Current and Novel Approaches for *Bacillus anthracis* and Surrogate Spore Decontamination

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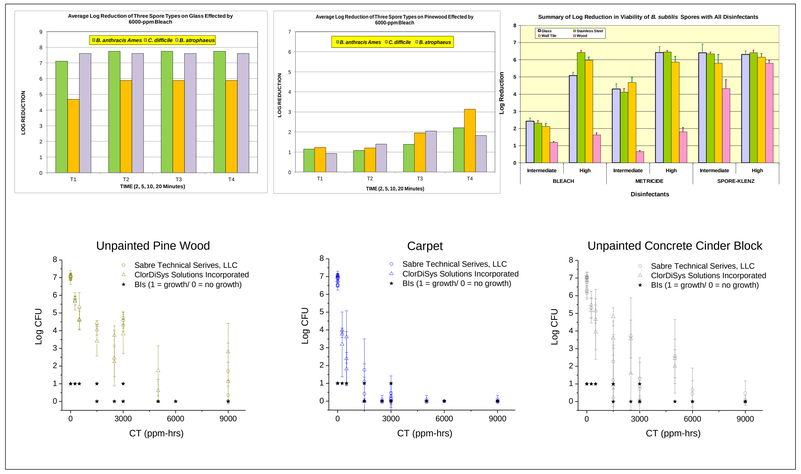
Introduction

Bacillus spores are one of the hardiest biological structures to inactivate. Spores of *B. anthracis*, the causative agent for deadly anthrax disease have been used as a bio warfare agent (BWA). Bioterrorism events on a large scale are expected to result in wide-area contamination of building interior/exterior of fixed site assets. Current doctrine for decontamination of such contaminated assets include use of fumigants, such as chlorine dioxide (CD) or vaporous hydrogen peroxide (VHP) or use of 10% bleach to decontaminate volumetric spaces and environmental surfaces. Two issues related to current doctrine for decontamination include possible spore re-aerosolization and significant generation of hazardous waste in case of bleach use.

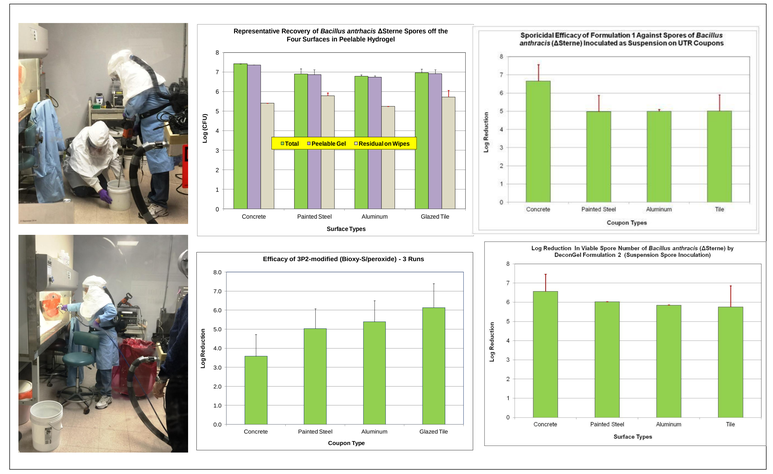
Augmented rapid germination/mild disinfection is one alternative option for *Bacillus* spore decontamination. Through collaborative efforts with CBI Polymer, Inc., our laboratory has optimized and developed a novel approach for spore decontamination. The approach is hydrogel-based and offers a highly desirable alternative for spore inactivation. DeconGel™ (DG) is a hydrogel, developed by CBI Polymer, Inc. to decontaminate surfaces contaminated with TICs/TIMs, including radiological materials. The viscous gel is either applied or sprayed over contaminated surfaces, allowed to dry, and then peeled off as a thin film. The hydrogel was modified by the addition of sporicidal components and tested for its efficacy in decontamination of *B. anthracis* spores.

Results from this study unequivocally demonstrate the effectiveness of the unmodified DG to sequester spores off the surfaces (>99.9%). The modified DG was highly effective in both, spore sequestration and spore kill (>6-logs). The results will be presented to show decontamination of environmental surfaces by the modified DG. This technology offers unique advantages over the current doctrine in not only minimizing the spore re-aerosolization but also in reducing the hazardous waste generation. For future direction, approaches based on functionalized nano-materials will be very suitable.

Sporicidal Chemicals & Gases



Efficacy of Decon Gel



Current Bio-decon Options

Liquid Sporicidal Agents -

1. pH-amended bleach (6000-ppm, pH 7) for a contact period of at least 30 minutes
   - Corrosive and requires appropriate PPE
   - Works on almost all surfaces, except cellulosic materials such as wood

2. Peroxide/per-acetic combination, such as Spor-Klenz®(~1% hydrogen peroxide, >0.07% per-acetic acid, and 5% acetic acid, pH 1.5-2) for a contact period of 30 minutes
   - Works on almost all surfaces, except concrete, soil, and aluminum
   - Potential fire hazard and requires appropriate PPE due to strong reactive nature

Fumigant Gases/Vapors -

Chlorine Dioxide (CD), vaporous hydrogen peroxide (VHP), Methyl Bromide (MB)
- Requires special handling conditions and MB is an ozone depleter
- CD and MB be scrubbed before release
- VHP ineffective on concrete, soil and aluminum surfaces
- Optimal conditions must be established specific to surface type being decontaminated
- Requires appropriate water content (75% for CD and 35% for VHP)

Thermal (Hot Humid Air) -

Chlorine Dioxide (CD), vaporous hydrogen peroxide (VHP), Methyl Bromide (MB)
- Requires 75C, 90% RH, and 3 days of exposure
- Organic debris has detrimental effects on the efficacy of hot humid air

Novel Decon Approach - Gel Concept

- Apply a viscous hydrogel polymer over the contaminated surface → let dry → peel and dispose
- CBIP developed the technology to clean and decontaminate surfaces contaminated with toxic chemicals and radioactive materials
- During the drying process, the gel traps and encapsulates the surface contaminants
- Can the DeconGel be reformulated to decontaminate C/B/R/N threat materials?

- **Reduced hazardous waste**
- **No re-aerosolization of spores, as gel locks in the threat material**
- **Gel matrix allows penetration through other contaminants to the spore surface**
- **Gel matrix improves wetting of active ingredients through the spore surface**
- **Gel matrix increases exposure time of active ingredients**
- **Forensic evidence preserved and retrievable**
- **No special trainings required**
- **Corrosiveness and material incompatibility issues significantly reduced or eliminated**
- **Long shelf-life reduces replacement cost / logistical burden**
- **Multiple options for application – spraying, pouring and spreading, brush painting**

Conclusions and Future Directions

- DeconGel has a lot of potential for indoor decon applications
- Additional surfaces must be evaluated before a real-life demonstration
- Re-formulations of base gel can easily be adapted to accommodate other developmental sporicidal chemistry
- In future, R&D must focus on developing functionalized nano-material based approaches, such as carbon nanotube
- To minimize reaerosolization, a sticky aerosol/fogging system must be developed to first augment spore adhesion to diverse common indoor and outdoor surfaces

Approved for Public Release

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