Evaluation of Dry Fogging System for Microbial Inactivation

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Objectives

• Dry fog: An Overview
• Preliminary Studies
• Dry fog in a Containment Level 4 laboratory
• Dry fog vs computer
• Conclusions
Dry Fogging System

• Fog particle size: ~7.5µ

• 1/10 Minncare™ (Peracetic acid solution, MarCor, USA)
  – 22% Hydrogen peroxide, 4.5% Peracetic acid
Mechanism

- PAA is a strong oxidizer
- Oxidation of microbial cell proteins and enzyme systems
- Not deactivated by peroxidase, catalases that break down $\text{H}_2\text{O}_2$
Dry Fogging System

Advantages of PAA/Dry Fog System

• No residue/toxic byproducts (H₂O, O₂, CO₂)
• Effective at low temperature (10°C)
• Portable (Dry Fog System)
• Rapid Decontamination
• Rapid Aeration
• High soil load tolerance
Dry Fogging System

Disadvantages of PAA

• Material compatibility
• Compatibility to electronics?
# HCOH, GCD, DFS & VHP

<table>
<thead>
<tr>
<th></th>
<th>HCOH</th>
<th>GCD</th>
<th>DFS</th>
<th>VHP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Health Risk</strong></td>
<td>Carcinogen</td>
<td>Non-carcinogen</td>
<td>Non-carcinogen</td>
<td>Non-carcinogen</td>
</tr>
<tr>
<td><strong>Humidity Requirement</strong></td>
<td>65 - 80%</td>
<td>65 - 80%</td>
<td>65 - 80%</td>
<td>10 - 60%</td>
</tr>
<tr>
<td><strong>Microbicidal Activity</strong></td>
<td>Broad</td>
<td>Broad</td>
<td>Broad</td>
<td>Broad</td>
</tr>
<tr>
<td><strong>Neutralization</strong></td>
<td>Yes</td>
<td>No, scrubbed or vented out</td>
<td>No, aerated out</td>
<td>No, catalytically destroyed</td>
</tr>
<tr>
<td><strong>Real time con. Monitoring</strong></td>
<td>None</td>
<td>Yes</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>By-products</strong></td>
<td>Hexamine (powder)</td>
<td>Chlorites and chlorates</td>
<td>H₂O, O₂, CO₂</td>
<td>H₂O, O₂</td>
</tr>
<tr>
<td><strong>EPA registration</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Compatible to electronics</strong></td>
<td>No</td>
<td>?</td>
<td>?</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Aeration time</strong></td>
<td>Long</td>
<td>Shortest</td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>$</td>
<td>$$$</td>
<td>$</td>
<td>$$$$</td>
</tr>
</tbody>
</table>
Dry Fogging System (Portable)

Ikeuchi, USA
• AKIMist “D”
• 1-4 Nozzles
• 2.5 - 12 L/hr
• $5000 USD
• 19L reservoir
Dry Fogging System (Mini)

MarCor, USA

- MiniDry Fog System
- 1 Nozzle
- 500 mL/hr
- $5000 USD
- 500 mL reservoir
DFS Decontamination Process

3 Step Process

1. Dry Fogging
   • Up to 75-80% RH.

2. Decontamination
   • Overnight (~18 hours) for laboratory decons.

3. Aeration
   • Down to <1ppm Hydrogen Peroxide.
DFS: Decontamination Cycle

![Graph showing RH% and Temp °C over time from 9:41 AM to 1:51 PM.](Graph.png)
DFS: Process Validation

• Chemical Indicators (CI)
  ➢ Changes from white to grey or black
  ➢ Indicates a concentration greater than 1%

• Biological Indicators (BI)
  ➢ Spores of *Geobacillus stearothermophilus* (≥10^6)
Detection

- Dräger Polytron 2 w/H₂O₂ Sensor
- Dräger Pac III w/H₂O₂ Sensor
- Dräger H₂O₂ Detection Tubes
- Safe concentration: <1ppm
Small Scale Experiments: Setup
Small Scale Experiments: Setup
Disinfectant Testing: QCT

• Quantitative Carrier Test
  ➢ Soil load (BSA, Mucin, Tryptone)
  ➢ Brushed stainless steel
  ➢ Dried test inoculum
## DFS: Effect of Soil Load

<table>
<thead>
<tr>
<th>Microbial agents</th>
<th>Initial titre**</th>
<th>Exposure</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vesicular stomatitis virus</td>
<td>5.9</td>
<td>2 hours</td>
<td>NG</td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>6.9</td>
<td>1 hour</td>
<td>NG</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>6.2</td>
<td>1 hour</td>
<td>NG</td>
</tr>
<tr>
<td><em>Bacillus atrophaeus spores</em></td>
<td>5.8</td>
<td>Overnight</td>
<td>NG</td>
</tr>
<tr>
<td><em>Geobacillus stearothermophilus spores</em></td>
<td>6.0</td>
<td>30 min</td>
<td>NG</td>
</tr>
</tbody>
</table>

* Biological Indicator spore strips, contain no protein soil load

** titres are in $\text{LOG}_{10}$

NG: No Growth
Dry Fogging Experiments: Setup

- Simulated lab space
- Metal framing, polypropylene sheets
- ~700 ft³
Dry Fogging Experiments: Setup

Location of BIs: Floor (bottom), Ceiling (top), Wall (middle)

1, 6   11   2, 7

14         5, 10    12

4, 9   13   3, 8

15, 20   16, 21

19, 24

18, 23   17, 22
CFIA CL4 Lab Decon using DFS
BI Locations
DFS: Main Lab vs. Autoclave Room

![Graph showing temperature and humidity data for Main Lab and Autoclave Room.]
DFS: RH & Temp

Relative Humidity (%RH)

Temperature (°C)

Relative Humidity

Temperature
Results: Failed BIs
What happened?

- The fog failed to rise to ceiling
  - Raise fogger arm higher, articulating head fogger
- Heat from lab equipment caused stratification of T
  - Higher temp will ↓H, prevent dry fog from contacting surface
  - Add fans to circulate air, ↓heat load
- May not have achieved desired RH at ceiling
  - Add fans to circulate air
Is Dry Fogging System Compatible to Electronics?

- Test Vehicle: Dell Inspiron 560

Sheet metal
Plastic
Aluminum
Copper
Decon Chamber
Validation Conditions (RH)
Validation Plan

PCs (5)
- Control PC (1)
- Test Pcs (4)

No more exposure, only testing (1)

Powered on (2)
- 1
- 1

Powered off (2)
- 1
- 1

No more exposure, only testing (1)
Results

• BIs
  - PC, power on --> BI pass (3/3)
  - PC, power off --> BI pass (2/3)

• Physical
  - No visual evidence of corrosion, discoloration

• Functional
  - No evidence of functional impairment by PC-Doctor
Conclusions:

- Potential use for Dry fog/PAA in decontamination of high containment laboratories and sensitive electronics
- PAA able to penetrate soil load
- More validation studies required
Acknowledgements

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