Evaluation of Nylon Net Screens as Diffusion Media for Nanoparticles

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Background

Diffusion screens rely on diffusion to remove ultra-fine particles (<300 nm) from a laminar-flow aerosol stream. Diffusion Screens consist of a compact surface with uniform thickness, fiber diameter, mesh opening, and packing density that provide a consistent airflow that allows for accurate prediction of filtration based on theory.

Nylon net screens consist of rows of parallel equidistant nylon fibers with uniform diameter interwoven at 90° angles with mesh openings ranging between 10 and 180 µm. Nylon net screens provide an inexpensive disposable collection surface that can be analyzed under electron microscopy or be digested for chemical analysis. We plan to use this media for the development of a novel nanoparticle sampler.

Diffusion screen theory has not been validated for use with estimating collection of particles with nylon net screens.

Objective

Evaluate diffusion screen theory for estimating the collection of particles with nylon net screens

Methods

Nylon screens (Millipore, Billerica, MA) mesh opening sizes:

- Small – 60 µm (NY60)
- Medium – 100 µm (NY1H)
- Large – 180 µm (NY8H)

Flowrates:

- 2.5 Lpm
- 4 Lpm
- 6 Lpm

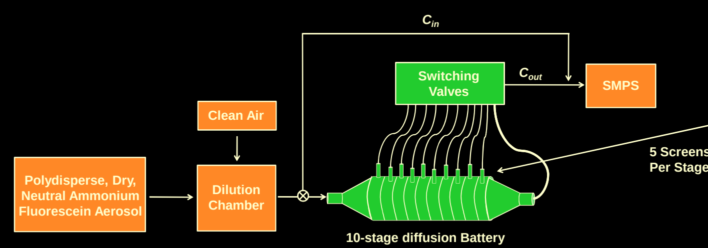
Aerosol and Measurements:

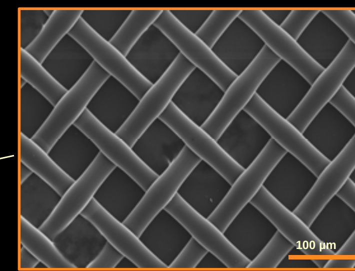
- Ammonium fluorescein aerosol
- Scanning mobility particle sizer (SMPS) channels 10 – 300 nm

Experiments and Equations:

- Load 5 screens per stage in 10 Stage diffusion battery
- Measure aerosol concentrations at even stages (C_{out}) alternated with measurements of unfiltered aerosol C_{in}
- Calculate aerosol penetration $P = C_{out}/C_{in}$
- Obtain slope (m) of regression line P = m*n+b, where n = number of screens
- Calculate single fiber efficiency as $\eta = m^{*}\ln 10/B$, where $B = 2\alpha h/\pi(1-\alpha)a$, α = screens packing density, h = screen thickness, a = screen wire radius
- Compare experimental efficiency with Kirsch and Stechkina (1978) filtration and pressure drop theory

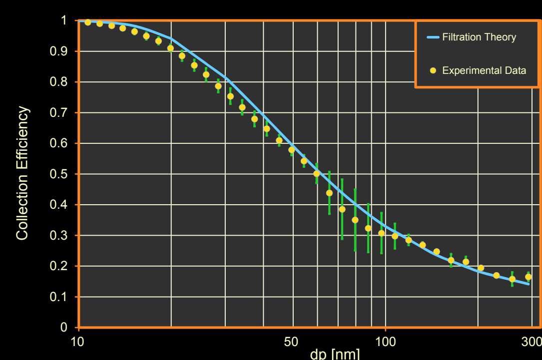
Experimental Setup



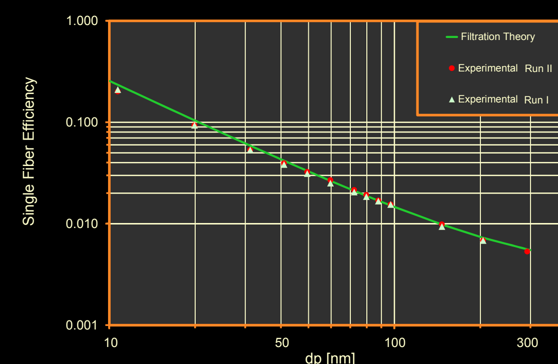


Scanning Electron Microscopy Image of NY60 Screen

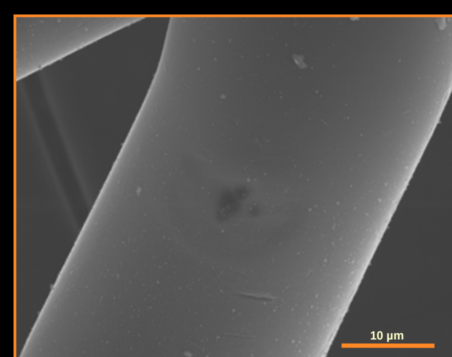
Results



Collection Efficiency by Size Through 30 NY60 Screens at 4 Lpm



Single Fiber Efficiency of NY60 Screens at 4 Lpm



Scanning Electron Microscopy Image of Ammonium Fluorescein Nanoparticles Loading (White Spots) on NY60 Screen Fiber

Discussion and Conclusions

Filtration theory can be used to effectively estimate collection efficiency of nylon net screens

Pressure drop was measured across nylon net screens in the diffusion battery and a linear relationship was found between pressure drop and flow rates indicating constant flow resistance

Nylon net screens provide a low-cost, disposable collection surface suitable for collection of nanoparticles and compatible with a wide range of analysis methods

The ability of collecting and analyzing nanoparticles will aid in estimating worker's exposure to nanoparticles

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