Peracetic Acid as a Biocide

REVOX™ sterilization technology uses a room temperature vapor composed of three active compounds; hydrogen peroxide ($\text{H}_2\text{O}_2$), acetic acid and peracetic acid (PAA). PAA is formed by the reaction of acetic acid and $\text{H}_2\text{O}_2$ with the addition of a catalyst; these compounds exist in equilibrium and their eventual decomposition results in oxygen, carbon dioxide and water.

$$\text{H}_3\text{C} \quad \text{O} \quad \text{H}_2\text{O}_2 \quad \text{CATALYST} \quad \text{H}_3\text{C} \quad \text{O} \quad \text{OH}$$

ACETIC ACID PERACETIC ACID

PAA was introduced as an antibacterial agent in 1955 and is used extensively in the food industry and for disinfecting sewage sludge. Although all three compounds provide antimicrobial activity, PAA delivers the most according to the Canadian Journal of Microbiology. PAA is a highly biocidal oxidizer that maintains its efficacy in the presence of organic soil while also removing surface contaminants. As with any gas sterilization process, the system will only sterilize surfaces that are contacted by the sterilant.

Peracetic acid is a highly effective chemical sterilant, and by using it in a vaporized form, the REVOX™ method can easily disinfect products safely that would normally be damaged by a liquid chemical or by moisture and heat. Test data shows vaporized PAA is less corrosive and has a better material compatibility than liquid PAA.

The REVOX™ sterilization process includes mechanisms to confirm the efficacy of the sterilization system. Testing with multiple organisms reveals that biological indicators (BIs) should be inoculated with Geobacillus stearothermophilus; MEDIVATOR test conditions are stringent and inactivates a wide variety of microbes. A chemical monitoring strip that detects the active ingredient is used routinely as an additional process control for REVOX® Sterilization Solutions.

Mode of Action

The mechanism of action of VPA is thought to function as other oxidizing agents, i.e., it denatures proteins, disrupts cell wall permeability, and oxidizes sulfhydryl and disulfide bonds in proteins, enzymes, and other metabolites. The VPA interacts with numerous cellular constituents breaking them down and inactivating routine functionality. With the disintegration of the bacterial cell wall, internal components will no longer be contained. Proteins are rapidly attacked by VPA through oxidation of amino acids to carbonyls, particularly tryptophan, cysteine and methionine.

Microbiocidal Activity

VPA will inactivate gram-positive and gram-negative bacteria, fungi, and yeasts in <5 minutes at <100 ppm. In the presence of organic matter, 200-500 ppm is required. For viruses, the dosage range is wide (12-2,250 ppm), with poliovirus inactivated in yeast extract in 15 minutes with 1,500 to 2,250 ppm. Bacterial spores in suspension are inactivated in 15 seconds to 30 minutes with 500 to 10,000 ppm (0.05 to 1)%. Dr. Michelle Alfa, Clinical Microbiologist, along with her co-workers, compared a VPA system with ethylene oxide (ETO) and demonstrated the high efficacy of such a VPA system. Only the VPA system was able to completely kill $6\log_{10}$ of Mycobacterium chelonae, Enterococcus faecalis, and B. atrophaeus spores with both an organic and inorganic challenge. Like other sterilization processes, the efficacy of the process can be diminished by soil challenges and test conditions.
The PAA vapor interacts with numerous cellular constituents breaking them down and inactivating routine functionality.

---

**How VPA Works**

The ideal sterilization system involves an active component with high microbicidal activity, a wide range of compatibility with materials, operation at temperatures that do not affect the product or packaging, low/no residuals, safe to use for operators, and short processing times. REVOX® Sterilization Solutions uses a chamber at room temperature (18 - 30°C), has a wide range of material compatibility, maintains a low level of residuals that breaks down into oxygen & water and provides turnaround times as quickly as same day. REVOX™ sterilization technology can be used to terminally sterilize medical, pharmaceutical and industrial products.

The VPA sterilization cycle consists of four phases and a hold time. They are:

1. **Chamber Evacuation Phase**: Removes the air from within the chamber and the packaging of the product being sterilized.

2. **Chemical Injection Phase**: Vaporizes the PAA sterilant while raising the pressure within the chamber. **Hold Time**: The time between chemical injection and dehumidification. This phase allows the chemical to remain in contact with the product for an amount of time sufficient to ensure sterilization.

3. **Chamber Dehumidification Phase**: Removes the chemical from the chamber.

4. **Ventilation Phase**: Removes any residual chemical from the chamber and product.

The REVOX™ non-toxic sterile processing solution leaves behind no harmful residuals. After sterilization, the sterilant breaks down into carbon dioxide, oxygen, and water, and leaves products sterile, dry, and free from residuals.

---

**REFERENCES**