Evaluation of Porous Foam for Use in a Nanoparticle Respiratory Deposition Sampler

Levi W.D. Mines[1], Jae Hong Park[1], Imali A. Mudunkotuwa[2], Vicki H. Grassian[2], T. Renée Anthony[1], Thomas M. Peters[1]

[1]Department of Occupational and Environmental Health, The University of Iowa

[2]Department of Chemistry, The University of Iowa

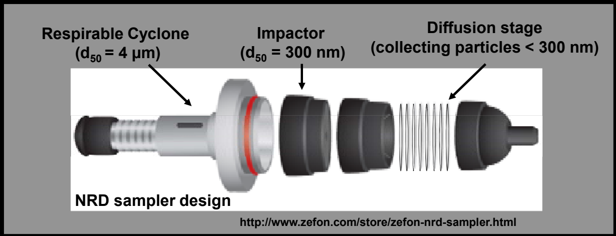
Background

Some metal nanoparticles have greater toxicity than larger particles of same composition for the same mass.

Ways to measure exposure (*e.g.*, respirable sampling) are costly (*e.g.*, electron microscopy ~$300/sample) to resolve nanoparticles from larger particles.

The Nanoparticle Respiratory Deposition (NRD) sampler (ZNRD001, Zefon, Ocala, FL) streamlines measurement by collecting particles < 300 nm on 8 nylon meshes with efficiency mimicking deposition in the respiratory system.

Nylon mesh contain titanium (Ti), which makes exposure assessment of titanium dioxide (TiO_2) difficult.



Objective

Evaluate foam as collection substrate for the NRD sampler

Methods

Characterize Foam and Nylon Mesh Substrates

- Porous polyurethane foam (neutral color; 110 ppi) was cut into cylinders (25-mm diameter by 40-mm depth).
- Metals content (Ti, Fe, Cr, Mn, Ni, Cu, Cd, Zn) was measured by inductively coupled plasma-optical emission spectroscopy.

Foam Collection Efficiency and Pressure Drop

- Collection efficiency by size of pristine foam was measured for salt and metal fume aerosols with scanning mobility particle sizer (SMPS; 3936, TSI, Shoreview, MN). Efficiency was calculated as:

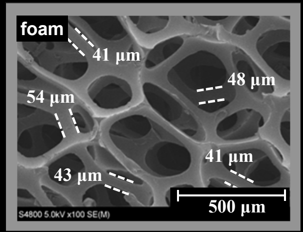
$$\eta = 1 - \frac{C_{\text{substrate}}}{C_{\text{bypass}}}$$

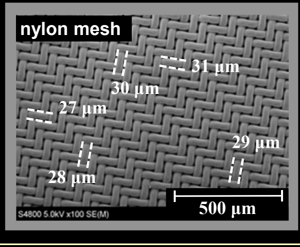
where $C_{\text{substrate}}$ is the number concentration measured downstream of the substrate and C_{bypass} is that measured with no substrate in place.

- Collection efficiency was compared to the nanoparticulate matter (NPM) sampling criterion.
- Collection efficiency of foam and nylon meshes was measured after loading the substrates with metal fume.

Results

Characterization of Foam and Nylon Mesh Substrates

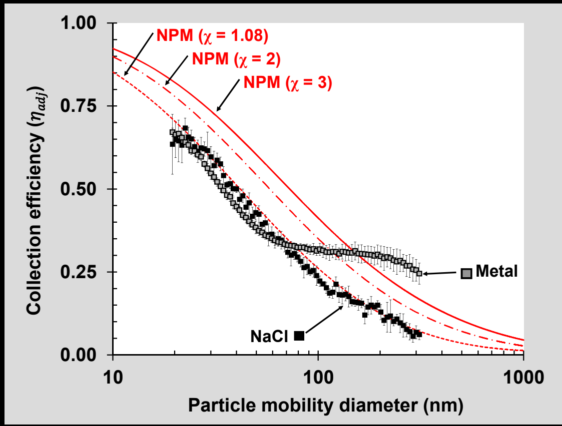




Metal content	Polyurethane foam		Nylon mesh		Mass collected at 1/10th OEL
	µg substrate^{-1}	LOD (µg)	µg substrate^{-1}	LOD (µg)	µg
Ti	0.173	0.673	125.	190.	15.1
Cd	0.126	0.454	ND	ND	0.100

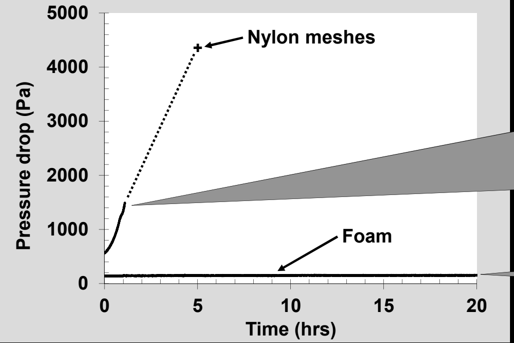
LOD is three standard deviations above the mean metal per blank sampler
OEL is NIOSH REL for Ti nanoparticles and ACGIH TLV for Cd

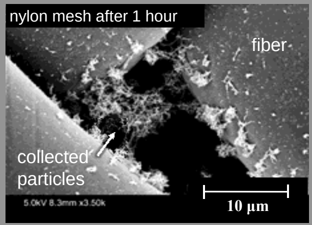
Collection Efficiency of Foam



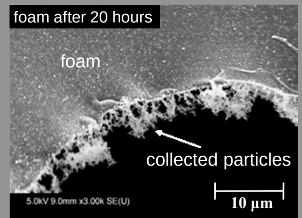
Collection efficiency of foam for salt and metal fume aerosols. Error bars represent one standard deviation (n=5). The NPM criterion was adjusted for shape factor (χ).

Changes in Pressure Drop During Metal Fume Loading



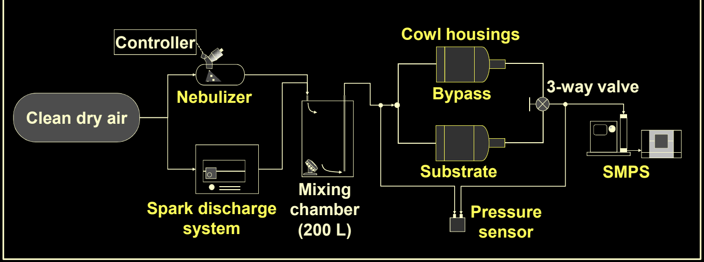


Collected particles act like small fibers, increasing pressure drop and collection efficiency



Large pores minimize the changes in pressure drop and collection efficiency from collected particles

Experimental Setup



Conclusions

Foam had low metals content, making it a suitable material for detection of Fe, Cr, Mn, Ni, and Cu, but not Cd.

Foam collection efficiency of salt was similar to target NPM criteria.

Foam was substantially more resilient to loading than nylon mesh.

Acknowledgements

This research was funded by The Heartland Center for Occupational Safety and Health supported by Training Grant No. T42 OH008491 and by The Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health grant R01 OH010238.