



## Pesticides: Topical & Chemical Fact Sheets

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Anthrax Spore Decontamination using Chlorine Dioxide

# Anthrax spore decontamination using chlorine dioxide

### Resources

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[Bleach](#), [chlorine dioxide](#), [ethylene oxide](#), [hydrogen peroxide](#) and [peroxyacetic acid](#), [methyl bromide](#), [paraformaldehyde](#) and [vaporized hydrogen peroxide](#) were pesticides used in federal

decontamination responses to the bioterrorism attacks of October 2001. These attacks involved the intentional placement of *Bacillus anthracis* spores (the causative agent of the disease anthrax) into letters addressed to various locations on the East Coast of the United States. [More information about biological threats](#).

This page describes the Agency's actions with regard to the chemicals used in the anthrax spore decontamination activities. EPA temporarily approved these pesticides for sale, distribution, and use based on the remediation action plans submitted for each specific site and only in accordance with the requirements of each crisis exemption under [Section 18 of FIFRA](#). These chemicals were not intended for use by the general public.

## What is chlorine dioxide?

Chlorine dioxide is an antimicrobial pesticide recognized for its disinfectant properties since the early 1900s. Chlorine dioxide kills microorganisms by disrupting transport of nutrients across the cell wall.

Chlorine dioxide smells somewhat like chlorine bleach. Chlorine dioxide should not be confused with chlorine gas. They are two distinct chemicals that react differently and produce by-products that have little in common.

## Registration of pesticides containing chlorine dioxide

In 1967, under the authority of the [Federal Insecticide, Fungicide, and Rodenticide Act \(FIFRA\)](#), EPA first registered the liquid form of chlorine dioxide for use as a disinfectant and sanitizer on a variety of sites such as animal farms, bottling plants, food processing, handling, and storage plants. Other industrial uses of liquid chlorine dioxide include:

- bleaching pulp and paper
- bleaching textiles
- washing fruit and vegetables
- disinfecting flume water
- disinfecting meat and poultry
- disinfecting food processing equipment
- sanitizing water
- controlling odors
- treating medical wastes
- treating municipal water

In 1988, EPA registered chlorine dioxide gas (generated from sodium chlorite, the active ingredient) as a sterilant for use in manufacturing and laboratory equipment, environmental surfaces, tools, and clean rooms.

Pesticide products containing either sodium chlorite or stabilized chlorine dioxide are usually mixed with another "reactive" chemical - usually an acid - to produce chlorine dioxide in a liquid or gaseous state. The resulting mixture is applied within a specific sterilization or disinfection system. The liquid chlorine dioxide is then applied to hard surfaces with a sponge or mop or as a coarse spray. Chlorine dioxide gas is also generated on site and is released into a sealed treatment area where it remains for several hours before being removed. After the treatment is completed, the chlorine dioxide gas is neutralized with sodium bisulfite.

## Responding to emergencies under FIFRA

Under Section 18 of FIFRA, the EPA "may exempt any Federal or State agency from any provision of this Act if the Administrator determines that emergency conditions exist which require such exemption." To respond as rapidly as possible to the bioterrorism attacks, the Agency decided in 2001 to develop and issue the crisis exemptions itself.

To obtain a crisis exemption from EPA for the unregistered use of a pesticide against anthrax, anyone who needed to use an antimicrobial product to inactivate *Bacillus anthracis* spores at contaminated sites had to submit:

1. a written request to the Agency listing the antimicrobial product(s) to be used and describing how, when and where they would be used;
2. data demonstrating efficacy of the product against bacillus spores; and
3. remediation, sampling, and monitoring plans specific to the location of use.

Before issuing an exemption, EPA reviewed the request and the supporting information and then determined whether the product could be used safely and effectively (i.e., cause "no unreasonable adverse effects").

If during this review data were found to be deficient or missing, or adverse human health or environmental concerns were identified, EPA could deny the exemption request.

If a crisis exemption was issued and EPA determined that use of the product would be needed beyond the 15 day use period, EPA completed an application for a public health exemption. This allowed the crisis exemption to continue in effect until the application was either withdrawn or EPA issued a public health exemption.

## Crisis exemptions for chlorine dioxide

EPA reviewed data related to the safety and effectiveness of using liquid and gaseous chlorine dioxide for inactivation of *Bacillus anthracis* spores. Available data indicated that liquid and gaseous chlorine dioxide would reduce bacterial spore populations under specific conditions including concentration, pH, and contact time. EPA determined that the product could be used safely and effectively, and that no unreasonable adverse effects would occur from the requested uses.

Subsequently, EPA issued crisis exemptions for the limited sale, distribution, and use of liquid and gaseous chlorine dioxide for decontaminating buildings and their contents. EPA determined that the public health threat posed by the "anthrax attacks" constituted a public health emergency of such immediacy that normal processing and review of a conventional public health exemption under FIFRA was neither prudent nor practical.

Under the crisis exemption for liquid chlorine dioxide, registered products (containing sodium chlorite) were permitted to be sold or distributed only to employees of federal, state or local government agencies, or of the U.S. Postal Service (November 9, 2001).

Crisis exemptions for gaseous chlorine dioxide (generated from registered sodium chlorite products) were issued to:

1. decontaminate the Hart Senate Office Building (November 30, 2001),
2. treat the exterior of mail packages received by U.S. government offices (February 26, 2002),
3. test lockers in a trailer at the U.S. Postal Service Brentwood Processing and Distribution Center, Washington, D.C. (June 21, 2002); and
4. fumigate an office building located at 5401 Broken Sound Boulevard, Boca Raton, FL (April 21, 2004).

Since issuing the initial crisis exemption on November 9, 2001, EPA tested the effectiveness of liquid chlorine dioxide and found that it was effective on hard surfaces (500 milligrams per liter, at 30 minutes contact time), but not effective on porous surfaces (e.g., carpeting, chairs, couches, and other fabric surfaces) under the conditions of use specified in the crisis exemption of November 9, 2001.

On March 28, 2002, EPA amended the crisis exemption for liquid chlorine dioxide to limit its use to hard surfaces only. This amendment did not affect the results of the site cleanups performed with liquid chlorine dioxide before that time because all porous surfaces were pre-treated and removed for final disposal at a facility capable of destroying any remaining spores.

Liquid chlorine dioxide, along with other methods and technologies, continues to be effective against anthrax spores on hard surfaces.

## **Use of liquid chlorine dioxide for decontamination**

Application of the pesticide products under the crisis exemption is limited to specific buildings or treatment sites identified by EPA or other federal, state, or local governmental authorities, or the United States Postal Service. Applications must be conducted according to use instructions from federal, state, or local emergency response personnel following a plan that included the following steps:

- Pre-sampling to determine the extent of spore contamination at specific locations.
- Spot remediation of highly contaminated surfaces through HEPA filter vacuuming.
- Gross surface decontamination with liquid chlorine dioxide.
- Post-treatment sampling to determine that the anthrax decontamination has been effective; and
- Re-treatment with liquid chlorine dioxide if viable spores are detected.

These steps applied to facilities where the treated surfaces would be reused or the facility would be re-occupied. These steps did not necessarily apply to wastes or debris intended for disposal in an appropriate facility.

On March 28, 2002, the Crisis Exemption for liquid chlorine dioxide was amended to specify its use to decontaminate hard surfaces only. Applications had to be conducted according to use instructions from federal, state, or local emergency response personnel following a plan that included the following steps:

- Pre-sampling to determine the extent of spore contamination at specific locations.
- Spot remediation of highly contaminated surfaces through HEPA filter vacuuming.
- Gross surface decontamination using a liquid solution of chlorine dioxide under the following conditions:
  - only hard surfaces may be treated;
  - a rate of 500 mg/L liquid chlorine dioxide may be applied;
  - applications will be made at room temperature (68 degrees Fahrenheit, 20 degrees Celsius); and
  - treatments will have a contact time of at least 30 minutes.
- Post-treatment, environmental sampling to determine whether viable anthrax spores remain.
- Re-treating with liquid chlorine dioxide if viable spores are detected; and
- Post-treatment testing to determine that the anthrax decontamination has been effective.

Any remaining liquid chlorine dioxide had to be removed from the treated areas of the building

before people were allowed to re-enter. After treatment, experts had to determine through post-treatment sampling that the treatment was effective before anyone was allowed back into the building.

## **Use of gaseous chlorine dioxide for decontamination**

Based on review of available data, EPA concluded that gaseous chlorine dioxide could be used in a facility decontamination procedure that included sampling, cleaning, treating, and re-sampling, followed by additional treatment if necessary.

The crisis exemptions for gaseous chlorine dioxide issued for fumigating:

- Senator Daschle's suite in the Hart Senate Office building (November 28, 2001),
- the exterior of mail packages (February 26, 2002); and
- an office building located in Boca Raton, FL

involved products containing sodium chlorite as the active ingredient to generate gaseous chlorine dioxide on site, followed by post-treatment environmental sampling to confirm that the treated areas were free from anthrax spores (no sample could show growth when cultured in the laboratory).

The conditions of application are described below. These conditions did not necessarily apply to personal protective equipment and other debris that was further treated offsite.

- Initially at the Hart Building, a minimum target concentration 500-550 ppm chlorine dioxide gas was applied for a minimum of 12 hours, for a minimum total CT (concentration multiplied by time) of 6,000 ppm-hours.
- Later, the concentration was increased to 750 ppm for a total CT of 9,000 ppm-hours at the Hart Building and for the mail packages.
- At the Boca Raton, FL building, the target concentration was increased to 3,000 ppm and the contact time was reduced to 3 hour, but the total CT exposure minimum remained at 9,000 ppm-hours.
- The minimum temperature was 70 degrees Fahrenheit.
- The minimum relative humidity was 65 percent.