Testing Activated Carbon Fibers for Respiratory Protection Use

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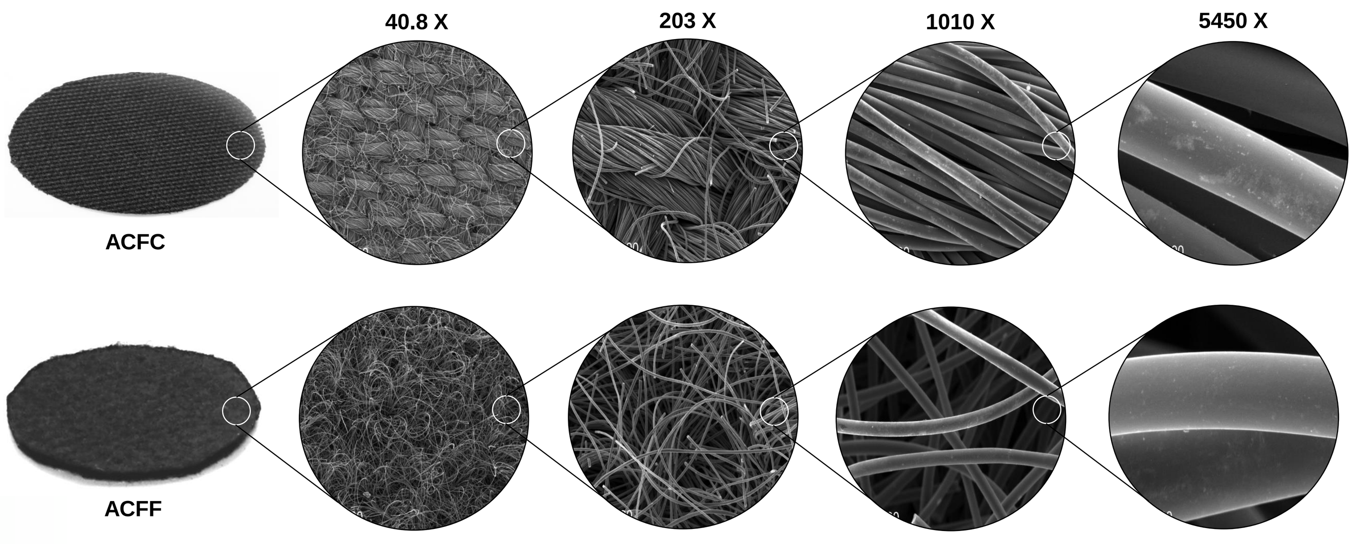
Introduction

- Activated carbon fibers (ACFs) are taken into consideration as alternative adsorbent materials to Granular activated carbon, for developing respirators for gases and vapors because of their large surface area, light weight and fabric form.
- The purpose of this study is to determine the adsorption characteristics of different types of commercially available ACFs for toluene to understand how thin a respirator can be and what would be its service life.

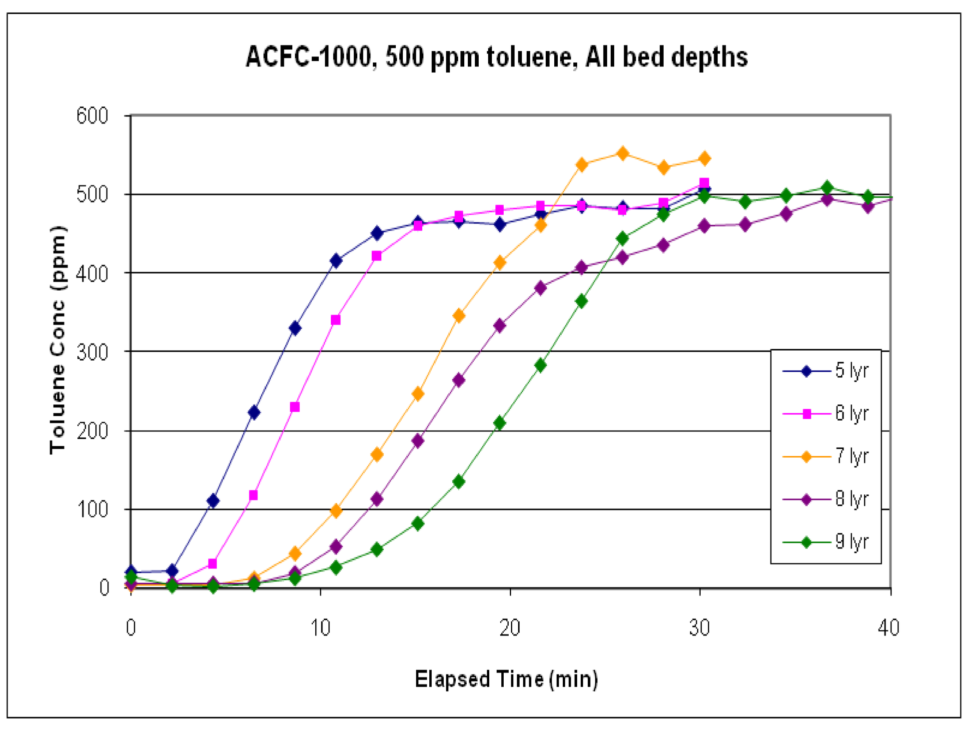
Materials & Methods

- Materials: ACF in cloth (ACFC) and felt (ACFF) forms with 3 different surface areas (1000, 1500, 1800 or 2000 m^2/g) per form
- Materials were challenged with 6 concentrations of toluene (50, 100, 200, 300, 400 and 500 ppm) at constant air temperature (23°C), relative humidity (50%) and air flow (16 LPM) at different adsorbent bed depths.
- Breakthrough data were obtained for each adsorbent using gas chromatography.
- The surface area of each adsorbent was measured by an automatic physisorption analyzer (Micromeritics ASAP 2020®) using high purity nitrogen (99.99%) at 77 K.



Results

- The time (min) at which 10% and 50% of the challenge toluene concentration passing through the ACF was obtained from the breakthrough curves to calculate the critical bed depth and adsorption capacity, respectively, using the modified Wheeler equation



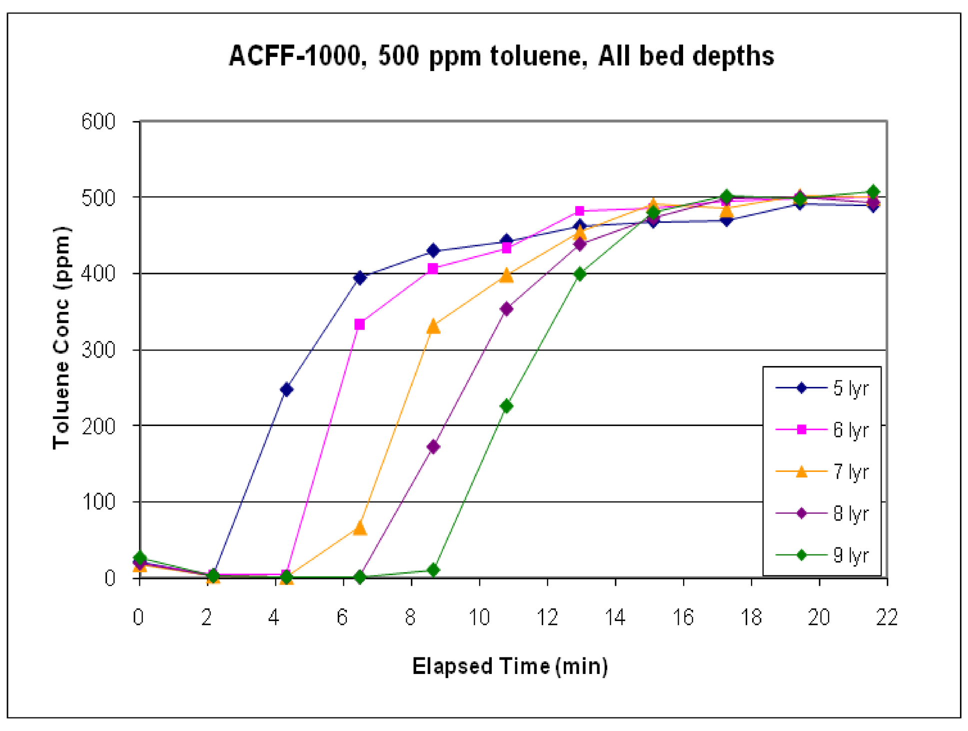


Table 1. Critical Bed Depth and Adsorption Capacity of ACF Types by Toluene Concentration

ACF Type	BET Surface Area (m^2/g)	Critical Bed Depth (cm)						Adsorption Capacity (mg/g)					
		50 ppm	100 ppm	200 ppm	300 ppm	400 ppm	500 ppm	50 ppm	100 ppm	200 ppm	300 ppm	400 ppm	500 ppm
ACFC 1000	754 ± 5	0.21 ± 0.22	0.22 ± 0.03	0.22 ± 0.02	0.22 ± 0.03	0.18 ± 0.04	0.25 ± 0.02	345 ± 10	345 ± 6	403 ± 3	357 ± 3	395 ± 2	407 ± 1
ACFC 1500	1173 ± 8	0.11 ± 0.04	0.12 ± 0.03	0.13 ± 0.03	0.16 ± 0.02	0.16 ± 0.03	0.15 ± 0.05	434 ± 19	439 ± 7	429 ± 4	488 ± 2	523 ± 3	549 ± 1
ACFC 2000	1614 ± 5	0.14 ± 0.04	0.13 ± 0.04	0.11 ± 0.06	0.16 ± 0.05	0.12 ± 0.03	0.22 ± 0.04	595 ± 42	675 ± 25	683 ± 15	732 ± 10	732 ± 5	878 ± 5
ACFF 1000	799 ± 12	0.48 ± 0.10	0.56 ± 0.12	0.65 ± 0.09	0.780 ± 0.12	0.91 ± 0.10	0.96 ± 0.05	251 ± 4	221 ± 6	307 ± 2	310 ± 2	318 ± 0	342 ± 1
ACFF 1500	1100 ± 44	0.29 ± 0.05	0.27 ± 0.05	0.30 ± 0.03	0.25 ± 0.05	0.34 ± 0.16	0.27 ± 0.07	358 ± 8	364 ± 3	369 ± 2	364 ± 1	410 ± 2	451 ± 1
ACFF 1800	1559 ± 17	0.24 ± 0.03	0.22 ± 0.05	0.29 ± 0.05	0.22 ± 0.03	0.19 ± 0.06	0.39 ± 0.04	354 ± 3	393 ± 2	431 ± 2	456 ± 2	485 ± 1	616 ± 1

Critical Bed Depth

- The minimum adsorbent depth required to reduce the concentration by 90%
- The lower the critical bed depth, the better for the adsorbent to be used for a respirator.
- ACFC 1500 and 2000 have the lowest critical bed depths for each toluene concentrations.

Adsorption Capacity

- The maximum amount of contaminant retained per unit weight of adsorbent at a certain concentration.
- The higher the adsorption capacity, the longer the adsorbent will last.
- The adsorption capacity increases as the toluene challenge concentration increases for all of the ACF types.

- The adsorption capacity has an increasing trend as the surface area increases for both ACFC and ACFF.
- ACFC 2000 has the highest adsorption capacity for each toluene concentration.

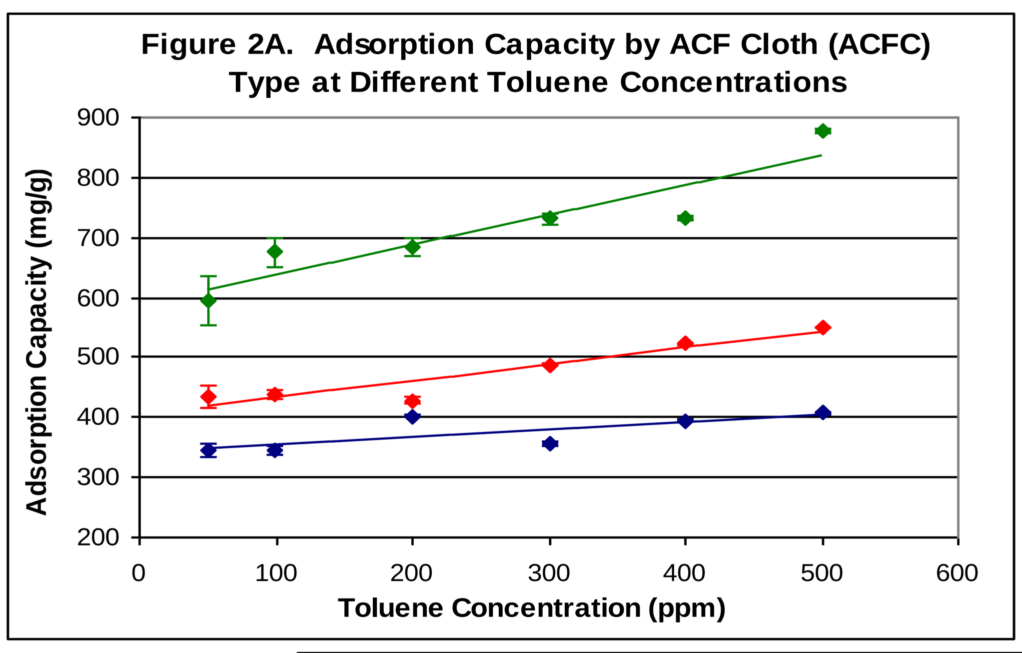


Figure 2A. Adsorption Capacity by ACF Cloth (ACFC) Type at Different Toluene Concentrations

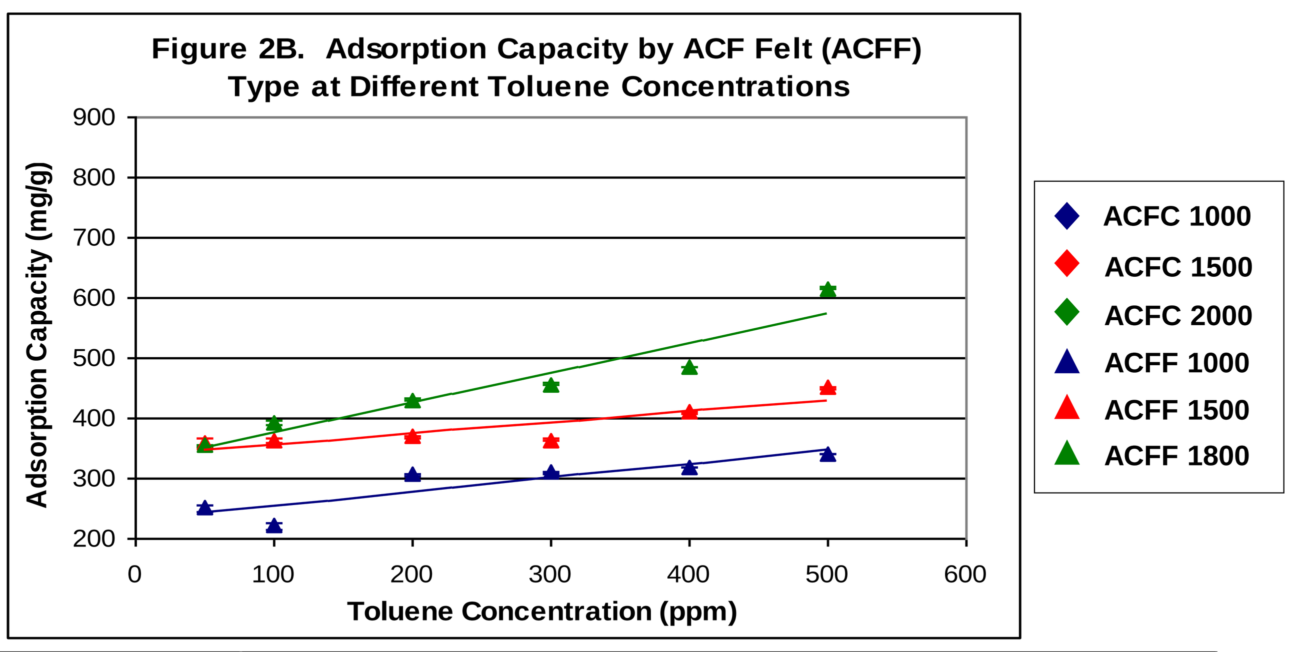
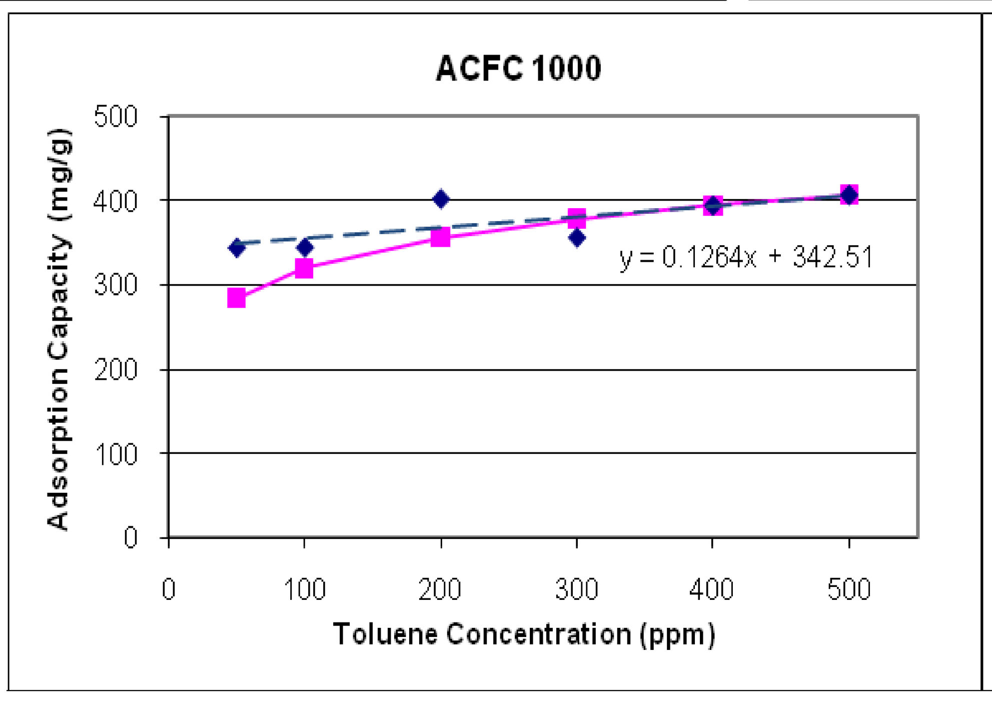
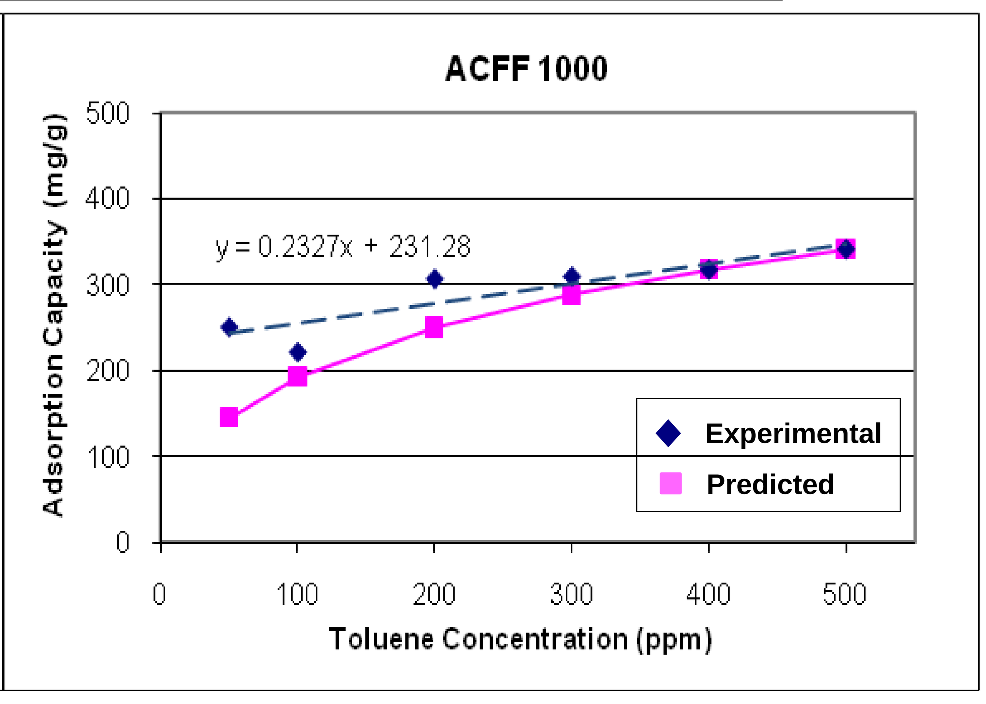


Figure 2B. Adsorption Capacity by ACF Felt (ACFF) Type at Different Toluene Concentrations

Modeling

- D-R equation was used to predict the adsorption capacity at lower concentrations.
- When the experimental adsorption capacity was compared with predicted, ACFs with lower surface area had the smallest difference.





Conclusions

- The surface area and physical form of the ACF are both determinants of the critical bed depth and adsorption capacity.
- Activated carbon fiber has a great potential for application in respiratory protection for toluene.
- ACFC with the highest surface area (ACFC 2000) was shown to be the best ACF type based on its critical bed depth and adsorption capacity.
- The ACFC's lower critical bed depth and higher adsorption capacity for toluene, as compared to ACFF's, show that they are better candidates for thinner and efficient respirators.

Acknowledgements

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