

By Frank A. Brigano & Vincent P. Nero

Keeping Public Water Supplies Safe

Antimicrobial soaps, hand lotions, kitchen utensils, clothing, bedding and many other products are commonplace today. These products contain functional additives to reduce the presence of microorganisms in an attempt to protect the user from potential microbial illnesses. When it comes to drinking water, however, we rely on the presence of chlorine, chloramines or other water disinfectants to protect us from microbial illness. It goes without saying that the most significant public health protection event was the advent of chlorination of the water supply.

Microbiological reduction filtration solutions



Chlorination is responsible for significantly reducing the incidence of waterborne disease. Generally, the water we consume—either from the tap or out of the bottle—is safe to drink from a microbiological standpoint. But even with the presence of a disinfectant residual in the water supply, there are incidences of waterborne illnesses. The more famous of these were the 1993 *Cryptosporidiosis* outbreak in Milwaukee and the 2000 outbreak of *E. coli* O157:H7 and *Campylobacter* in Walkerton, Ont., Canada.

Many of these outbreaks have been documented and many have not. It is estimated that many waterborne illnesses actually go unreported.¹ This underreporting results in endemic illness, primarily gastroenteritis, within the population that mostly goes undetected.

Supplemental Barriers

The POU and POE industry was built on the premise that individual consumers have the right to improve the quality of their water. That is, the consumer can customize his or her water to meet individual water quality needs. This customization should include the ability to incorporate a supplemental antimicrobial barrier

prior to water consumption.

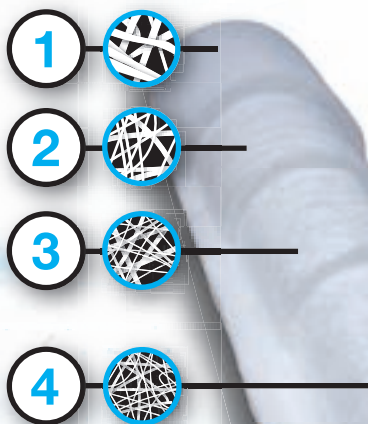
The NSF International Drinking Water Treatment Unit (DWTU) Joint Committee has been working for a number of years to develop comprehensive testing protocols and NSF/ANSI standards to certify microbial reduction drinking water products. Unfortunately, this process is yet to be completed. Therefore, our industry relies primarily on the 1988 U.S. Environmental Protection Agency (EPA) microbial purifier guide protocol, which has been incorporated into NSF Protocol P231, to certify microbial reduction drinking water products. This protocol calls for the reduction of 6 logs (i.e., 99.9999%) of bacteria, 4 logs (i.e., 99.99%) of viruses and 3 logs (i.e., 99.9%) of cysts. Microbial cyst reduction certification is incorporated within NSF/ANSI Standard 53, “Drinking water treatment units—Health effects.”

KX Technologies, LLC, an industry leader in carbon-block filtration and immobilization technologies, has developed a unique process for the reduction of microbes (bacteria, viruses and cysts) from water. This technology exceeds the U.S. EPA Guide protocol for bacteria reduction at greater than 6 logs and virus reduction at greater than



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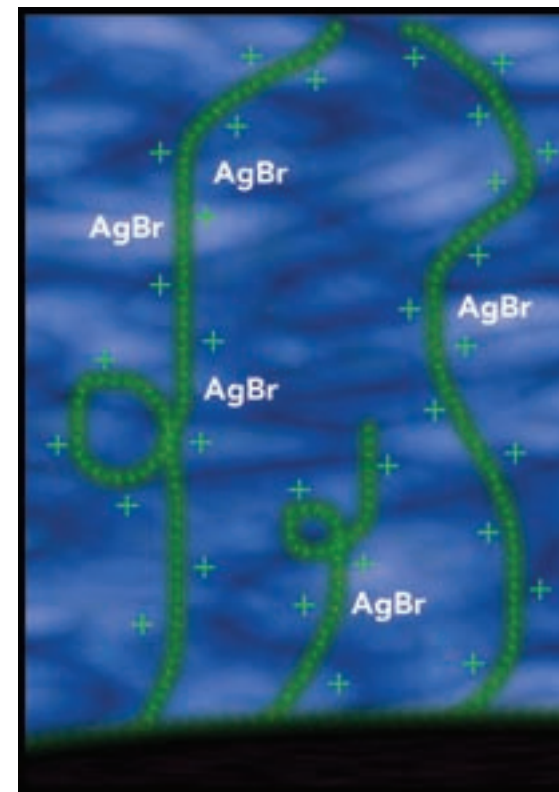


Figure 1: Graphical representation of micro-biological interception technology showing the high molecular weight positively charged polymer extending from the filter medium surface with the silver bromide complex associated to prevent microbial growth.

4 logs, and it meets or exceeds the cyst reduction requirement of NSF/ANSI Standard 53.

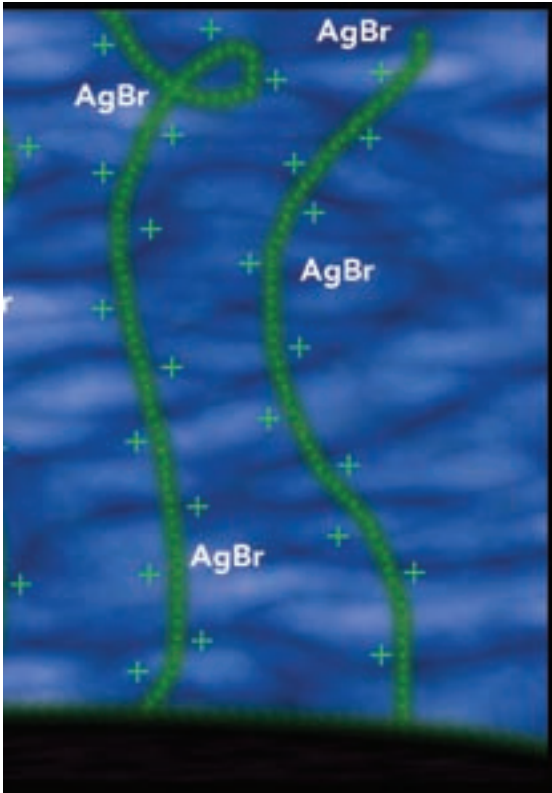
This technology features an automatic natural clogging shutdown feature that reduces flow through the medium due to the associated presence of organic materials in the water. This failsafe mechanism reduces the chance of product use beyond its intended life and thus safeguards the product user.

Microbiological Interception Mechanism

The filter is a microporous activated carbon-block structure formed by an extrusion process, using a thermoplastic polymeric binder.² The resulting carbon block has a mean flow path of one micron or less. In addition to activated carbon and binder, the filter medium contains a microbiological high molecular weight polycationic interception agent, a cationic silver halide complex and a pH-altering material.

The basic carbon structure with its mean flow path will permit some channels for microorganisms (Figure 1). This structure, however, would be sufficient to intercept *Cryptosporidium* and larger bacteria. The block's capacity to intercept microbiological organisms, including viruses, was greatly enhanced by treating the microporous activated carbon with a long-chain cationic polymer. The cationic polymers will electrostatically attract negatively charged microbes, which approach the positive surface where the microbe will irreversibly stick. In our case, the cationic polymers are partially converted to the bromide form and firmly adsorbed onto the carbon.

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The converted bromide cationic polymers have a molecular weight averaging 400,000 daltons that consist of approximately 2,500 monomer units. These individual monomer units of polymeric cationic molecules will be electrostatically repulsed from adjacent intermolecular polymeric units and forced into a greatly extended conformation, especially when placed in contact with water.

Because each monomer has a length of approximately 20 angstroms, a molecular strain of the converted bromide cationic polymer could theoretically extend to several microns beyond its fixed powder carbon base. All of the open pores of the carbon block will therefore be effectively filled with an electrostatic net. With this, the microbiological interception is complete.

Viral particles are theoretically more efficiently and electrostatically captured than bacteria because viruses have a much higher charge-to-mass ratio. Although a virus has smaller total surface charge than bacteria, it has a significantly less total mass.

The cationic silver halide complex is added to the filter media to prevent the growth of the intercepted bacteria on the filter medium. The buildup of entrained bacterial material could possibly provide a growth media for long-term colonization of the filter. The resulting growth in the block might possibly lead to microbial bypass.

To prevent the proliferation of bacteria on the filter, the cationic polymer is treated with a silver bromide complex. A silver bromide complex is preferred over a silver chloride complex because silver bromide is extremely insoluble in water. This complex is sufficiently insoluble to guarantee its presence throughout the lifetime of the filter. The silver ion acts as a biostat to prevent bacterial growth on the filter medium.

A pH-altering material is added to the block matrix to ensure that

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microbiological materials present in an influent stream will always have negative surface charge.

Pathogens have phosphoric or carboxyl functional groups on their surfaces. At high pH levels, these functional groups will be above their isoelectric point. The isoelectric point is the pH where a given pathogen will have a net neutral charge.

In a basic environment, the pathogen will have a net negative charge. As long as the pathogen maintains a negative charge, it will be attracted to the cationic polymeric surface and will adhere irreversibly to that surface.

Flow through this filter system will decrease and eventually clog when exposed to an excess of polyanionic acids. These natural and manmade

polyanionic acids appear in the environment as microorganisms and humic acids. Their presence will shut down the filter when the filter is exposed to contaminated water.

Product Qualification & Certification

A rigorous product testing and certification process is required for

microbiological reduction products. First, the product must meet the performance and material safety requirements of NSF/ANSI standards 42 and 53. Microbial cyst reduction claims can be certified using NSF/ANSI Standard 53.

Bacterial, cyst and virus reduction for the microbiological interception product is verified using proprietary protocols adapted from the EPA purifier guide protocol. Testing to guarantee microbial purifier performance over the life of the product is paramount.

Filters are challenged to the stated water capacity of the product and flow rate at a defined on/off cycle. The system is periodically challenged with the specified bacteria, viruses and particulates. The challenge water is made up to the specification outline in the EPA guide protocol and contains a given amount of organic material from humic acid. Enumeration of the bacteria and viruses occurs over the course of the testing, including at the end of filter life. The microbial reduction filter must demonstrate microbial log reductions consistent with the purifier guidelines over the course of the testing.

The Next Phase?

Significant progress has been made in developing technologies to protect the consumer from incidental microbes that may be present in the water. It is only natural that there is a progression from cyst-reduction POU drinking water systems to systems that can reduce bacteria and viruses in the water. *wqp*

References

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² U.S. Patent 5,249,948, "Apparatus for the continuous extrusion of solid particles."

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