A NANOFIBER/ CARBON COMPOSITE FOR OSTOMY VENTS

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Introduction

An ostomy (also referred to as a colostomy, ileostomy or urostomy) is a type of surgery required when a person loses normal bladder or bowel function due to birth defect, disease, injury or other disorder. Following an ostomy, body waste needs to be expelled through a stoma on the abdominal wall and into a special appliance called an ostomy bag. Body waste can contain significant amounts of gases, such as amines, ammonia, hydrogen sulfide and mercaptans.

Ostomy bags are usually accompanied with deodorizing gas filters where flatus gases can be vented from the bag via the filter. Such a filter reduces or prevents ballooning and, at the same time, deodorizes the escaping gases. Impregnated activated carbons are usually used as adsorbents in these filters. Major challenges in this technology are pressure drop, fluid leakage at the vent, and short filter life for odor control.

The objective of this project is to develop an adsorbent nanofiber-activated carbon composite label filter for ostomy bags that allows gases to vent while removing key odorous compounds, such as H_2S. The choice of a nanofiber-adsorbent composite allows for increased capacity and kinetics through the ability to incorporate activated carbon powders while maintaining a structure that minimizes pressure drop. The impact of carbon type, basis weight, humidity, structure, and flow direction are evaluated in this study.

Experimental

H_2S tests were conducted on the filter parts without any preconditioning beyond ambient conditions of RH or temperature. The samples were challenged with 25 ppm H_2S at an air flow of 500cc/min and 50% RH. The tests were stopped at 2ppm H_2S breakthrough time. The effect of humidity was also studied by repeating the tests at the following relative humidity settings: 6%, 35% and 50%. The nanofiber-activated carbon composite filter technology developed at Donaldson Co., Inc., will be referred to as UltraWeb-OC (UW-OC). The carbon basis weight was calculated experimentally using nitrogen adsorption isotherms where the surface area of the raw activated carbon and the filter parts are compared. The basis weight results were confirmed using thermal gravimetric (TGA) weight loss curves from a method developed for this purpose.

Results and Discussion

The filter assembly as described in Figure 1 has two sides: a bag side to be sealed on the ostomy bag and an outer side exposed to the external environment. The filter assembly is placed over a vent opening in an ostomy bag that is configured to contain body waste products. The filter in Figure 1 comprises of an outer sealable, liquid impermeable, gas permeable microporous film layer (e.g. ePTFE); plus an inner filter layer that incorporates reactive or adsorptive particles (e.g. activated carbon) which are held together by polymeric fine fibers. The combination of particles and fibers results in a material that offers several advantages: increased diffusion; and increased permeation into the reactive/adsorptive layer. The nanofiber-activated carbon matrix is laminated to and/or encapsulated by micro-porous or nonporous films to create a highly effective and low profile ostomy vent capable of selective gas adsorption, catalysis, or a combination of both.

The efficiency of the filter in removing H_2S can be further increased via lateral flow by adding a gas impermeable layer at the bottom of the filter; hence forcing the gas flow from the sides as shown in Figure 2.

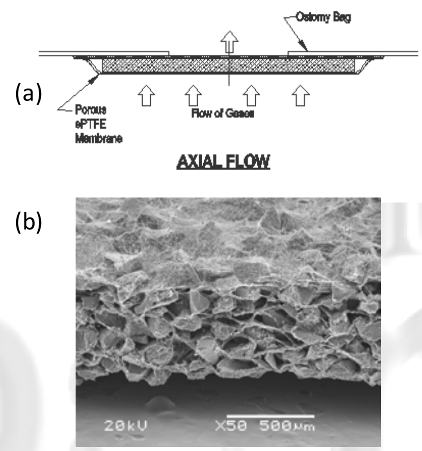

FIG. 1 Cross-sectional view of the filter assembly adhered to an ostomy bag (a) axial flow (b) SEM image of a filter assembly described in FIG. 1a.

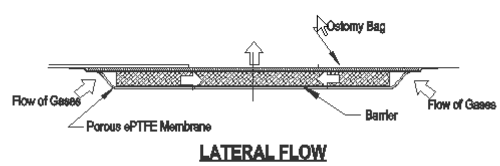

FIG. 2 Cross-sectional view of the filter assembly adhered to an ostomy bag: lateral flow.

The choice of activated carbon for the filter assembly is based on the detail investigation presented in a previous paper [1]. The optimum activated carbon is a modified activated carbon with a combination of impregnants to enhance its surface affinity for H_2S removal via specific adsorption and catalytic oxidation [1-3]. One of the impregnants on this carbon is basic in its chemical nature and the other is classified as an oxidant [1]. This carbon showed a significantly longer breakthrough time for H_2S compared to other commercial carbons.

Table 1 shows the impact of chemical impregnation of activated carbon on the enhanced performance of the filter media. A comparison between the impregnated activated carbon based media to a non impregnated activated carbon based media reveals a significantly longer breakthrough time after impregnation. It is important to note breakthrough times were measured when the downstream H_2S concentration reached 2ppm from a 25 ppm challenge concentration, 35% RH, and an axial airflow of 500 cc/min.

Table 1. A comparison of H_2S breakthrough time for nanofiber matrices using impregnated and non impregnated activated carbon

Media	Breakthrough time (minutes)
Activated carbon and fiber matrix 130 g/m^2	260
Non impregnated media	5

The impact of carbon particle loading level was also studied by varying the carbon basis weight from 100 g/m^2 to 500 g/m^2. Figure 3 shows the relationship between carbon loading and filter life for H_2S adsorption at 25 ppm and 35% relative humidity. It is evident from the results presented in Figure 3 there is an increase in filter breakthrough time with carbon basis weight, thereby indicating effective use of the adsorbent within the nanofiber matrix.

The impact of humidity on filter life for H_2S removal was also studied in the range of 5-50% RH. Figure 4 shows the increase in the filter life with an increase in relative humidity. This is supported by the mechanism explained in a previous publication [1].

Figure 5 shows a comparison between the performance of a Donaldson Co., Inc., ostomy bag filter design (UW-OC) for H_2S control with other products currently on the market. The results clearly demonstrate the enhanced filter life obtained using nanofiber/activated carbon filter structures.

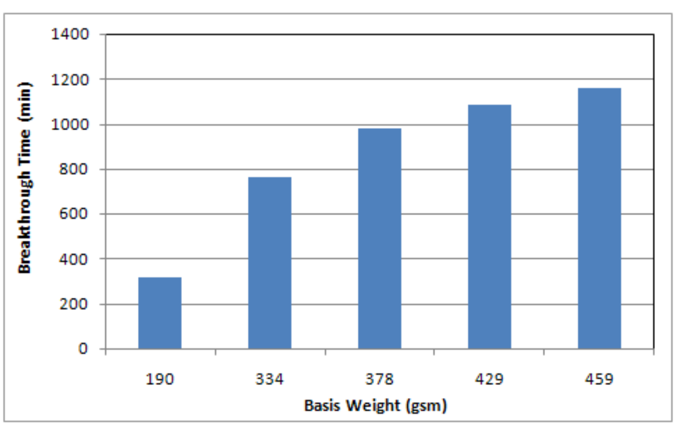

Fig. 3 Relationship between filter life and carbon basis weight.

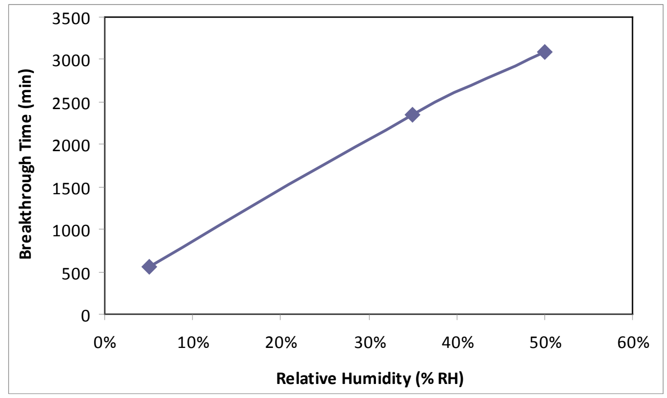

Fig. 4 Relationship between filter life and relative humidity.

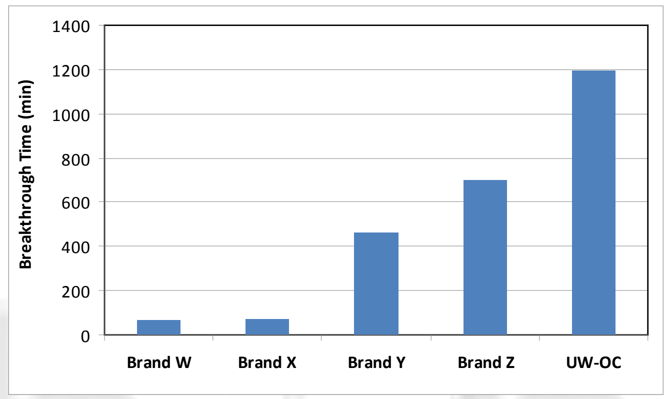

Fig. 5 Comparison of Donaldson Co., Inc., nanofiber-activated carbon filter technology with commercially available products.

Conclusions

The uniqueness of nanofiber-activated carbon ostomy bag filter technology and how it works is explained. This technology effectively uses the activated carbon surface and structure while providing increased adsorption capacity and kinetics. Furthermore, it provides composition, design and application flexibility currently not found in most adsorbent venting filter structures currently available. Design optimization enabled UltraWeb-OC (UW-OC) to outperform filters currently on the market for ostomy bag odor control.

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References

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