Submicron Aerosol Particle Losses in Metalized Bags

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ABSTRACT

Two new types of conducting bags were tested for aerosol particle storage and sampling, a 3M Company Velostat bag and a bag constructed from 3M Type 2100 Static Shielding Film. The half-lives of unipolar, unit-charged 0.025 μm, 0.050 μm and 0.090 μm sized aerosol particles stored in the Velostat bag and the film bag were 130, 190 and 270 min and 40, 70 and 180 min, respectively. These results depend upon the history of bag filling. The values given here apply to bags which had not previously been filled on the day of experimentation. The lifetimes exhibited by the aerosol particles stored in the Velostat bag are the longest found to date.

1. Introduction

Aerosol samples are often temporarily stored in large sampling bags for the convenience of later analysis. However, aerosols stored in this manner decay within a few hours because of electrostatic precipitation. The specific decay rates for particles in the Aitken nucleus size range stored both in aluminized Mylar bags and in a modified paper bag with an interior aluminum foil coating were measured by Cooper *et al.* (1979). The half-lives determined for 0.050 μm size particles were typically less than 10 min in aluminized Mylar bags, and 110 min in the aluminum paper bag.

The purpose of this work was to test two additional types of metalized bags for aerosol particle sampling and storage. The types tested were a 3M Company Velostat bag and a bag constructed from 3M Type 2100 Static Shielding Film.

2. Experimental methods

The apparatus was the system used by Cooper *et al.* (1979). A collision atomizer, described by Cooper (1979), was used to generate NaCl aerosol. From the generator, the polydispersed aerosol was sent through a Kr^{85} charge equilibrator, where the particles were brought to equilibrium with bipolar ions. Of the charged particles leaving the equilibrator, most were singly charged. These were then classified with a Liu and Pui (1974) mobility classifier.

After the monodispersed aerosol emerged from the classifier, its concentration was measured by allowing a small stream of the particles to pass through a detector. The current produced by the particles across a grounded filter mounted in the detector was measured by an electrometer. This current is directly proportional to the concentration.

At the beginning of each run, each bag was filled to a final volume of ~103 ℓ if it was a Velostat or ~130 ℓ if it was made from Type 2100 Static Shielding Film; the filling times for the two bags were 8 and

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TABLE 1. Half-lives and fraction precipitated during filling of bags for unipolar unit-charged aerosol particles.

Bag type	Diameter (μm)	Trial number*	Filling concentration (cm^{-3} × 10^3)	Initial bag concentration (n_0) (cm^{-3} × 10^3)	Percentage fraction lost during filling	Volume (ℓ)	$t_{1/2}$ (min)	Comments
2100	0.090	1	20.4	9.6	53	130	180	
		1	3.5	0.73	79	60	80	
		2	6.8	5.2	24	130	185	
	0.050	1	8.3	5.6	33	130	70	
		2	9.3	5.4	42	130	110	
	0.025	1	3.3	1.2	64	130	40	
		2	3.5	1.7	51	130	50	
		3	3.5	1.7	51	130	60	
Velostat	0.090	1	20.9	15.2	27	103	270	aged bag
		2	17.4	15.4	11	103	310	
	0.050	1	15.2	13.2	13	103	190	
		2	16.2	13.8	15	103	210	
	0.025	1	5.6	4.7	16	103	130	
		2	5.1	3.8	26	103	170	
		3	5.6	3.6	35	103	170	
		1	5.6	4.2	25	103	130	new bag
		2	4.5	3.4	24	103	90	

* Number refers to whether this was the first, second or third successive filling of the bag on a single day.

10 min, respectively. During the filling process, the side stream to the detector was eliminated so that the highest possible concentration could be obtained.

Immediately after the bag reached its final volume, the concentration within (designated n_0) was measured with a G.E. counter (General Electric Model No. GE1-45069).[2] Subsequent readings were taken intermittently after intervals of 10 to 30 min, also with the G.E. counter.

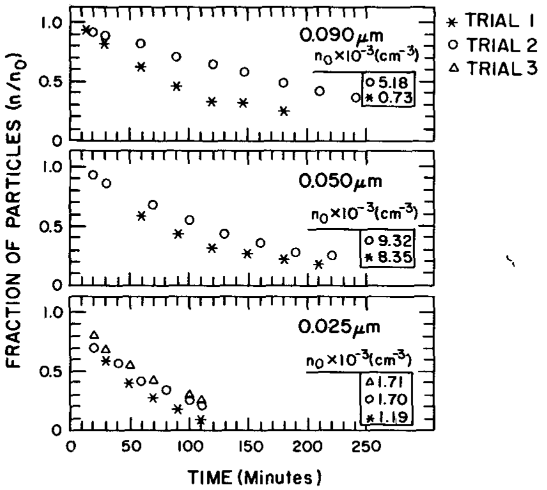

FIG. 1. Fraction of aerosol particles not precipitated in bag made of 3M Type 2100 Static Shielding Film. (Trial number refers to whether the filling was the first, second or third successive filling of the bag on a single day; n is the instantaneous concentration, n_0 the filling concentration.)

Once the concentration in the bag reached an arbitrary value, readings were discontinued and the bag was drained and allowed to rest until background counts from the bag reached zero. This rest period was typically 10–40 min. At this point, the bag was refilled with particles of the same size and concentration readings were taken again via the same procedure as above. Each bag was refilled at least once and occasionally twice if time permitted. Experiments involving different-sized particles were separated by at least one day. The sizes selected for experimentation were 0.025, 0.050 and 0.090 μm.

3. Results and discussion

Sampling bags constructed from the Static Shielding Film (3M Type 2100, ~63.5 μm thick) lost anywhere from 79 to 14% of the incoming concentration during the filling process. These results, summarized in Table 1, also show that the loss is a function of both the size of the aerosol and the final bag volume. The larger the volume, the smaller the loss.

Note that the volume is not the actual factor, but rather the volume-to-surface ratio. Since the surface area remains fixed, the higher the volume, the larger the ratio and the smaller the proportional area available for electrostatic precipitation.

The half-life of the aerosol contained in the bag is defined as the length of time after which the concentration of aerosol within the bag is reduced to half of its original value. For this type of bag, as can be seen from Fig. 1 and Table 1, the half-life in-

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[2] The G.E. counter had been modified as suggested by Hogan (personal communication in Cooper and Langer, 1979) by removing the plactic surfaces.

creased with both increasing aerosol size and bag volume (volume-to-surface ratio).

The half-life is also a function of the bag's past history, that is, whether the bag had previously been filled with aerosol on the same day. Aerosols used in second and third fillings of the bag typically had extended half-lives, but the percent of increase of the half-life fell with each refilling.

It may be that the first filling neutralizes any islands of electrostatic charge on the bag, so that subsequent fillings are not as readily precipitated by electrostatic charges. These effects are of short term, however, as bag fillings separated by one day displayed essentially identical half-lives and decay characteristics.

Velostat bags (102 μm thick) lost only 35–11% of the incoming concentration during the filling process. These results, also given in Table 1, show that the losses are not significantly a function of aerosol size for aerosol particles in the 0.025–0.090 μm diameter size range. Although the variability of the losses with bag volume was not tested, it is assumed that this, as with the Type 2100 bag, is dependent on the volume, as was shown previously.

When the Velostat bags were new, they exhibited the characteristic of decreasing half-life with repeated fillings on the same day. After a period of two weeks, during which the bag was successively filled and emptied, the bag presumably became "aged" and displayed increasing half-life with repeated fillings on the same day. These results, similar to those for the bags made from Type 2100 Static Shielding Film, are probably from identical causes, and are equally short-lived. Differences from day to day were negligible after "aging." Plots of the lifetimes are given in Fig. 2.

4. Conclusions and recommendations

The half-lives of 0.024, 0.050, 0.100 and 0.150 μm aerosol particles stored in aluminized Mylar bags and the aluminum paper bags studied by Cooper *et al.* (1979) were (not tested), 18, 45 and 70 min and 50, 105, 175 and 320 min, respectively. The half-lives of 0.025, 0.050 and 0.090 μm aerosol particles stored in bags made from 3M Type 2100 Static Shielding Film and in Velostat bags were 40, 70 and 180 min and 130, 190 and 270 min, respectively.

Thus, on the basis of the results from Cooper *et al.* (1979) and the present work, the Velostat bags should be used in the future for "grab" sampling and short-term storage of aerosol particles. This type of bag is especially useful for airborne measurements because of its long aerosol particle storage characteristics and durability. However, the characteristics of the Velostat bags do depend on their history, hence their use may not always yield precisely predictable results. Therefore, whenever it is possible, intermediate storage should be avoided by *in situ* measurement of aerosol.

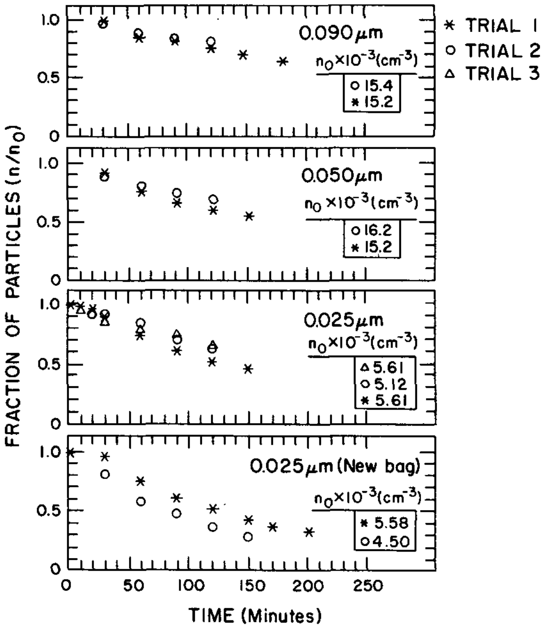

FIG. 2. Fraction of aerosol particles not precipitated in 3M Velostat bags. (Trial number refers to whether the filling was the first, second or third successive filling of the bag on a single day; n is the instantaneous concentration, n_0 the filling concentration.)

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