AWS GROUP
Safer Sanitation, Better Solutions

Blog Series: Biofilm Part 1

INTRODUCTION TO UNDERSTANDING BIOFILMS

"Biofilms are layers of different types of pathogens including bacteria and fungi that attach to all type of surfaces"

They can form on solid or liquid surfaces as well on soft tissue in living organisms and are typically resistant to conventional methods of disinfections.
They are predominantly made up of pathogenic cells encased in an extracellular polymeric (EPS) matrix which they produce. The EPS is responsible for the cohesion and adhesion (to surfaces) of the biofilm and is composed mainly of polysaccharides and proteins.
Biofilms are common in nature and their formation is a strategy that pathogens use in order to survive in hostile environments. They start to develop when bacteria or other microorganisms attach to a surface. As well as encasing the pathogens the polymers produced by the microbial cells play a role in the adhesion process, by creating a "polymer bridge" between the cells and the molecules adsorbed at the surface.

Many factors affect the formation and properties of biofilms including characteristics of the microbial species and strains, composition and roughness of the surface where the microorganisms attach, the liquid composition (its pH & temperature) and the ionic strength of the fluid.

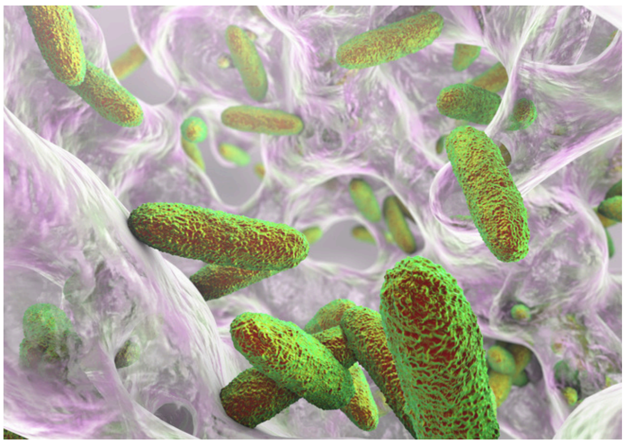
Although biofilms play crucial roles in many processes (like the biodegradation of environmental pollutants or the microbial balances within a body) they are often unwanted and cause serious problems in various areas, including the industrial, food processing and medical fields. These problems lead to an increase in the costs of production and maintenance, as well as to public health and the environment. This leads to an increased use of antimicrobial chemicals, such as biocides, to remove and also control the formation of biofilms.

Strategies for biofilm control:

In industry, cleaning and disinfection are essential parts of GMP and the efficiency with which these operations are performed will greatly affect final product quality. Most cleaning procedures include removal of loose soil and dirt with cold or warm water followed by the application of cleaning agents, rinsing, and a disinfection/sanitising application followed by a final rinse.
The cleaning agents suspend and dissolve contaminant residues by decreasing surface tension, emulsifying fats, and denaturing protein. Many situations require the occasional use of acid cleaners to clean surfaces soiled with precipitated minerals or having high mineral content.

Mechanical action (water turbulence and scrubbing) is recognized as being highly effective in eliminating biofilms but hot water can also minimise this requirement. An effective cleaning procedure must break up or dissolve the extracellular EPS matrix associated with the biofilm so that disinfectants can gain access to the pathogens inside the biofilm.

The cleaning process can remove 90% or more of pathogens from a surface but won't necessarily kill them. They can resettle at other spots and given time, water and nutrients form another biofilm. As a result, disinfection must be used after the cleaning process to destroy the remaining pathogens.



Pictured above: Stock imagery of magnified biofilm

The aim of this step is to reduce the surface population of viable cells after cleaning and prevent pathogenic regrowth on surfaces before production restarts.

Disinfectants are also less effective if organic material (fat, carbohydrates, and protein-based materials) remain on the surface after the cleaning stage.
pH, temperature, water hardness, chemical inhibitors, concentration and contact time also impact on the efficacy of disinfectants which must be effective, safe and easy to use. They must also be easily rinsed off and leave no toxic residues.

At this point we need to differentiate between disinfectants, biocides and sanitisers as there is lot of confusion surrounding there meaning and usage.

- Biocide is a general term describing a chemical that deactivates microorganisms. It is also used to describe disinfectants and antiseptics that are used in the medical field on living tissue (hand sanitisers etc.)
- Disinfectants are chemical agents that kill a wide range of pathogens on surfaces and objects. These pathogens include viruses, fungi and bacteria.
- Sanitisers are chemicals that reduce the number of pathogens on a surface to meet minimum requirements for human safety. They are used mainly for bacteria but also work on certain types of viruses.

How they Work

Regardless of the type, all of the above undergo a series of steps in their actions on pathogens. Uptake by the cell, finding the target in the cell, concentrating around it and finally acting.

The way these chemicals work on pathogens can be divided into four main categories:

- Oxidation - where they act by eliciting the oxidation of organic material within the cell walls.
- Electrophilic -where they react covalently with cellular nucleophiles inactivating some enzymes.
- Acidic -where weak acids interfere with the cells membrane ability to maintain the pH balance leading to the failure of the cell wall.
- Cationic – where membrane active biocides rupture the cell resulting in loss of the cells internal fluids (lysis)

The following are some of the common chemicals used as disinfectants and sanitisers:
chlorine, chlorine dioxide, peracetic acid, quaternary ammonium compounds (cationic surfactants), amphoteric surfactants, polymeric biguanides, hydrogen peroxide.

Pathogenic Resistance to Biocides

Biofilm resistance to biocides is increasing, becoming a serious problem in the food and medical fields. Resistant bacteria are difficult to eradicate or even treat and this has huge economic and environmental implications.
In medicine, resistant bacteria are becoming frequent in hospitals and other healthcare institutions which can have serious consequences in patients. The extent of resistant bacteria in other areas can have adverse implications in processes like cooling water systems, drinking-water distribution and food processing.

Some explanations for bacterial resistance include:

- The limited penetration of antimicrobial compounds due to the presence of the EPS matrix.
- The imposition of nutrient deficiency in deeper biofilm bacteria.
- The transformation of the antimicrobial products into a non-toxic form by enzymes localized in the biofilm matrix.
- Pathogens becoming resistant to antimicrobials by spontaneous mutation or by acquiring the genetic information for resistance from other pathogens.

Over the coming weeks we will look in more detail at:

- **Detection and control of biofilms**
- **The various pathogens common in food and medical biofilms**
- **New types of biocides being developed and tested for biofilm control.**
- **The most efficient way to use common biocides**

To discuss your particular situation, please contact us info@awsgroup.co.nz

Written by: Don MacDonald, AWS Group Technical Manger

Pictured above: Stock imagery of industrial cleaning