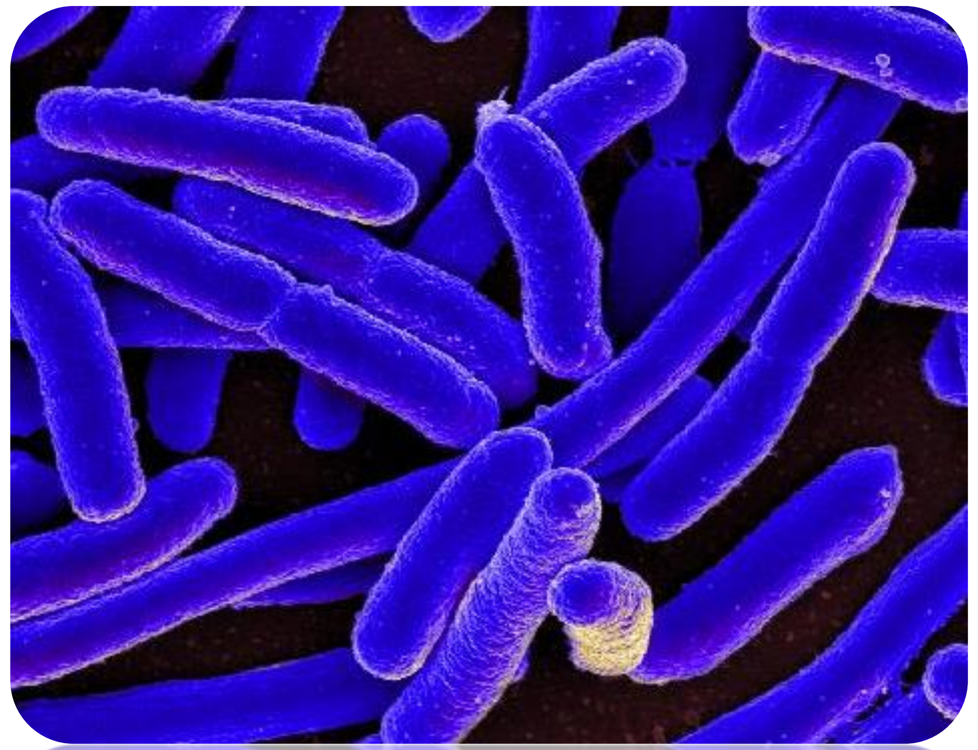
MICROBES AND BIOCIDES OVERVIEW

WHAT ARE THE DIFFERENT TYPES OF MICROBES?

VIRUS

0.2 microns



BACTERIUM

8 microns

FUNGUS/YEAST/ MOLD

12 microns

ALGAE

30 microns

PROTOZOAN

150 microns

WHAT DO MICROBES NEED TO SURVIVE AND GROW?

1

Water

The water content of most water based industrial products is sufficient to support microbial life, however some highly concentrated formulations may be self preserving. Broadly speaking a high percentage of water in an industrial product favors bacteria, whereas fungi are able to thrive even in environments with very little free water.

2

Favorable temperature and pH conditions

Microbes can adapt to a wide variety of pH and temperature conditions, however microbes may be killed if these conditions change too rapidly for them to adapt. Broadly speaking,

- Bacteria favor neutral to slightly alkaline pH (6.0 – 8.5). Bacteria tend to outcompete yeast & fungi when temperatures are warmer.
- Yeast and fungi favor acidic pH (2.0 – 6.0). Yeast and fungi may outcompete bacteria when temperatures are cooler.

3

A Nutrient Source

The organic ingredients in most water based industrial products can serve as a degradable nutrient source. Broadly speaking fungi are able to degrade a wider variety of materials relative to bacteria.

4

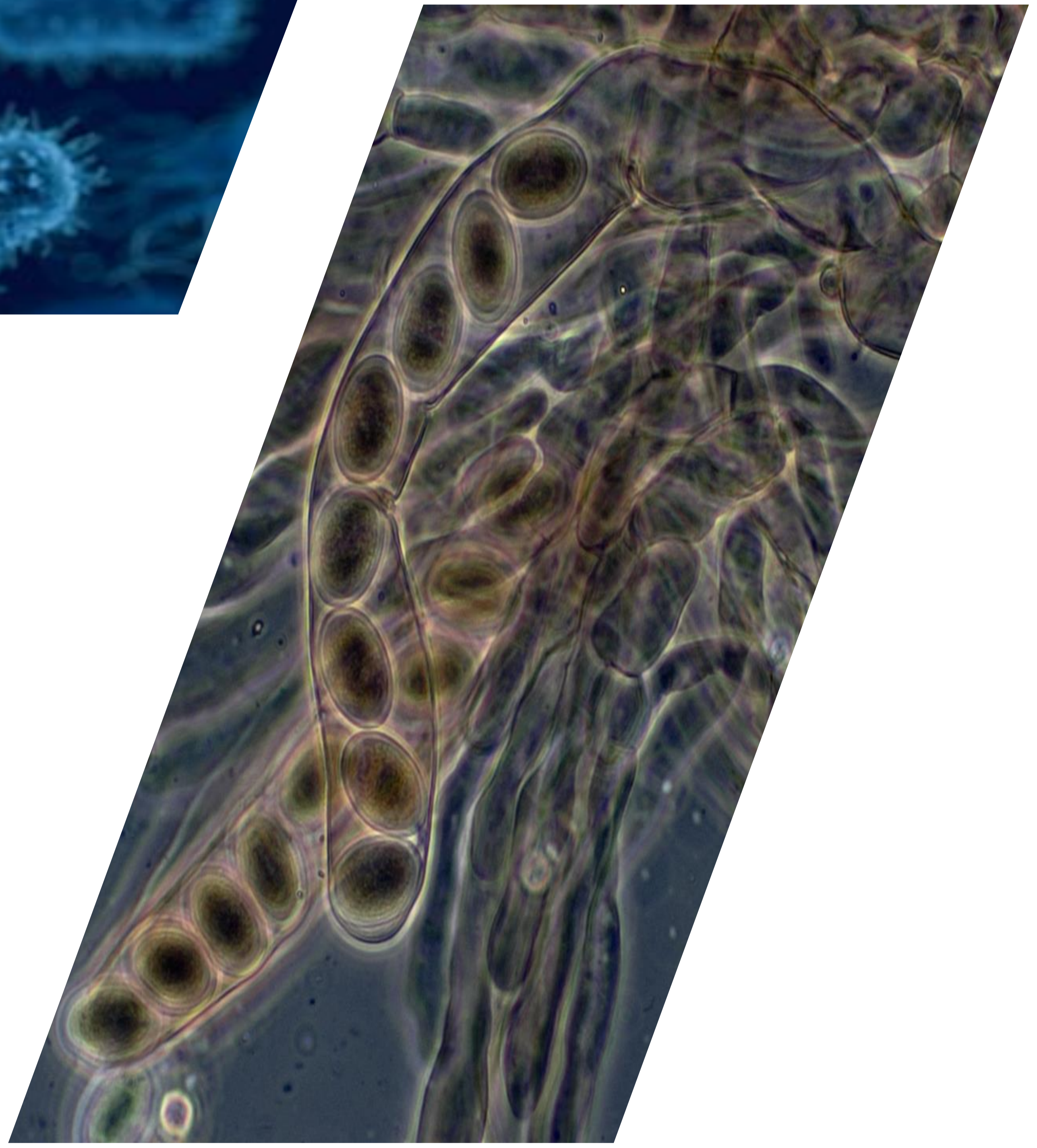
Microbes and Industrial Product Spoilage

In order to damage industrial products, microbes also need to gain access. In other words a sterile product in a sealed container will remain sterile until the can is opened and some form of microbial inoculation occurs. Product damage also requires that the microbial population reach a high enough level for a long enough period of time.

What is the difference between bacteria and bacterial spores?

Bacteria

Living bacteria take in nutrients and excrete waste. In a water based industrial product, the product ingredients may serve as the nutrient for the bacteria. Damage to product integrity can occur if the bacteria metabolize and enough of a critical product ingredient.



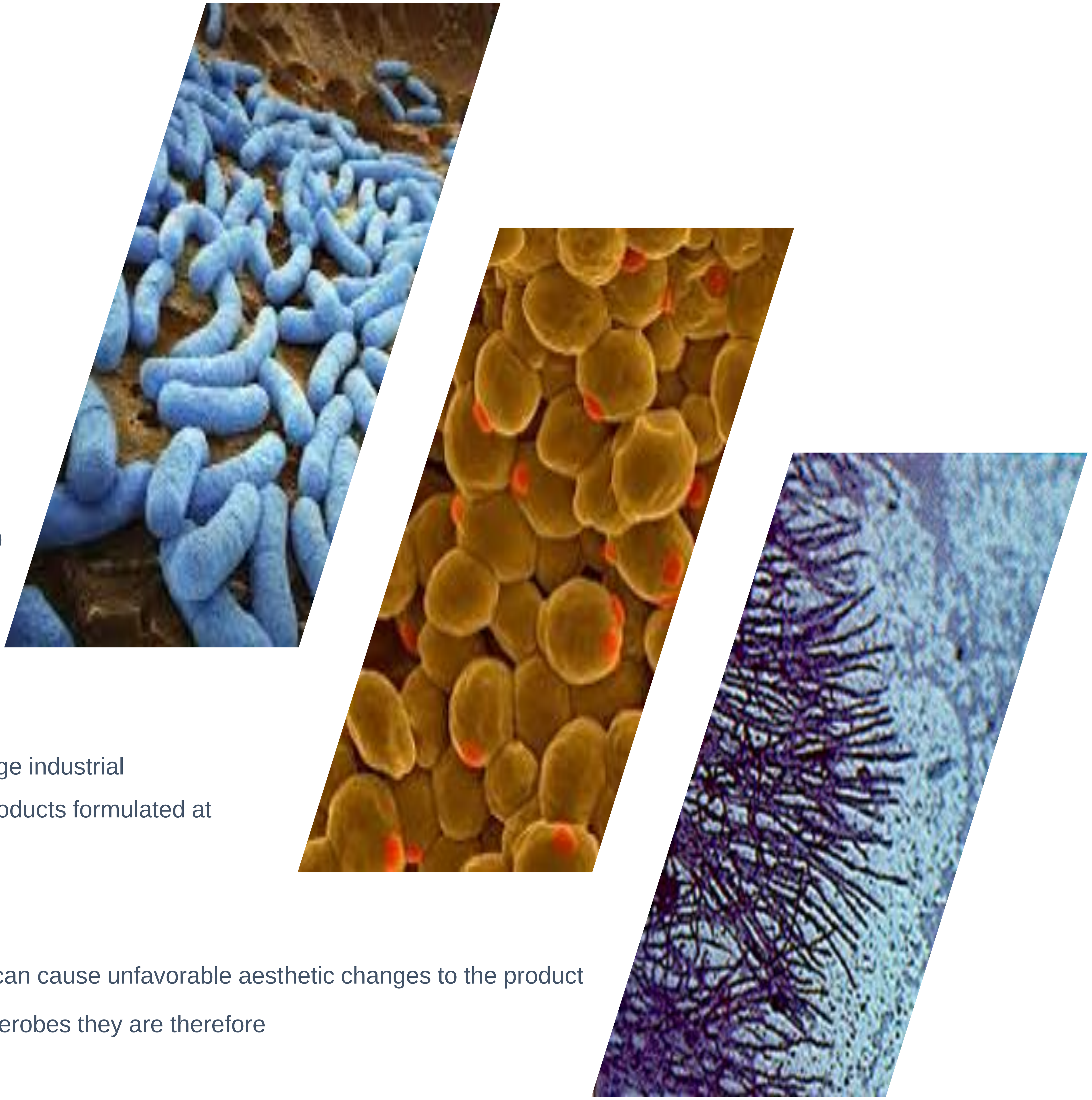
Bacterial Spores

A few types of bacteria can form microscopic survival structures known as spores. These are tough, spherical structures less than one micron in diameter that are resistant to heat and desiccation. Spores are typically formed when the growing bacteria experience difficult conditions such as a shortage of essential nutrients. Spores are not metabolically active, and therefore they do not damage product integrity.

Spores and Preservatives

Spores can germinate after long periods of dormancy and yield again a living bacterial cell. Most preservatives kill living bacteria but do not destroy the dormant spores. An industrial product with a stable preservative is still protected even when spores are present, because the preservative will kill any bacteria which germinates from a spore. However spoilage can arise when a preservative degrades during the dormancy period of the spores, and is then at a sub-lethal level when the spores germinate.

Which types of microbes are relevant for industrial products?



Bacteria

- Bacteria are the most common spoilage problem for water based industrial products
- Bacterial multiply rapidly, and they can quickly damage industrial products across a wide pH range
- Bacteria can grow in the presence of oxygen (aerobic), but also in the absence of oxygen (anaerobic)
- Bacteria can form spores, which are not metabolically active and do not cause product damage

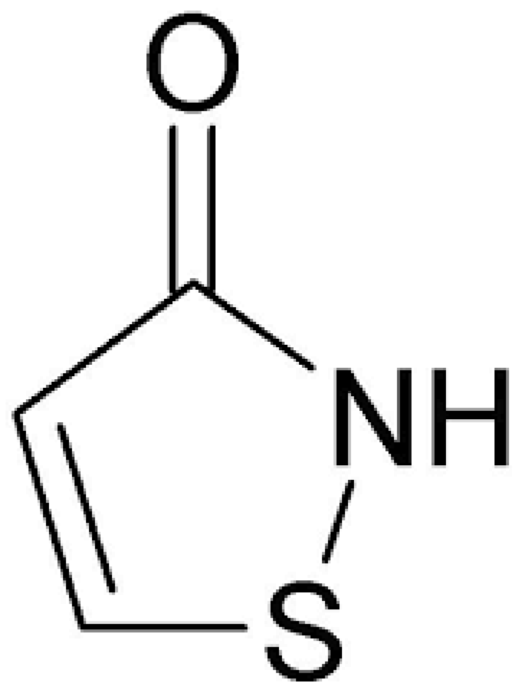
Yeast

- Yeasts are problematic spoilage organisms in a few types of water based industrial products
- Yeast typically multiply more slowly relative to bacteria, however they can reach levels that will damage industrial
- products. While yeast can grow across a wide pH range, they are most typically found in industrial products formulated at neutral to acidic pH

Fungi

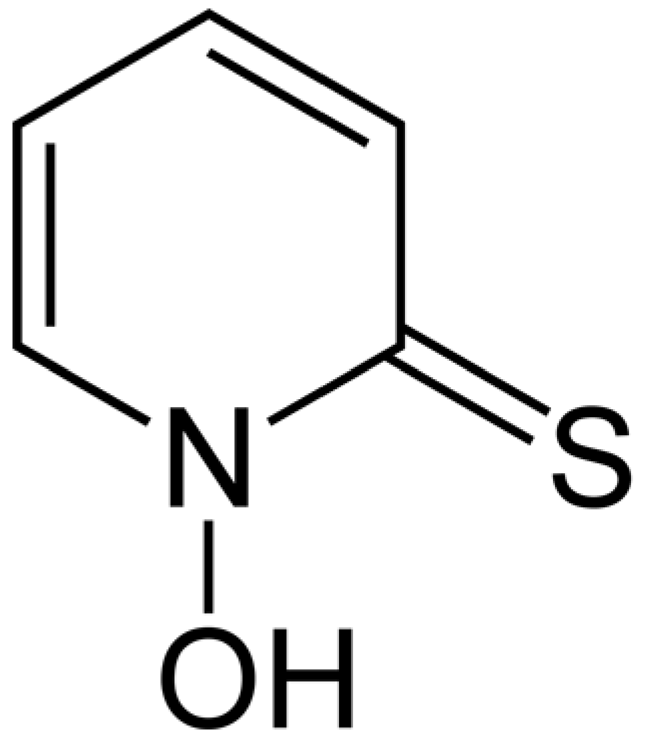
- Fungi are less problematic as spoilage organisms for water based industrial products, however they can cause unfavorable aesthetic changes to the product
- Unlike bacteria and yeast, fungi do not grow dispersed in the bulk liquid product. Fungi are obligate aerobes they are therefore typically found at the air / product interface
- Fungi and algae are relevant defacement organisms for industrial products that exist in a dry film state after application

What types of biocides are available?



Isothiazolinone Mechanism

- The isothiazolinone mechanism biocides represent a small group of molecules used in industrial preservation
- These molecules have different structures, however they all include the isothiazolinone ring as a sub-unit.
- Within the isothiazolinone group are some individual active agents commonly used for in-can preservation and some individual active agents commonly used for dry film protection

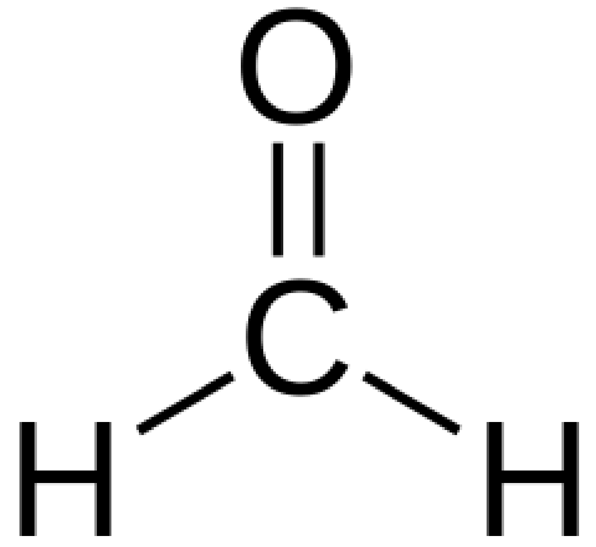


Pyrithione Mechanism

- The pyrithione mechanism biocides represent different salts of the pyrithione active agent.
- The pyrithione salts have very different water solubility which influences their use in in-can and dry film protection.

Other Mechanisms

- There are a number of biocide active agents in common use that do not fit the categories described above. Many of these actives have found particular niche uses and a full description of these is beyond the scope covered in this Learning Center. Contact your Lonza representative for details.



Formaldehyde Mechanism

- The formaldehyde mechanism biocides represent a large group of molecules used in industrial preservation
- These molecules have very diverse structures, with different compatibility profiles and formulation requirements.
- The formaldehyde mechanism biocides are used primarily as in-can preservatives. They may also be used as plant hygiene aids, however they are not use in dry film protection.

MAIN USES FOR BIOCIDES

This Learning Center focuses on three main use patterns for biocides associated with industrial products

In-Can Preservation

An in-can biocide protects a water based industrial product up to the point of application. In other words, it protects the product in its wet state during manufacturing, during storage & transport, and during application. Most commonly the problematic organisms in the wet state are bacteria or yeast. The in-can biocide must protect the preserved product throughout its entire wet state shelf life. This can range anywhere from a few days to several years.

Plant Hygiene Aid

A plant hygiene or quick kill biocide is typically used to reduce or eliminate a pre-existing microbial population in a water based product or raw material. Quick kill biocides are often more reactive relative to in-can biocides, and the half life of the quick kill biocide in the treated material may be quite short.

Dry-Film Protection

An in-can biocide protects an industrial product after application. In other words, it protects the product in its dry state. Most commonly the problematic organisms in the dry state are fungi or algae. The dry film biocide must protect the applied product throughout its entire service life. This can range anywhere from weeks to decades.

WHY IS PLANT HYGIENE IMPORTANT?

History

Many of the biocides used in history were broadly toxic compounds that controlled microbial growth but also had unintended consequences in terms of human health or environmental impact.

Today

Modern biocides are typically more narrow in their impact. These compounds do control microbial growth, however they are intended to be sufficient rather than excessive. In other words, biocides today are used at concentrations which are kept as low as possible and therefore tolerate only a limited microbial burden. Therefore one of the reasons that plant hygiene is important is minimize the amount of contamination that the biocide must overcome.

Consequences of Spoilage

Good plant hygiene minimizes the probability of experiencing the negative consequence of microbial spoilage. These consequences can include:

- Missed delivery deadlines and a damaged reliability reputation.
- Expensive recall / rework of contaminated product.
- Lost production time.
- Microbial damage to the manufacturing equipment (ex. clogged filters, microbial corrosion, etc.).
- Expensive disposal cost for product that can not be recovered.