

Another twist in filtration for high-purity and other systems

A filter media combines nano-alumina and powdered activated carbon.



By Henry Frank

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MORE INFORMATION

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Typically granular activated carbon (GAC) is used in a packed bed or is combined into a filter media. To incorporate these carbon granules into a filter media requires adhesives or a starch additive to keep the carbon from washing out; alternatively, the carbon granules can be enmeshed into a foam system.

A paradigm shift in carbon filtration is that fine activated carbon powder (-625 mesh) can now be used in a non-woven filter media when it is held within the structure by electroadhesive forces, without using adhesives or starches that would blind or possibly deactivate the carbon. Compared to media containing GAC, high-efficiency (powdered) activated carbon (PAC) offers a much greater external surface area, resulting in much more rapid adsorption of soluble contaminants (see Figure 1).

A further advancement in carbon filter media has come in the form of pleated filter cartridges that combine high-efficiency particulate filtration with this high-efficiency (powdered) activated carbon (PAC). Contaminants that can be removed with this include chlorine, iodine and soluble organics such as pesticides or volatile organic compounds that may be highly toxic or may cause unpalatable taste and odor.

The result is much greater adsorption efficiency at moderate to high flow rates and/or with thin beds of media, such as a single-layer pleated cartridge. At the same time, because of its electroadsorptive properties, this type of media is capable of retaining submicron

particulates — such as bacteria, viruses and colloidal particles — with a very high efficiency compared with a depth media, a microporous membrane or even an ultra-porous membrane (see test results below).

It can be used in high-purity water systems, production of laboratory water, drinking water production and many

other applications (sidebar).

Retaining particles due to their electropositive charge

In nature, many materials have certain physical characteristics that are enhanced when they become nanosized. This is particularly true in the case of a hydrated form of alumina (AlOOH). When it is reduced in size to the nanometer scale, the particles become highly electropositive. The electropositive charge is due to the water of hydration that makes it an ionic crystal and to the Al⁺³ ion that makes it highly electropositive. The very small size of the nano alumina is extraordinarily important, however, because it provides a much greater amount of charges that can reside on the surface of the fiber.

Using this phenomenon, we perfected a method whereby extremely small nanoalumina fibers are combined into a microglass fiber matrix to form an electropositive (approximately +50 millivolts) filter media. This media is then converted into pleated cartridges. The active ingredient is a nano-alumina fiber that is only 2 nanometers (nm) in diameter and about 250 nm long, grafted to a microglass fiber backbone. Coarser cellulosic and/or synthetic polymer fibers are added to enlarge the pore size and provide flexibility and strength.

The media is produced by a conventional wet laying process and is then pleated and end-capped to form a cartridge. Since virtually all small particles are electronegative in water, they are readily adsorbed. This was based on the discovery that very fine or even nano-size particles could be added to the media's matrix when fabricating the paper-like sheet. These ultra-small



Cartridge filters containing the PAC media described by the author.



Figure 1 — Adsorption of chlorine by various media

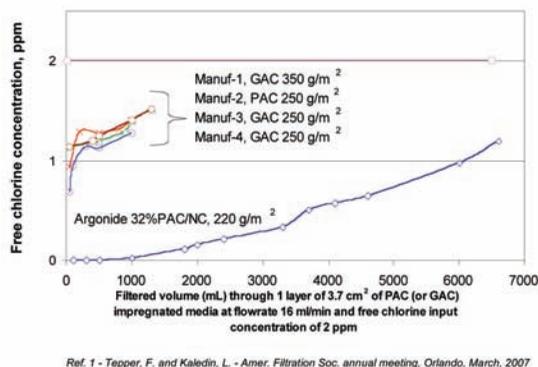
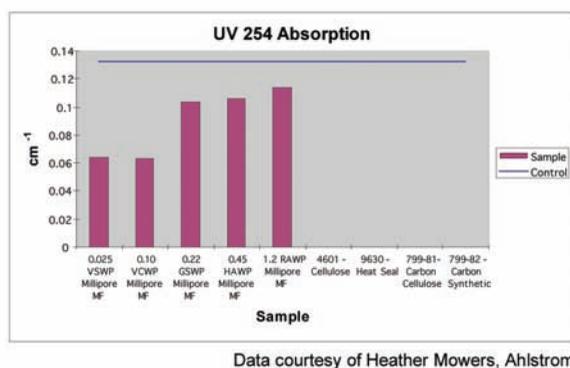


Figure 2 — UV254 Testing of media for humic acid absorption



particles are held so tightly that they can't be removed without destruction of the media or by other extraordinary means.

The first commercial implementation of this process has been a high-performance activated carbon media that contains 32 weight percent of a high surface area PAC (-625 mesh, iodine number = 1100 mg/g). The media has an average pore size of 3 microns and is laminated between layers of polyester spun-bond.

Low pressure drop

This carbon-impregnated filter media is laminated during the final stages of manufacture and provided as a roll-stock for conversion into various forms of filter media. The laminate material serves the dual purpose of adding strength to the "active" media and enables a much more robust and precise pleat for assembly into a filter cartridge.

This laminate material does not impact filtration efficiency or add to pressure drop across the surface of the media. The bal-

ance of a typical filter cartridge includes a polyethylene center core and netting and potted endcaps.

With the low pressure drop associated with this wide-open filter media, particularly in a pleated filter cartridge (more media which provides a large surface area), a standard double-open end (DOE) configuration can often provide the filtration efficiency associated with single-open end (SOE) cartridges.

Testing for filter efficiency

The efficiency of this type of media was illustrated through UV254 testing for humic acid adsorption (Figure 2). These tests indicated that the non-woven filter media (as used in our NanoCeram filter) are more efficient than 0.025-micron ultraporous membranes for retaining humic acid. The data came from testing five MF Millipore 38-mm diameter filters ranging from 0.025 micron to 1.2 micron and four versions of Ahlstrom's Disruptor™ filter media (two of

which our company uses in its filter cartridges.) Each filter was challenged with 150 mL each of the prepared humic acid solution in a Seitto filter holder set-up.

The filtrate was collected in clean, sterile containers and sent to an external laboratory for UV254 testing according to the Standard Methods for the Examination of Water and Wastewater 5910 Ultraviolet Absorption Method. Breakthrough curves confirm the ability of the filter to remove this class of sub-micron contaminants.

Media performance

This type of filter media has these capabilities:

- It filters chlorine and iodine with high efficiency. Figure 1 compares the retention of 2 parts per million (ppm) chlorine by the PAC media at a high flow rate (1 gallon per square foot per minute [gal/ft²/min]) versus four other carbon-containing media. Adsorption efficiency is greater than the other media. Similar results were reported¹ comparing dynamic iodine adsorption by single and multiple layers.

- It filters soluble organics (VOCs, toxic organics) very efficiently. A single layer of this PAC filter media removed greater than (>) 95 percent of chloroform at a high flow (1 gal/ft²/min);

- Turbidity stayed below 0.01 NTU when challenged by 250 NTU of A2 fine test dust until filter clogged at 40 psi.

- Silt density index (SDI), a sensitive measure of particulate contamination, is less than 1.0. SDI measures how long it takes for a water mixture to clog a 0.45 micron membrane. Manufacturers of reverse osmosis (RO) membranes suggest an SDI below 3.0, lower than can be attained with fibrous depth filters. Manufacturers of ultraporous membranes typically claim SDIs between 1.75 and 2.25. The PAC in this filter media is held tightly enough so that the resulting SDI is approximately 1.0.

- The PAC media will trap ultrafine carbon downstream of packed GAC beds.

- Bacteria retention: A 2.5" x 10" diameter cartridge using the non-carbon media retained >6 LRV of E. coli at a flow rate of 4 gpm; additional testing confirmed virtually no difference in virus retention with the

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PAC media.

- **Viruses:** A 2.5" x 10" diameter cartridge using this PAC media retained >3 LRV of MS2 (25 nm) at a flow rate of 4 gpm.

- **Cyst retention:** A line of standard-sized filter cartridges using this PAC media was tested by the Water Quality Association and was found to reduce cysts by at least 99.98 percent at high flow rates (4 gpm through a 2.5" x 10" pleated filter cartridge).

- **High dirt-holding capacity:** Although the media is loaded with 32 percent of particulate carbon, its dirt-holding capacity (as measured using A2 fine or even ultrafine test dust) is approximately 118 mg/in².

- It is effective between pH 5 and 9 and in the presence of 30 grams per liter of sodium chloride, simulating seawater.

- It also filters ultrafine iron oxides without requiring flocculation, soluble and insoluble total organic carbon (TOCs), and emulsified oil droplets.

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Applications for high-efficiency PAC cartridges

Applications include these:

- **Drinking water:** Removal of residual chlorine, toxic organic pollutants, disinfection byproducts (DBPs), cysts and other particulates in point-of-use (POU) and point-of-entry (POE) filter systems.

- **Polishing filtration:** Downstream of large granular carbon beds such as those used for solvent recovery, or downstream of coagulation and filtration water purification systems.

- **Filtration of wastewater:** Removal of volatile organic compounds (VOCs), disinfection byproducts (DBPs), and trace toxic organics such as organic pesticides and endocrine disruptors.

- **Prefiltration:** For protecting reverse osmosis (RO) membranes for both fresh water and seawater. It filters chlorine that can damage membranes as well as sub-micron particles and biological contaminants that tend to foul RO.

- **Iron and manganese removal:** In POU/POE drinking water systems as well as in chilled water systems and cooling towers.

- **Removal of particulate sorbents:** Downstream of filter beds (e.g., arsenic sorbents or ion exchange resins).

- **Chemical-biological filters:** For protection against terrorist contamination of water supplies.

— H.F.

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