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Technical note

Effect of xylene exposure on the performance of electret filter media

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Abstract

Performance degradation of electret filter media when exposed to xylene was investigated using a custom-made exposure apparatus. Three types of electret filter media were exposed to xylene in liquid and gas phases. Experimental data indicated that the penetration percentage of di-octyl-phtalate (DOP) aerosols through electret filter media was not influenced by exposure to xylene vapors for periods up to 8 h. The filtration performance for all three types of electret filter media decreased over 30% when the samples were exposed to liquid xylene. Pressure drop changes of the filter media prior and after exposure to liquid xylene were statistically negligible. Neither morphological changes nor degradation of the polymer fibers were observed after exposure of the filter media samples to liquid xylene. Thermodynamic simulations were performed to determine the molar flux of liquid and gas phases through the filter media specimens. Experimental results obtained via capillary gas chromatography were within 4% of the predicted values. The decrease in performance was attributed to changes in the density and spatial distribution of the electret charges on the surface of the polymer fibers.

Keywords: Electret filter; Xylene; Liquid exposure

1. Introduction

The effects of permanent static electric fields on filtration performance have been well established in the scientific literature (Ando, Takahashi, Togashi, & Okumura, 1990; Brown, 1981, 1992; Brown, Wake,

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Table 1
Filter media specifications

Test code	Basis weight code ($g\,m^{-2}$)	Thickness (mm)	Fiber	Charge
E1	112	0.99	Meltblown polypropylene	Corona
E2	185	1.78	Meltblown polypropylene	Corona
E5	80	0.76	Meltblown polypropylene	Corona
Mechanical	78	0.40	Microglass	N/A

Gray, Blackford, & Bostock, 1988; Chen & Huang, 1998). It is also well established that electret filter media exhibit better performance and lower pressure drop than mechanical filter media for particles in the .05–3 μm particle diameter range. Two theories have been advanced to explain the location and strength of the permanent electric field: a phenomenological theory, in which various polarization mechanisms play the primary role and charge injection is secondary, and the charge injection theory, where the electric field is caused by the external injection of charged particles, which may induce permanent electric dipoles (Yovcheva, Mekkishev, & Marinov, 2004). In either case, it is known that the charge effect is localized to the surface of the polymeric material, perhaps to the outermost 2 or 3 nm.

Previous studies (Biermann, Lum, & Bergman, 1982) have shown that direct exposure to liquid organic solvents, such as toluene, decreases filter media performance. However, some of these results have been under controversy as the experimental conditions were not properly controlled. It is the objective of this research work to determine the effect of exposure to xylene, in gas and liquid phases, on the performance of electret filter media under controlled experimental conditions.

2. Experimental procedure

2.1. Materials

Three different types of electret filter media as well as one type of mechanical filter media were used in this study. Technical specifications for these materials are shown in Table 1. All filter media were tested as received from the manufacturers (Table 2). The electret filter media was composed of melt-spun polypropylene nonwoven mats charged by means of corona treatment. The mechanical filter media consisted of a nonwoven mat of glass fibers without electrostatic charge. The chosen materials are typically used in commercially available particulate respirators rated by NIOSH (1995) as R, P and N.

ACS grade *p*-xylene and di-octyl-phthalate (DOP) were obtained from Sigma Aldrich (Milwaukee, WI) and used as received. Commercial grade nitrogen was used as a carrier gas, and was provided by Machine and Welding Supply Company (Dunn, NC).