By Jeff Roseman, Aqua Ion Plus+ Technologies

Changing the Face of Ultraviolet

Coiled Tubing Enables Longer Contact Time, Offers Greater Versatility

Innovations and advancements in technology in addition to public awareness and media exposure are changing water treatment equipment and marketing strategies. New ideas and the need for developing easier to use and easier to service products are at the forefront of the industry's manufacturers, suppliers and dealers worldwide. Producing water treatment equipment that works in the background is easy to maintain and produces great tasting, bacterial-free water, which is essential as we move through the new millennium. A change that is going to revolutionize the UV light arena of water treatment are coiled tubes that enable longer contact times and have excellent UV light transmission, versatility in application and a compact system design. This method of UV light transfer in applications such as drinking water, icemakers, beverage dispensers, water coolers and aquaculture make the task of changing the tube that protects the UV bulb safer and less costly to the consumer.

Test studies have shown excellent bacterial reduction, and tests on scaling prove this method of bulb protection will work very efficiently. Other uses include ozone contact chambers and aeration tubing for ozonated pools and spas. A close look at this tubing has revealed greater than expected results in bacterial reduction and scale issues associated with different water sources. The outcome of a few simplistic experiments has revealed enough positive information that more tests are warranted.

Efficacy and Scale Issues

Bacterial reduction tests and scale tests were performed on the fluoropolymers. The first reaction when observing the coiled tubes would be transmission levels of UV light into the water source. The opaque quality of the tubes would make one wonder if high enough transmission levels for bacterial reduction would be achieved. The tubes that were tested varied in clarity and smoothness, and transmittance levels were wide-ranging. Figure 1 shows the differences in transmission levels of the four tubing materials tested plus quartz. The FEP and MFA depict good transmission levels of UV light at 254 nanometers, but the EFEP and THV demonstrate between 80 percent and 90 percent transmission of the UV source, which is slightly below the levels achieved by quartz.

Figure 1. UV Transparency of Fluoropolymers

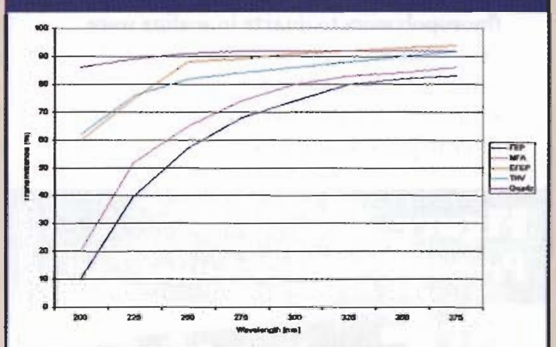


Figure 2. Comparison of Scaling in the Four Types of Fluoropolymers

Increased contact time makes up for the loss of transmittance to prove that fluoropolymers are a very good method of protecting the bulb, while allowing excellent bacterial reduction. The dose rate is calculated by multiplying the intensity of the bulb times the contact time multiplied by the transmission rate. An example would be a bulb with an intensity of 4 milliJoules per square centimeter (mJ/cm²) times a 20 second contact time multiplied by 70 percent would render a 56 mJ/cm² theoretical dosage rate. The increased contact time and turbulence caused by the coiled design allow very good reduction of bacteria.

A test was conducted on the MFA and FEP materials with favorable results being obtained for the reduction of coliforms and *E. coli*. This test was conducted to discover the efficacy of the tubing in UV light transmission. The intensity of the bulb was not measured for this test; only the bacterial reduction data was obtained. The initial tests were to observe bacterial reduction and justify further research. Without getting into a lot of detail as to how the tests were performed, there were significant reduction in bacteria, both in total plate counts (TPC) and also coliforms and *E. coli* recorded.

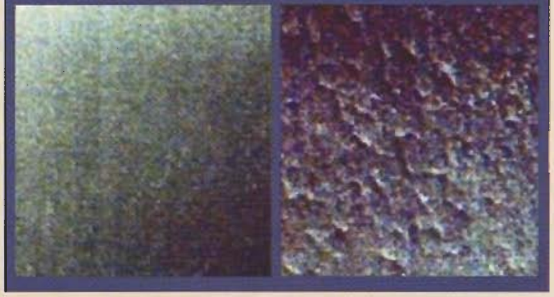
The first test used a prototype that contained a 9-inch bulb and then a second prototype using a 14-inch bulb. Both bulbs were 254-nanometers. The coiled tubing was used in the prototypes to protect the UV bulb from water while providing exposure of the water stream near the UV light. Water from a local lake was used, which tested positive for coliforms and *E. coli* and high bacterial counts. The qualitative test (a presence or absence test) was positive for both indicators of harmful bacteria. A quantitative test (numerical data recorded) was conducted to determine possible log reductions.

Several methods of testing were conducted that revealed very good results with filtration, UV light and coiled tubing to control bacteria. There was enough positive information gathered to warrant more research and development. With a three- to four-log reduction of coliforms, *E. coli*, and TPC, the coils proved very effective in bacterial reduction.

Now that the efficacy of the bacterial reduction had been examined, another issue of using coiled fluoropolymer tubes was to be analyzed, and that was the issue of scaling. UV light applications in most cases require the water to be pretreated to prevent excessive scale build-up caused by hard water minerals or iron. The test was conducted without pretreated water to compare scaling of four different types of fluoropolymers. MFA, EFEP, FEP and THV were used to manufacture the coiled tubes. The water was high in iron (5 ppm), tannins (4 ppm), chlorides (400 ppm), hardness (25 gpg), total dissolved solidas (TDS) (980 ppm) and alkalinity (280 ppm). The pH was tolerable at 7.4. More than 10,000 gallons of this putrid water was passed at 2 gpm through the tubes and each tube was equipped with a 14-inch, 254-nanometer UV bulb to create heat and simulate a working model.

The coils were examined and the materials compared to find out which fluoropolymers scaled the least. The MFA was the best material since it scaled the least; the EFEP was the worst. The other two, FEP and THV, were comparable in scaling. Figure 2 shows how the four compared and clearly reveals a drastic difference on how well the coils performed using different types of fluoropolymers. With proper pretreatment, these tubes would work very efficiently in UV bulb protection, while providing an excellent UV dosage rate to the water. The EFEP should have had less scaling, since it has a smooth surface very similar to that of MFA. (See Figure 3.) The resin supplier has revealed that a special grade of resin with a bonding enhancer was used in manufacturing the coil for the test. Standard grade resin will be obtained and the test will be repeated. Figure 3 also reveals the rougher texture of the FEP as a comparison to the MFA and EFEP materials used in manufacturing the coils. Efforts will continue to develop the optimum combination of qualities in coil design. A picture of the prototype can be viewed in Figure 4.

Figure 3. (Left) EFEP's Smooth Surface Similar to MFA's Texture; (Right) FEP's Rougher Texture



Comparatively Speaking

The results in comparing the coiled fluoropolymers to quartz in scaling were very similar. A quartz sleeve was tested using the same unfiltered water source. A standard UV light filter housing without a filter in place was used in this analysis and approximately 10,000 gallons of water were passed through the UV chamber. The quartz sleeve scaled very comparably to the coiled tubing. The sleeve was ruined, because it could not be cleaned and was left with a permanent orange hue. The sleeve was also difficult to remove and this reiterates the safety issue of the coiled tubing over the quartz sleeve, since the coiled tubing will not break or shatter.

Figure 4. Prototype of UV Coils

Information and Conclusions

When analyzing water treatment equipment and their components, a wide spectrum of water supplies could be used on such equipment and this variety of options must be considered in the analysis. Specifications must be set on the components so that a standard is shown for each component and they are accredited with NSF, the U.S. Environmental Protection Agency, Water Quality Association and other accrediting organizations.

Every water supply could have different results, and pretreatment generally is recommended with UV light systems to increase efficiency and reduce maintenance costs. In each application, the pretreated water provides a consistent source of feed so the UV system will operate optimally. The coiled tubes offer a great alternative to using quartz, and the jury is still out on many new applications. The availability, ease of use and cost effectiveness of the coils make this component for UV light transmission in water treatment a viable product for compact system design. The resistance of UV light exposure and ozone exposure that these fluoropolymers depict unveils many applications that will implement coiled tubing in water treatment system designs because of their versatility, cost and effectiveness. *WQP*

About the Author

Jeff Roseman is the owner of Aqua Ion Plus+ Technologies in La Porte, Ind. He has a background in chemistry and physics from studies in Electrical Engineering at Purdue University. The fluoropolymers discussed in this article are manufactured by Markel Corp., in Norristown, Pa.
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