# THE EVALUATION OF AEROSOL SAMPLING AND ANALYTICAL METHODS FOR AEROSOL CONCENTRATIONS OF MAN-MADE ORGANIC FIBERS

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## Abstract

The purpose of this study was to compare the results of airborne organic fiber measurements using different collection modes and counting techniques. Atmospheres of p-aramid or cellulose respirable fiber-shaped particulates (RFP) were generated in an inhalation chamber. For each experiment, 30 filters (10 gold-coated polycarbonate filters, 10 methyl cellulose filters, and 10 methyl cellulose filters and corresponding cowls) were exposed to fibrous aerosols at concentrations ranging from 25 - 50 f/cc. Subsequently, attempts were made to count and compare each of the filters by three optical techniques, namely light microscopy (LM) (PCOM- NIOSH 7400) scanning electron microscopy (SEM), and transmission electron microscopy (TEM). Preliminary results demonstrated that the gold-coated polycarbonate filters were not appropriate for counting by LM and TEM. In addition, washing the cowl onto the same filter did not contribute greater numbers of fiber counts and seemed to facilitate clumping. When comparisons were made between LM, SEM, and TEM counts on the same filters, the fiber numbers were not significantly different when evaluated via the different analytical techniques. These findings are in contrast with the preliminary data of other investigators who have reported a 2-5 x increase in the numbers of organic fibers when counted by SEM vs. PCOM. Studies are ongoing to resolve the differences between analytical methods for counting organic fibers.

## Introduction

Numerous organizations, including the American Fiber Manufacturers Association (AFMA) have expressed interest in evaluating sampling and analytical methods to determine airborne concentrations of man made organic fibers. It appears that there exist several variations of the traditional NIOSH 7400 method currently accepted for asbestos monitoring. AFMA was interested in comparing three methods under controlled conditions in an attempt to determine the most suitable method to be used by member companies to determine airborne fiber concentrations. Consistent, relatively uniform airborne concentrations of p-aramid and cellulose have been generated and maintained for subchronic/chronic experiments at Haskell Laboratory. Atmospheres were sampled using each of three techniques (German, NIOSH, NIOSH and washdown) and counted by each of three methods (PCM, SEM, TEM). Following exposures, the 10 filters from each method were collected and analyzed by PCOM, SEM, and TEM (all on the same filter). Thus, the purpose of this study was to compare the results of airborne organic fiber measurements using different collection modes and counting techniques.

## Methods

### Experimental Design

This study was designed to compare the results of airborne organic fiber measurements using different collection modes and counting techniques. Two different organic fiber-types were investigated and aerosol exposure experiments were conducted. Aerosols of para-aramid and cellulose respirable fibers (RFP) were generated, and the atmospheres were sampled using each of three different techniques. In the first experiment, p-aramid RFP (respirable-sized, fiber-shaped particulates) were aerosolized, and the atmospheres were sampled using each of three techniques/filter methods.

In the second experiment, cellulose RFP were aerosolized, and the atmospheres were similarly sampled using each of three techniques/filter methods.

### Inhalation Exposures

Briefly, atmospheres of p-aramid and cellulose were generated with a K-tron bin feeder (K-tron Co., Glassboro, NJ) equipped with twin screws. Baffles were inserted into the generation apparatus in order to increase the respirability of the samples. The fiber samples were metered into a plastic funnel connected to a cyclone where high-pressure air transferred the test material into a microjet apparatus (Micro-jet, Fluid Energy Co., Hatfield, PA). Preliminary studies were conducted to validate the consistency of the exposure (i.e., reduced variability within the chamber).

Table 1. Method Collection and Analytical Organization

| | | Analytical | |
|---|---|---|---|
| | PCOM | SEM | TEM |
| NIOSH (MCE) | X | X | X |
| NIOSH + Wash | X | X | X |
| German | X | X | X |

## Results and Discussion

The German filters (i.e. gold-coated polycarbonate filters) could not be evaluated by PCOM or by TEM and thus were utilized exclusively for SEM analysis. In contrast, the methylcellulose filters were processed and subsequently analyzed by all three methods, namely, PCOM, SEM and by TEM.

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Following p-aramid exposures, the fiber count comparisons made between PCOM, SEM, and TEM on the same filters, did not reveal any significant difference in the numbers of fibers, and in some cases the PCOM counts were higher than SEM counts (see Table 2) . In addition, the fiber counts were not significantly different or increased when the cowl was washed onto the filter and these results were compared to the fiber counts on the unwashed methylcellulose filters (Table 2). Moreover, morphological evaluation of these filters suggested that the process of washing the cowl may have contributed to the clumping of the fibers.

Following cellulose exposures, fiber count comparisons made between PCOM, SEM, and TEM on the same filters. Similar to the results from p-aramid exposures, there were no significant differences in the fiber counts when comparing the various microscopic methods (i.e. PCOM, SEM and TEM), (see Table 3) . In addition, as reported for the p-aramid experiments, the fiber counts were not significantly different or decreased when the cowl was washed relative to the numbers of counted fibers on the "unwashed" methylcellulose filter (Table 3).

The preliminary results reported here are important, because a standardized method must be developed for counting man-made organic fibers. The results of some pilot studies conducted in Germany indicate that there can exist a two- to five-fold increase in the numbers of fibers when counted by SEM vs. PCOM (personal communication from the Fraunhofer Institute and by M. Hengstberger et al.). However, these studies have not been conducted in a systematic fashion by making comparisons on the same filter or under similar experimental conditions. In this regard, Hengstberger and colleagues have conducted measurements in textile factories. Moreover, not all of the variables were controlled (e.g. processing). In contrast, the studies reported here were aerosol generation studies. To reconcile these differences among the findings of investigators, studies are ongoing to systematically evaluate the different analytical methodologies for counting organic fibers.

Table 2

| Experiment #1 | p-Aramid Respirable Fiber Counts | | |
|---|---|---|---|
| | PCOM | SEM | TEM |
| German Filters | ------ | 925 + 81 | -------- |
| MCE Filters | 1331 + 72 | 881 + 89 | 1002 + 177 |
| MC E Filters (washed cowl) | 1121 + 108 | 864 + 144 | 1024 + 208 |

Table 3

| Experiment #2 | Cellulose Respirable Fiber Counts | | |
|---|---|---|---|
| | PCOM | SEM | TEM |
| German Filters | ------ | 537 + 90 | -------- |
| MCE Filters | 570 + 79 | 537 +61 | 578 + 68 |
| MCE Filters (washed cowl) | 503+ 43 | 485 + 101 | 553 + 84 |