Essential expertise for improving chlorine biocontrol performance.

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Batteling Biofilm in Cooling systems using DiMethylHydantoin (DMH)

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Biofilms are extremely complex ecosystems that provide excellent protection for the microorganisms within. This often makes them difficult to kill, even with chlorine. Basic understanding of biofilm ecosystems and their behavior to chlorine and other oxidizing biocides can offer valuable insight into achieving better microbial control.

Biofilm control is critical to the efficient operation of cooling towers and to certain manufacturing processes such papermaking. In cooling towers, biofilms can block free water flow, significantly reduce water quality and prompt operational issues such as increased corrosion and decreased heat transfer efficiency. Uncontrolled biofilm formation in papermaking machines can lead to a variety of mechanical issues as well as problems with the finished product. In addition, disease-causing microorganisms such as *Legionella* often find a safe haven in biofilms, posing a public health risk.

A broad range of microorganisms can be found in biofilm. The primary groups found in cooling towers, for example, are algae, fungi and bacteria. Not only are cooling towers pulling in tons of air to get evaporative cooling of the water, they are also essentially scrubbing the air. The microorganisms in the air along with all the pollen, debris and other suspended solids are now in the water where they can thrive and multiply."

Biofilms can produce rapidly in cooling water systems. Areas of slow water flow and stagnation encourage biofilm formation, especially on condensers and on cooling surfaces of recirculating systems, and in the wet end of papermaking machines.

Chlorine has long been the mainstay in the industry for biological control in cooling towers and "slime" control in papermaking processes. This wide adoption of its use is due primarily to its broad spectrum of activity, fast kill rates, and low cost. With any biocide, however, biofilm control poses a big challenge.

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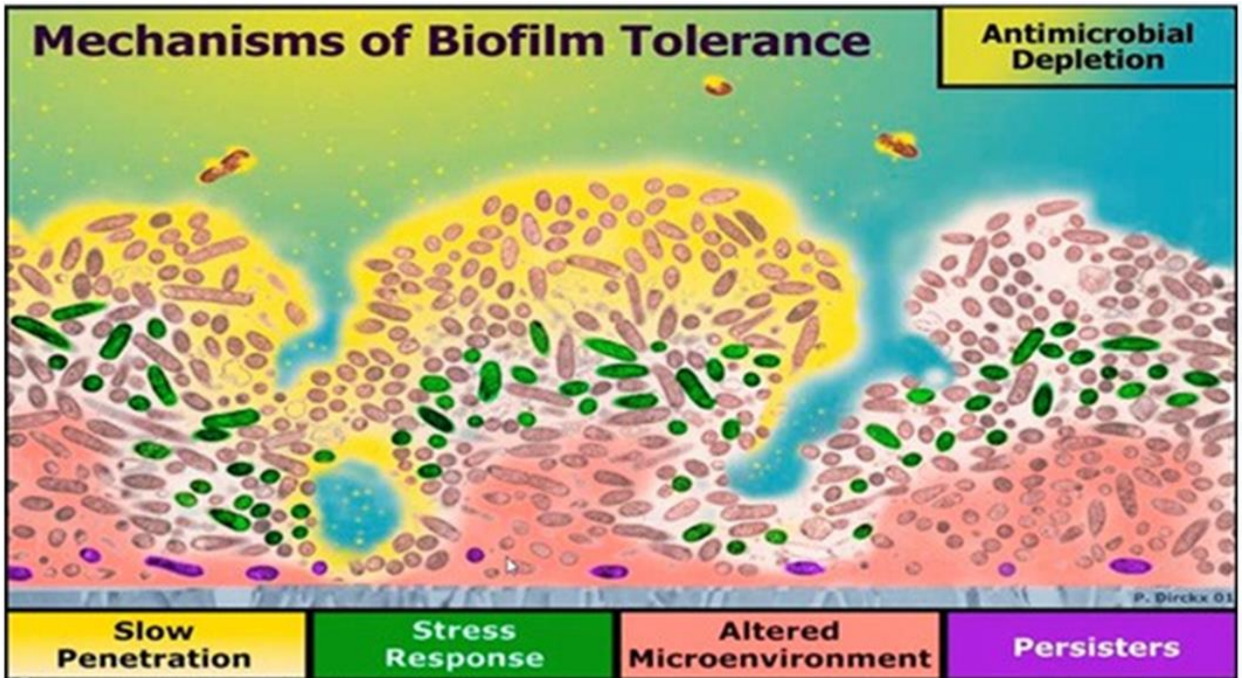

The Biofilm Ecosystem

The basic complexity of biofilm is illustrated in this figure.

If uncontrolled, free-floating (planktonic) mircroorganisms come together to become a sessile aggregate that adheres to surfaces and then forms biofilm to protect the organisms.

Slow Biocide Penetration. The top layer of biofilm makes it difficult for the biocides to migrate through to their targets. Because biofilms are very viscous, it takes more time for the biocide to get through it, often depleting the oxidant before it can do much damage to it."

Stress Response. Because it often takes chlorine too much time to penetrate the biofilm, the resident microorganisms have a chance to be alerted and develop a stress response. These organisms are amazingly adaptable. They can lower their metabolism, making them more resistant to biocides, or they can express different genes or do a number of other things to exhibit stress responses that allow them to endure the more harsh condition brought by an approaching biocide."

Altered Microenvironment. Although there is plenty of oxygen in the upper reaches of biofilm, there is typically anaerobic activity at deeper levels. Often, an entirely different chemistry presents with those organisms at the bottom depths of the biofilm. An antimicrobial agent must be able to work in these anaerobic zones as well as the aerobic zones of the biofilm.

Peristers. Persisters form spores and these are like little escape capsules for a few lucky microorganisms. When their biofilm environment is destroyed, persisters go off and recolonize somewhere inside the system that is morefriendly to their existence. These little tough guys cansurvive just about anything."

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Biofilm Risks & Control

From public health perspective, the biggest organism to be concerned with is *Legionella.*"*Legionella* is a bacteria that is out in the environment – it's in our rivers, in our streams and lakes -- and it can easily get into a cooling tower. Once there, it can attach to a surface, quickly grow in population and form a biofilm, presenting a health risk. From an operational standpoint, once enough of these surface organisms collect and grow a slime layer, a cooling tower is not going to have good heat exchange, thereby reducing energy transfer" she says. Biofilms also create a blocking of the various channels within the towers, inhibiting water flow, causing further serious issues from biofouling. Also, if left uncontrolled, algae can produce dense mats that can slough off and cause physical damage to a cooling tower.

Biofilms can contain iron-depositing and sulfite-reducing bacteria that can destroy steel. Biofilms are the primary cause of microbiological corrosion and their presence also increases the risk of scale formation.

In papermaking, wet-end biofilm (slime) control is a key element in a mill's effort to optimize efficiencies and maintain quality control. The results of poor slime control include deposits, corrosion, sheet defects, increased downtime, and rejected end product.

The key to biofilm control is for chlorine, or other biocides, to remain active in the water long enough to break down this highly viscous film and kill the microorganisms that are being protected by it.

Many studies of the effect of chlorine on biofilm have been performed. It was found that often hundreds of parts per million of chlorine are needed to destroy biofilm.
By comparison, most cooling towers have no more than a couple of ppm chlorine residual in the water runningthrough the system.

Gaining a "Chemical Equilibrium"

One method that has shown to greatly enhance biofilm control is the addition of the chlorine stabilizer DMH (DiMethylHydantoine).

15% 5,5-dimethylhydantoin (DMH) solution, is an innovative liquid stabilizer possible to use in cooling water systems. It binds to the chlorine to create a chemical equilibrium. This approach is already used successfully for decades in the pulp and paper industry.

The reactivity of chlorine is continually switching on and off by the chemical equilibrium produced when chlorine is blended with DMH. This slows down chlorine's reactivity to allows it to get through the biofilm's initial barrier so it can do its job of killing the organisms deeper in the bio-mass.
Laboratory studies with sessile microorganisms treated with a 5ppm and 10ppm of bleach provided 67% and 72% control. In the study, 5ppm chlorine blended with DMH stabilizer provided 97% microbial film control.

Flexible Blending

Before organisms can form a biofilm, they're going to first float around, be planktonic. If you can kill them at this stage, before they can colonize and form biofilm, that would be the number one thing to do. Also you want to kill those little guys in theirescape capsules coming off other biofilm.

Unstabilized or less stabilized chlorine is more efficacious against most planktonic microorganisms, due to the chemical's high reactivity. DMH stabilized chlorine is significantly more effective against sessile microorganisms within biofilm, due to the chemical equilibrium produced by the blended solution. The key strategy is to base bleach-to-stabilizer ratios on current system conditions.

Bleach is mixed with DMH solution at different ratios, depending upon what's happening within the system. If the system has a low halogen demand, a minimum ratio of 5:1 bleach-to-stabilizer is used. If there's high demand, a ratio closer to a 2:1 is needed, to prevent antimicrobial depletion within the system and allow for better biofilm penetration. The ability to adjust blending ratios based on current systemconditions provides new ammunition and greaterflexibility in today's challenging battle of biofilm control and prevention.

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