (10 nm to 30 μm) **(Peters et al 1993)**. In the present study, the BARC developed PASS-LP **(Sanjay et al, 2005)** and GRIMM 1.108 Optical Particle Counter have been compared with the GRIMM Scanning Mobility Particle Sizer (SMPS). The 11 stage Cascade Impactor has seven stages operating at normal pressure and four at low pressure (150 mm Hg). The operational flow rate is 10 lpm with the minimum cut off diameter of 0.1 μm. The GRIMM 1.108 Aerosol Spectrometer works on the principle of light scattering and gives number size distribution in 15 size channels from 0.3 μm to 20.0 μm. The GRIMM SMPS classifies particles based on their electrical mobilities in an applied field and hence can be regarded as a primary calibration system. The instrument segregates particles in 44 size channels ranging from 9.8 nm to 874 nm. However, the comparisons need to be made with caution because while the impactor and the optical counter give the aerodynamic diameter and the optical diameter respectively, the SMPS estimates the mobility diameter. This calls for appropriate conversions and correction factors to be used to arrive at near-accurate comparisons.

Experimental Set Up

The study consisted of two sets of experiments: (1) Comparison of mass size distribution obtained from LP Impactor with Number size distribution from SMPS and (2) Comparison of Number size distribution from SMPS with the same obtained from OPC.

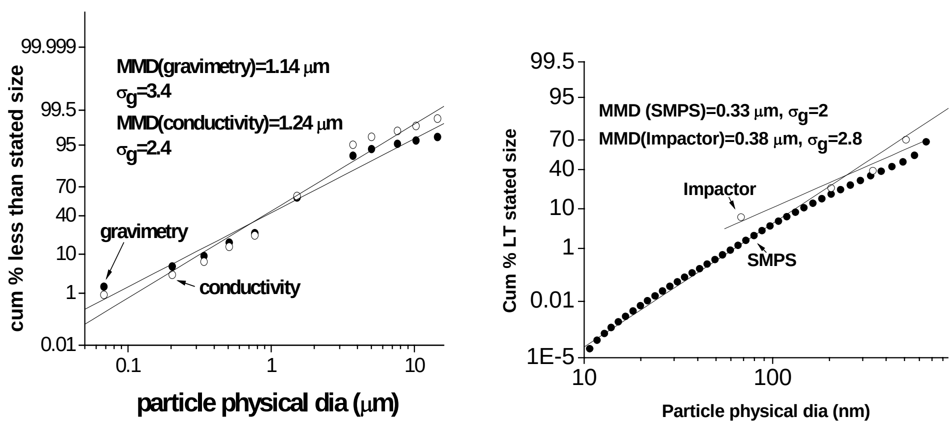
Study 1: In this study, test particles used were NaCl aerosols generated by a compressed air nebulizer using 5 % salt solution. These were fed to a chamber of volume 27 litres with sampling port arrangements. For drying of generated aerosols, extra N_2 gas was continuously supplied @ 20 l min^{-1}. Parallel sampling was carried out with 11 stage LP-PASS impactor and SMPS. To measure the total particulate concentration inside the chamber, gross filter paper sample @10 lpm was taken. The mass-size distribution and the total mass concentration were estimated by subjecting the filter paper substrates of the impactor and the gross sampler respectively to both gravimetry as well ionic conductivity techniques. The overlapping size range of the two instruments being compared was 0.1-0.75 μm.

Study 2: In the second study, particle number concentrations obtained from the OPC were compared with those obtained from the SMPS in the overlapping range (0.3-0.8 μm). The aerosols used in this study were ambient room aerosols and particles generated from a UV source lamp.

Results and Discussions

Study 1: The total mass concentration measured by gravimetry in all the 11 stages of the impactor (<21.3 μm) was found to be 44.06 mg/m^3, which was in good agreement with 40.1 mg/m^3 obtained from the gross filter paper sample. Using conductivity measurements, total concentrations were found to be 61.82 mg/m^3 and 57.25 mg/m^3 from impactor and grab sample respectively. The Mass Median Diameters (MMDs) estimated by gravimetry (with appropriate density corrections for NaCl aerosols) and conductivity measurements were found to be 1.14 μm (GSD= 3.2) and 1.24 μm (GSD= 2.6) respectively [Fig 1 (a)]. Although the concentrations estimated by conductivity are 1.4 times higher than that from gravimetry, the impactor estimated masses are consistent with the gross filter results by both the techniques.

The number concentrations obtained from the SMPS were converted to the mass size distributions assuming the density of NaCl particles as 2.16 gm/cm^3. In case of the impactor data, care was taken to convert the aerodynamic diameters to the physical diameters using the density corrections so as to make the data amenable to comparison with the SMPS data. The SMPS data gave a Count Median Diameter (CMD) of 0.064 μm with a GSD of 2.07 (in the sizes below 0.75 μm) which corresponds to a Mass Median Diameter (MMD) of 0.33 μm. This is in close agreement with the MMD value of 0.38 μm, GSD=2.8) obtained by fitting the impactor data in the size range 0.77-0.06 μm to a lognormal distribution. [Fig.1(b)].

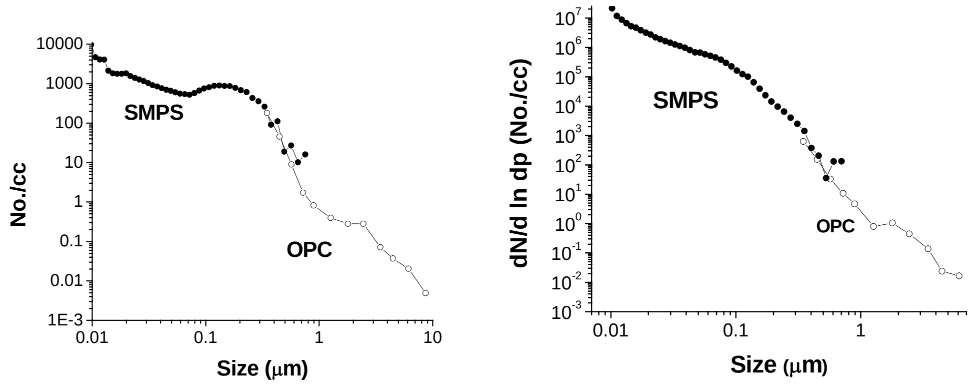


(a) (b)

Fig 1.: (a) Impactor based mass size distributions: gravimetry and conductivity techniques (b) MMDs obtained from SMPS and Low Pressure Impactor in common size ranges.

Interestingly, the total masses in the common size range (<0.75 μm) were also found to be fairly close; 10.42 mg/m^3 from the impactor and 8.15 mg/m^3 from SMPS.

Study 2: The number size distributions obtained by SMPS and OPC for ambient room aerosols in room environment were compared with each other. The instruments show good agreement in the common size channels [Fig. 2 (a)]



(a) (b)

Fig 2: Number size distribution recorded by SMPS and OPC for (a) ambient room aerosols. (b) UV source generated aerosols

As a second test involving very high particle concentrations, particles generated by UV source (known to generate particles in the 15-20 nm range) were used as test aerosols. In both the cases, the continuity and the trends of the size distributions were retained when the data from the two instruments were plotted together. Also, the data points of the two instruments in the overlapping size ranges were in close proximity [Fig 2(b)].

Conclusion

The experiments show that the size distributions obtained by the indigenous impactor and SMPS instruments were in good agreement with each other. Measurements also indicate good agreement between SMPS and OPC in their overlapping size region.

References:

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