using UV for dechlorination

For many years, chemical disinfection techniques have been used to provide microbiologically pure water for industrial and domestic use. Free chlorine, typically introduced by municipal water treatment plants in gaseous form, has been employed for many decades as a primary oxidizing agent for the control of microbiological growth. Free chlorine can also be introduced through the injection of sodium hypochlorite, chlorine dioxide and other chlorine compounds.

By Jon McClean

UV proves to be an effective dechlorination technique without drawbacks

When chlorine is injected into waters with naturally occurring humic acids, fulvic acids or other natural material, trihalomethane (THM) compounds are formed. Approximately 90% of the total THMs formed are chloroform, with the remaining 10% consisting of bromodichloromethane (CHCl2Br), dibromochloromethane (CHBr2Cl) and bromoform (CHBr3). Since THMs have been shown to be cancer-causing to laboratory animals in relatively low concentrations, there is concern about limiting their prevalence. The U.S. Environmental Protection Agency (EPA), for example, has set the maximum contaminant level in primary drinking water to 100 ppb.

Although chlorine is widely used in the industry, many processes cannot tolerate it because of contamination and unwanted chemical reactions. It can accelerate corrosion of process vessels and piping and cause damage to delicate process equipment such as reverse osmosis (RO) membranes and deionization resin units. It can also affect the taste and smell of liquids. It therefore must be removed once it has performed its disinfection function.

To date, the two most commonly used methods of chlorine removal have been granular activated carbon (GAC) filters and the addition of neutralizing chemicals such as sodium bisulfate. Both of these methods have their advantages, but they also have a number of significant drawbacks.

Granular activated carbon

Activated carbon is frequently used in industrial applications, such as beverage and pharmaceutical manufacturing, and in point-of-use (POU) units for residential and commercial applications. However, GAC filters, which are usually located upstream of the RO membranes, also can serve as an incubator of bacteria because of their porous structure and nutrient-rich environment. Additional problems encountered with the use of GAC filters are increased headloss, regeneration costs and unpredictable chlorine breakthrough.

Sodium metabisulfite

This is either purchased in solution or bought as a dry powder and then mixed on site. It is commonly injected in front of RO membranes used in the pharmaceutical and semiconductor industries. One common problem with this approach is that the solution itself becomes an incubator of bacteria, causing biofouling of the membranes. It is also another chemical that has to be documented in use, handling and storage for regulators such as environmental protection or health and safety agencies. Additional problems encountered with the use of sodium metabisulphite are:

- Maintenance of dosing equipment;
- Handling of hazardous material;
- Scaling of RO membranes;
- Potential formation of sodium sulfate, which acts a stimulant to sulfate-reducing bacteria; and
- Odor and taste implications.

The UV alternative

An increasingly popular dechlorination technology—with none of the above drawbacks—is ultraviolet (UV) treatment. High intensity, broad-spectrum UV systems (also known as medium-pressure UV) reduce both free chlorine and combined chlorine compounds (chloramines) into easily removed byproducts.

Between the wavelengths 180 and 400 nm, UV light produces photochemical reactions that dissociate free chlorine to form hydrochloric acid. The peak wavelengths for dissociation of free chlorine range from 180 to 200 nm, while the peak wavelengths for dissociation of chloramines (mono-, di- and tri-chloramine) range from 245 to 365 nm. Figure 1 shows the UV output of a high intensity Hanovia medium pressure UV lamp. Up to 5 ppm of chloramines can be successfully destroyed in a single pass through a UV reactor, and up to 15 ppm of free chlorine can be removed.

Many water treatment systems include RO units, which commonly use thin-film composite membranes because of their greater efficiency. However, these membranes cannot tolerate much chlorine, so locating the UV unit upstream of the RO can effectively dechlorinate the water, eliminating or greatly reducing the need for neutralizing chemicals or GAC filters.

The UV dosage required for dechlorination depends on total chlorine level, ratio of free versus combined chlorine, background level of organics and target reduction concentrations. The usual dose for removal of free chlorine is 15 to 30 times higher than the normal disinfection dose. Therefore, membranes stay cleaner longer because the dose for dechlorination is so much higher than the normal dose used if dechlorination was not the goal. Additional benefits of using UV dechlorination are:

- High levels of UV disinfection;
- TOC destruction;
- Elimination of the safety hazards associated with mixing bisulphate;
- Elimination of risk of introducing microorganisms into RO (via GAC or injection of neutralizing chemicals); and
- Overall improved water quality at point of use.

As with other dechlorination technologies, the UV dosage required at a given flow rate is dependent on several process parameters, including:

- Process water transmittance level.
- Background organics level, and
- Influent chlorine level and target effluent chlorine concentration level.

UV applications

Successful UV dechlorination applications range from pharmaceutical, food and beverage processing to semiconductor fabrication and power generation. In all of these industries, dissatisfaction with conventional dechlorination methods has encouraged the development of alternative methods. The following are examples of some applications in which high intensity, broad-spectrum output (medium-pressure) UV has been successfully used for dechlorination:

Pharmaceutical industry. A Hanovia UV dechlorination unit was installed at a Procter & Gamble manufacturing plant in Georgia. The unit was installed before two banks of RO membranes; prior to this, dechlorination was achieved using sodium bisulphate. Trials that ran soon after the UV system's installation showed a dramatic reduction in the RO membrane wash frequency—down from an average of eight cleanings per month to only two per month. This amounted to an annual savings of $70,000. The number of shutdowns for RO membrane maintenance has also been significantly reduced.

Brewing industry. A mid-sized U.S. brewery uses well water from a municipal source for plant makeup water. The municipality was forced to begin chlorinating this water due to federal regulation. Unfortunately, the chlorination altered the taste of the product.

The brewery chose to use carbon to remove the free chlorine, but high capital costs, increased maintenance expenses and difficulty sanitizing and cleaning the carbon discouraged the brewers. The chlorine levels were up to 1 ppm, but after a trial period using UV for dechlorination, the brewery reported results of 0.04 ppm to 0.01 ppm. The company therefore elected to eliminate carbon entirely and use UV dechlorination instead.

Many breweries, soft drink manufacturers and other processors also use UV for general disinfection of product makeup and process water. UV kills all known spoilage microorganisms including bacteria, viruses, yeasts and molds (and their spores), and it has many advantages over alternative methods. Unlike chemical biocides, UV does not introduce toxins or residue into process water and does not alter the chemical composition, taste, odor or pH of the fluid being disinfected.

One example is the Shepherd Neame brewery in the U.K., one of the oldest in the country. It uses a UV system to treat water drawn from a private well and used for deoxygenated beer cutting. The water passes through the UV treatment chamber before entering a storage tank. From there, it passes through a series of sterile filters before use. In addition to treating cutting water, the UV system also disinfects water used for bottle rinsing.

As can be seen from the above examples, the potential applications for high intensity, medium-pressure UV for dechlorination and disinfection cover a wide variety of industries and processes. UV dechlorination offers real opportunities for those willing to invest in this innovative technology. WWD

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