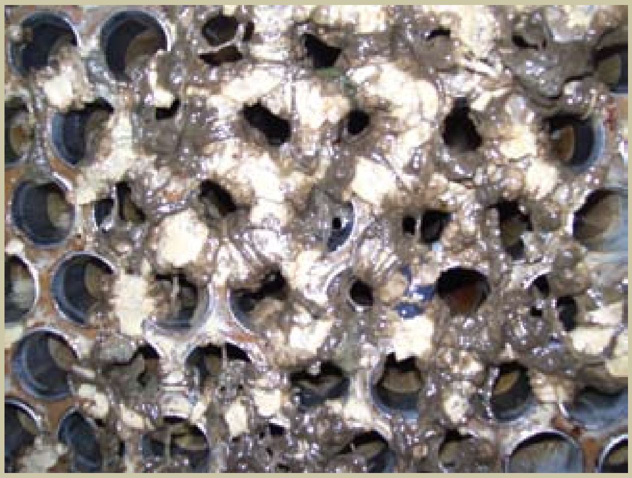
Biofilm Control

A Simple, Powerful Disinfectant

By Beth Kennedy



A main condenser tube sheet after extended run in a NIPSCO power plant before cleaning, after non-MIOX treatment.

A main condenser tube sheet after extended run in a NIPSCO power plant before cleaning, after 2.5 months of MIOX treatment.

Effectively controlling tough biofilms

Industrial fluid processing operations can face a number of serious problems due to bacterial biofilms. Biofilm-induced corrosion, mechanical blockages and impedance of heat transfer processes result in huge monetary losses each year. In engineered systems, additional risks of biofilm-mediated contamination include negative public health consequences and product spoilage. This article addresses aspects of biofilm control strategies for industrial processes and introduces a promising disinfectant.

Overview of Biofilms

Biofilms are aggregates of predominately bacterial cells attached to and growing on a surface.[1] These biofilms are found in aqueous environments and often are resistant to disinfection. A biofilm forms when bacteria begin to excrete a slimy, sticky substance that allows them to adhere to surfaces. An additional structural feature called the extracellular polymeric substance (EPS) is thought to provide the biofilm with increased resistance to antimicrobial agents and biocides. Within a given contaminated system, the biofilm mass often varies with location, and is typically composed of many species of microorganisms, including bacteria, fungi, algae and protozoa. Once initial adhesion occurs, biofilm is difficult to remove.[2]

Even small numbers of surviving organisms can regrow, introducing the risk of a product recall due to negative health outcomes. Biofilms also can shelter disease-causing microorganisms, such as *Legionella*, *Listeria* and temperature-resistant bacterial spores, which normally are inactivated readily in their planktonic, or single-cell, form.

Industries that must control bacterial populations (including water and wastewater distribution systems, cooling towers, swimming pools and remote areas where access to operations is difficult) would benefit greatly from a safe, user-friendly and viable method for controlling biofilms. Improved biofilm control technologies also could decrease costs by minimizing system sizing or the use of high-temperature or high-energy processing steps.

Strategies for Biofilm Removal

There are many strategies and chemical regimens for controlling biofilms. Flooded clean-in-place systems are used in many processing facilities. Flooded systems involve completely filling all the pipes exposed to product with water, chlorine, biocide, caustic or other chemical for a prescribed amount of time according to application protocol.[3] Other applications use continuous biocide injection procedures to prevent biofilm growth.

A Novel Biofilm Solution

Many biocide treatment regimes exist, including a multitude of combinations of cleaning (hot caustic, such as sodium hydroxide) and disinfection chemicals (quats, chlorine or proprietary biocides). An alternative to these variable regimes is MIOX's Mixed Oxidant Solution (MOS). MOS is a simple, cost-effective cleaning and disinfection solution that has the potential to also provide enhancements to biofilm control strategies. MOS, a proprietary blend of hypochlorite and other oxidants, has been generated on site by MIOX Corp. since 1994 through the use of salt, water and an electrolytic cell. The chlorine-based product of electrolysis has clearly exhibited the ability to remove biofilm, unlike traditional chlorination technologies. Third-party research, visual documentation from municipal and industrial operators and a number of improvements in water quality that are understood to result from removal of biofilms provide evidence for the biofilm control ability of MOS.

Application: Hot Springs and Swimming Pool Facilities

Hot springs are popular in several cultures. However, a number of sites suffer from positive coliform counts and biofouling because the warm aqueous environment provides an ideal breeding ground for bacteria.

At one facility in 2002, dosing at 1.5 mg/L of free available chlorine with sodium hypochlorite barely maintained a 0.2 mg/L residual. Coliforms and *Legionella* were frequently detected. After establishing a baseline borescope camera image, the interior of the pipes was videotaped at six and 22 days after treatment with MOS began. Upon conversion, sloughing was immediately apparent. In the feedwater pipe, substantial removal was evident after six days, and after 22 days, biofilm removal appears to be complete. Bacterial monitoring and residual chlorine measurement provide quantitative data to complement the compelling boroscope images. The chlorine dosage was reduced by 60% to only 0.6 mg/L after conversion to MOS and removal of biofilm, while the residual more than doubled to 0.4 mg/L. Coliforms and *Legionella* were not detected.[4]

Application: KOA Kampground

Biofilm removal by MOS was initially observed in New Mexico in 1995, and later reported by Montana State University during a field study conducted at a KOA Kampground in Great Falls, Mont.[5] The campsite has a small potable water supply, as well as showers and a swimming pool.

The site previously used powdered sodium hypochlorite and experienced frequent positive coliform hits, even with free chlorine slug dosage levels as high as 1,000 parts per million. The positive counts in the presence of free chlorine were indicative of biofilm contamination, also evidenced by a black biofilm slime in the showers.

Whenever a power outage occurred, the distribution system contained accumulated biofouling that required flushing from the system. Because of the heavy accumulation of biofilm, the existing cartridge filters required cleaning every two to three days.

As a potential solution, MIOX installed an MOS generator at the site to replace the hypochlorite. The KOA Kampground has not experienced a non-compliance coliform event since conversion to MOS. The black slime in the showers disappeared within a few weeks. Initially, biofilm visibly sloughed from the pipelines. The water eventually ran clear, indicating the system had reached a stabilization point.

The filters now are cleaned every three to four weeks, according to camp operators, rather than every few days. Whenever power outages occur, no discoloration of the water occurs, indicating that the biofilm does not regrow, even when disinfection is temporarily interrupted. The MOS system was responsible for elimination of biofouling at the campground, ultimately resulting in safer drinking water with no bacterial contamination, ease of maintenance with no flushing required and greatly extended filter runs.

One hypothesis for the consistently better biofilm control exhibited by MOS as compared to hypochlorite is that MOS removes more of the polysaccharide attachment matrix constituting the framework that protects biofilms and allows them to thrive. Research supporting this hypothesis was conducted at the Orange County Water District in California. Researchers performed several studies comparing hypochlorite and MOS efficacy at controlling *Psuedomonas putida* biofilms on cellulose acetate RO membranes.[6] Based on several lines of analysis, including microbe staining and microcopy techniques that indicate areas where DNA is present, researchers reported that MOS appeared to remove the polysaccharide biofilm substrate, while chlorine had less effect at the same dose and exposure times.

Conclusions

MIOX Corp. has amassed a large body of laboratory and field data indicating that MOS can provide both cleaning and disinfecting properties, excellent features for an ideal biofilm control strategy in industrial processes. More research is needed to understand how best to optimize process cleaning, especially in applications where soils and ideal biofilm growth conditions exist.

MIOX is building a laboratory-scale flow-reactor system capable of testing several chemical and biological parameters. These types of bench-top flow systems have been previously described in academic literature.[7]

The flow-reactor system is designed to test a variety of applications and conditions, including a coupon system and a method to add and remove pipe sections so that different pipe materials can be tested for biofilm growth and control. This system also can be used to further examine the issue of chemical corrosion, complementing nearly two years of research already conducted on the issue. The CIP system will be upgraded as needed and will provide an excellent test bed for comparative studies. *wqp*

References:

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