Length Separation of Glass Fiber Aerosols with Aerodynamic Aerosol Classifier

Taekhee Lee[1], Bon-Ki Ku[2], Rachel Walker[1], Pramod Kulkarni[2], Teresa Barone[1], Steven Mischler[1]

[1] Pittsburgh Mining Research Division, NIOSH [2]Health Effects Laboratory Division, NIOSH

Introduction

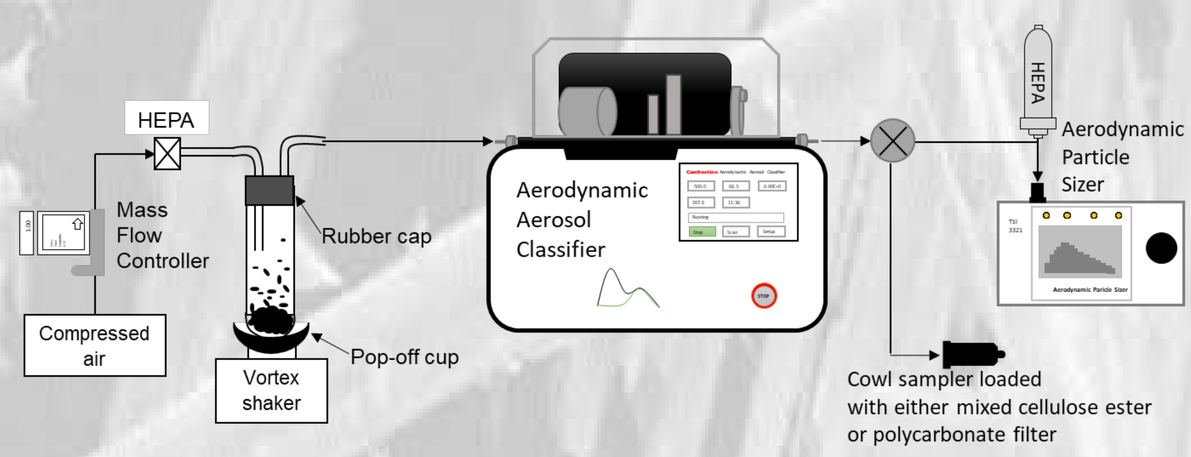
Description:

The NIOSH Pittsburgh Mining Research Division is establishing a research effort to understand elongate mineral particle (EMP) exposures in the mining industries to find an optimal method for fiber classification in terms of particle size (fiber length and/or diameter) distribution and collection rates. The objective of the present presentation is to evaluate methods for the aerodynamic separation of glass fibers aerosols with an Aerodynamic Aerosol Classifier (AAC).

Situation/Problem:

The role of fiber length in determining the toxicity of EMPs is not scientifically clear. There is no established method for separating EMPs by length with the capability of collecting a large enough mass for toxicity studies. NIOSH investigated the classification of fibers by length and developed a Fiber Length Classifier (FLC) to employ in toxicology studies. This system utilized dielectrophoresis—separation induced by the movement of neutral particles in a gradient electric field—and showed promise in achieving fiber separation by length for a narrowly defined distribution. However, the system was only able to separate fibers at rates up to 1 mg/day, which made it difficult to conduct a large-scale toxicological evaluation.

Materials and Methods



Experimental setup for glass fiber aerosol separation with Aerodynamic Aerosol Classifier.

Experimental parameters of AAC for glass fiber aerosol classification

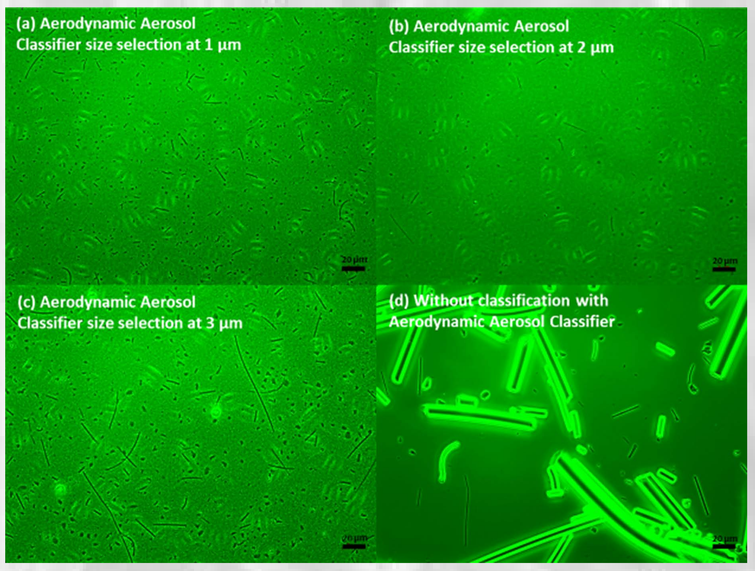
Selected aerodynamic diameter in AAC (µm)	Speed (rad/s)*	Sheath flow rate (L/min)	Sample flow rate (L/min)
0.5	207.7	11.36	0.3
0.75	114.6		
1.0	111.0		
1.25	90		
1.5	75.7		
2.0	57.5		
2.5	46.3		
3.0	38.8		

*1 rad/s: 9.55 revolutions per minute

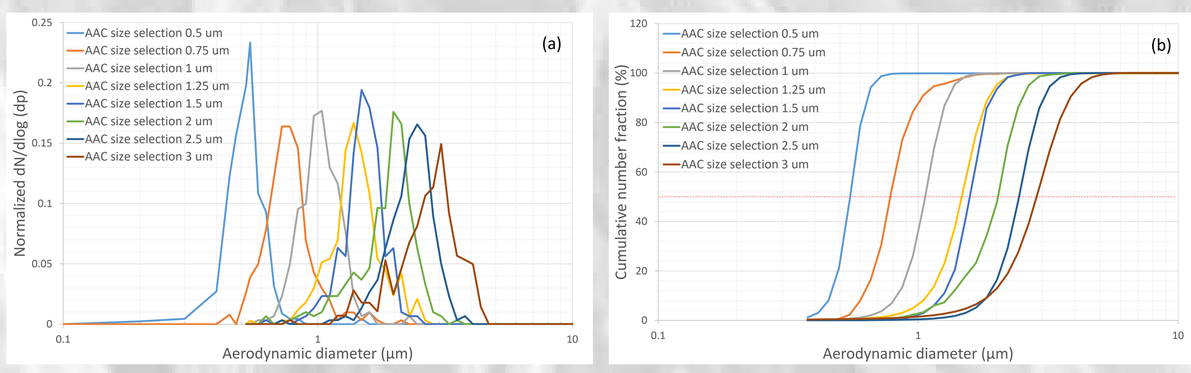
REFERENCE

Taekhee Lee, Bon Ki Ku, Rachel Walker, Pramod Kulkarni, Teresa Barone and Steven Mischler, Aerodynamic size separation of glass fiber aerosols, *Journal of Occupational and Environmental Hygiene*, https://doi.org/10.1080/15459624.2020.1742915

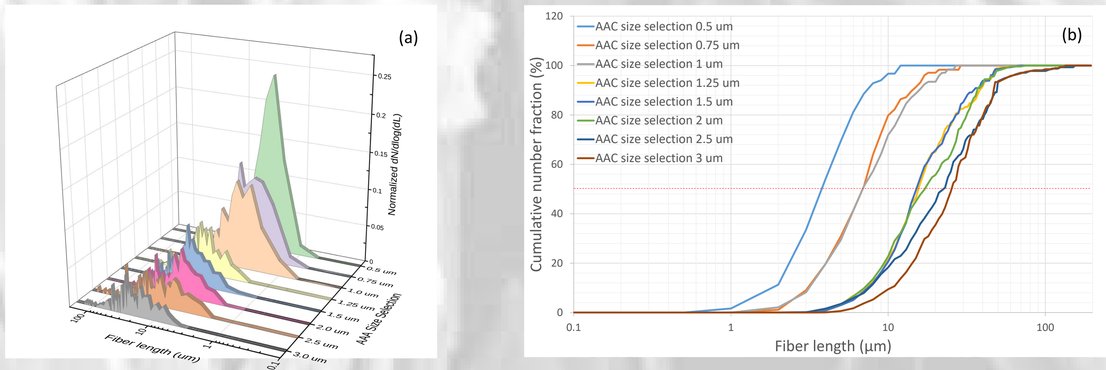
Results



Phase contrast microscope images (400x magnification) of glass fiber aerosols with the Aerodynamic Aerosol Classifier selected aerodynamic diameters of (a) 1 µm, (b) 2 µm, (c) 3 µm, and (d) without separation.



Normalized particle number-weighted distribution of glass fiber aerosols between Aerodynamic Aerosol Classifier size selection (a) and cumulative number distribution for aerodynamic diameter of glass fiber aerosols (b).



Normalized particle number-weighted distribution as a function of glass fiber length (a) and cumulative number distribution as a function of glass fiber length (b).

Physical characteristics of classified glass fiber aerosols with Aerodynamic Aerosol Classifier determined by field emission scanning electron microscope analysis

Selected d_{ae}[1] with AAC (µm)	Sample number	Fiber d_{ae}		Fiber length		Fiber width	
		GM[2] (µm)	GSD[3]	GM (µm)	GSD	GM (µm)	GSD
0.5	216	0.54	1.12	2.81	1.49	0.17	1.14
0.75	301	0.79	1.18	4.77	1.52	0.24	1.19
1	301	1.06	1.16	4.75	1.58	0.34	1.24
1.25	333	1.46	1.19	11.02	1.60	0.42	1.23
1.5	301	1.56	1.16	11.42	1.58	0.46	1.16
2	301	1.90	1.22	11.28	1.65	0.6	1.22
2.5	301	2.39	1.18	12.96	1.69	0.74	1.18
3	282	2.71	1.26	17.84	1.55	0.81	1.22

[1]Aerodynamic diameter [2]Geometric mean [3]Geometric standard deviation

Conclusions

Airborne glass fibers were separated aerodynamically with an Aerodynamic Aerosol Classifier prior to the classification of elongate mineral particles including regulated asbestos. The glass fiber aerosol separated using the AAC showed a slightly narrow fiber length distribution (geometric standard deviations ranged from 1.49 to 1.69). Based on the findings from the present experimental study, the separation of glass fiber aerosols with an AAC is likely to produce two different length fiber groups with different aerodynamic size selection of the AAC and the production rate was similar to a previously published technique involving separation by dielectrophoretic mobility. The production rate or mass throughput may be further improved by increasing the sampling flow rate.