Technical Brief

Characterization of 3M Purification Betapure™ NT-T Series Filter Cartridges Employed as D.E. Trap Filters in a Major U.S. Brewery

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3M

INTRODUCTION

Diatomaceous earth (D.E.) filters, sometimes called Kieselguhr, pressure leaf, or primary filters, are one of the most prevalent filters found in modern breweries. The majority of beer produced around the world, pasteurized or non-pasteurized, will pass through a D.E. filter. One of the drawbacks with D.E. filters however, is that they can shed D.E. fines into the beer, resulting in unacceptable turbidity and sediment in the bottom of the beer bottle once allowed to settle. To prevent this, D.E. trap or guard filters are installed downstream of the D.E. filter, just before the bright beer tank.

BACKGROUND

In the process of qualifying the Betapure™ NT-T Series filter for D.E. trap service, a major US brewery requested that 3M Purification Inc. evaluate a filter which was used in an initial trial. The filter, part number NT30T050S0BC, is a 5.0 micron absolute rated polypropylene depth filter commonly used in breweries worldwide. The filter was contained in a filter housing of 36, 40" filters. The filter had processed between 6000 and 7000 bbls of beer before becoming permanently fouled in the normal course of operation. The filter was backwashed on a routine basis at least once per week, and hot water sanitized daily. While the brewery was very satisfied with the filter performance in regards to both filter service life and the quality of the beer, they were interested in the mechanics of how the Betapure NT-T Series filter design trapped the diatomaceous earth. In many breweries, alternative D.E. trap filters, once plugged, exhibit a great deal of D.E. on the surface of the filter. The Betapure NT-T Series filter however, did not seem to have an excessive amount of D.E. fines on the surface of the filter structure.

BETAPURE NT-T SERIES FILTER DESIGN

3M Purification Betapure NT-T Series filters were designed to provide consistent, absolute rated filtration, as well as the high D.E. fine holding capacity needed in the brewery. Betapure NT-T Series filter construction combines a unique polypropylene filter media with fluid distribution netting to form multiple layers. Critically positioned media flow channels allow greater movement of fluid from layer to layer (Figure 1).

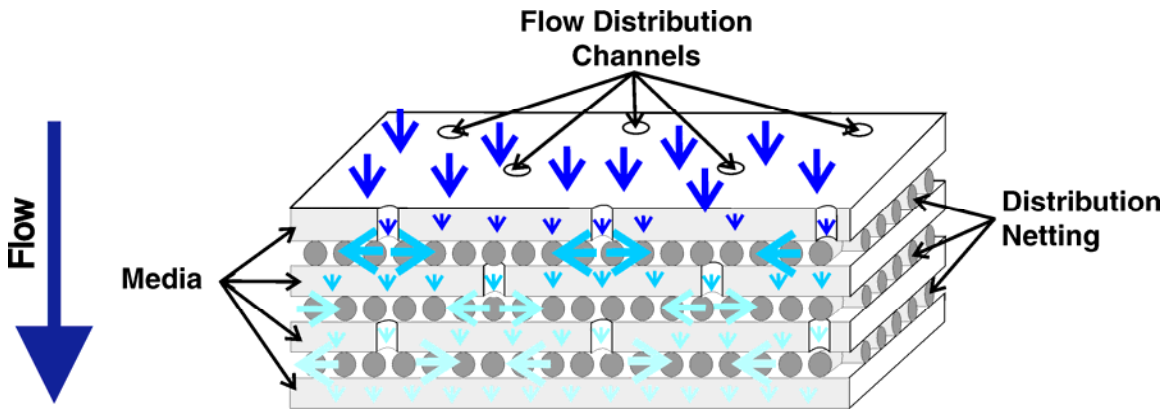


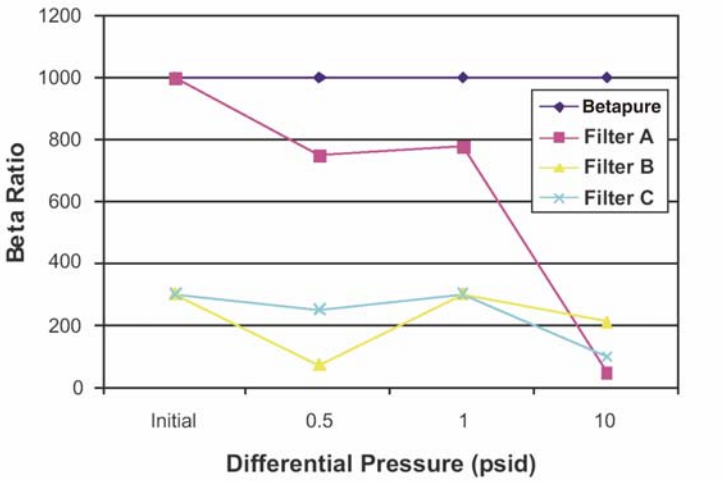
Figure 1. Betapure NT-T Series filter media design

Three distinct media sections, made from multiple media/netting layers, are combined to form a filter cartridge (Figure 2). The outer and middle sections contain multiple layers of interleaved filter media and fluid distribution netting. Within each media layer, a portion of the fluid travels through the media while the balance of fluid is delivered directly to the next distribution layer through the flow channels. The fluid distribution netting provides longitudinal and latitudinal flow paths to evenly distribute fluid flow across the surface of each successive filter media layer.

Figure 2. Betapure NT-T Series filter cartridge design

Unlike common string-wound or melt-blown filters, Betapure NT-T Series filters are absolute rated at the stated micron rating over the entire service life of the filter. Absolute removal ratings for Betapure NT-T Series filters are determined using a filter performance method complying with the general procedures outlined in ASTM STP 975. The absolute ratings are defined as the particle size (x) providing an initial Beta Ratio (x) = 1000. At this Beta Ratio, the removal efficiency is equal to 99.9%. Additionally, 3M Purification defines an absolute rating as being maintained over the life of the filter, even as differential pressure builds across the filter as D.E. fines are captured. This aspect is particularly important in retention of D.E. fines by trap filters, since the filters can remain in service for months at a time and are required to operate consistently over the life of the filter. Common string-wound or melt-blown filters have been shown to unload previously retained particles as differential pressure builds across the filter. This is due to the nature of the filter construction, which is typically composed of unfixed yarn or polypropylene fibers. As pressure builds, the yarn or fiber can shift and compress, allowing previously retained particles to enter the filtrate. This phenomenon is called unloading and it is typically the cause of intermittent unacceptable beer turbidity.

As ***Graph 1*** shows, **Betapure NT-T** Series filters maintain their absolute rating throughout the entire life of the filter, retaining particles even as the differential pressure builds. Filters A, B, and C show degradation in the Beta Ratio as the differential pressure increases. These filters exhibit a pattern of unloading previously retained particles, or a loss of filtration efficiency.



Filter A: polypropylene gradient pore structure melt-blown filter with core
Filter B: polypropylene graded density structure melt-blown filter without core
Filter C: cotton string-wound filter (10 micron nominally rated)

Graph 1. Beta-ratio comparisons of 20 micron filters

MATERIALS AND METHODS

Stereo Light Microscopic Analysis

One of the Betapure NT-T Series cartridges used in the initial trial was cut in half perpendicular to the cartridge length to prepare a cross section of the cartridge. The filter was then examined and documented with a Nikon® SMZ-10, Optical Stereo light microscope (SLM). Digital photographs of the cross-section of the cartridge were taken. The media layers were carefully separated and photographs of the surfaces of media layers 2, 5 and 10 were also taken. The cartridge is constructed with 14 alternating layers of filter media and polypropylene fluid distribution netting layers.

SEM/EDS Analysis

After stereo light microscopic examination of all the excised and separated media layers, representative media samples from media layers 1, 4 and 6 were randomly selected and removed for analysis. The samples were prepared using a Denton Desk II, Sputter Coater and examined with a Topcon® DS 130, Scanning Electron Microscope (SEM).

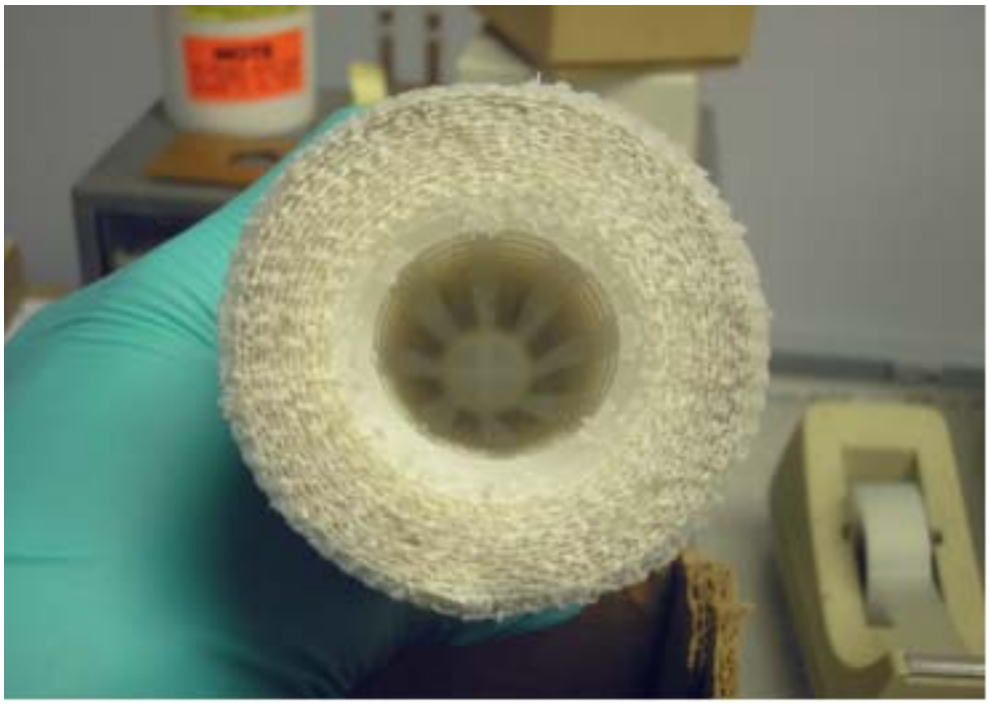
As a control, an unused Betapure NT-T Series filter cartridge was prepared and examined using the same procedure.

RESULTS AND DISCUSSION

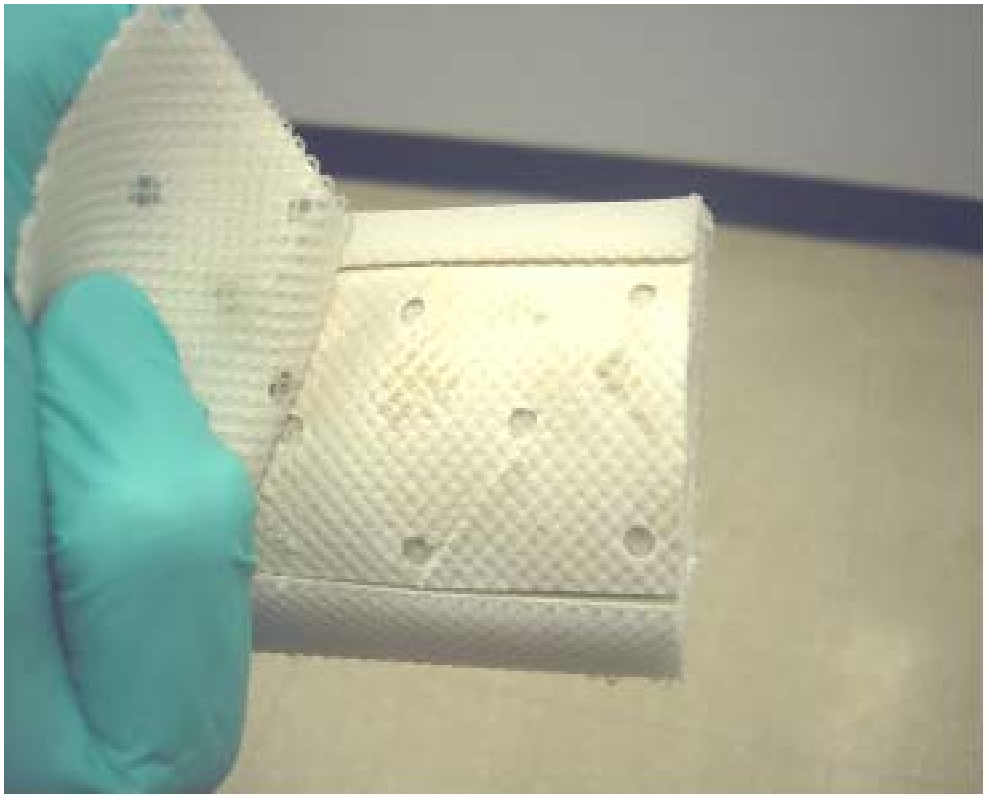
The resulting cross section indicated that the contaminants plugging the cartridge had penetrated approximately 2/3 of the depth of the filter cartridge (as shown in the photograph presented in Figure 3A). A beige powdery substance was clearly evident on the outermost media layers, its intensity gradually diminishing toward the downstream center of the cartridge, until it was no longer visible by approximately the 10^{th} media layer (as presented in the photographs in Figures 3B, 3C and 3D).

Beige colored contaminant particulates were found predominantly covering the upstream surfaces of media layers 1, 4 and 6 of the plugged cartridge. A heavier layer of this contaminant was noted on media layer 1 than on media layers 4 and 6, indicating the level of contaminants decreases through the depth of the cartridge.

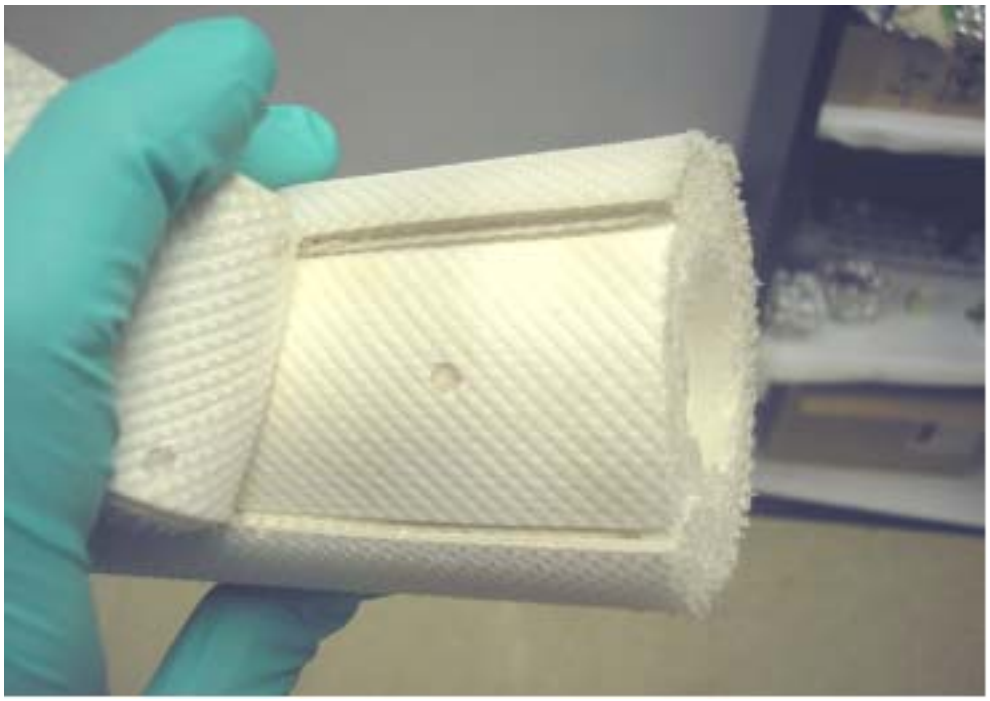
Figure 3.
Photographs of Cross sections and Contaminated Media Layers



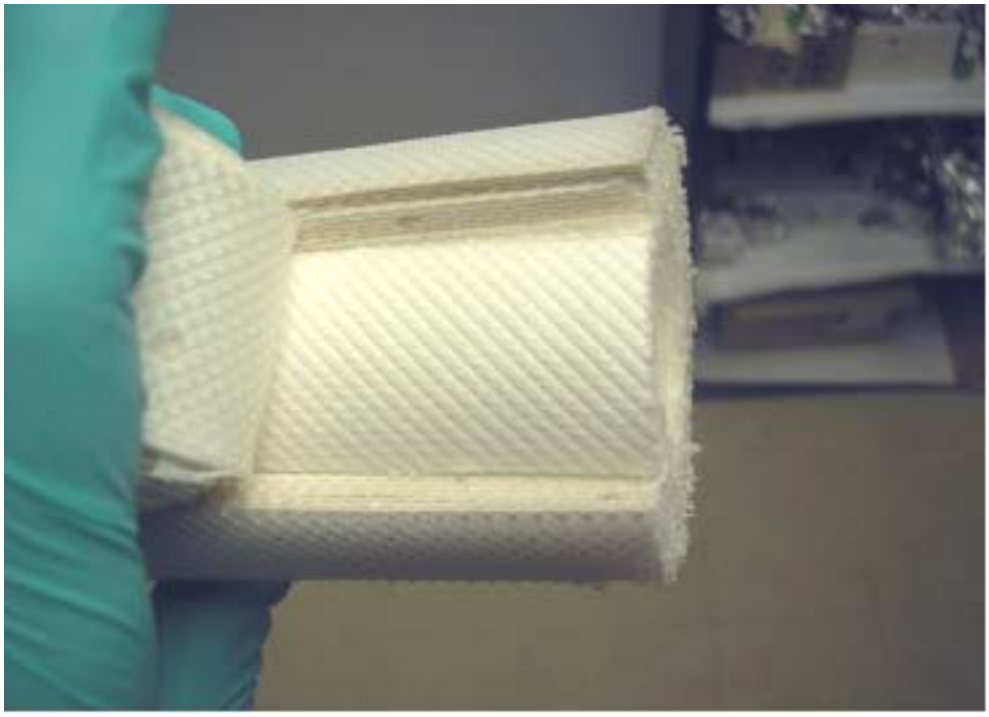
3A. Cross section of Returned Betapure NT-T Series Cartridge – note penetration of D.E. fines into the media pack of the filter.



3B. Photograph of Media Layer #2 showing contamination



3C. Photograph of Media Layer #5 showing lesser contamination

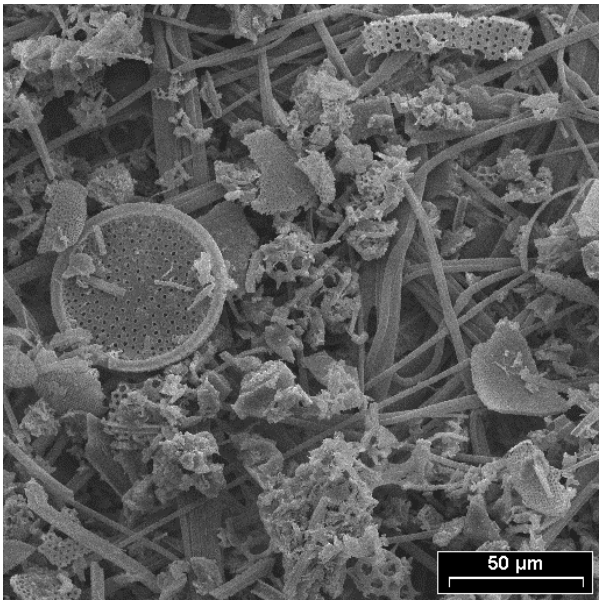


3D. Photograph of Media Layer #10 showing the absence of visual contamination

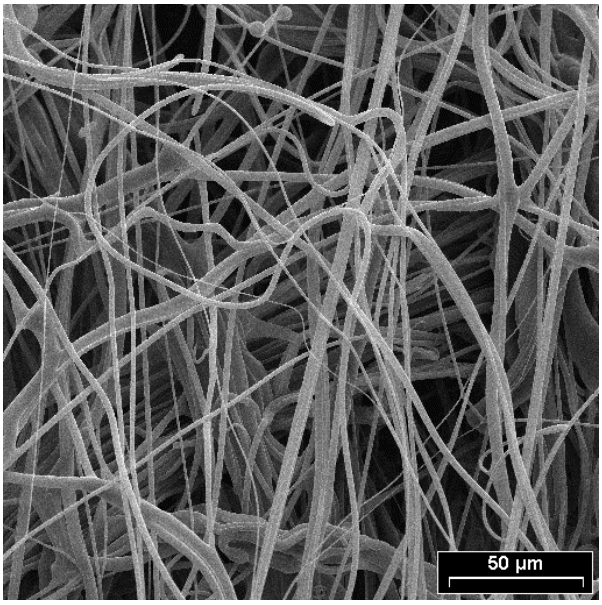
SEM examination revealed the majority of the contaminant particulates found on all three media layers were D.E. (diatomaceous earth) as shown in the SEM photomicrographs presented in Figures 4-6. Higher magnification examination revealed occasional amorphous contaminants embedded with aggregates of microorganisms were also found (as shown in the SEM photomicrographs presented in Figures 4C, 5C & 6C).

Figure 4.

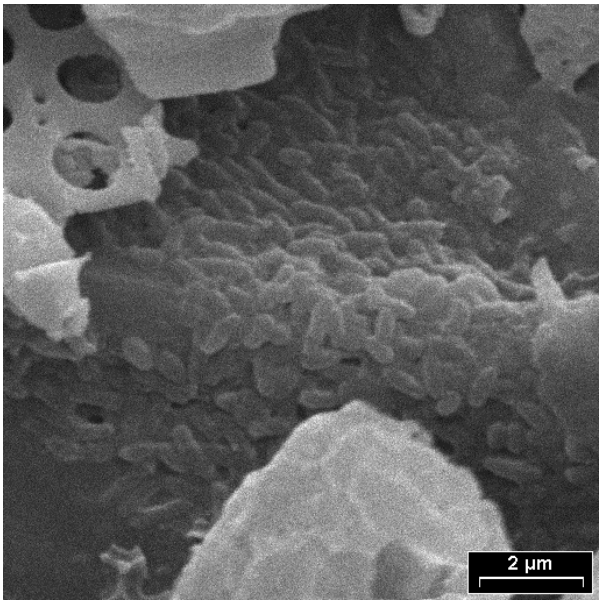
SEM Photomicrographs of Media Layer #1



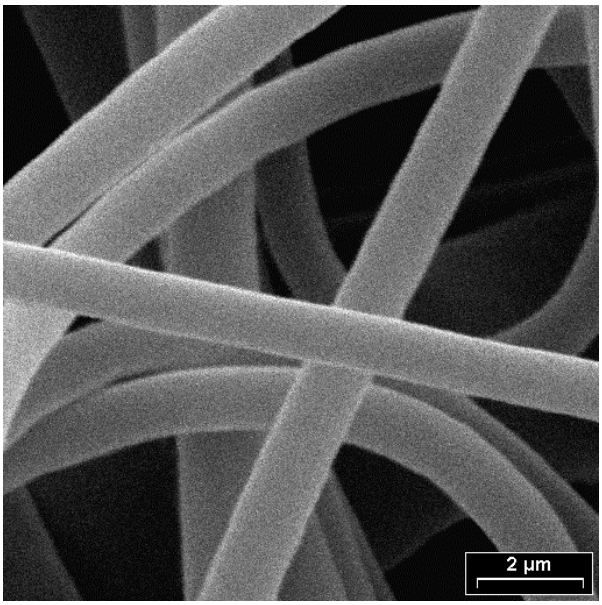
4A. Used filter media layer #1



4B. Unused filter media layer #1



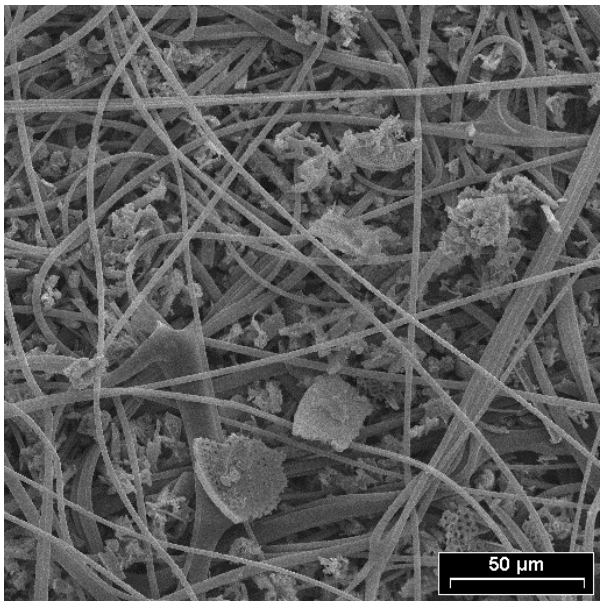
4C. Used filter media layer #1
Note microorganisms embedded in amorphous material.



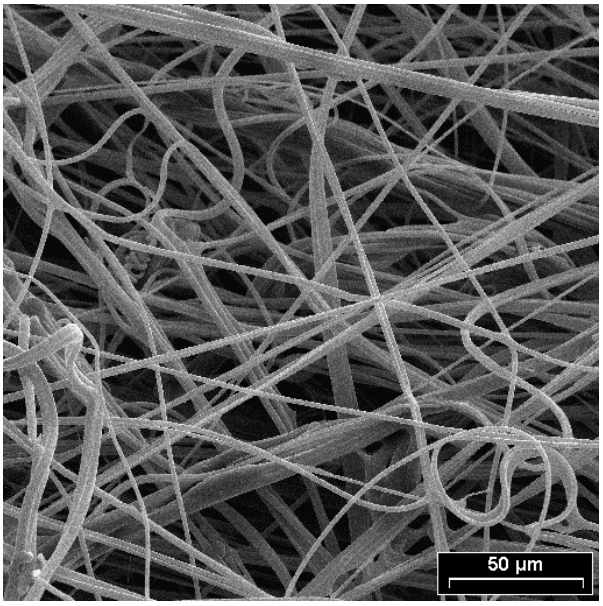
4D. Unused filter media layer #1

Figure 5.

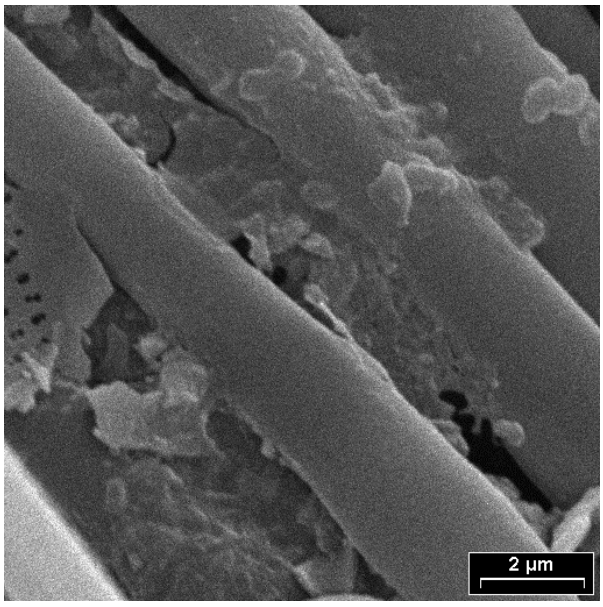
SEM Photomicrographs of Media Layer #4



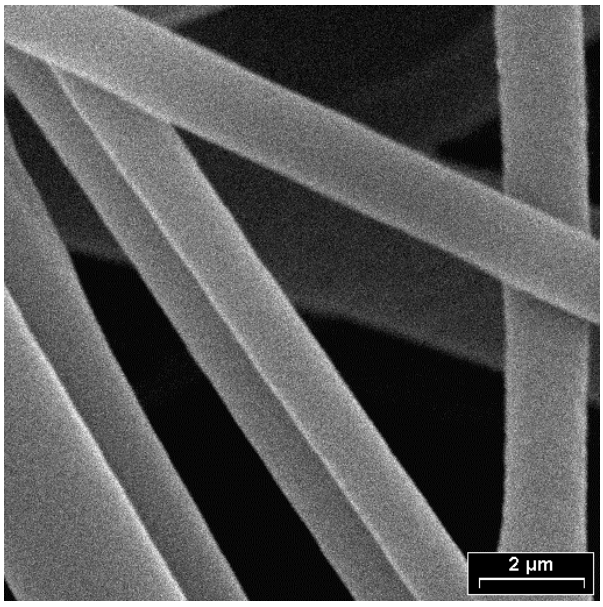
5A. Used filter media layer #4



5B. Unused filter media layer #4



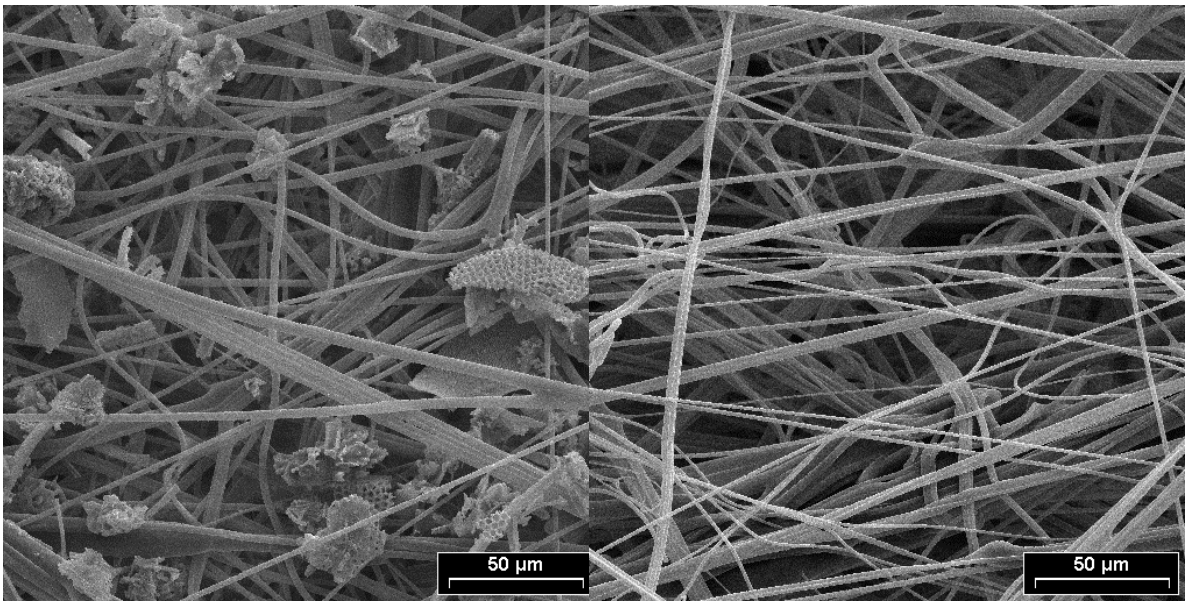
5C. Used filter media layer #4



5D. Unused filter media layer #4

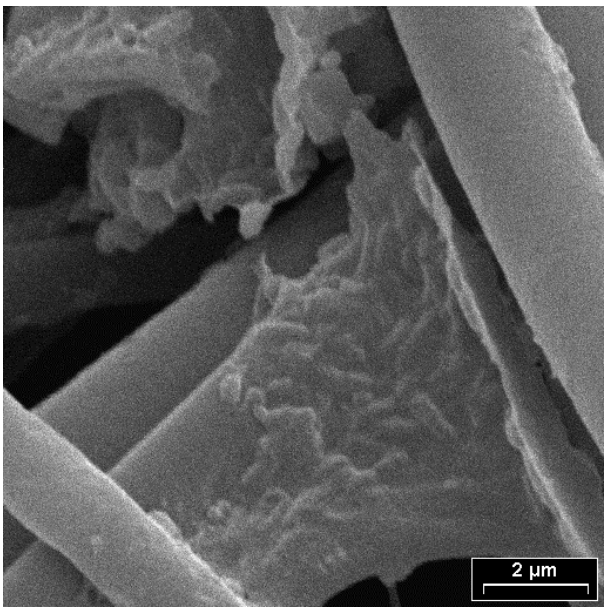
Figure 6.

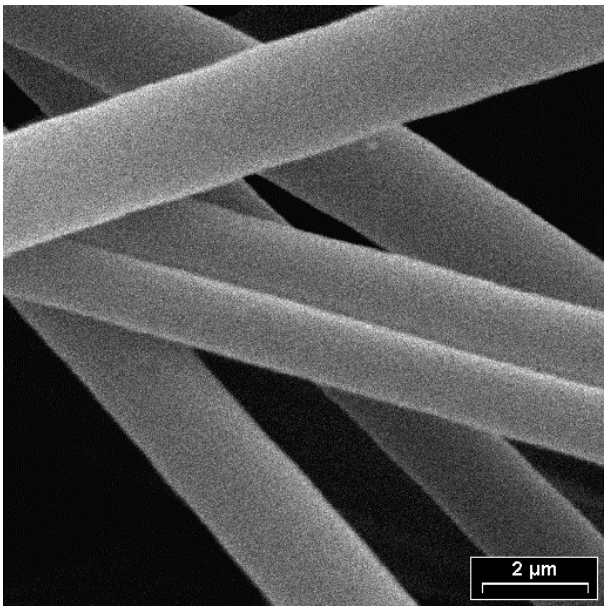
SEM Photomicrographs of Media Layer #6



6A. Used filter media layer #6

6B. Unused filter media layer #6





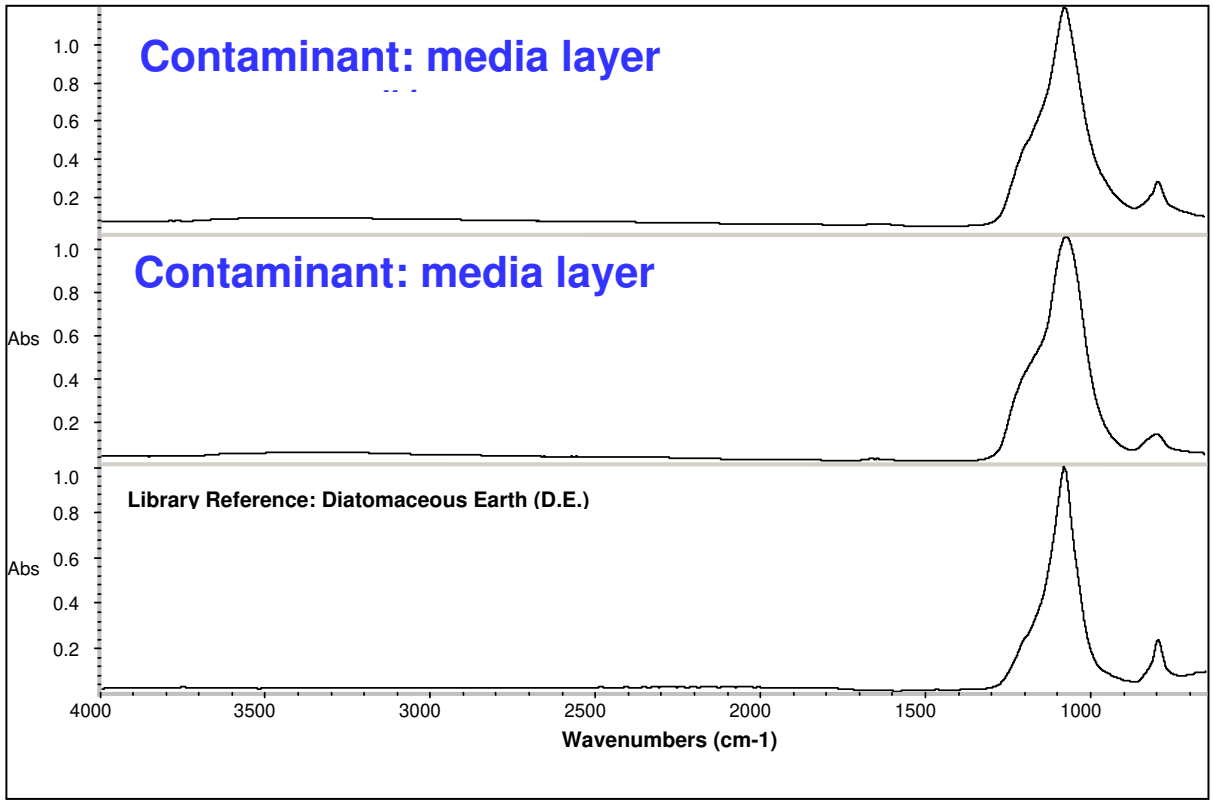
6C. Used filter media layer #6

6D. Unused filter media layer #6

FTIR

The beige powdery contaminant found on most layers of the Betapure NT-T Series cartridge produced spectra that were consistent with D.E. (as presented in the FTIR spectra shown in Figure 7).

Figure 7.



CONCLUSION

The contaminants found on the media layers are predominantly Diatomaceous Earth (D.E.) as expected for a filter installed as a D.E. trap filter. Occasional amorphous contaminants embedded with aggregates of microorganisms were also found.

The contaminants found penetrate approximately 2/3 of the way through the media layers of the returned Betapure NT-T Series cartridge. This indicates that the grade of Betapure NT-T Series filter selected was open enough to allow penetration of the contaminants into a significant depth of the filter media for maximum utilization of the effective media depth. Maximum utilization of the media ensures longer filter life.

The lack of penetration through the depth of the filter all the way to the inner most media layers of the cartridge indicates the grade of Betapure NT-T Series filter selected trapped the D.E., carbon particles, and other contaminants that were present in the beer.

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