

NANOCERAM® FILTERS

Winner of 2005 Space Foundation Hall of Fame Award



Argonide Corporation, Sanford, Florida
www.argonide.com



DTRA

SUMMARY

- We invented a revolutionary microbial filter, capable of retaining sub-micron particles with high efficiency, yet it has a high flow rate
- The active ingredient in the filter is a nano alumina fiber that is highly electropositive
- The filter retains all types of particles by electroadsorption, including silica, natural organic matter, metals, bacteria, DNA and virus.
- It has high capacity for micron size as well as nano size particles.
- Pleated filter cartridges are now available for sale.
- It has wide applications in chemical, microelectronic, and pharmaceutical manufacture, food and drink, cleaning coolants, prefilters for reverse osmosis and for cleansing drinking water.

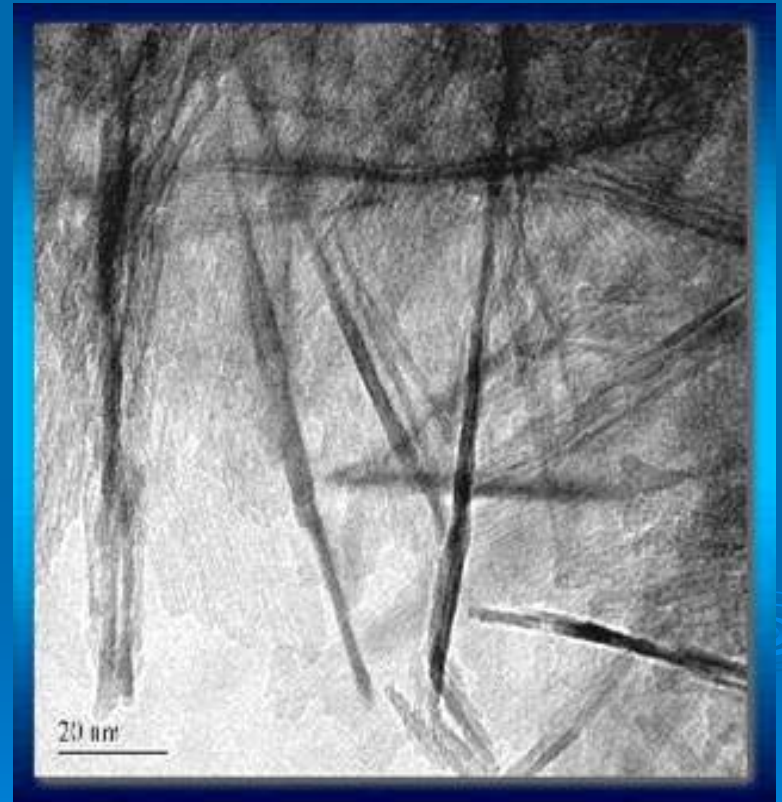
About Argonide

- **Founded in 1994 to develop nano powders**
- **Argonide invented the NanoCeram[®] filter media based on a nano alumina fiber**
- **The development has been supported by NASA for purifying recycled water in space**
- **Other sponsors include the Departments of Energy, Air Force and the EPA**
- **A U S patent has issued and others have been applied for**
- **The NanoCeram[®] technology received the 2005 Hall of Fame award from the Space Foundation**

Electron Microscopic Image

NanoCeram[®] Fibers

The active ingredient of the filter media is a nano alumina (AlOOH) fiber, only 2 nanometers in diameter. The nano fibers are highly electropositive.



Nano Alumina On Microglass Fibers

The nano fibers are first dispersed and adhere to glass fibers. The nano alumina is seen as a fuzz on the two glass fibers.

Other fibers are added and the mixture is processed at a paper mill to produce a non-woven filter.

Because the nano alumina is dispersed, particles have easy access to the charged surface.



Features of NanoCeram® Filters

- Flow rates (flux) tens to hundreds of times greater than ultraporous membranes
- NanoCeram separates particles by charge rather than size
- Higher retentivity for virus than “Absolute” ultraporous membrane filters
- Endotoxin removal > 99.96%
- DNA removal > 99.5%
- Resistant to clogging by fine and ultra fine particles
- Pleated versions have 5-10 times higher dirt holding capacity than typical cartridges
- Filtration efficiency for micron size particles >99.995%

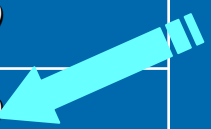
Pilot lot of NanoCeram media



The media is manufactured like paper. A major cost barrier was overcome when continuous manufacture was demonstrated

Zeta Potential & Virus Removal

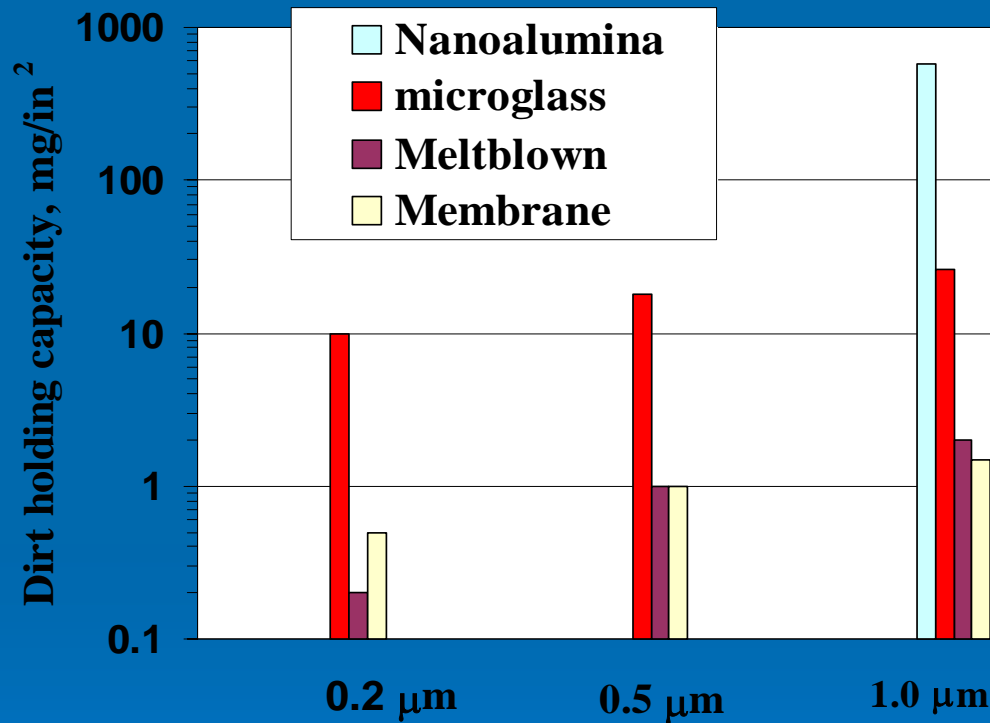
NanoCeram [®] Wt % on Glass	Zeta potential, mV	MS2 Retention (%)
0	-35	8
5	-10	29
10	7	94
15	12	>99.9999
25	32	>99.9999
40	29	>99.9999
50	23	>99.9999



Zeta potential becomes positive with increasing nano alumina and this causes a marked increase in virus (MS2) retention

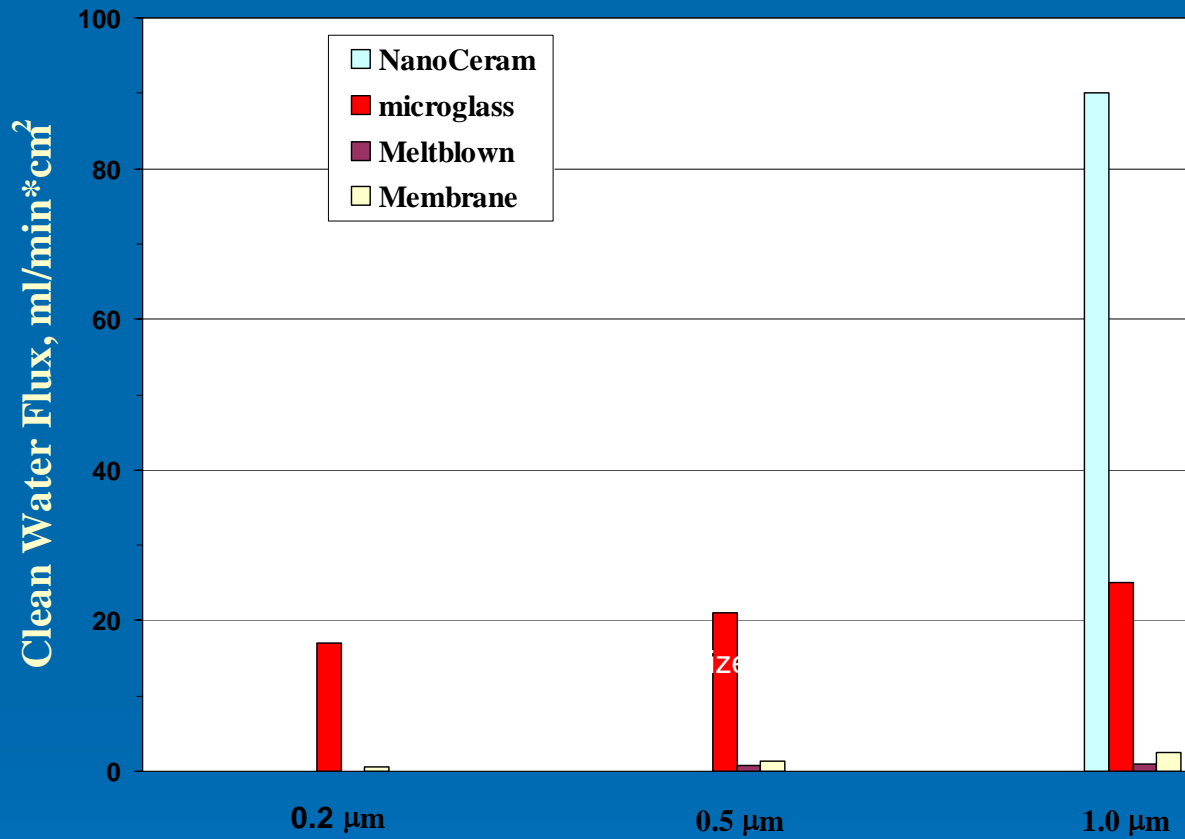
Filtering dirt particles

This compares the dirt holding capacity for A2 fine test dust (~1-4 μm)



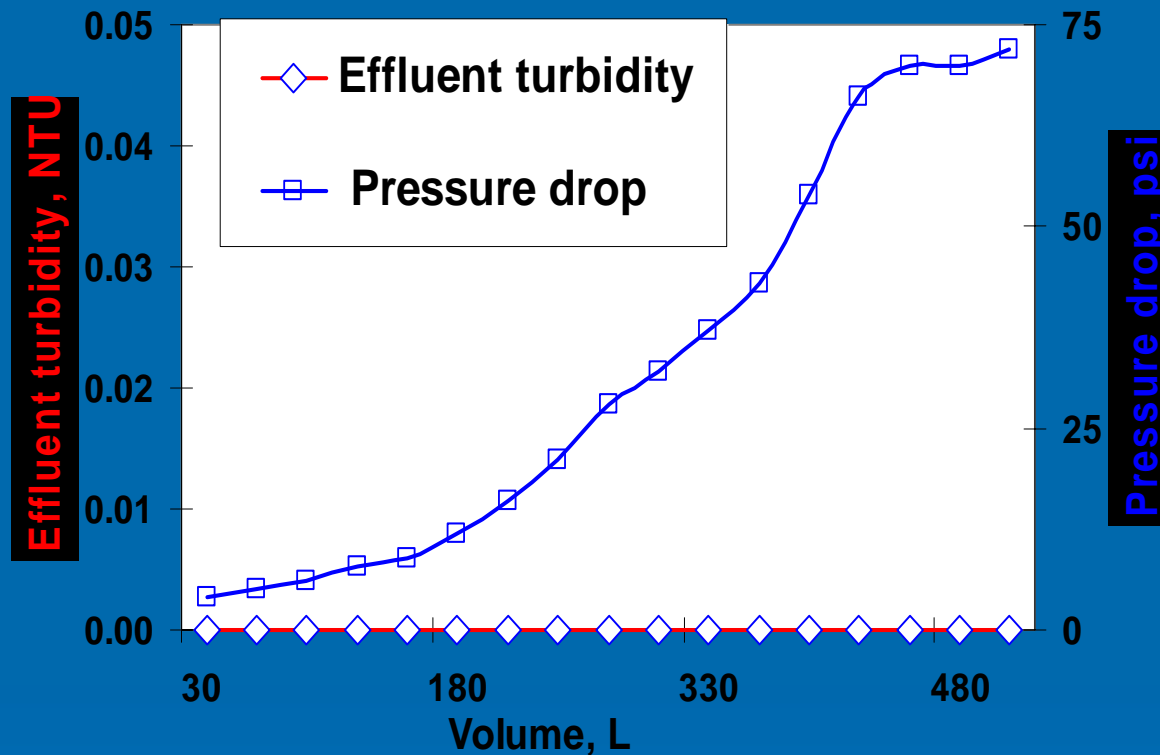
The dirt holding capacity of NanoCeram® is almost twenty times greater than microglass filter media and 300 times greater than either meltblown or membrane media

COMPARISON OF FLOW CAPACITY



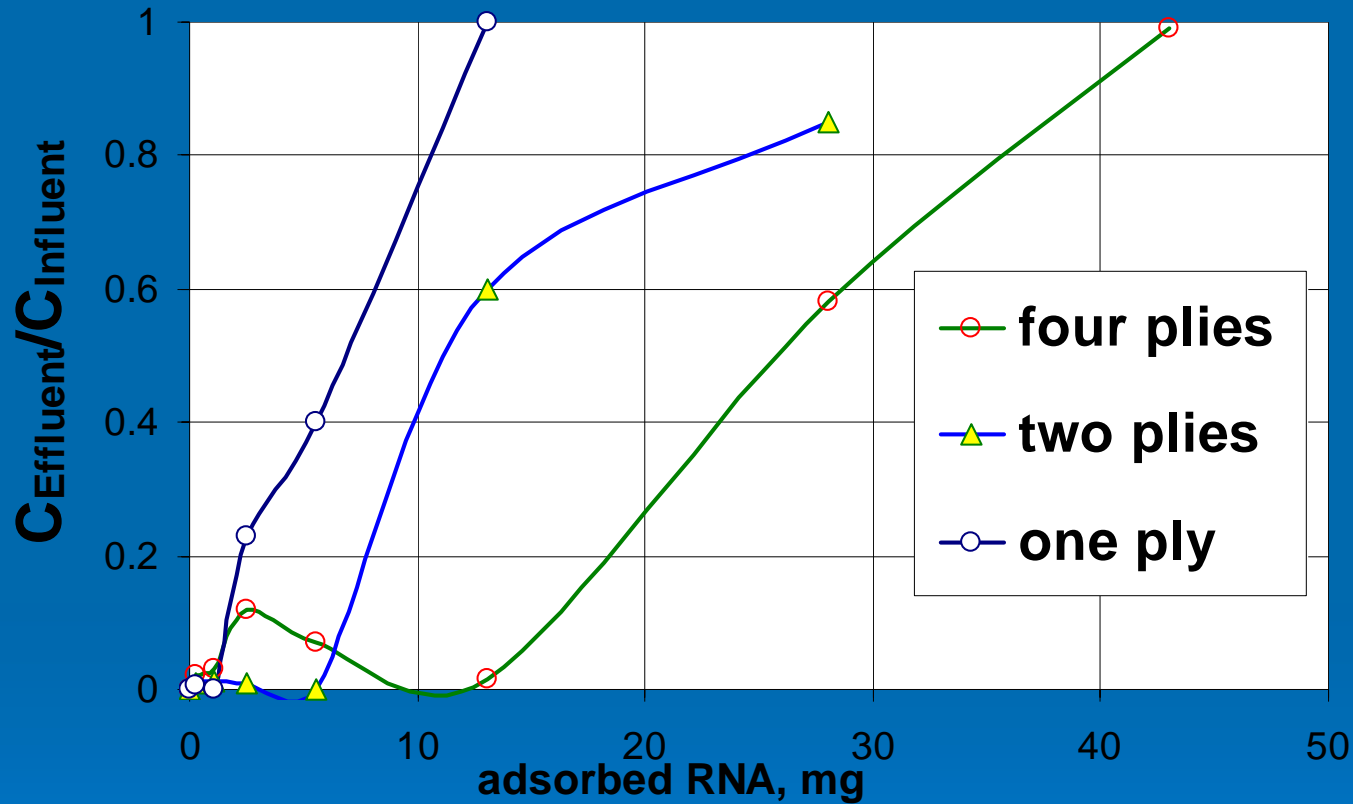
NanoCeram® can support a much higher flowrate than other filters rated at 1µm pore size or below.

Dirt holding capacity of a pleated cartridge



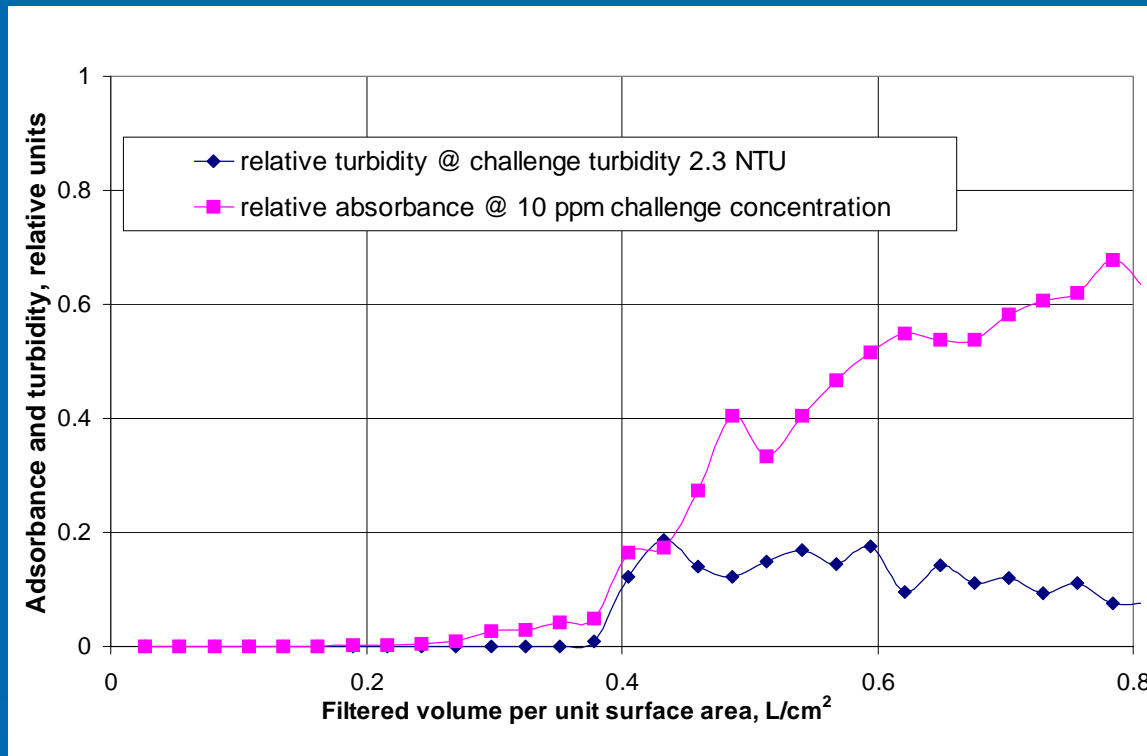
A 2.5" diameter X 5" pleated cartridge was challenged by 250 NTU of fine test dust at 1.5 gallons/min. At 90 minutes (141 gallons) it had filtered out 119 grams of dust while producing an effluent < 0.01 NTU, at which point the test was terminated because of excessive pressure drop, but without breakthrough. It had removed >99.996% of dirt throughout the test.

RNA Adsorption Curves as Function of Thickness



DNA and RNA are filtered much like virus. The thicker the filter, the higher is the retention factor.

FILTRATION OF SUB-MICRON ORGANIC PARTICLES



The filter is excellent for adsorbing turbidity. Filters (25 mm diameter) removed humic acid, an organic particle small enough to pass through “Absolute” 0.2 μ filters. Note the high filtration efficiency until at least 0.4 liters of fluid/cm² of filter area.

Nano ink adsorption – Slide # 1



A pigment ink with a particle size of about 2 nm was diluted until it was transparent.

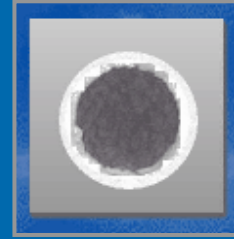
Ink Test - #2

When forced through a 25 nm ultraporous (UP) membrane (Millipore VS), the back pressure was very high. The small amount of ink that passed through the UP membrane was as colored as the influent.



After the test, the UP filter showed very little color change

Ink Test - #3



When the ink was injected through the NanoCeram[®] filter, the back pressure was low and filtration was easy. Yet the effluent came out water white. The filter (above) was intensely colored, proving that it retained nanometer size particles.

Filter configurations

- Pleated filter – Large area with high flow, high dirt capacity, and high efficiency. Excellent for filtering particles down to about 0.1 microns.
- Thicker depth filters are necessary for achieving >99.99% retention of virus to meet EPA certification as a drinking water filter. Such filters are in development.

DEVELOPMENT AND MANUFACTURING STATUS

Pleated cartridges 2.5" diameter, 5" and 10" long are currently available and 20" long will be available September 2005

Pleated 4.5" cartridges 10" and 20" long will be available in September

Design and development is underway for a cartridge suitable for certification to the EPA Guide Standard for Drinking Water Filters

PLEATED NANOCERAM[®] CARTRIDGES



2.5" diameter cartridges – 5" and 10" long (P2.5-5 and P2.5-10) are shown.
The smallest unit is a prototype.

4.5" diameter X 10" long (P4.5-10) is also shown.

SUGGESTED APPLICATIONS – PREFILTERS FOR REVERSE OSMOSIS MEMBRANES


- RO filters are highly sensitive to fouling by sub-micron particles and are expensive to replace.
- Ultraporous (UP) membranes are used as RO prefilters. They are also easily fouled, so they are also used in a cross-filtration mode to minimize fouling.
- Cross flow filtration results in a waste stream, often 3-10 times greater than the stream being purified.
- NanoCeram[®] is used in direct flow and there is no waste stream
- NanoCeram has a very high capacity for particles without needing to be cleaned as in the case of UP membranes

CLEAN-UP OF WATER COOLANTS

- Coolants can harbor pathogenic bacteria such as Legionella. NanoCeram® will filter bacteria and turbidity and because of its higher capacity. The cost of changing out filters is substantially reduced.
- Coolants are also used in cutting and grinding and EDM (electro discharge) machines. The fluid is filtered to remove suspended metals. Ultra-fine metal powders are generally not removed by conventional filters and re-circulate, affecting tolerances and causing poor finishes. Suspended particles contain nickel and other metals that are potential health hazards. Bacteria also build up in such coolants.

NanoCeram® will filter out suspended metals and bacteria reducing their potential to be aerosolized and dispersed when the fluid is reused.

PHARMACEUTICAL AND BIOTECH APPLICATIONS

- Removal of contaminants from incoming water
 - Prefiltering for reverse osmosis filters
 - Filtering endotoxins, bacteria and virus
 - Filtering hazardous pharmaceutical waste before disposal
 - Separation of proteins
- 

OTHER APPLICATIONS

- Swimming pools and spas (we are tooling up for large (20+ gallons/min) capacity filters)
- Processing food and drink- Removal of bacteria, yeast and sediment from wine and beer
- Prefiltration prior to ultraviolet or ozone treatment to minimize the burden on such processes
- Filtering turbidity, cysts and bacteria from household well water
- Biological warfare filters for military, hospitals and other critical buildings

Argonide Corporation

Sanford, Florida

(407) 322-2500

Info@argonide.com

www.argonide.com

