Development of a high volume air-into-liquid aerosol collector for $PM_{2.5}$ and ultrafine particulate matter

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A novel high volume aerosol sampler for $PM_{2.5}$ and ultrafine particulate matter (PM) was developed to collect ambient aerosols directly into a liquid phase, for application areas such as toxicity studies of PM as well as for direct chemical analysis of the collected suspension samples, thus overcoming limitations associated with the conventional filter samplers. This new collector was designed to be coupled with the USC Versatile Aerosol Concentration Enrichment System (VACES) technology described by Kim et al (2001), by integrating an inertial impactor to collect the super micron ambient aerosols after their condensational growth in the VACES, in the form of an aerosol suspension in liquid. The high-flow (200 LPM), low pressure drop (6.5 inches of water) impactor allows prolonged and unattended operation of the system.

Laboratory tests were conducted to evaluate the performance of the impactor. The collection efficiency of the inertial impactor was determined using monodisperse aerosols generated by atomizing suspensions of Polystyrene latex (PSL) particles (1, 1.5, 3 and 6μm) with a constant output nebulizer. Figure 1 presents the collection efficiency of the impactor as a function of particle aerodynamic diameter.

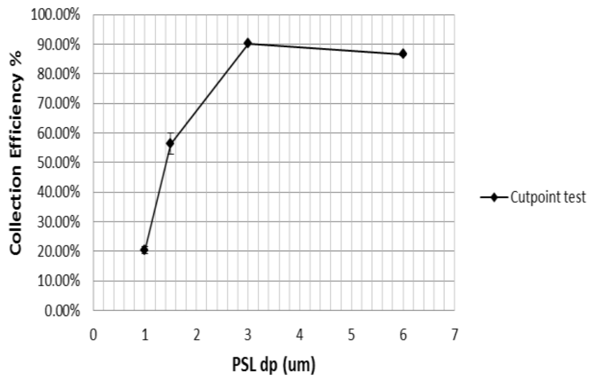

Figure 1. Collection efficiency curve of different PSL particles

Collection efficiency of the VACES-inertial impactor system was evaluated by testing different monodisperse PSL particles in sub-micron range: 42.5, 100, 300, 750nm and 1 μm, and polydisperse aerosols: glutaric acid and ammonium nitrate. The generated particles were first grown in the VACES prior to collection in the impactor. A fluorescence detector was used to measure the fluorescence signal of PSL particles on upstream and downstream filters and residual on the collector inlet and impaction walls, while mass concentration was measured by DustTrak upstream and downstream of the collector for polydisperse aerosols. Overall, the average collection efficiency of this collector was above 90%, as shown in Table 1.

Table 1. Collection efficiency of the new impactor

Aerosol	Efficiency	Inlet	Wall	Suspension
42.5nm	96.40%	4.53%	9.43%	82.44%
100nm	90.33%	2.11%	7.51%	80.71%
300nm	98.95%	1.17%	6.29%	91.49%
750nm	95.15%	2.87%	11.17%	81.10%
1 μm	99.08%	1.79%	9.30%	88.00%
glutaric acid	97.09%	-	-	-
ammonium nitrate	96.56%	-	-	-

Comparison of collection performance between the new impactor and the VACES/biosampler tandem was conducted using PSL particles of 300 and 750nm. Fluorescence signals of suspensions collected by these two samplers were measured and compared Results indicated that the aerosol collection performance was equivalent in both the impactor and biosampler.

Lastly, the whole system was deployed in the field and ambient $PM_{2.5}$ samples were collected both in the new collector and on filter substrates, similar to the test described by Daher et al (2011) to validate that the chemical compositions of suspension samples collected by the new impactor are equivalent to those on filter samples. This analysis is underway and results will be presented soon. Continuity test will be conducted to demonstrate the ability of prolonged and unattended operation.

Kim, S., P. A. Jaques, et al. (2001a). "Versatile aerosol concentration enrichment system (VACES) for simultaneous in vivo and in vitro evaluation of toxic effects of ultrafine, fine and coarse ambient particles - Part I: Development and laboratory characterization." Journal of Aerosol Science. 32(11): 1281-1297.

Daher, N., Z. Ning, et al. (2011). "Comparison of the Chemical and Oxidative Characteristics of Particulate Matter (PM) Collected by Different Methods: Filters, Impactors, and BioSamplers." *Aerosol Science and Technology*. **45**(11): 1294-1304.