Improving Health - Protecting the Environment

Ahlstrom Disruptor® Nonwoven Filter Media

Updated September 2015

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What is Ahlstrom Disruptor® Technology?

Welcome to this introduction to **Ahlstrom Disruptor®** - a unique and broad spectrum water filtration technology!

Series of 5 presentations:

1. **Ahlstrom Disruptor® - General information**
2. Ahlstrom Disruptor® - Legionella removal
3. Ahlstrom Disruptor® - Powder activated carbon (PAC)
4. Ahlstrom Disruptor® - Pathogen reduction
5. Ahlstrom Disruptor® - Membrane biofouling

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Two types of innovation: Incremental and Breakthrough

Ahlstrom Disruptor® is a breakthrough technology. It is not directly comparable to any other water filtration media now in the market.

Breakthrough

- Exploits innovation
- Shifts a market or business paradigm
- Engenders new product capability

Incremental (Typical)

- Fundamental product or process improvements
- Existing technology
- Keeps pace with competitors

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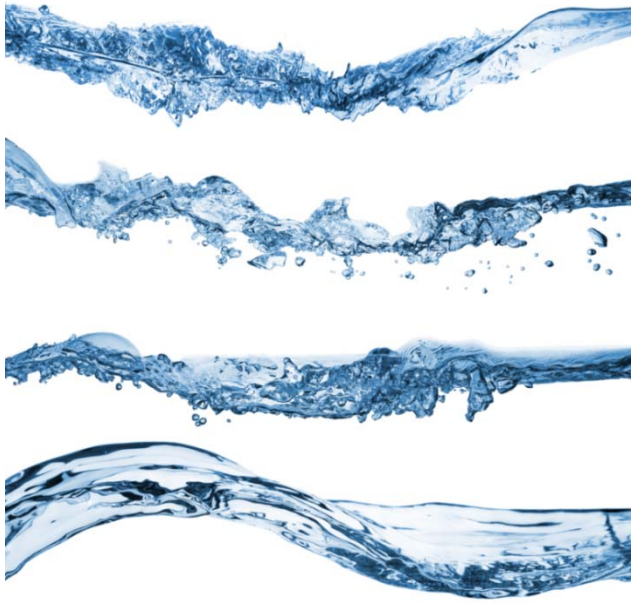
Ahlstrom Disruptor® - a new filtration technology!

- The development of this electroadsorptive technology started nearly 10 years ago with fundamental research by Fred Tepper of the Argonide Corporation. His early work was partially funded by an SBIR grant from NASA for the development of water filters to be used on space exploration vehicles. As work progressed, many intriguing aspects of the media were identified. **In 2006, Ahlstrom became the exclusive** licensee of the electroadsorptive technology and introduced it as Ahlstrom Disruptor®.

- This technology is changing the world of filtration because **it is not a mechanical** filter media. Instead, it removes submicron contaminants through **electroadhesion and ion exchange**. As users become accustomed to working with a non-mechanical filter media, many new and exciting applications are being developed.



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Ahlstrom Disruptor® - a new filtration technology!

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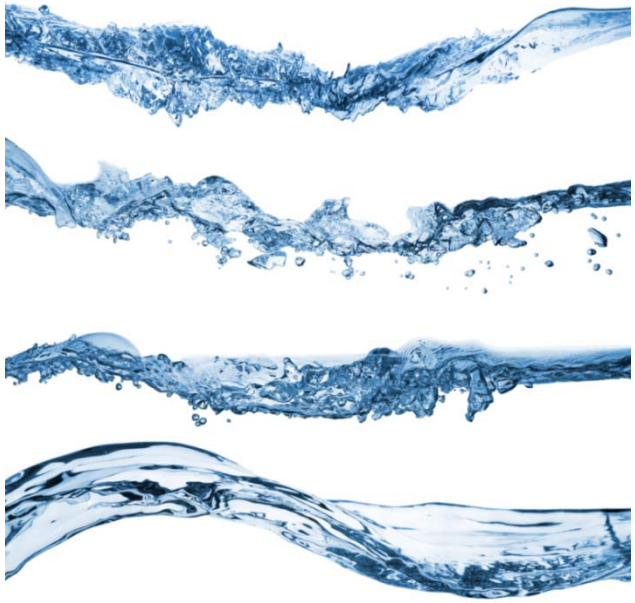

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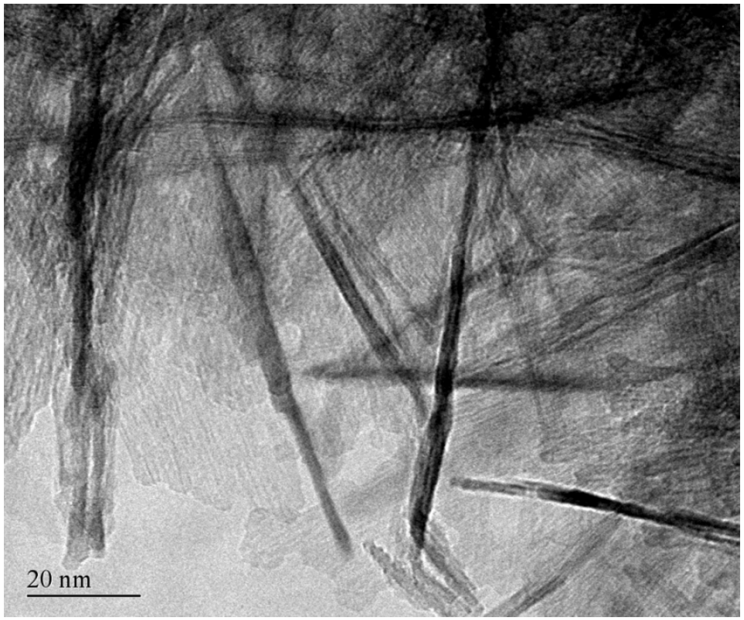
Active ingredient is a natural mineral fiber

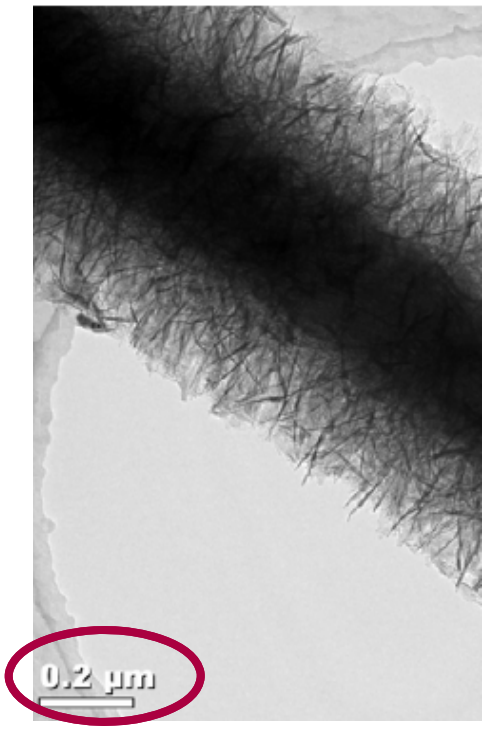
Ahlstrom Disruptor® technology is based on the mineral pseudoboehmite, AlO(OH). Each gram of alumina fiber has a surface area of greater than 500 square meters. The active fibers are 2 nm in diameter and approximately 250 nm in length. The crystal structure of the mineral creates a natural electrokinetic potential of Al+++ on the surface of the fiber.

- Therefore, the charge is not an electrostatic charge that can be dissipated by alcohol immersion, but instead is a charge potential that maintains integrity between 5–9.5 pH in polar liquids.
- The available hydroxyl group in each fiber will also exchange protons with many electropositive colloids to retain them through a form of ion exchange.



Ahlstrom Disruptor® technology

- Ahlstrom Disruptor® is different due to its electro adsorptive nature
- Based on the crystalline properties of the mineral pseudoboehmite, AlOOH
- The small size of the AlOOH allows for electro adsorption of submicron particles



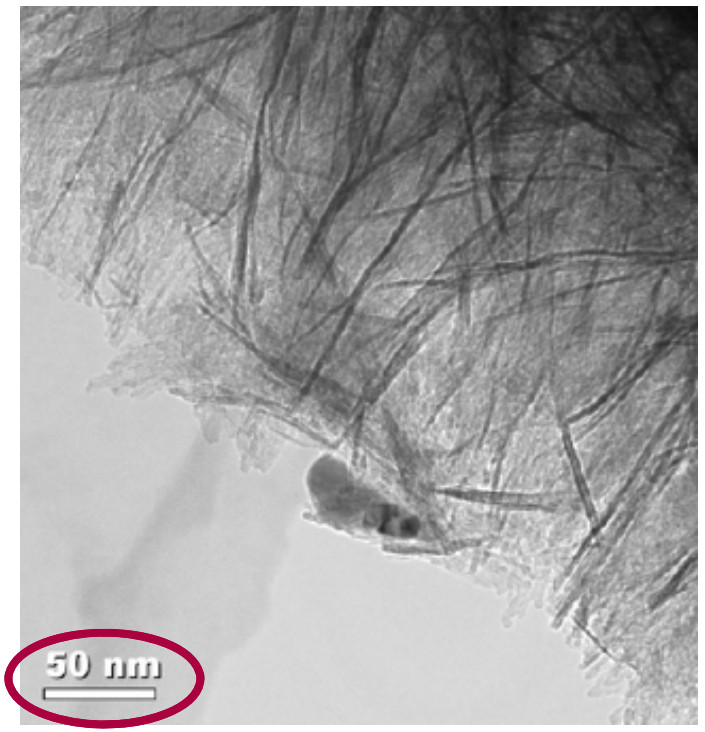
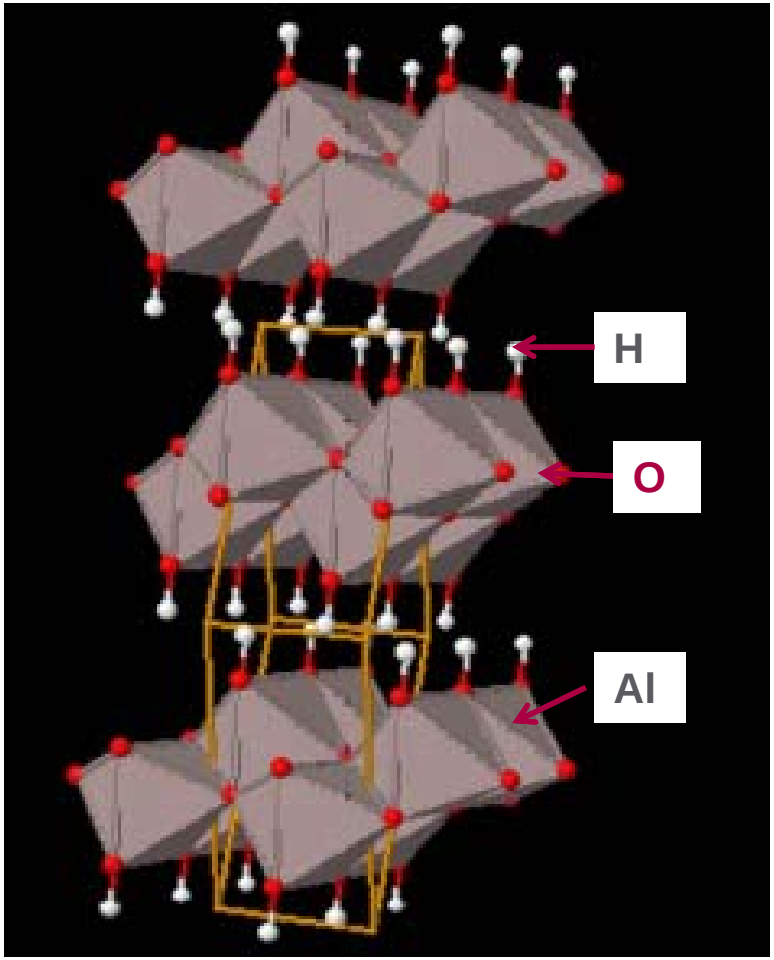


Photo courtesy of R. Ristau, IMS, Univ. of Conn

Pseudoboehmite at crystal structural level

The **crystal structure** allows for an extremely high surface area and a large number of active sites for submicron contaminant removal.



Source:http://www.crystal.unito.it/vibs/boehmite/

Mechanical *and* Adsorptive filter media

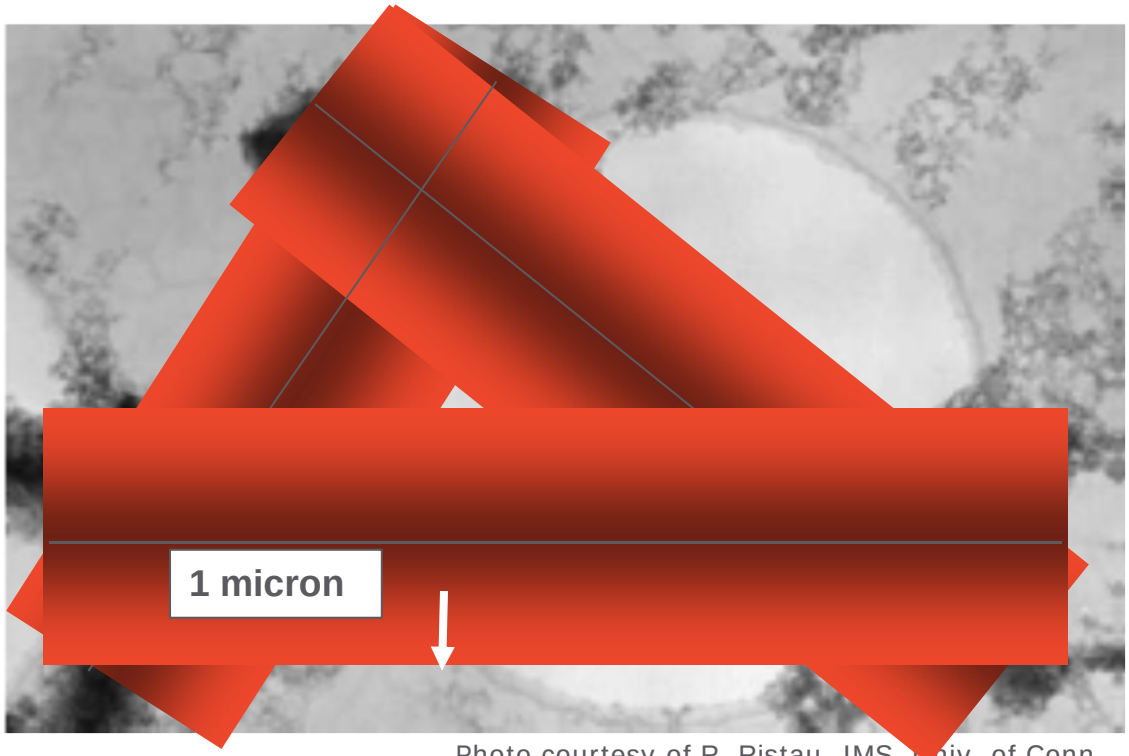


Photo courtesy of R. Ristau, IMS, Univ. of Conn

- The pore size of the media is engineered such that the charge field covers the entire void volume of every pore
- There are approximate 400 layers of these pores in the thickness of the media that contamination pass through during filtration, creating a tortuous path
- The charge field removes the negatively charged, submicron particles while larger particles are captured within the fiber structure of the media

Ahlstrom Disruptor® adsorptive technology

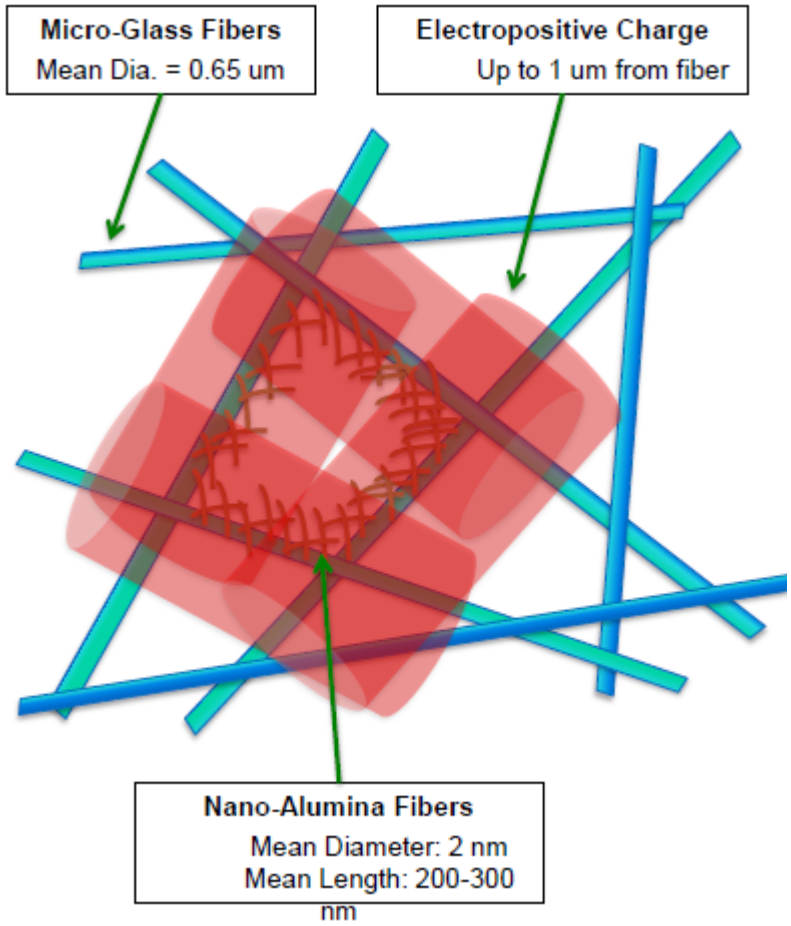


Image - Dr. J. Brant Univ of Wyoming

- > 50 millivolt streaming zeta potential
- Removes “small” materials not captured by conventional filters
- Captures organic/microbial macromolecules
- Removes virus and bacteria
- Mean pore size 1.25 microns
- Cartridge pressure drop < 0.1 bar

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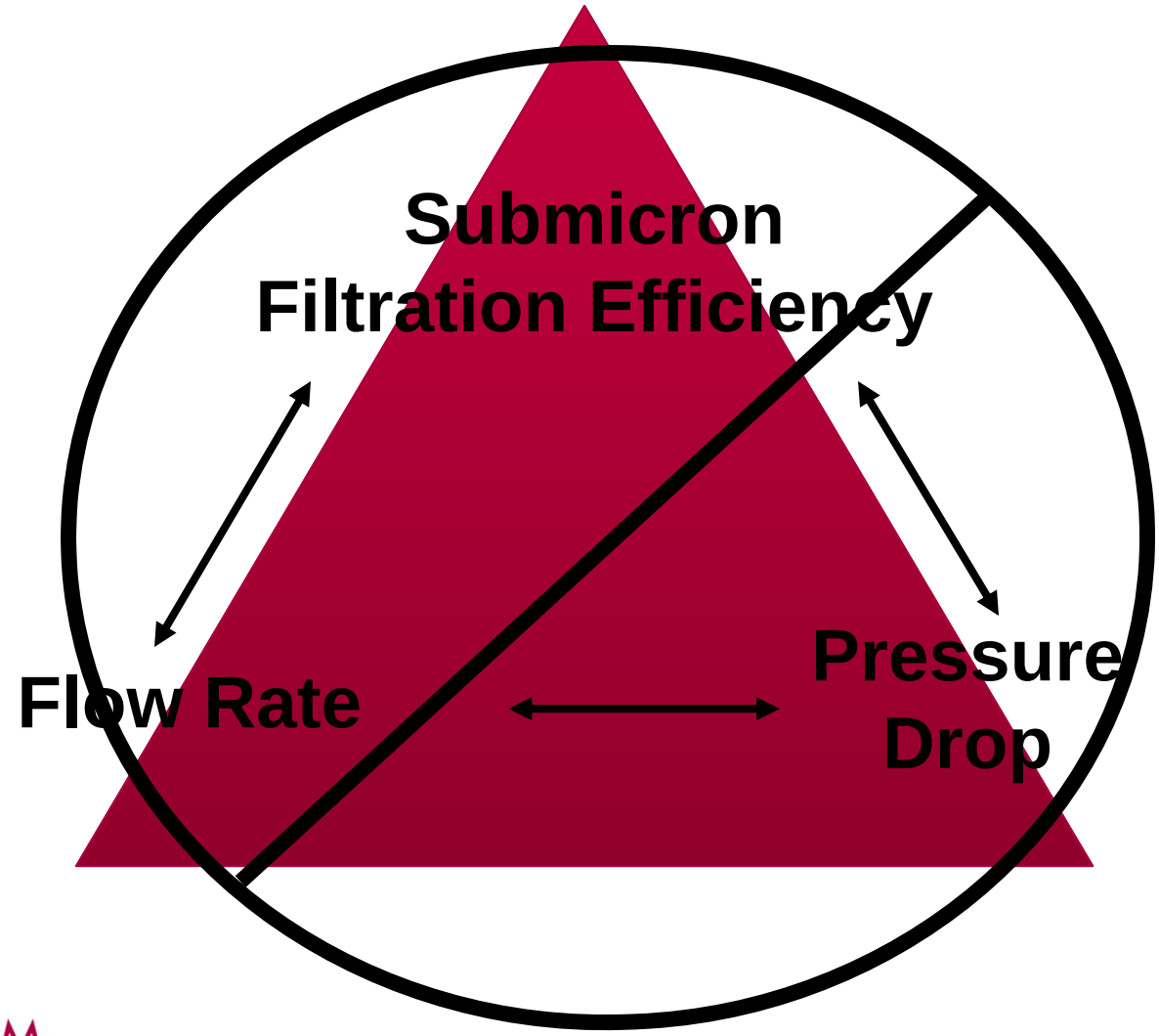
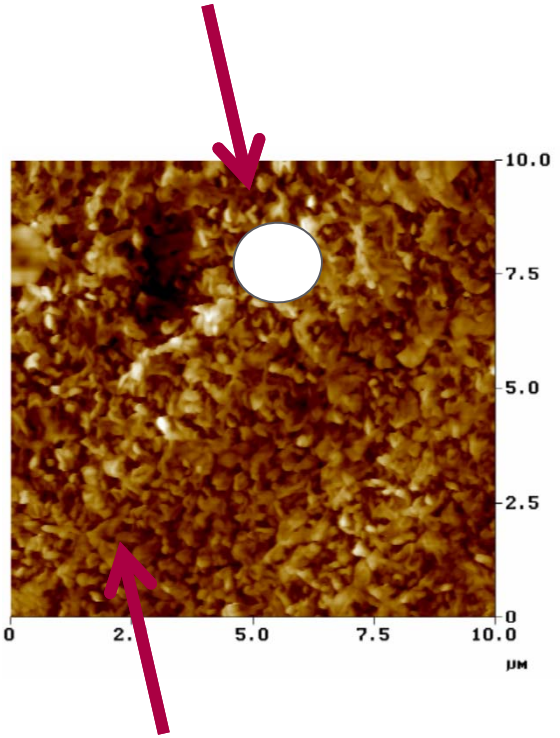
Paradigm shift in filtration technology



Ahlstrom Disruptor® pore vs. RO Membrane

Disruptor® pore size on same scale!



RO Membrane surface

RO membranes work on the basis of mechanical filtration and contain very small pores to remove submicron particles.

The extremely tight pores of a membrane cause low flow rates and high pressure drop.

Ahlstrom Disruptor® media has a **much larger physical pore size** which allows for higher flow rates and lower pressure drop, and can still remove submicron particles due to the inherent charge field extending across the void volume of the pores.

Image courtesy of Ibrahim El-Azizi, and Robert J. G. Edyvean, University of Sheffield, UK

Charge related removal

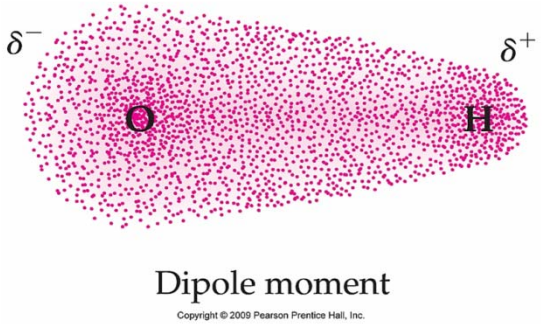
One possible mechanism of adsorption electropositive beside the charge field is the phenomenon of "dipole induced“ attraction.

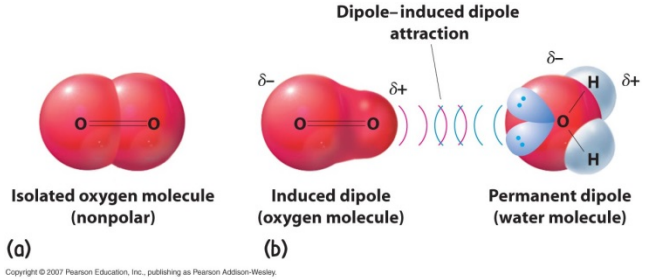
The electric field from the Nanoalumina / Microglass has been measured as penetrating into the surrounding water up to 300 microns.

The process within the pores (or capillaries) is somewhat different. There should be an excess of hydroxyl ions close to the nanoalumina surface (that means high pH caustic conditions) and depletion of hydroxyl ions close to the center of the pore (or capillary), i.e., acidic conditions.

Now imagine an electropositive particle with high isoelectric point in neutral pH=~7 water. When such a particle (together with surrounding double layer water envelope) gets closer to the nanoalumina surface, the closest side of the particle will be negatively charged with hydroxyl ions and the farthest part will be positively charged depending on particle size as compare to the pore size.

Then the mechanism will be the charge (surface) - dipole(spatial field gradient) formed on the particle. This mechanism is slightly different from the "charge(surface)-"induced dipole".





Sources: Leo Kaledin, Argonide Corp. Wikipedia, Dipole Moment

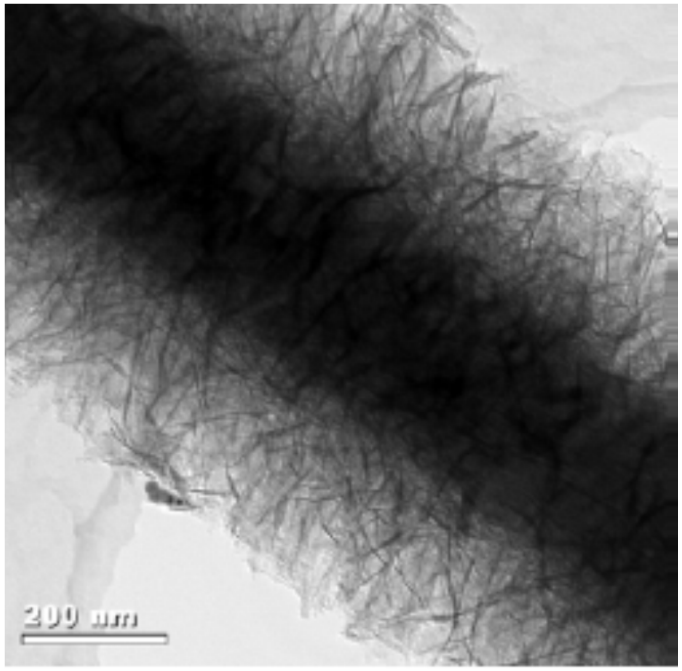
Creating water filter media

Ahlstrom Disruptor® technology is patented in the US, EU, Russia, China, India and other countries of the world. The patent protects both the manufacturing process for the alumina fibers as well as the method of attaching these small fibers to microglass carrier fibers.

Other patents also protect the use of the media in a range of filter devices and for the inclusion of many functional additives.

The alumina coated microglass fibers (as seen in this image) can now be easily produced into a depth filter media using standard wet laid, nonwoven manufacturing technology.

The base media is laminated between layers of spunbond to provide both strength and pleat support to allow the media to be made into virtually any size filter cartridge.



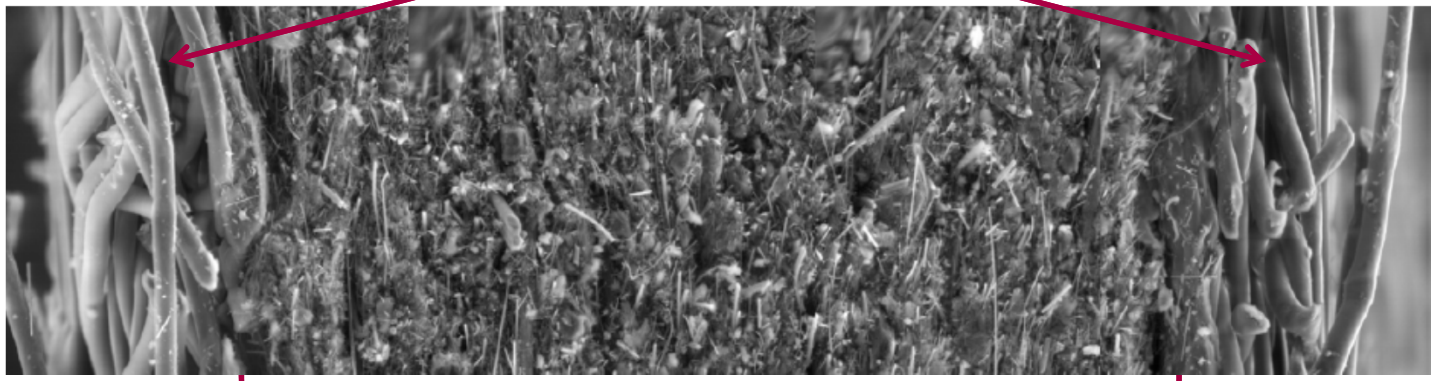
Cross section of Ahlstrom Disruptor® media

- **Ahlstrom Disruptor® is a 3- layer laminate:**
- Core is the active, **alumina filter media** with **spunbond laminate** on outside for
- strength and pleat support

- Unique Benefits: High Flow, Low pressure drop and Submicron retention

Spunbond Polyester Scrim Layers:

- **Pleat support**
- **Burst strength**



Active Layer:

- **Nanoalumina**
- **Powdered Activated Carbon**
- **Antimicrobial**
- **Has approx. 400 layers of charged fibers**

Photo courtesy of R. Ristau, IMS, Univ. of Conn

Filtration attributes of Ahlstrom Disruptor®

Filters through multiple mechanisms:

- Depth
- Torturous particle path
- Electro adsorption
- Van der Walls attraction

Result = Enhanced removal capability for:

- Submicron particles – organic and inorganic
- Colloids
- Biologic materials – virus, bacteria, organic acids, cell debris, endotoxins

Comparison Video

Comparative technologies

Filtration Technology Comparison Table

Water Remediation Technologies - Residential, Commercial, Industrial, Municipal, Desal								
	Disruptor® PAC Technology	**RO**	**NF**	**UF**	**MF**	**Particulate Cartridges**	**Carbon Block**	**Ultra Violet**
Contaminants								
Dissolved Salts		X						
Endotoxin	X	X	X	X	X	X		
Virus	X	X	X					X
Bacteria	X	X	X	X	X	X	X	X
Cysts	X	X	X	X	X	X	X	X
Polysaccharides (TEP)	X	X	X	X	X			
Colloids	X	X	X	X				
Particulates	X	X	X	X	X	X	X	
Chemical Reduction	X	X					X	X
Trace Pharmaceuticals	X	X					X	X

Membrane definition: Reverse Osmosis=RO; Nanofiltration=NF; Ultrafiltration=UF; Microfiltration=MF.

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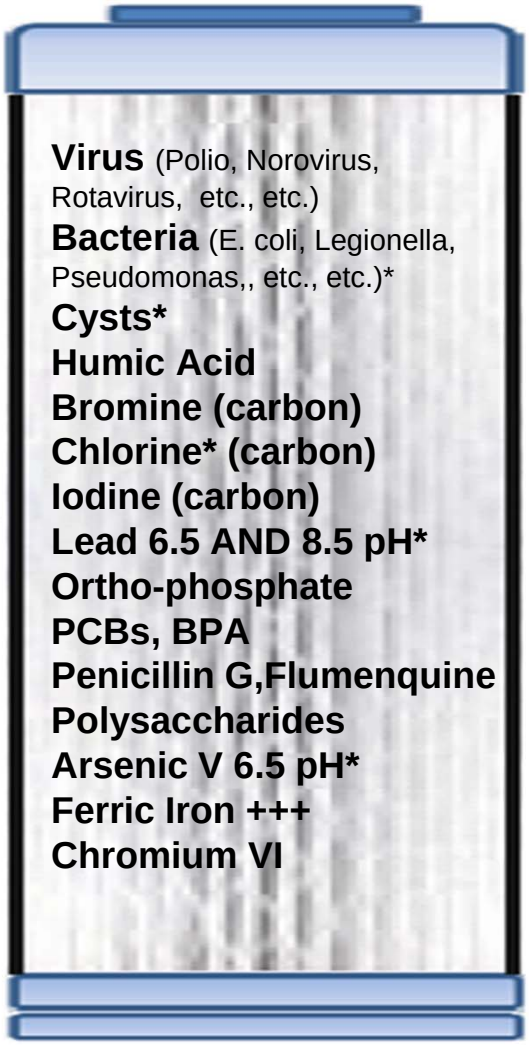
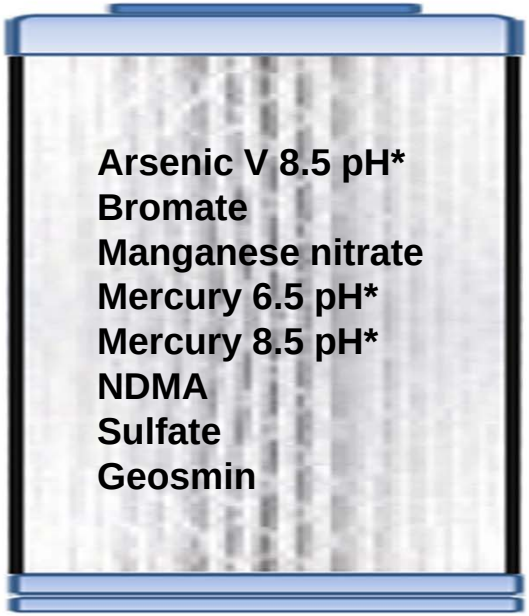
Summary of Ahlstom Disruptor® removal capabilities



Significant Removal

Some Removal



Minimal to No Removal

*All marked with *: NSF concentration standard followed*

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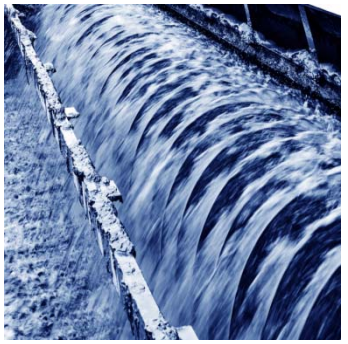
Ahlstrom Disruptor® product family

5283	5284	5288	5289	5292
White	PAC	White	PAC with silver antimicrobial	High Flow / Prefilter
Heat -sealable	Heat-sealable	Heat –sealable with silver antimicrobial	Heat-sealable	White, Heat-sealable
1.25 micron mean pore size	1.25 micron mean pore size	1.25 micron mean pore size	1.25 micron mean pore size	8 micron mean pore size
Removing pathogens and colloids	Removing pathogens, colloids, chlorine taste and odor, some chemicals., humic acid etc.	Removing pathogens and colloids	Removing pathogens, colloids, chlorine taste and odor, some chemicals., humic acid etc.	Good upstream protection to any other Ahlstrom Disruptor® grade to increase life and minimize surface blinding
Very good loading capacity	Very good loading capacity	Very good loading capacity	Very good loading capacity	

Applications for Disruptor® technology

Water Filtration:

- **pH:** 5-9
- **POU**: water bottle, gravity, counter top, under sink, RO
- **POE**: whole house
- **Appliances**: refrigerator, water dispenser,
- **Commercia**l: beverage dispensing, ice machines, bottled water
- **Industria**l: boiler feed water, sanitization, waste water treatment
- **Municipa**l: potable and waste water treatment



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Limitations or weakness of Disruptor® technology

Physical “limitations”

- Is a nonwoven, not a membrane
- Contaminants must have a negative or neutral charge to be removed
- Dead end filter
- Cannot be regenerated
- Needs to be pleated
- Cannot differentiate between contaminants with a negative charge
- Under specific conditions retained virus can be eluted

Not Applicable due to specific high extractible materials

- Blood filtration
- Dialysis
- Ultrapure water
- Injectable pharmaceutical

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Ahlstrom Disruptor® Safety

Meets NSF/ANSI Standards 42 and 61

Water Quality Association Gold Seal

TESTED AND CERTIFIED
Water Quality
UNDER INDUSTRY STANDARDS

Certificate of Compliance

to certify that

Ahlstrom Filtration, LLC

Ahlstrom Filtration, LLC

Has successfully met the applicable requirements of Standard(s):

Standard:	NSF/ANSI 42: Drinking Water Treatment Units, Aesthetic Effects*
Model(s):	5281, 5282, 5283, 5284, 5287, 5288, 5289, 5290
Standard:	NSF/ANSI-61: Drinking Water System Components - Health Effects
Model(s):	5281, 5282, 5283, 5284, 5287, 5288, 5289, 5290

SCC Accredited PCB OCP Accredité OCN

ANSI

Water Quality

Issue Date: 01/05/2012

Expiration Date: 12/31/2012

Signature

This Certificate, or any part thereof, may not be used in a misleading manner and validation of its use is contingent upon the Official WQA web-listing.

Silver Antimicrobial: important to note

- It is important to note the **distinction between nanosilver and the silver impregnate zeolite** we use in Disruptor® products
- Nanosilver is typically 25 nanometers in size and can freely move through the dermal layer and in between human cells
- The Agion® silver impregnated zeolite we use has an **average diameter of 2 micron** (2000 nanometers) or approximately **100 times larger than nanosilver**
- This difference in size eliminates the possibility of the Agion® zeolite being considered to be nanoparticle. In addition, the Agion® product contains the silver internal to the zeolite. Silver is **not available in a free form**.
- This means the silver contained within the zeolite can only be released in the presence of other ions, taking the place of the silver in the zeolite. This method of ion exchange provides for **controlled delivery.**

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Fact Sheet from USAPHC

USAPHC

Alumina Nanofiber Filters in Drinking Water Treatment

FACT SHEET 31-015-0211

What are Alumina Nanofibers?

Alumina nanofibers are very small fibers made from aluminum metal or aluminum containing materials. The fibers range in size from 1-100 (nm) in diameter and can be up to several micrometers in length (reference 1). To give perspective, a sheet of paper is about 100,000 nanometers thick. Alumina nanofibers consist of either aluminum oxide (Al_2O_3) or aluminum hydroxide, such as aluminum oxide hydroxide (AlOOH), commonly referred to as boehmite, or aluminum trihyroxide [$Al(OH)_3$], commonly referred to as gibbsite, bayerite or nordstrandite (reference 1).

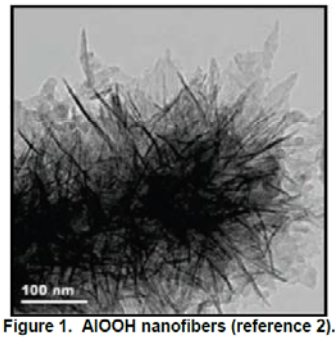

Figure 1. AlOOH nanofibers (reference 2).

How can Alumina Nanofibers be used for Treating Drinking Water?

Alumina nanofibers have been incorporated into cartridge filters to increase their ability to remove contaminants. The nanofibers have two particular attributes that make them attractive for use in drinking water filters – the proven capability of alumina to adsorb various contaminants in conjunction with the extremely high surface areas of the nanofibers allow for potential adsorption of significant amounts of contaminants (references 3, 4). This could extend the life of a filter. The electrostatic attraction allows for the potential adsorption (and thus removal) of viruses which are on the submicron and nanoscale. This would improve a filter's microbial pathogen removal capabilities. Research has shown the potential for Al_2O_3 alumina materials and Al_2O_3 alumina nanofibers to remove or reduce virus concentrations in water (references 5-8).

Currently, one company uses alumina nanofibers for drinking water treatment. The nanofibers are aluminum oxide hydroxide, or boehmite (AlOOH). The boehmite nanofibers are about 2 nm in diameter and 200-300 nm in length (Fig. 1). The nanofibers are incorporated onto submicron glass fibers which are then bonded onto a pleated filter medium (references 9, 10). The resulting filter has pore sizes of about 2-3 micrometers. However, due to the electrostatic attraction much smaller particles (e.g., viruses) could potentially be removed through adsorption, effectively making the filter function as though it had much smaller, submicron pore sizes similar to a membrane filtration technology such as ultrafiltration. With an actual pore size of about 2-3 micrometers, the filter could allow a high rate of flow with a low pressure drop compared to membrane technologies – an advantage over traditional membrane technologies. Some research shows Al_2O_3 alumina nanofiber filters of similar design to this company's filters performing effectively at high flow rates (references 8, 11).

Do Alumina Nanofibers used for Treating Drinking Water Pose any Human Health or Environmental Health Risks?

Alumina nanofibers used in drinking water treatment could be shed from a filter and be ingested or enter the environment.

U.S. Army Public Health Command (Provisional)
Water Supply Management
Aberdeen Proving Ground, MD 21010-5403
Commercial (410) 436-3919/DSN 584-3919
Email: Water.Supply@amedd.army.mil

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Stay ahead™

Thank you

Questions and for more information
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rod.komlenic@ahlstrom.com filtration@ahlstrom.com www.ahlstrom.com/disruptor