Aerosolized Activated Hydrogen Peroxide for Airborne and Surface Decontamination

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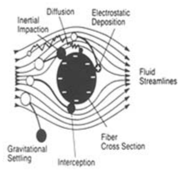
Improving the Capture of Airborne Contaminants

Physical properties of the knockdown spray droplets are important for optimal collection of agent vapors, liquid aerosols, and particles



- Particles may be collected by falling droplets with various mechanisms
  - Diffusion
  - Interception
  - Impaction
  - Thermal effects
  - Electrostatic effects
- Collection efficiency may be enhanced by certain physical properties of the droplets
  - Droplet size
  - Charge on the droplet
  - Concentration of the droplets
  - Surface tension (wetability)2

The optimal properties of the knockdown spray parameters are determined through modeling and experimental work

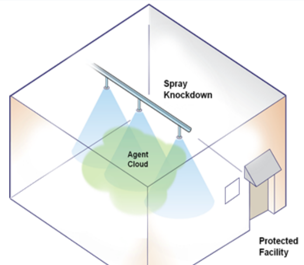
Abstract

Achieving effective decontamination of sensitive equipment and platforms consisting of complex geometries including tight spaces presents a difficult challenge. Typical gaseous decontamination technologies such as ClO_2 may have corrosive effects on critical components. Sandia's DF200 reduces these material compatibility concerns, but has typically been applied as a foam or liquid spray. To effectively aerosolize the DF200 formula methods were utilized to generate electrically charged aerosols enabling a nearly uniform deposition of droplets on all surfaces throughout a contaminated space. These prototypes were used in a series of tests at Sandia National Laboratories' aerosol test facility. Biological Indicator coupons doped with spores of *Bacillus atrophaeus* (BG) were placed at multiple locations in an aerosol test chamber. DF-200 was then aerosolized using either stationary ESS nozzles or the Rotary ITW Nozzle. After releasing a peroxide-based aerosol for one hour, complete kill was observed for both airborne spores and spores on coupons near chamber walls. This method of aerosolized decontamination has significant potential for, 1) the uniformapplication of liquids on downward facing and hidden surfaces in complex geometries, and 2) the avoidance of damaging sensitive electronic equipment. Minimal aerosolized spray volumes are required, thus minimizing the logistical burden of soldiers or civilian first-responders.

Fundamental Requirements for Airborne Agent Knockdown & Neutralization System

Define the Threat	Detect the Agent Cloud	Knockdown and Neutralize the Agent Cloud
▪ Agents of Concern ▪ Airborne Concentrations and Exposures ▪ Knockdown & Neutralization Efficacy Required	▪ Stand-off Detection ▪ Direct Detection ▪ Particle Detectors	▪ Chemical Properties for Neutralization – Efficacy – Solubility – Safety and Environment ▪ Physical Properties for Efficient Collection – Droplet Size – Charge ▪ Deployment – Disperse Knockdown and Neutralize: Spray into Agent Cloud

We have utilized fundamental physics and experimental work to determine the required physical properties and tested prototypes

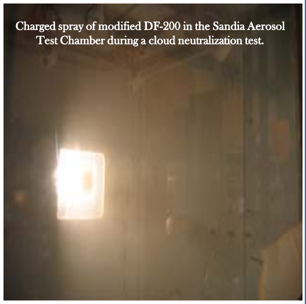


Summary of Sandia Airborne and Surface CBW simulant Decontamination

- Sandia has successfully demonstrated knockdown and neutralization of airborne CBW agent simulant releases in small spaces.
- Various deployment scenarios have also been developed using portable delivery systems for aerosolized decon.
- A portable prototype system has been developed and successfully tested with good dispersion and a high kill efficiency of BW simulant on surfaces.

A release mitigation spray safety system will remove airborne CBW contaminants, decontaminate surfaces, protect personnel, limit contamination spread, and minimize overall remediation timelines.

Charged spray of modified DF-200 in the Sandia Aerosol Test Chamber during a cloud neutralization test.



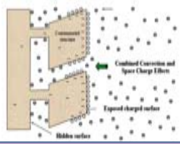
Charged Droplet Surface Deposition Model

The model begins with the premise that to have adequate deposition of a liquid on surfaces of every orientation in a room, the deposition rate of charged droplets on upward-facing surfaces should be no more than three times the deposition rate on downward-facing surfaces. For liquid droplets traveling to surfaces from an aerosol nozzle, this is possible when the velocity component due to the electrostatic force is twice as great as the velocity component due to gravity alone.

For aerosol flow in a small horizontal cylindrical tube at a constant velocity and uniform concentration, the ratio of deposition on upward facing surfaces (B) to downward facing surfaces (T) can be written as:

$$\frac{B}{T} = \frac{C_d(2\pi M r c_m^2) + G_d \cdot g}{C_d(2\pi M r c_m^2) - G_d \cdot g}$$

Where C_d is the size dependent electrostatic time constant, G_d is the size dependent gravity time constant, M is the mass-based aerosol concentration, r is the radius of cylindrical space, c_m is the charge to droplet mass ratio, and g is the gravitational force.



Applications for Aerosolized Decontaminant Sprays

Many applications for fundamental capability.

Potential applications for military use
- Force protection (battlefield)
- Force protection (fixed sites)
- Chemical demilitarization
- Immune building

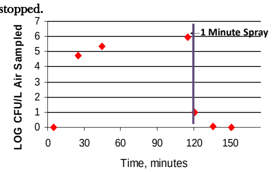
Potential applications for civilian use
- Chemical plants
- Subways
- Nuclear plants
- High-profile buildings
- Special events
- Medical facilities

Decon Efficacy of Airborne BW Simulant in a Fixed Site System

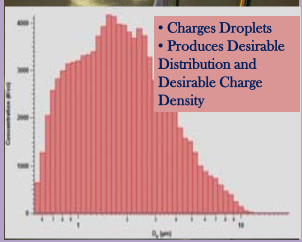
ESS Nozzles Located Inside Aerosol Test Chamber (Below)

DF-200 Knockdown & Neutralization Spray

- Sandia's DF-200 formula is non-toxic and non-corrosive.
- Tests were conducted against 'weaponized-like' *Bacillus atrophaeus* spores
- Spores were introduced into the chamber at a concentration of 10^6 log CFU/l. After 120 minutes of mixing, DF-200 spray was deployed for one minute through the ESS nozzles.
- The simulant was collected by aerosol sampling and concentration in the chamber was determined by culturing at <5, 15, and 30 minutes after the end of the spray period.
- The results demonstrated a 5 log knockdown and kill of the simulant immediately after the spray was stopped.

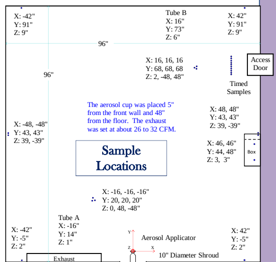


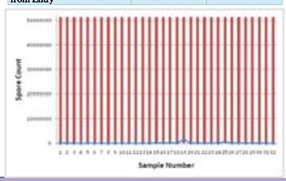
Portable ITW Nozzle for Charged Aerosol Spray of DF-200



Aerosolized, Charged Droplet Decon Efficacy on Surfaces using Rotary ITW Nozzle

Sample Location	Spore/Cell Samples	Spore Samples
Right Front Wall	1	2
Left Front Wall	3	4
Left Wall Near Ceiling	5	6
Left Wall Near Floor	7	8
Back Left Wall	9	10
Back Right Wall	11	12
Right Wall Near Ceiling	13	14
Right Wall Near Floor	15	16
Front Floor Near Applicator	17	18
Back Floor Away From Applicator	19	20
Front Ceiling Near Applicator	21	22
Back Ceiling Away from Applicator	23	24
Front Stand Near Applicator	25	26
Back Stand Away from Applicator	27	28
Partially Enclosed Box Near Entry	29	30
Partially Enclosed Box Away from Entry	31	32





The average spore count of controls is depicted in maroon in the figure on the bottom left. The blue lines show the spore count of 32 samples removed from the chamber after the run was complete. The efficacy of the process is seen by comparing the red (initial spore count) and blue (ending cell count) colors. A legend that describes the placement of coupons as they are related to sample number is provided in the top left.

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