Particle loss and loaded particle mass effects on the collection efficiency of the Well Impactor Ninety-Six $PM_{2.5}$ sampling inlet

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The WINS (Well Impactor Ninety-Six) is designated as the inlet for USEPA $PM_{2.5}$ FRM (Federal Reference Method) samplers (Peter *et al*., 2001a). Loaded particle mass and particle loss are the limitations of inertial impactors. Instead of being collected on the impaction substrate, particles deposit on the inner walls of the impactor (Chen *et al*., 2007), leading to the underestimation of the collection efficiency. The loaded particle mass on the impactor plate also shifts the cutoff diameter of the WINS to a smaller diameter (Kenny *et al*., 2000). The main aim of the present work is to recalibrate and determine particle loss in the WINS, and study the loaded particle mass effect on the cutoff diameter.

The WINS with the original inlet tube (inner diameter = 28.4 mm) have two contractions (28.4 to 12.7 mm, then 12.7 to 3.91 mm) before the nozzle of 3.91 mm in diameter. Since particle loss is very likely in the contractions due to inertial impaction and interception (Chen *et al*., 2007), a small inlet tube with the inner diameter of 4.0 mm was made to reduce particle loss in this study. The WINS was also re-designed as a modified WINS (M-WINS) to test the effect of loaded particle mass. The M-WINS has a wetted flat impaction surface with a 0.8 mm hole in diameter at the center of the plate. A wetted glass fiber filter on the plate was also tested. A cleaning deionized (DI) water flow is introduced upward at the center of the impaction plate by using a syringe pump to wash off deposited particles from the impaction surface continuously.

The WINS and the M-WINS were tested in the laboratory using a vibrating orifice aerosol generator (VOAG, TSI model 3450) to generate monodisperse solid ammonium fluorescein particles with the aerodynamic diameter ranging from 1.0 to 4.0 μm for the particle collection efficiency (Peter *et al*., 2001b) and for the particle loss (Liu *et al*., 2011). The particle collection efficiency curve was determined by counting particle concentrations upstream and downstream of the WINS and the M-WINS using a TSI Model 3321 APS. To test the particle loss in the WINS, cotton clothes were used to recover the deposited particles at the inner wall of the inlet and nozzle. Solid particles collected on cotton clothes was dissolved in DI water and measured by the Ion Chromatography (IC, Metrohm Model 883 Basic IC plus) for ammonium ion concentrations.

Fig. 1 shows the particle collection efficiency curves of the WINS and the M-WINS with the original and small inlet tubes and compare to previous results. The cutoff diameter of the WINS and the M-WINS equal 2.48 ± 0.05 μm, which agrees with that in Peter *et al* (2001a) and Kenny *et al* (2000). The GSD (geometric standard deviation) of the WINS with the original inlet and the small inlet tubes are 1.2 and 1.24, respectively. In comparison, the GSD is 1.23 and 1.18 reported in Kenny *et al* (2000) and Peter *et al* (2001a), respectively. The GSD of the M-WINS with the original inlet and the small inlet tubes are 1.24 and 1.25, respectively. The collection efficiency curve of the M-WINS is slightly less sharp than that of the WINS when water is used instead of oil.

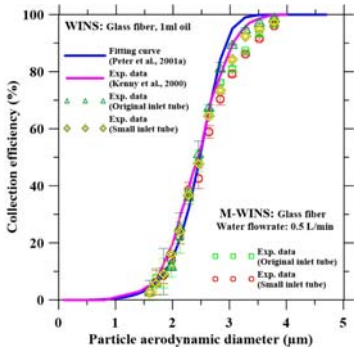

Figure 1. The particle collection efficiency curves of the WINS and the M-WINS.

Paricle loss for particles larger than the cutoff diameter is larger in the original inlet tube (13% - 21%) than that in the small inlet tube (<10 %). This leads to a sharper particle collection efficiency curve of the WINS with the original inlet tube than that with the small inlet tube as particle loss is considered as a part of the collection efficiency is determined by the APS. Without contractions, the small inlet tube indeed has a much small particle loss, which results in a less sharp collection efficiency curve. A wetted impaction surface to keep the impaction surface free from particle pile-up was shown to keep the cutoff diameter nearly constant with particle loaded mass up to 6 mg. The results of these new findings will be reported in the conference.

Chen, S. C., Tsai, C. J., Wu, C. H., Pui, D. Y. H., Onischuk, A. A., and Karasev, V. V. (2007) *J. Aerosol Sci.*, 38, 935-949.

Kenny, L. C., Gussman, R., and Meyer, M. (2000). *Aerosol Sci. Technol.*, 38, 15-22.

Liu, C. N., Chen, S. C., and Tsai, C. J. (2011) *Aerosol Sci. Technol.*, 45, 1480–1487.

Peters, T. M, Vanderpool, R. W., and Wiener, R. W. (2001a) *Aerosol Sci. Technol.*, 34, 389-397.

Peters, T. M, Vanderpool, R. W., and Wiener, R. W. (2001b) *Aerosol Sci. echnol.*, 34, 398-406.