Water Environment Federation
the water quality people®

# PERACETIC ACID DISINFECTION

*Peracetic acid has emerged as an effective alternative to traditional disinfectants at water resource recovery facilities.*

## Peracetic Acid (PAA) Overview

- Can be a cost-effective option for water resource recovery facility (WRRF) disinfection when compared to other disinfection technologies
- Strong oxidizing agent and potent germicide that is efficient at reducing bacteria concentrations
- Disinfects comparably to chlorine and often requires less *contact time* at the equivalent dose for bacteria; however, greater contact times or higher doses may be needed for viruses
- An organic acid widely used as a disinfectant in the food and medical industries and for wastewater in Europe
- Full-scale PAA disinfection systems have operated successfully at water resource recovery facilities (WRRFs) in the U.S. for more than 10 years
- Interest in this alternative disinfection method is growing because it does not produce chlorinated disinfection byproducts (DBPs)
- Has low aquatic toxicity and breaks down rapidly in the environment to acetic acid, oxygen, and water
- Enhances the performance of older or under-performing UV systems and improves their operational efficiency
- Approved by the U.S. Environmental Protection Agency (U.S. EPA) for wastewater disinfection, but not all states have granted permit modifications

**Table 1 Advantages and Disadvantages of Peracetic Acid**

| Advantages | Disadvantages |
| --- | --- |
| • No chlorine-based DBPs<br>• Most applications do not require quenching (neutralizing the disinfectant residual)<br>• Rapid inactivation of fecal indicator bacteria<br>• Adds dissolved oxygen to effluent<br>• Low capital cost for converting to PAA<br>• Not significantly affected by changes in effluent quality<br>• Unaffected by ammonia<br>• Does not require a Risk Management Plan<br>• Boosts performance of aging ultraviolet (UV) systems | • Can increase organic content of the effluent (chemical oxygen demand), which may contribute to bacterial regrowth<br>• May require longer contact time or higher dose for viruses, protozoa, and bacterial spores<br>• Not yet approved for use by every state<br>• Effluent PAA concentration requirements differ from state to state |

## How PAA Works

- PAA ($CH_3CO_3H$) exists in equilibrium with hydrogen peroxide ($H_2O_2$), water, and acetic acid ($CH_3COOH$) (Figure 1)

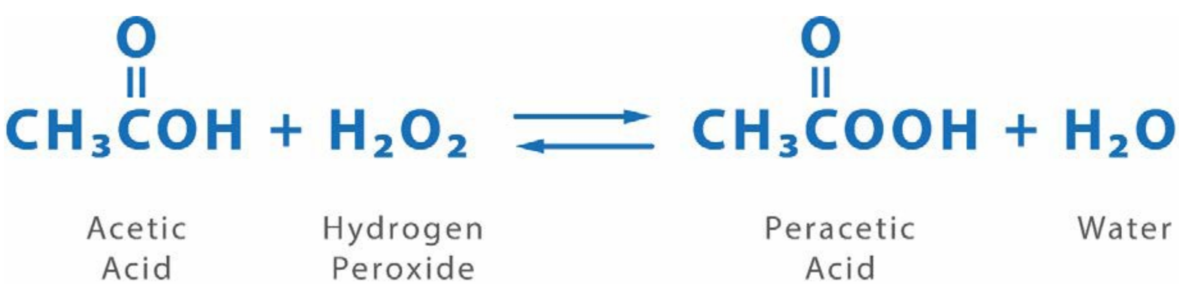


**Figure 1 Peracetic Acid Equilibrium Chemistry (Reprinted with permission from PeroxyChem).**

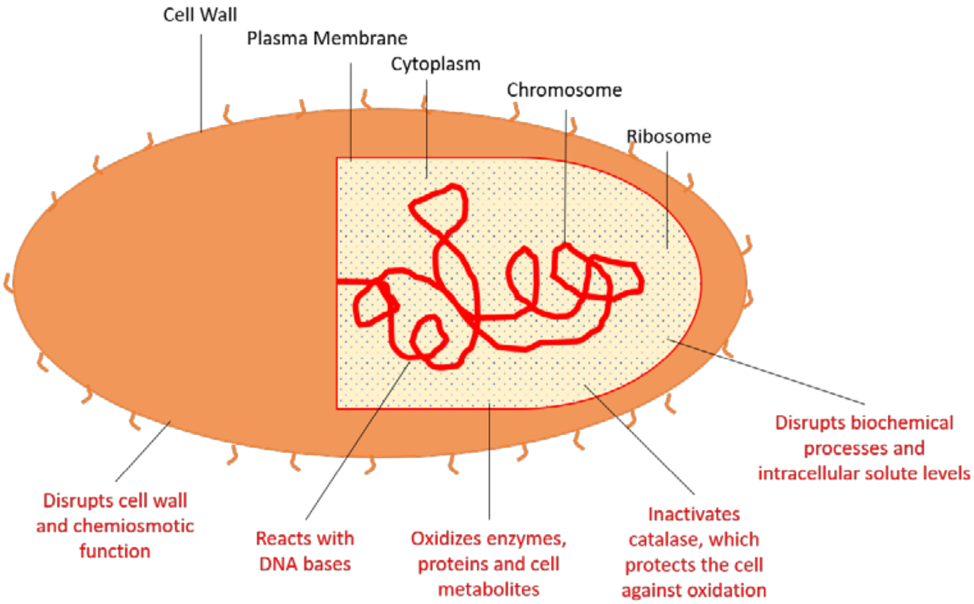


**Figure 2 Modes of PAA Disinfection (Courtesy of Philip Block; (Reprinted with permission from PeroxyChem).**

- PAA disrupts multiple cell processes (Figure 2), so it is effective at low concentrations and under a wide range of effluent conditions

## PAA Performance

- Performs comparably to chlorine and chloramines at disinfecting *fecal indicator bacteria*

WRRF discharge permits typically include effluent limits for *fecal indicator bacteria*. While these bacteria are not usually pathogens, they indicate that fecal contamination has occurred, and pathogens may be present. Indicator organisms include fecal coliforms and *E. coli*.

- Usually more effective on *E. coli* than on fecal coliforms (Falsanisi et al., 2006)
- Effective at short contact times against many pathogens
- Requires greater contact times or higher doses for some viruses
- Figure 3 shows PAA efficacy for general classes of microbes as surveyed from published literature

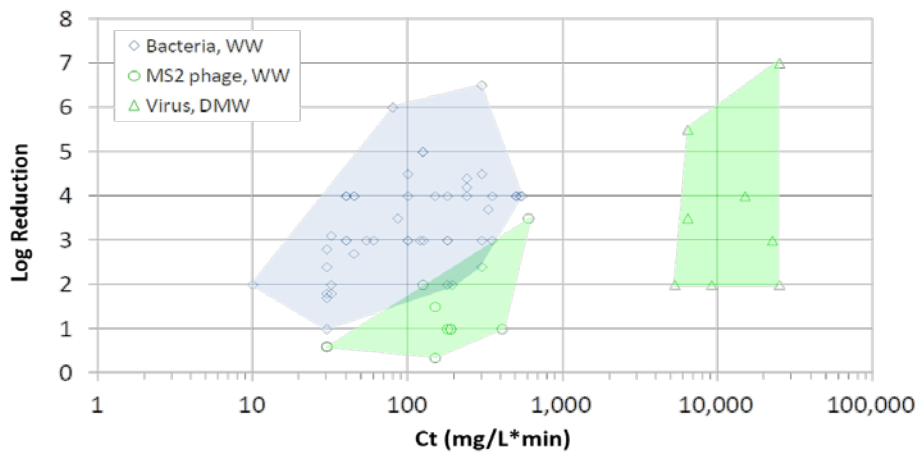


**Figure 3 PAA Efficacy on Bacteria, Bacteriophage MS2, and Virus as a Function of Contact Time (Reprinted with permission from PeroxyChem).**

*Ct = dose x contact time; WW = wastewater; DMW = distilled mineral water*

*Log reduction* refers to levels of pathogen inactivation by factors of 10, which convert easily to percent reduction. One log reduction signifies a decrease in pathogens by 90%. A five-log reduction is a 99.999% decrease in pathogens.

## PAA Storage and Use

- PAA is a clear, colorless liquid delivered in drum, tote, or bulk volumes
- Commercially available products commonly range in concentration from 12–22% PAA by weight
- In-use PAA doses typically range from 0.5–5 mg/L
- Secondary effluent is dosed with PAA using standard pump skids and piping (Figures 4–6)
- PAA storage and delivery system components are very similar to those for a sodium hypochlorite storage and delivery system. However, materials compatible with PAA are different than those used with sodium hypochlorite (Table 2)
- Carrier water or pre-dilution should not be used with PAA, as the PAA will hydrolyze upon addition to water; the PAA solution is delivered from the storage vessel directly to the effluent

- PAA is highly soluble and diffuses into the water rapidly, so chemical mixers and diffusers are not usually needed

- Adding a quenching agent is not generally required but requirements vary by state

**Figure 4 PAA Tote Storage and Pump Skid System**

**Figure 5 PAA Delivery Pump Skid**

**Figure 6 PAA Tote Storage and Pump Skid System**

**(Figures 4 through 6 reprinted with permission from PeroxyChem).**

**Table 2 Materials Compatibility with PAA[a]**

| Material | Component | Compatibility |
|---|---|---|
| Passivated 304L/316L stainless steel | Storage tank/piping | Very good |
| High-density polyethylene (HDPE) | Storage tank | Moderate |
| Teflon | Wetted parts | Very good |
| Kalrez | Wetted parts | Very good |
| Kynar | Wetted parts | Very good |
| Carbon or galvanized steel | Wetted parts | Very poor |
| Natural rubber | Wetted parts | Very poor |
| Copper, brass | Wetted parts | Very poor |
| Fiber reinforced plastic (FRP) | Storage tank | Very poor |

[a]*Check with the PAA vendor prior to installation of any storage and delivery system.*

## Analytics

- PAA in wastewater can be measured quantitatively using one of two methods.

  1. **Colorimetric** – oxidants like PAA react with a reagent—typically DPD—to form colored products; PAA is then measured based on the change in color (EPA Method 330.5)

  2. **Amperometric** – the change in electrical current between two probes provides a measure of PAA concentration

**Figure 7 Commercially Available PAA Probes and Test Kits (Reprinted with permission from PeroxyChem).**

**Table 3 PAA Measurement Methods**

| Measurement Method | Accuracy | Use | Interferents |
|---|---|---|---|
| Colorimetric | • ±3% at 1.0 mg/L PAA<br>• ±6% at 0.50 mg/L PAA<br>• ±15% at 0.25 mg/L PAA | • Use as needed<br>• Grab wastewater sample<br>• 5–10 minute analysis time<br>• Done in field<br>• Use of a wastewater blank recommended | • Oxidants (e.g., ferric ions, halogens, and cupric ions) |
| Amperometric | • ± 3% at 1 mg/L PAA<br>• ± 8% at 0.5 mg/L PAA<br>• ±15% at 0.25 mg/L PAA | • Continuous, on-line measurement<br>• Daily and weekly probe maintenance required | • High temperature<br>• Surfactants in wastewater |

## Safety

- Like all strong oxidants, PAA requires an understanding of its safety and handling characteristics in order to ensure the proper and safe use of the chemical.
- Refer to the safety data sheet (SDS) as the primary source of information on PAA properties and safe handling procedures

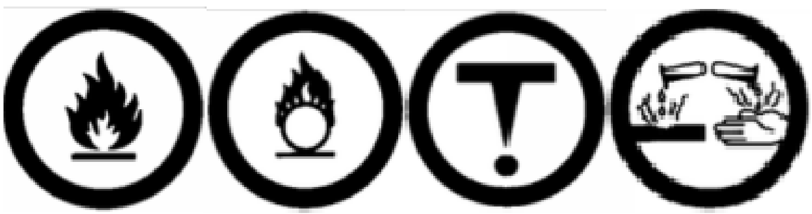

**Figure 8 Workplace Hazardous Materials Information System (WHMIS) Symbols for PAA (Left to Right): Combustible Liquid, Oxidizing Material, Toxic Material, Corrosive Material (Reprinted with permission from PeroxyChem).**

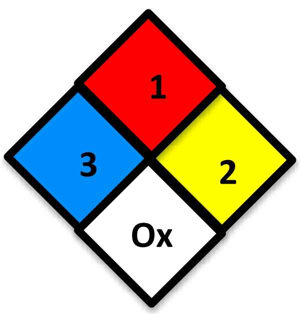


**Figure 9 National Fire Protection Association Hazard Diamond for PAA[a] (Reprinted with permission from PeroxyChem).**

[a]*The numbers and abbreviations within the diamonds indicate the following:*

- *Blue (3) – PAA poses a serious health hazard*
- *Red (1) – PAA is slightly combustible; it is a fire hazard above 93 °C (200 °F)*
- *Yellow (2) – PAA is moderately unstable and violent chemical change is possible*
- *White (Ox) – PAA is a strong oxidizer*

## PAA Permitting and Regulatory Approval

- U.S. EPA has approved PAA as a wastewater disinfectant

- Generally, a PAA discharge of 1 mg/L (1 ppm) is allowed at the utility's point of effluent. The federal registration does allow for the use of dilution factors to be considered when determining the final effluent discharge concentration. However, the PAA discharge limit can vary by state

## References


Dunkin, N.; Weng, S.; Schwab, K.J.; McQuarrie, J.; Bell, K.; & Jacangelo, J.G. (2017). Comparative Inactivation of Murine Norovirus and MS2 Bacteriophage by Peracetic Acid and Monochloramine in Municipal Secondary Wastewater Effluent. *Environment Science & Technology, 51*(5): 2972–2981.

Falsanisi, D.; Gehr R.; Santoro D.; Dell'Erba A.; Notarnicola M.; & Liberti L. (2006). Kinetics of PAA demand and its implications on disinfection of wastewaters." *Water Qual. Res. J. Can, 41*(4): 398–409.

Gehr, R.; Wagner, M.; Veerasubramanian, P.; Payment, P. (2003). Disinfection Efficiency of Peracetic Acid, UV and Ozone after Enhanced Primary Treatment of Municipal Wastewater. *Water Research, 37*(19): 4573–4586.

Kitis, M. (2004). Disinfection of Wastewater with Peracetic Acid: A Review. *Environment International, 30*(1):47–55.

Luukkonen, T. and Pehkonen, S. (2017). "Peracids in water treatment: A critical review." *Critical Reviews in Environmental Science and Technology, 47*(1):1–39

## Authors

Brian Hilts, CDM Smith

Philip Block, PeroxyChem

Thomas Worley-Morse, Hazen and Sawyer


## Keywords

Peracetic acid, PAA, disinfection, oxidation, training guide, indicator bacteria