Section 3 (b): Evaluating size cut of nuclepore filters via optical particle sizer

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General summary: We tested the size cut of the AirPhoton inlet and various nuclepore filter diameters using an optical particle sizer (TSI model 3330). 8-micron greased nuclepore filters showed, within error, a near- 50% capture efficiency at 2.5 microns.

Background motivation: We wished to verify whether our nuclepore filters were appropriate for a $PM_{2.5}$ size cut. We did not have access to aerosols with known properties (a cost and time-prohibitive venture) so we used ambient, dusty air. We chose an area that being renovated in the LSRI building. The dust/PM levels were high and the air was dry (< 35% RH). The mean ambient concentration of PM_{10} particles was large at 30/cm^3 (or 82 μg/m^3).

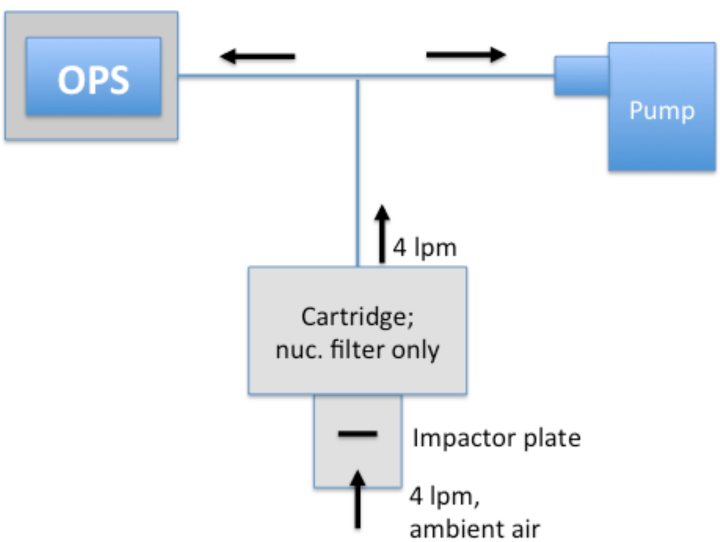

Figure 1: Schematic of sampling arrangement between OPS, air pump, and cartridge

Figure 1 is the sampling setup. We needed an external pump since the max flow of the OPS was 1.2 lpm.

We loaded cartridges (containing nuclepore filters only) with various-sized holes: 5 μm (ungreased), 8 μm (greased and ungreased), 10 μm (ungreased), and no filter. We obtained the escape efficiency ratio by running the OPS in ambient air (without any filtration) vs runs using the given filter.

We ran a 5-minute sampling run for every nuclepore size for each one of the eight filter slots. The particle ratios were then averaged together.

The OPS requires an assumed particle density; we chose 1.8 g/cm^3, although the fine dust in the air may be heavier than this (possibly 2.5 g/cm^3).

We also overlaid a theoretical curve for 8um filters; a capture efficiency curve defined by

$$E = 1 - (2R - R^2)^{1.5},$$

where R = (geometric mean of particle size bin)/8 μm (John et al., 1983). Since there are many such equations, some involving variable exponents, disobeying this curve is not a clear sign there is any issue with either the nuclepore filters or OPS.

Results and Discussion:

Figure 2 shows the 50% size cut is about 2.9 μm for the greased 8 μm nuclepore, which is the one we are presently using in SPARTAN to capture coarse material. The cut point can be accepted as 2.5 microns to within error. We show here both the escape and capture efficiency, (same data, only one is the mirror of the other). The size cuts for all filters is higher than expected for the finer material, i.e. < 1 um. Particles this small should have an escape ratio nearing 100%.

The 50% size cut is not exactly 2.5 μm for the 8 μm filters. Could the greased impactor plate be the cause? (The first size cut should not be affecting particles much smaller than 5 um)

Since the aerosol input density had to be assumed, so we assumed a value of 1.8 g/cm^3, however this value may be incorrect for semi-liquid particles or dust. (hence the bins could be offset either to the left or right).

Could the use of ambient dusty air from non-liquid aerosols be affecting the OPS optics? It is also possible fine solid particles with too much bounce are escaping through the membrane surface.

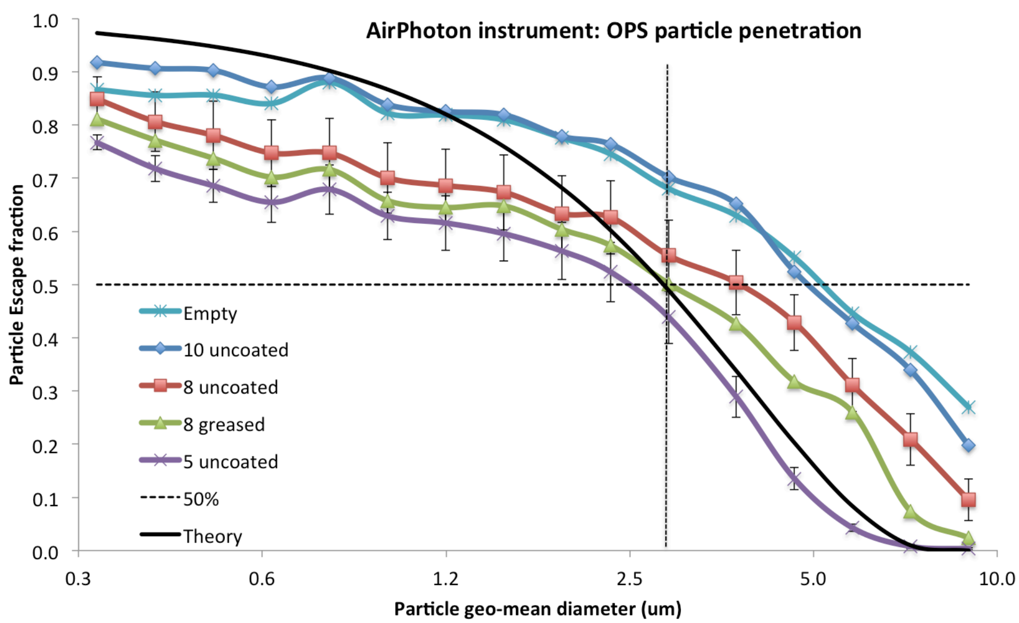

Figure 2: Particle escape efficiency for the TSI Optical Particle Sizer using variable-sized nuclepore filters.

References

John, W., Hering, S., Reischl, G., Sasaki, G. and Goren, S.: Characteristics of Nuclepore filters with large pore size—II. Filtration properties, Atmos. Environ., 17(2), 373–382, doi:http://dx.doi.org/10.1016/0004-6981(83)90054-9, 1983.