



Surfactant and Oxidant Systems for Biodecon

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Wide Area Anthracis Spore Decontamination Workshop

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Outline

- Material requirements for wide area decontamination
- Conflicting requirements for decontaminants
- EPA registration under FIFRA
- TDA Research's Applicable Decon Efforts
 - Surfactant based decon – Sensitive equipment
 - Oxidant generation
- Wide area decon applications
- Conclusions

Wide Area Decon Scale

- Assume any decontaminant will be applied as aqueous solution – liquid to distribute decontaminant and enhance mass transport, water for safety and materials compatibility
- Water required to wet surface: 0.15 L/m^2
 - Determined in tests at TDA on vertical CARC panels
- For wide area decon, this equates to 150,000 L per square kilometer (~40,000 gal)
 - Comparison: 1 cm of rainfall on this area is 1,000,000 L
- Water requirement sizes the decon applicator system; select specific decon to meet other requirements

Wide Area Decon Scale

- What to add to that 150,000 L of water?
- Surfactant to remove threats, enhance contact of reactive chemistries with threats (alone or in contaminants)
 - With TDA's SuperSoap, the amount required at full strength is 10,000 L (about 50 drums)
 - Cost of materials \$26.4K - \$96.7K
- Reactive decon plus surfactant
 - With TDA's eClO₂ system, the amount required is 15,000 Kg
 - Cost of materials \$160K - \$320K
- Material cost is insignificant compared to cost of labor and verification testing

Conflicting Requirements for a CB Decontaminant

- Highly active for immediate effect on threats
- Safe and readily transportable
- Stable for years in storage
- Should not create any residual hazard once applied
- Good materials compatibility
- Neutralize threats on surfaces – absorbed into porous materials, in corners and crevices, and in the presence of common liquids such as oil and fuel

EPA, FIFRA and Bacterial Spores

- Disinfectants or Pesticides must be registered with the Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)
- FIFRA defines a “Pesticide” as “any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest.” FIFRA § 2(u), 7 U.S.C. § 126(u).
- A product is considered to be for pesticidal purpose if it claims, states, or implies the product prevents, destroys, repels or mitigates a pest.
- Currently there are two EPA approved pesticides effective against anthrax

Sensitive Equipment Decontamination

A large military aircraft, possibly a C-130, is shown in a hangar. The aircraft is dark grey with "U.S. AIR FORCE" and the number "1532" visible on its side. A propeller is being worked on or removed from the engine. The hangar has a complex structure of white beams and supports. The text "Sensitive Equipment Decontamination" is overlaid in blue at the top.

- If anthrax spores contaminate an airplane, it's a BIG problem
- Highly sensitive to corrosion
- No reactive decontaminant will be applied
- No decontaminant not approved for aircraft will be applied

Aircraft Cleaning Compounds

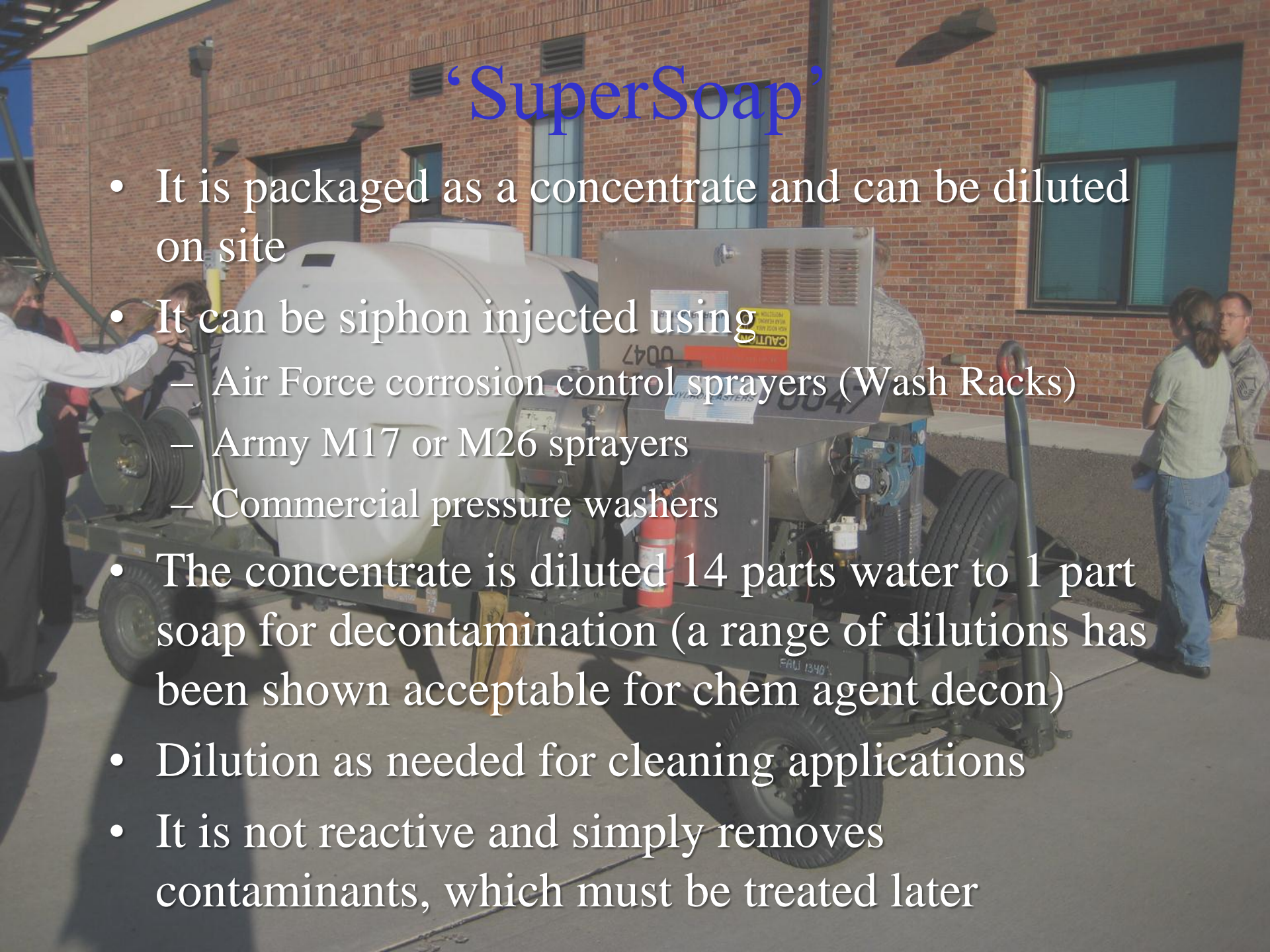
- Military aircraft cleaning mixtures are tested and regulated under MIL-PRF-87937D “Performance Specification: Cleaning Compound, Aerospace Equipment”
- 25 testing criteria involving corrosion, cleaning capability, biodegradability, toxicity, heat and cold stability and one year shelf life.
 - Requires excellent materials compatibility
- Products that pass this extensive testing can be used to clean aircraft. Products containing reactive substances will not pass these stringent tests.

‘SuperSoap’

- Is an aqueous surfactant blend that was originally formulated at P&G
- Designed to be dual purpose
 - It was developed to pass MIL-PRF-87937D as well as be effective at removing chemical and biological warfare agents
- **This keeps the product turning over instead of stockpiling large amounts of product that must be destroyed at the end of its shelf life**
- It is used identically to current aircraft cleaning protocols and can be used as a routine aircraft cleaner. Mid-range cost compared to other commercially available cleaners.

'SuperSoap'

- It is packaged as a concentrate and can be diluted on site
- It can be siphon injected using
 - Air Force corrosion control sprayers (Wash Racks)
 - Army M17 or M26 sprayers
 - Commercial pressure washers
- The concentrate is diluted 14 parts water to 1 part soap for decontamination (a range of dilutions has been shown acceptable for chem agent decon)
- Dilution as needed for cleaning applications
- It is not reactive and simply removes contaminants, which must be treated later



‘SuperSoap’

- It is non-hazardous and has no shipping restrictions
- It is made from commercially available products
- Will be available in 5 and 55 gallon quantities
- Has begun MIL-PRF-87937D testing
 - All completed tests show conformity, 22 of 25 tests completed.
 - Biodegradability and toxicity results are pending.

'SuperSoap'

- ECBC continues live chemical agent testing
- Is compatible with some reactive decontaminant components
 - Once mixed it will no longer comply with MIL-PRF-87937D
 - No longer qualified for aircraft wash

‘SuperSoap’ and Export Compliance

- TDA takes the position that ‘SuperSoap’ is not subject to U.S. export controls
 - Several surfactant products are identified in Government documents as useful against WMD and are not export controlled
- If ‘SuperSoap’ is combined with a CB disclosure or decon system that is itself export controlled, then the combination would then be subject to export controls

‘SuperSoap’

- NSWCDD will perform live biological agent testing, including tests with anthrax spores
- At this time there is no standard or EPA-approved protocol to validate spore removal efficacy
- If SuperSoap is used to mitigate anthrax spores, EPA will restrict sales and use to Federal On-Scene Coordinators, trained military personnel and persons trained by the registrants in the past 24 months (training program to be approved by EPA)
- SuperSoap could still be used in routine aircraft washing
 - Non-pesticidal claim per PR Notice 98-10

Reactive Decontaminants

- Robust materials can be decontaminated with reactive decontaminants
 - Reactive components must still have good materials compatibility
 - Must pull agents out of paint without destroying coating
 - Can not corrode metals or etch critical optics
 - Reactive component must be reactive but stable for ease of shipping and to meet shelf life requirements
 - The long shelf life reactive materials must quickly decompose after application and not persist in the environment

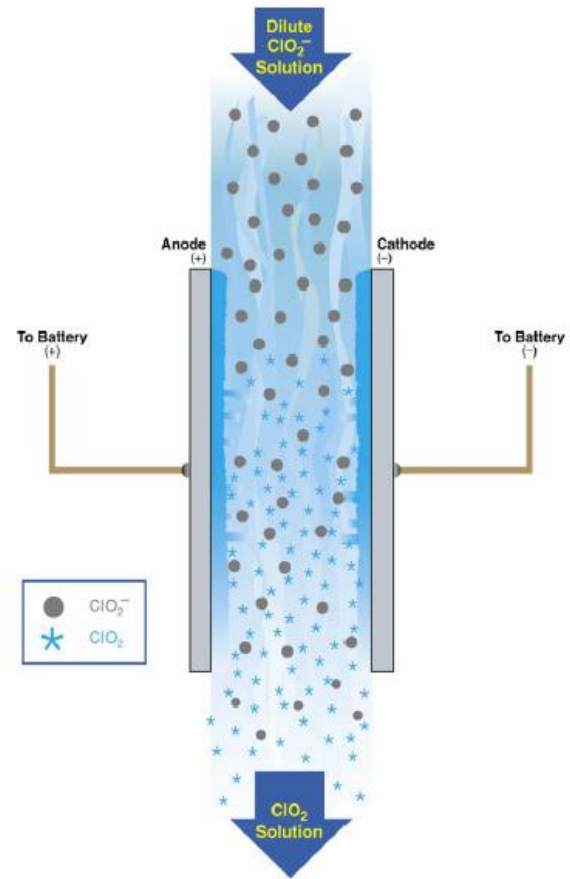
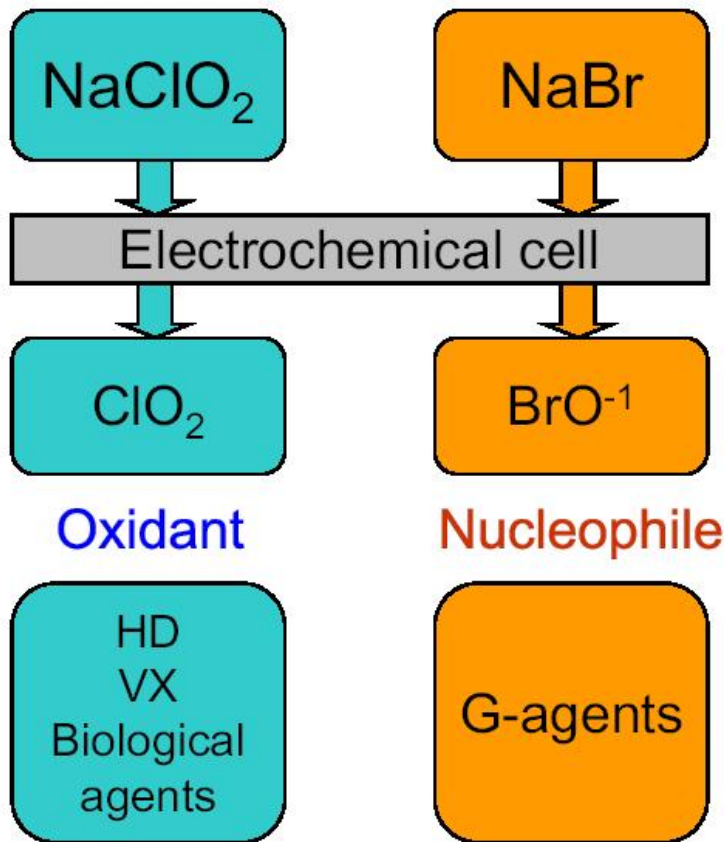
Electrochemical Decon Technology

- To resolve conflict between need for stability on storage and shipping vs. fast activity against threat agents - **generate active species on site**
- Electrical power from battery or generator is converted to chemical potential energy in electrochemical cell
- Generate active species when and where needed.

How Does the EC Decon System Work?

- “Salts” are packaged, stored and shipped as a solid.
 - Minimizing weight and bulk of decontaminant
- “Salts” are reconstituted with water on-site
 - Starting salt solutions are stable for months
- Energy stored in lithium batteries
 - 10-year shelf life
- Salt solution converted to active species during application through electrochemical cell
 - Reactive species generated as needed
- Oxidants react quickly, are not persistent
- Applicator/generator units are scalable
 - Electrochemical cell sized based on desired flow rate

Technology Summary



eClO₂ Development History

- TDA is leading development, R&D has been supported under multiple contracts
- Technology originated at P&G, adapted for use as a decontaminant effective against chemical and biological warfare agents¹
- ARO and DTRA supported development
 - Started in 2005
- TDA continues to mature the technology for the U.S. military and first responders.

¹Tinlin, J., A. Willey, V. Gartstein, L. Procell, Z. Hess, D. Gehring and M. Hall (2005). “From the Kitchen to the Battlefield: Chlorine Dioxide as a Decontaminating Agent.” DECON 2005: Joint Service Chemical and Biological Decontamination Conference, Tucson, Dec. 13-15.

Technology Overview

- Sodium chlorite and sodium bromide solution is electrochemically converted to an aqueous chlorine dioxide and hypobromite active solution
- Solid salts are dissolved in water to generate the starting salt solution. Only the solid salts are stored and transported.
- Contains surfactant to help lift agents (SuperSoap)
- Spray applicators consist of a starting solution reservoir, electrochemical cell, pump and spray wand
- Electrochemical cell and application pumps can be battery powered or powered from a generator or other source

How will it be used?

Each applicator will be packaged with a sprayer, batteries and salt package

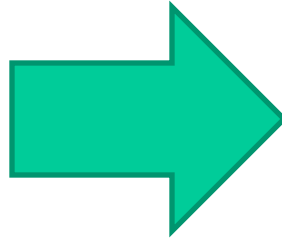
1. Tear open salt package and place contents into sprayer reservoir
 2. Fill reservoir to the line with water
 3. Shake reservoir to mix (dissolution time ~1-2 minutes)
 4. Install batteries (if not already in place)
 5. Pull trigger to apply to intended surface
 6. Ensure target is completely wetted until dripping
 7. Allow solution to reside on target for 15 minutes (or dry)
- To refill and reuse, repeat steps 1-7

Single operator can easily perform all tasks

Backpack Applicator

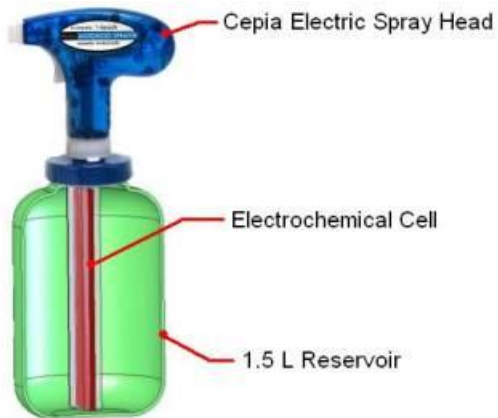
- Target Mobile Applicator
- Man portable and single operator set up and operation
- Enough decontaminant for one HMMWV sized vehicle (~14 liters)
- 1 Liter per minute flow rates
- Improved pumps, electronics, flexibility, ergonomics
 - Siphon injection, electrochemical cell bypass
- Unit hardened for demonstration
- Improved hand wand and spray nozzle

Backpack

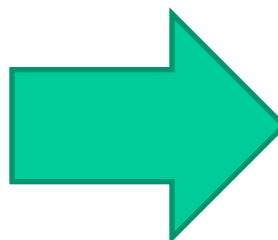
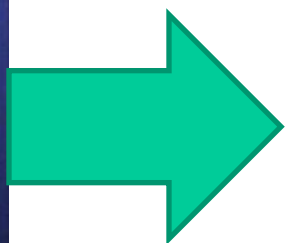
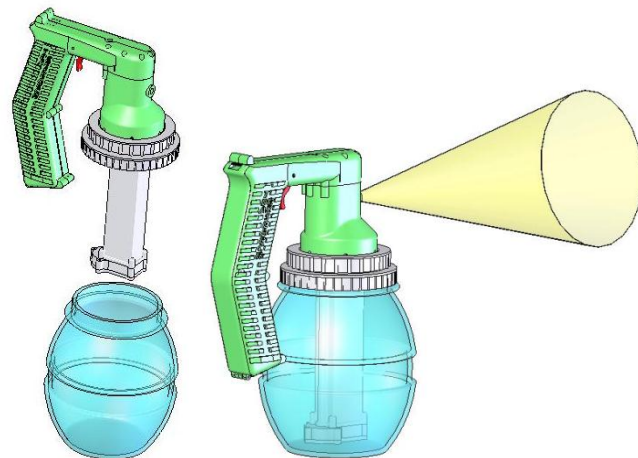


Handheld Applicator

- Initially deemed too small for operational needs.
 - One liter capacity, hatches and latches
- Inexpensive, disposable units were assembled for laboratory testing
 - Backpacks are too large and cumbersome for lab testing
- Flow rates around 250 – 350 ml per minute
- Li primary battery operated, 10 year shelf life
 - Powers pump and electrochemical cell
- One event use field item, keeps cost down and minimizes maintenance
- Improved reliability, hardened unit for demonstration



Handheld



Materials Compatibility

Two separate materials compatibility testing **series** have been performed

1. Based on established ASTM testing procedures

No obvious material incompatibilities have been determined

2. Testing according to TOP 8-2-061 “Chemical and Biological Decontaminant Testing”

Only bare 4140 steel showed an increase in corrosion rate with immersion (less than Bleach)

- Conclusions:

- Electrochemical decon has good materials compatibility with military surfaces. There is an increased corrosion rate observed on unpainted steel, however painted steel is not affected and CARC coatings are not softened.

Bio-Efficacy Against Spores

- TDA with SGM Biotech (Bozeman, MT) have investigated the efficacy of the technology using *B. atrophaeus* spores (Anthrax spore surrogate)
- Growth/no-growth and population testing used to determine effectiveness
- Variables
 - Surfaces: Glass, Tire Rubber, CARC coated Al
 - Temperature
 - Contaminants: Diesel fuel, antifreeze, blood simulant
- The eClO₂ system was effective at high and low temperatures, and in the presence of contaminants

Bio-Efficacy

- Bio-efficacy testing for EPA registration of the technology under FIFRA as a sporicidal decontaminant is complete (SBIR Phase II)
- Testing protocol approved by EPA using GLP
- Testing performed at NSWCDD (Dr Tony Buhr)
- Results:
 - Reduction of *B. anthracis* Δ Sterne (EPA approved organism, non-virulent) **7 log reduction in less than 1 minute**
 - Reduction of *B. anthracis* Ames (virulent, BSL 3 testing) **7 log reduction in less than 1 minute**

EPA Registration

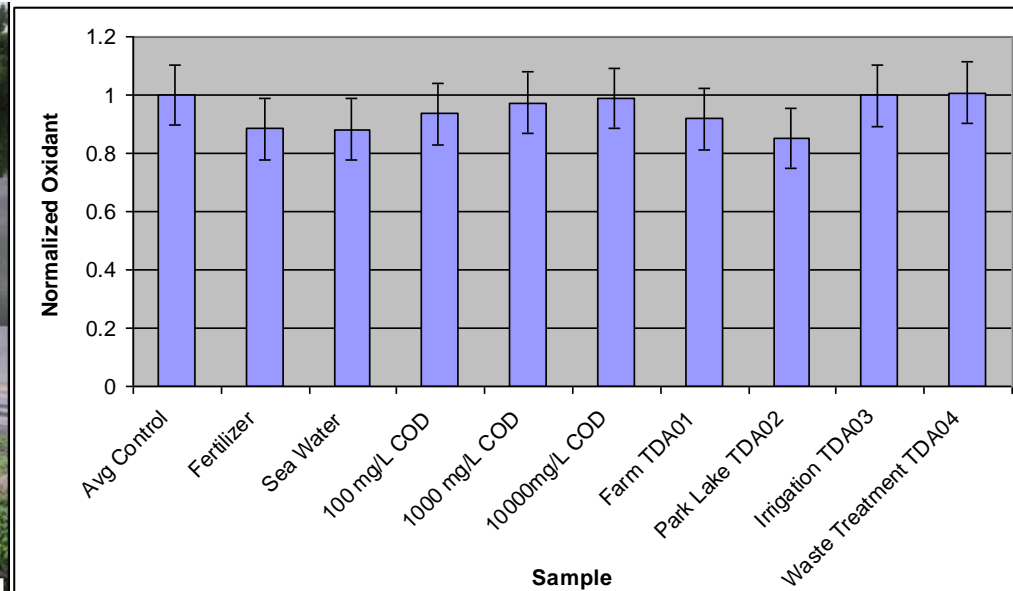
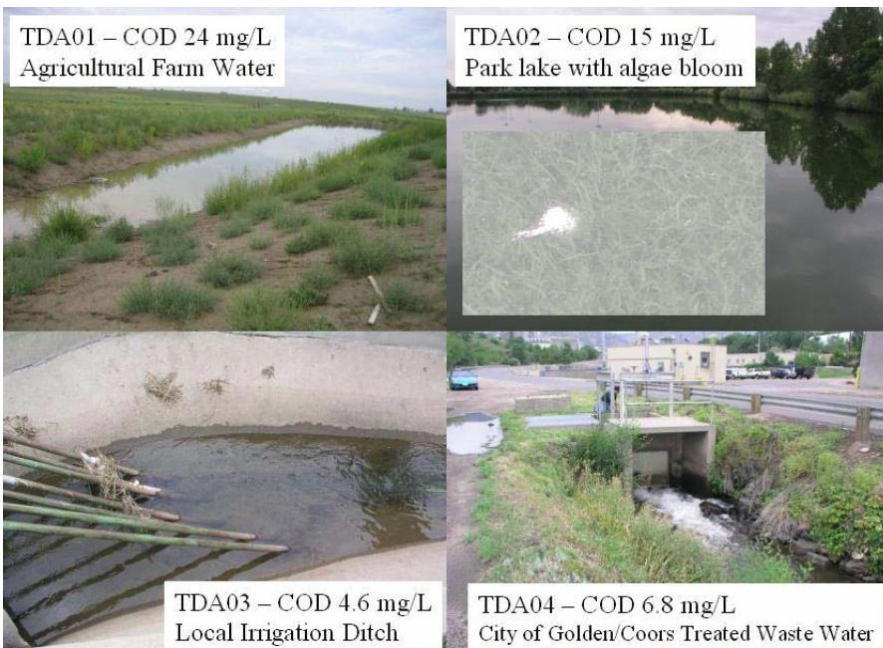
- The eClO₂ system has minimal environmental impact due to short lifetime of active ingredients
- Still requires comprehensive toxicology testing and product chemistry as mandated by EPA
- Once that work is complete, TDA will apply for registration

Oxidant Lifetimes

- Both chlorine dioxide and hypobromite degrade, they are not persistent in the environment
- Oxidant concentration decreases over time (even in the absence of chem-bio agents)
 - There is a significant change in 0 to 30 minutes
 - The oxidants are essentially gone within an hour
- Reactive oxidants are generated on demand, used immediately then degrade

Water Sources

- Any surface water can be used
- Tests have included Seawater, multiple surface water samples and artificial control samples
- All oxidant levels within one standard deviation of DI water control



Warfighter Review

- eClO₂ has been evaluated by warfighters during the HaMMER ATD EUA #1
- Questionnaires showed the warfighters appreciate its ease of use, safe transport, on demand generation of oxidants, reduced logistical footprint and rapid mixing

Wide Area Decon Applications

- Sensitive equipment, airports/airplanes can be decontaminated using commercial spray applicators and TDA's 'SuperSoap' product
- The effluent would be captured and remediated (e.g., bleach) to ensure deactivation of the anthrax spores
- SuperSoap can be applied in combination with some reactive species for biodecon
 - Compatible with $e\text{ClO}_2$ and others

Wide Area Decon Applications

- The electrochemical decon technology is scalable. Larger units have been designed but not assembled.
 - Larger electrochemical cell is required for higher flow rates. Generator to power.
- Oxidants are not persistent and do not remain in the environment. Surfactants are biodegradable.
- Broad Spectrum: works against Bacillus spores, viruses and vegetative bacteria
- Rapid: Anthrax Deactivation within 1 minute of contact

Wide Area Decon Applications

- **eClO₂ Logistics:**
 - Components are commercially available solids, already used industrially in large quantities
 - Low Cost
 - Shipped as solids and mixed with available water on site.
 - Once mixed with water the solution is stable for months.
 - Reactive species generated when and where needed.
 - Can be shipped easily on commercial aircraft.
 - Small amounts of decontaminant are required, enough to wet the surface until dripping. Surface must remain wet for at least 1 minute

Wide Area Decon Applications

- Both ‘SuperSoap’ and eClO₂ have extensive live agent testing already collected or funded to be collected.
 - Low development risk
- Data collection has been on militarily relevant surfaces
- Neither has been tested on ‘civilian’ surfaces (concrete, carpet, latex paint, etc)
- eClO₂ efficacy is well documented
 - FIFRA registration is underway

Summary

- SuperSoap and eClO₂ are effective decontaminants against both chemical and biological threats
- SuperSoap was formulated for materials compatibility and removal of chem bio agents
- eClO₂ is very effective and quickly destroys *B. Anracis* Ames Spores within one minute contact
- eClO₂ registration with EPA under FIFRA as a bacterial sporicide is underway
- Both SuperSoap and eClO₂ were developed for vehicle size decontamination but their success could be leveraged for wide area decontamination needs

Acknowledgements

- Dr Alan Willey and his team at P&G
- Dr Tony Buhr and his team at NSWCD

- Funding
 - DTRA
 - Electrochemical decontamination system
 - Currently funded under contract HDTRA1-10-C-0042
 - ARO
 - ‘SuperSoap’
 - Currently funded under contract W911NF-10-C-0062