

PA45) PM10/2.5/1.0 Trichotomous 도입부 설계 및 성능평가 Design and performance of Low-Volume PM10/2.5/1.0 Trichotomous Sampler Inlet

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1. INTRODUCTION

Particulate matter smaller than 10 μm in aerodynamic diameter (PM10) is known as thoracic particles that are capable of reaching the thoracic region of humans. PM10 is further divided into two size ranges, which are fine particles (nuclei mode plus accumulation mode) and coarse particles, based on different sources and chemical composition. Fine particles can penetrate deep into the alveolar region of the human lungs, while coarse particles be deposited in the upper respiratory system. Although there is clearly a separation between the two size ranges, it is still difficult to select a definite cutoff size for an air monitoring purpose. Most scientists agreed that the cutoff size should lie somewhere between 1.0 and 2.5 μm (Lundgren and Burton ; Lundgren et al.).

The purpose of the trichotomous sampling inlet described in this paper is to provide information not only on PM10, PM2.5, and PM1.0, but also on those in between those sizes (i.e., PM2.5-10 and PM1.0-2.5).

2. DESIGN AND EXPERIMENT

Figure 1 is a schematic diagram of PM10/2.5/1.0 trichotomous sampling inlet. The PM2.5/1.0 two-stage virtual impactor was designed based on the research of Loo and Cork ; the ratio of minor flow to major flow ($\approx 10\%$) was chosen as a compromise between higher losses at lower values and higher contamination of fine particles in the coarse particle stream at higher values of that ratio, the diameter of acceleration nozzle of is critical in determining the particle velocity, hence the cutoff size, as expressed by the critical Stokes number, the critical ratio of collection probe to the acceleration nozzle in the range of 1.3 - 1.4 must be used to minimize the loss peak near the cutoff size, and the ratio of spacing between the acceleration nozzle and the collection probe to the acceleration nozzle should be kept within the range of 1.2 - 1.8.

The performance of the designed two-stage virtual impactor was evaluated in a laboratory. Monodispersed polystyrene latex (PSL, Duke Scientific Corporation) particles ranging from 0.5 to 4.0 μm were used for the impactor. For each tested PSL particle size generated by an atomizer (TSI Inc., Model 9302), the measured geometric standard deviation ranged from 1.10 to 1.16.

3. RESULTS AND DISCUSSION

The laboratory evaluation for the PM2.5/1.0 two-stage virtual impactor resulted in the cutoff characteristics shown in Figure 2. The indicated particle sizes shown in the figure are the aerodynamic particle diameter as measured by the Aerosizer. The separation efficiency curves were fitted based on all experimental data using the 4-parameter-sigmoidal equation in SIGMAPLOT version 5.0 software. The 50% cutoff sizes are 2.58 μm and 0.97 μm and the sharpnesses are 1.56 and 1.40, respectively, for the PM2.5 virtual impactor (Stage 1) and the PM1.0 virtual impactor (Stage 2). Detailed experimental results are also summarized in Table 1. Particle losses of virtual impactors have a maximum near the cutoff size (Chen et al. ; Sioutas et al.).

Particle losses were calculated using a mass balance of particle concentrations. The average particle loss is 22% for particle ranged from 0.5 to 4.0 μm with higher values in the neighborhood of the 50% cutoff sizes.

Table 1. Cutoff size and sharpness of tested two-stage virtual impactor.

	Inflow (l/min)	Minor flow (l/min)	Major flow (l/min)	Flow ratio	Cutoff size (μm)			Sharpness	Re
					Designed	Tested	Difference		
Stage 1 (PM2.5 virtual impactor)	25	2.2	22.8	1:10.4	2.5	2.58	+3.2%	1.56	9820
Stage 2 (PM1.0 virtual impactor)	22.8 ^a	2.2	20.6	1:9.4	1.0	0.97	-3.0%	1.40	16110

a. Same as major flow of Stage 1, b. Calculated using $\sigma_g = (D_{15.9}/D_{84.1})^{0.5}$

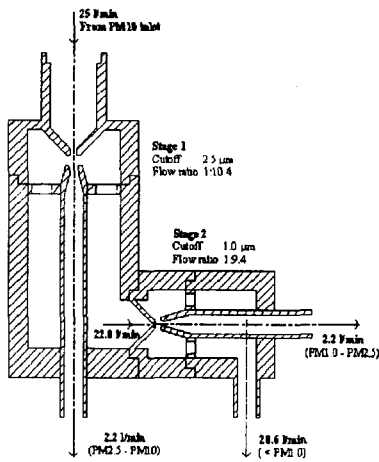


Figure 1. schematic diagram of PM10/2.5/1.0 trichotomous sampling inlet.

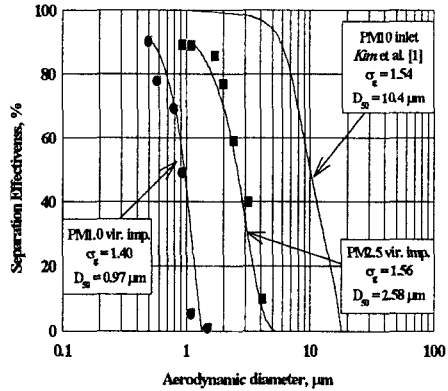


Figure 2. Performance curve for two-stage virtual impactor.

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REFERENCE

- [1] D. A. Lundgren, D. N. Hlaing, T. A. Rich, V. A. Marple: PM10/PM2.5/PM1 Data from a Trichotomous Sampler. *Aerosol Sci. Technol.* 25 (1996) 353-357.
- [2] B. T. Chen, H. C. Yeh, Y. S. Cheng: A Novel Virtual Impactor: Calibration and Use. *J. Aerosol Sci.* 16 (1985) 343-354.