ProKlean Services
REVOLUTIONIZING KLEAN

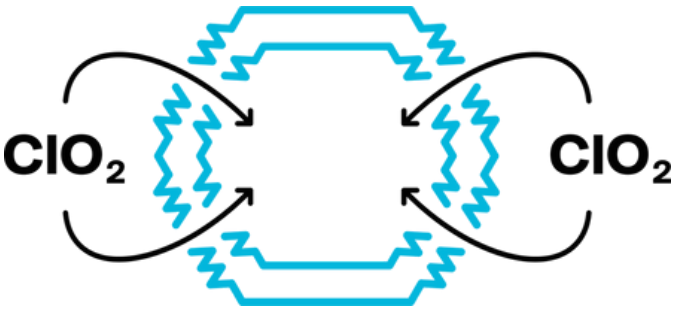
# The Science Behind $ClO_2$ & Odor Control

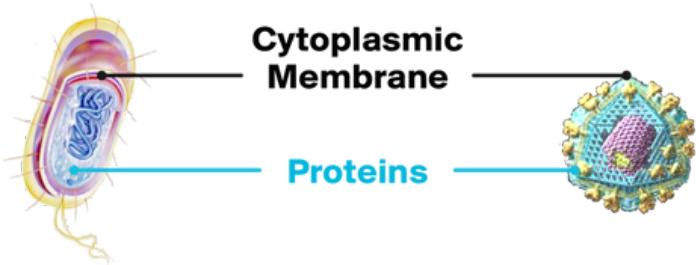
For nearly 80 years, $ClO_2$ (Chlorine Dioxide) has been widely accepted as the preferred deodorization and disinfection solution for large scale projects, such as municipal water treatment.

Recent technological advances have made it cost effective to produce $ClO_2$ for jobs of any scale. This advance has paved the way to the discovery of $ClO_2$ as a powerful new way to eliminate a wide variety of odor types.

$ClO_2$ eliminates odors via a process called oxidation. More accurately, $ClO_2$ works in a chemical reaction that involves the transfer of electrons between molecules and/or atoms.

We all know what skunk spray smells like - that odor is generally known as Mercapton. $ClO_2$ steals electrons from the Mercapton molecule. By doing so, it changes the composition of the molecule so that it no longer smells. This also does the same for other odors.



# The Science Behind $ClO_2$ & Odor Control

$ClO_2$ is small. This plays into the effectiveness of deodorization. Small odor molecules, like smoke from natural materials (roughly 0.1 micron) can easily embed into surfaces making their removal very difficult.

$ClO_2$ is 100x smaller than a smoke molecule. This makes $ClO_2$ a perfect option to oxidize the smoke residual leaving an odor free environment with no residue.

## Oxidation, What is it?

A chemical reaction that involves the transfer of electrons between molecules and/or atoms

Redox Reactions

**Red - Reduction** **Ox - Oxidation**

**Reduction**

**Oxidant + $e^-$ ⟶ Product**

**(Gain of Electrons) Oxidation Number Decreases)**

**Oxidation**

**Reductant ⟶ Product + $e^-$**

**(Loss of Electrons) Oxidation Number Increases)**

# Oxidation of a Generic Mercaptan → Reduction of Chlorine Dioxide

Smelly Odor — No Odor

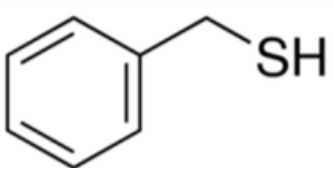
$$5\ R\text{-}SH + 8\ ClO_2 + 2H^+ \rightarrow 5\ R\text{-}SO_3H + 8\ Cl^- + H_2O$$

Oxidation States: 2- +4 +6 → -1

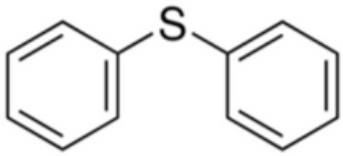
1/2 Reactions

Oxidation Reaction: $R\text{-}SH \rightarrow R\text{-}SO_3H + 8\ e^-$ LEO

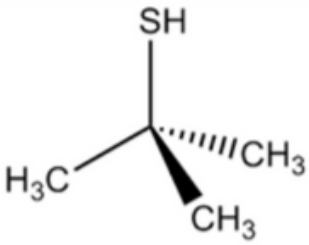
Reduction Reaction: $5\ e^- + ClO_2 \rightarrow Cl^-$ GER




Benzyl Mercaptan



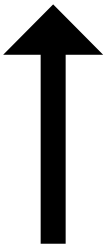

Diphenyl Sulfide




Tert-butyl Mercaptan - Skunk

# Selective Oxidation & Higher Oxidation Capacity

| Decontaminating Agent | Oxidation / Corrosion Potential (V) |
|---|---|
| Ozone | 2.07 |
| Peracetic Acid | 1.81 |
| Hydrogen Peroxide | 1.78 |
| Bleach | 1.49 |
| Chlorine Dioxide | 0.95 |



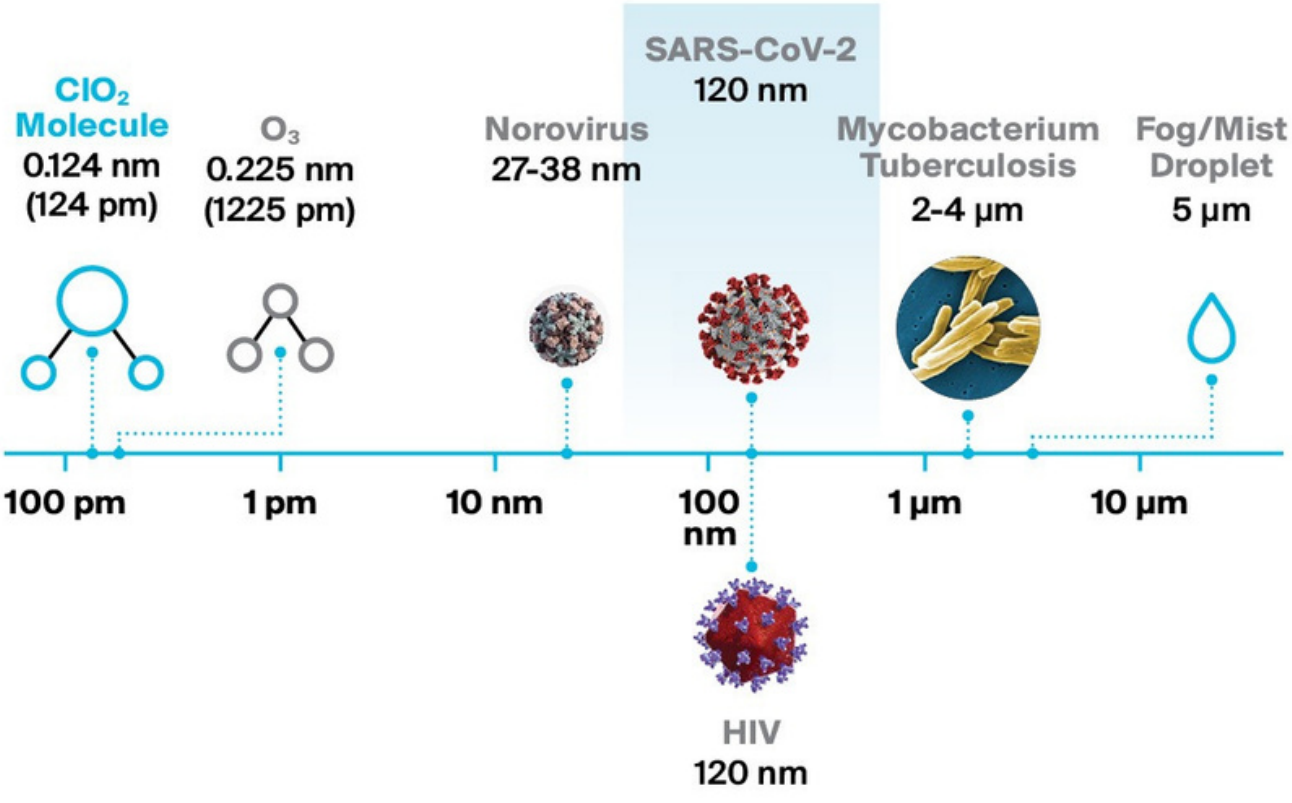
MORE CORROSIVE

- $ClO_2$ has lower oxidation strength. It is more selective in its reactions
- Free chlorine ($Cl_2$) or Bleach (HOCl)* is a more powerful oxidizer than chlorine dioxide and will react with a wider variety of chemicals, including ammonia
- $ClO_2$ has an oxidation number of +4. For this reason, it accepts 5 electrons when reduced to chloride ion which has a -1 oxidation state
- HOCl (Bleach)* has an oxidation number of 0. It can accept 2 electrons total, 1 from each atom
  - Peracetic Acid and Hydrogen Peroxide can accept 2 also, 1 from each Oxygen
  - Ozone, $O_3$ can accept 2 electrons

- By way of comparison, $ClO_2$ contains more than 2.5x the oxidation capacity
- Less chlorine dioxide is required to obtain an active residual concentration of the material when used as a disinfectant
  - *$Cl_2$ in water undergoes hydrolysis to form Bleach (HOCl) and $OCl^-$, pH dependent)

# Smaller is Better

- $ClO_2$ is a very small molecule, e.g., it can penetrate into very small areas.
- As a gas $ClO_2$ will completely and evenly fill any space, giving it unmatched distribution and diffusion.
- $ClO_2$ is much smaller than viruses, fungi, bacteria and their spores. This means the gas is able to contact organisms wherever they are located.
- Penetration into tight, hidden or difficult to reach areas, including microscopic cracks and crevices.



# Liquid & Gas Applications

## Complete Distribution

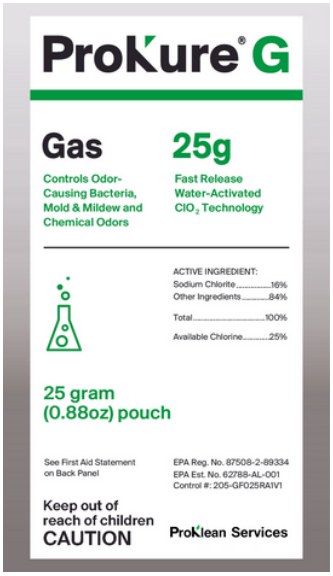
For a true gas such as chlorine dioxide, its small molecular size (approximately 124 pm) and natural ability to fill any space offers an unmatched distribution ability.

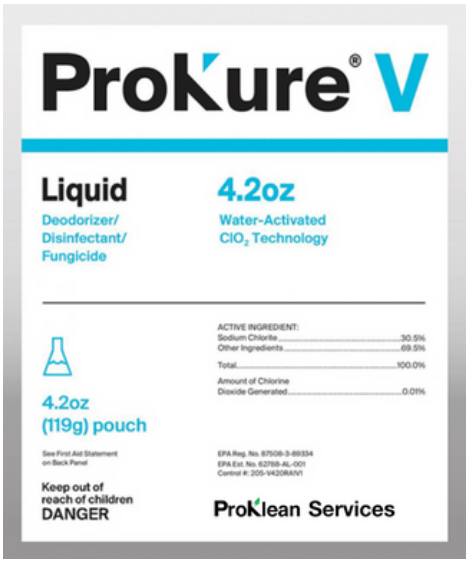
## Total Penetration

Chlorine dioxide gas is a selective oxidizer allowing it to easily penetrate surfaces, cracks and crevices and can even penetrate through organic matter like bio-films.

## Concentration & Contact Time

In gas phase and dissolved in water, the chlorine dioxide concentration can be accurately measured and monitored.




**ProKure® G**

**FAST DEODORIZING GAS**

**ProKure® V LIQUID**

**DEODORIZIER & DISINFECTANT**