Characterizing the Particle Losses of a Large Diameter Nafion® Dryer

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Controlling the humidity of the air sample is critical to getting consistent results for aerosol and particle analyses across a wide range of ambient conditions. Small diameter gas sample dryers with Nafion® membrane technology have been shown to control air sample humidity well in many analysis applications but until now have shown high particle losses due to their small pathway diameters.

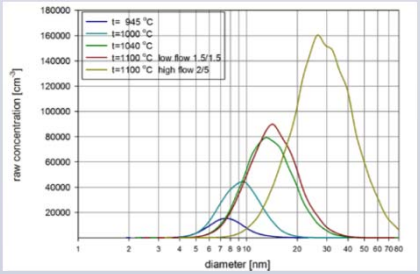
A Perma Pure MD-700 Nafion® based air sample dryer with a large diameter inlet and 0.700" diameter flow path is evaluated for particle losses across the Nanoparticle size range from 5 to 40 nm. This size range was chosen to amplify loss measurements and to show a "worst case scenario". Real losses are measured and compared with a similar configuration of bare tubing without the membrane. This type of dryer has been shown to remove the amount of moisture required for most particle analysis flow rates and applications. The drying performance is included in the Results section as a reference.

The laboratory infrastructure at TROPOS was used for the generation of the silver Aerosol used to characterize the dryers.

1. Aerosol Generator

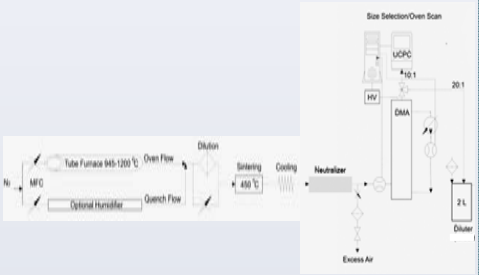
For the generation of silver particles a tube furnace with three temperature controlled heating zones (Linn model FRH-3-70/750/1250, Linn High Therm GmbH, Eschenfelden, Germany) was used. Specific particle size distributions are generated by altering the temperature of the furnace, as shown in figure 1.

Figure 1 – Furnace Temp vs. Particle Size



A dilution part consisting of a filter and a manual bypass valve allows the adjustment of the particle number concentration. Behind the dilution a spiral is used to cool down the silver particles to room temperature.

Figure 2 – Aerosol Generation

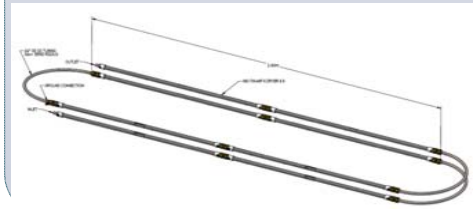


After the cooling the silver particles enter the measuring and sintering unit (see figure 2, above). Before feeding the silver particles into the DMA (Differential Mobility Analyzer) they are neutralized by a 370 MBq Kr85 neutralizer. A TROPOS made Hauke short DMA with an aerosol flow of 3 l/min and a sheath air flow of 20 l/min was used to select a monodispersed particle size.

2. Test Nafion Dryer Assembly

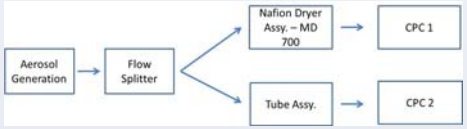
The flow was diluted and split into two identical flows, one into the MD-700 dryer assembly and one into the tube assembly of the same physical configuration of 10m of dryers assembled in series. The second was assembled with bare aluminum tubing to serve as the comparison. A length ten times longer than would be normally installed was chosen to amplify any differences in results as the calculated theoretical losses are so low.

Figure 3 – MD-700 Dryer Assembly



At the end of each line an identical CPC (Condensation Particle Counter -TSI model 3772) was used to count the number concentration of silver particles flowing through each test assembly.

Figure 4 – MD-700 Test Set-Up



In Table 1 the particle transmission measurements (in %) are corrected for length and displayed for one 120 cm MD-700 dryer versus a straight tube. The losses are highly dependent on the size of the particle being measured, and as the particle size increases to 40 nm any losses become insignificant.

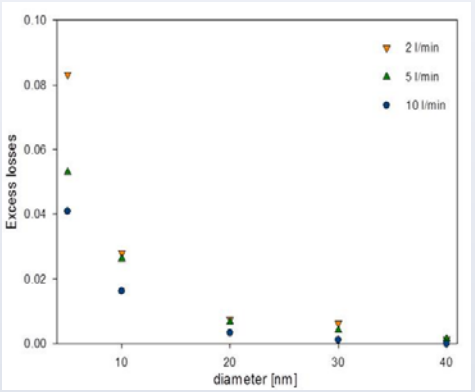
Table 1 – Particle Loss Test Results

Penetration through a straight tube			
dp	2 l/min	5 l/min	10 l/min
40	0.986	0.986	0.995
30	0.980	0.989	0.993
20	0.967	0.982	0.988
10	0.921	0.956	0.972
5	0.814	0.895	0.932

Penetration through a Perma Pure MD-700 dryer			
dp	2 l/min	5 l/min	10 l/min
40	0.985	0.985	0.995
30	0.974	0.985	0.992
20	0.960	0.975	0.985
10	0.896	0.931	0.956
5	0.747	0.848	0.894

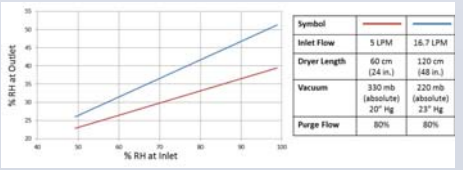
The graph below charts the excess losses – or difference – between the MD-700 Nafion® dryer assembly and the bare tubing shown in the tables for all three flow rates.

Figure 5 – MD-700 Excess Losses vs. Bare Tubing



As a reference, the moisture removal performance for the 120 cm dryer and one 60 cm dryer is shown using a vacuum reflux purge set up, whereby the sample aerosol flow is filtered and used as the purge gas.

Figure 6 – MD-700 Moisture Removal Performance



CONCLUSION

The test data presented shows that the Perma Pure MD-700 large diameter Nafion® dryer has very low particle losses in practical operation. Users and researchers measuring PM 2.5, PM1, or nanoparticles, or performing aerosol research and analysis now have an effective option to control humidity while improving measurement accuracy for their analyses.