Innovation In The Prevention And Elimination Of Biofilm In Food Processing Plants

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Presented By: Adel Makdesi
Corporate Senior Microbiologist
BIOFILM
What Is A Biofilm?

- Biofilm is a natural habitat for microorganisms
- A biological structure formed by microorganisms
- It consists of populations of microorganisms, proteins, fats, sugars (carbohydrates), byproducts, acids, mineral scales and polysaccharides, etc.
- Can be formed within 8 – 24 hours
- Biofilm development is most rapid in flowing and wet systems where adequate nutrients and water are available
- Biofilm can break to release millions of microorganisms into the surrounding environment
Common Places For Biofilm In Food Plant Environment

- Potable water distribution systems
- Extended piping and **dead ends/legs**
- Product transfer piping and holding tanks
- Rubber gaskets in CIP system's at pipes connection points
- Cooling towers and heat exchange
Common Places For Biofilm In Food Plant Environment (Continued)

- Rough wet floor
- Cooling units drip pans and their draining pipes
- Underside of processing equipment
- Floor Drains
- Conveyor belts
- Water holding tanks
1. Bacteria, such as *Salmonella* and *Listeria*, can be transferred to the surfaces by different means (from raw products, hands, environment or floor drains to equipment surfaces, walls and floors, etc.)
2. Once on a surface with no nutrients, this triggers the bacteria to make chemical signals using (AHL’s) chemicals.
   • (AHL’s) are then used to tell other bacteria that:
     - That they are in the area
     - Help them detect other bacteria in the area
     - We are starving and we must respond
   • **Quorum Sensing** - Once the concentration of signals has reached a critical density ("the Quorum), the bacteria are able to coordinate their behavior
   • When this **critical population density** has been reached certain genes are activated that lead to the formation of biofilms
3. Coordinated bacteria begin producing a slimy material called EPS (Extracellular Polymeric Substances) polysaccharides (complex sugar) to form the “matrix”:

- Attach themselves to the surface
- Helps bind their cells together, to the surface, and to other particulate materials
- To protect themselves from grazers and harsh environment
In early stages, a biofilm is comprised of a microbial cell layer attached to a surface.

As microbial cells grow and divide, they form a dense mat that is numerous layers thick.

**Biofilm can be very thin (invisible) to few inches thick.**

During this process bacteria capture nutrients (protein, carbohydrates, minerals, etc.) from the surrounding environment.
Biofilm structure is connected by organized channels that deliver food, oxygen and remove waste.

The biofilm matrix produced by microorganisms in a biofilm are chemical resistant.

Microorganisms in a biofilm are highly resistance to detergents, sanitizers and antibiotics.
Two types of microorganisms in a biofilm based on their position in a biofilm:

a. **Planktonic**: floating on the surface of the biofilm (easy to kill)

b. **Sessile**: embedded in the matrix, anchored to the surface by polymeric sugars or polysaccharides (difficult to reach and kill)

Control of planktonic organisms does not necessarily mean control of biofilm (false sense of security)
Why Is It Dangerous To Have Biofilms in Food Plants?

- Biofilm can contain pathogenic microorganisms (*Listeria, Salmonella, E. coli*, etc.)
- It can break down and release bacteria and contaminate processing equipment and food products
- It can move from point A to point B and contaminate food and surfaces
- It contains chemical resistant microorganisms that are more difficult to kill than regular microorganisms
- Biofilms can contentiously shed and release microorganisms into food processing environment
Bacterial Biofilm Can Move — And Therefore Contaminate Food Products

- Biofilm in a food environment can spread and travel and contaminate food, and cause food-borne illnesses and shorten food products shelf-life.
Biofilms forming on food-contact surfaces can lead to hygienic problems and economical losses due to food spoilage

• Biofilm invisibility and therefore lack of detection have always left food processors uncertain over its presence or absence

• Indication of its presence - sudden increase in microbial count

• When in doubt, testing and sampling is needed
  ➢ Sampling is very difficult because Biofilms adhere to surfaces very tightly
  ➢ Scraping or high pressure swabbing techniques are recommended
Conventional cleaners and disinfectants have **limited effectiveness** against biofilm.

Daily thorough cleaning and sanitizing is required.

A. **Biofilm on vertical and open flat surfaces are removed using**

   - Chlorinated alkaline cleaners are preferred – hydrolyze proteins and dissolve organic acids in the biofilms.
   - Acid cleaners remove scales to prevent biofilm’s bacteria form clinging on the surfaces.

If detected on the surfaces, **manual scrubbing** (scrubbing pads and brushes) with soap is required

   - **Time and labor consuming**
   - Miss spots
   - Difficult to access areas – very common
B. Biofilm removal in CIP systems:

• Requires strong oxidizing agents to penetrate and remove the chemical-resistant polysaccharide matrix.

• Long circulation time (5 – 8 hrs) with one of the following oxidizing sanitizers is required after regular cleaning with an alkaline detergent
  - Chlorine/bleach/sodium hypochlorite
  - Chlorine dioxide
  - Peroxyacetic acid (peroxyacetic acid)/ Hydrogen peroxide

• Most effective alternative for all surfaces is the PerQuat Technology products (Zep’s FilmPurge)
• Concentrated, easy to use 2-part products:
  – **Part 1 product - (FilmPurge Solution #I):**
    - Contains both active ingredients:
      - Quaternary Ammonium Chloride
      - Hydrogen Peroxide
  – **Part 2 product - (FilmPurge Solution #II):**
    - Source of alkalinity

• A powerful combination chemistry developed by pairing the negatively charged Perhydroxide ion with a positively charged Quaternary Ammonium compound

• The two molecules form an intimate ion pair resulting in “PerQuat”, a Hydrogen Peroxide and Quat hybrid with unique cleaning and antimicrobial efficacy
How Does PerQuat Chemistry Work?

• It hydrolyzes, oxidizes and solubilizes biofilm polymer matrix
• It attacks biofilm matrix and the adhesions that glues biofilm to the surfaces
• Then the biofilm collapses and breaks down resulting in it’s complete removal from the surface
• Therefore, no manual scrubbing is needed when using this chemistry
• Also, it possesses multiple antimicrobial mechanisms (synergistic antimicrobial effect)
Step 1
Attack and bombard the biofilm matrix

Step 2
Penetrate the outer layer and dissolve into the matrix

Step 3
Destroy and eliminate the biofilm matrix by a unique combination of hydrolysis, oxidation, and solubilization
Comparison - Biofilm Treatment with Different Disinfectants (Microscopic Images)

Other products do not effectively remove biofilm

Before Bleach

Before Quat

Before Glutaraldehyde

After Bleach

After Quat

After Glutaraldehyde
Surface Before and After FilmPurge Use (Microscopic Image)

Surface prior to FilmPurge Treatment

Surface after FilmPurge Treatment
• It can be used to clean surfaces, such as:
  - Walls
  - Drains
  - Floors
  - Food and beverage processing equipment
  - Industrial equipment
  - Pesticide equipment
  - Sewage equipment
  - Farm production equipment
  - Hatchery equipment
  - Anywhere organic microbial films may be present
FilmPurge Markets

• Food and beverage processing plants
  ➢ Meat (all stages)
  ➢ Poultry
  ➢ Dairy
  ➢ Wine
  ➢ Beer
  ➢ Beverage (fruit, soft drinks)
• Food service restaurants and supermarkets
• Dairy farms
• Egg washing, grading, breaking facilities
• Hatcheries
1. **Foam application** on equipment, walls, floors – no need for manual scrubbing

2. **COP tank** (soaking) – soak up to 1 hour

3. **CIP System** (circulation) - low foaming version - 30 – 60 min

4. **Drain program** - foam or pour into drains - (20 – 30 min)
• **Equipment, environmental surfaces Programs:**
  
a. Shocking treatment (microbial problem or heavy soil):
    - Foam surfaces with FilmPurge (12 oz./gal)
    - Repeat treatment daily until problem disappears

b. Maintenance program (light soil accumulation):
    - Foam surfaces with FilmPurge weekly (6 – 10 oz./gal)

• **Food contact surfaces must be rinsed with potable water before reuse**

• FilmPurge can be safely flushed into sanitary waste systems
• **Floor Drain Programs:**
  a. **Shocking treatment (microbial problem or heavy soil):**
     - Foam drains with FilmPurge (12 oz./gal)
     - Repeat treatment daily until problem disappears
  b. **Maintenance program (Light soil accumulation):**
     - Foam surfaces with FilmPurge weekly or twice a week (6 – 10 oz./gal)
• Foam each drain for 20 – 30 sec vs. 15 min for traditional cleaners (time and labor saving)
• Let foam sit for 20 – 30 min before rinsing
• Use any existing foaming equipment
• Special foaming attachment for drains are required
FilmPurge Foam Treatment in Drains and Trunk Line

- Drain
- Slime/Biofilm
- Foam Attachment
- FilmPurge Foam (360° coverage)
- Drain Trunk Line
- Waste Water
FilmPurge vs. Liquid Sanitizer in Drain Trunk Line

Foam Cleaning with FilmPurge
(Covers full pipe interior surface at 360°)

Liquid sanitizer
(covers only bottom portion of pipe interior surface)
FilmPurge vs. Traditional Products

- **Liquids cleaners and sanitizers:**
  - Do not penetrate and remove biofilm and its sessile microbes
  - Require scrubbing
  - Do not provide full coverage of surfaces and drain trunk line surfaces (upper part of the trunk line)
  - Can upset WWTP (Waste Water Treatment Plant), such as quat sanitizers

- **Sanitizer rings (for drains):**
  - Do not penetrate and remove biofilm and its sessile microbes
  - Can be expensive
  - Do not provide full coverage of drain trunk line surfaces at 360 degrees
  - Kills microbes in the draining water, not inside the biofilm
Benefits of Using PerQuat Technology/FilmPurge

- Removes stubborn organic buildup/biofilm from surfaces and destroys and controls their microorganisms
- Foam application provides:
  - Visual confirmation of treated areas – ensures complete coverage & removal of biofilm
  - Extended contact time with the surfaces - necessary to effectively remove biofilm
- Eliminates the need for manual scrubbing (save time and labor)
- Ideal for treating difficult-to-reach areas
- Eliminates spikes in microbial counts
- Extend food products shelf life
- Eliminates fruit flies in the drains
- Easy and quick (20 – 30 sec/drain) foam application into the drains and trunk lines
- Provides full coverage of the entire trunk line at 360°
Recommended Foaming Units

- 5 Gal. Portable Foamer
- 2 Gal. Pump-Up Foamer
- 10 Gal. Battery Foamer
- 25 Gal. Portable Foamer
- 15-Gal. Rolling Foamer
Recommended Drain Foaming Attachments

Drain Foam Assembly

Drain Foam Attachment 7”

Drain Foam Attachment 12”

Black Drain Foam Plunger
Titration Kit
For more information about this technology and for assistance with all your sanitation needs, please contact **Blaine Morton – Director of Sales Food Division** at 404-824-4961, or at **blaine.morton@zep.com**

You can also visit our website at **www.zepfooddivision.com**