Self-Decontaminating Materials & Multifunctional Coatings Workshop

In Search of the Silver Bullet: The Reactive Solution

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Air Force Research Laboratory

Report Documentation Page

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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Self-Decontaminating Materials

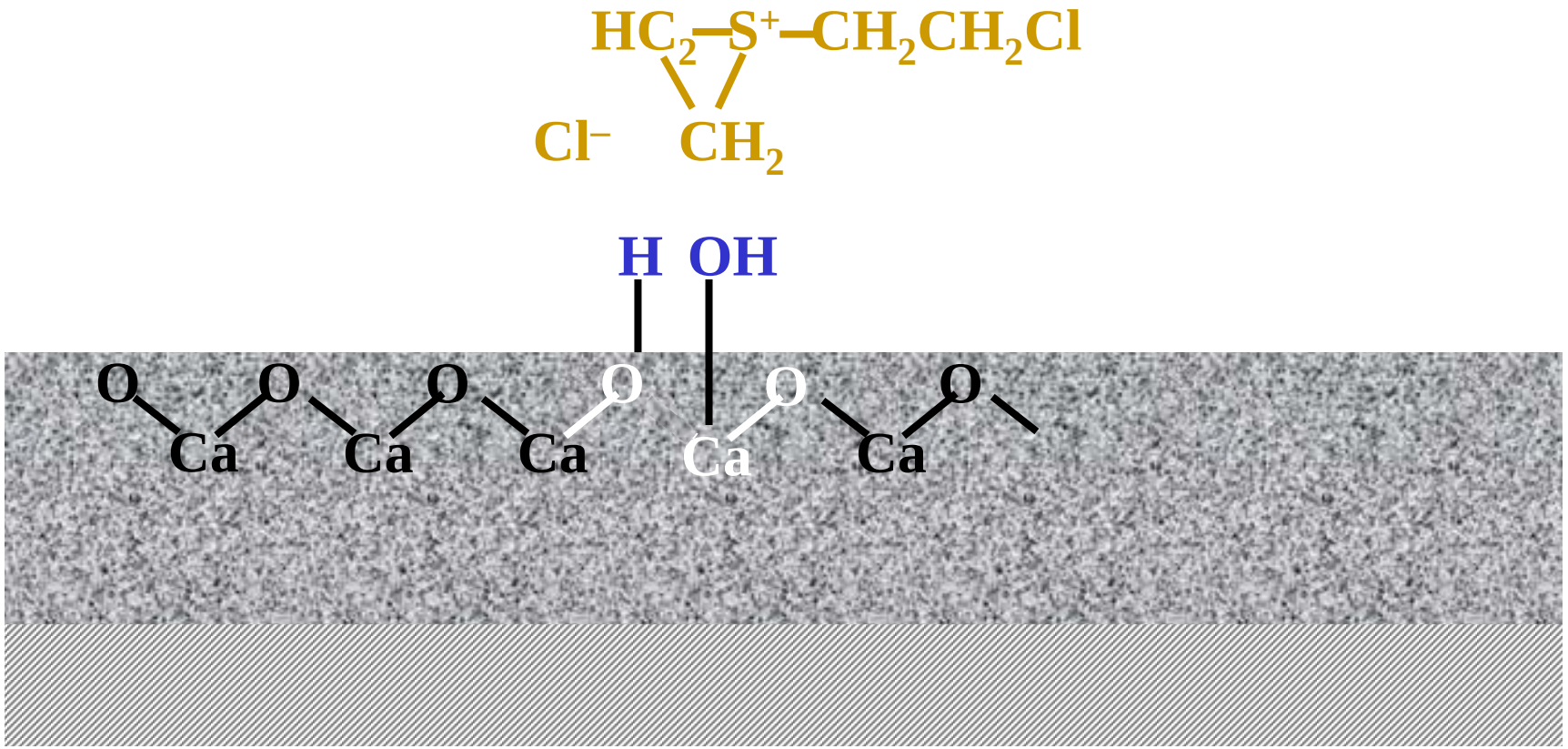
CONCEPT:

Development of ‘upgradeable’ coatings and textile treatments that will react to neutralize and/or entrain pathogens, toxic industrial chemicals/materials (TIC/M), radioisotopes, and/or chemical agents on contact.

The property of self-decontamination may reside in one or more components rather than throughout complete systems.

Intrinsic Self-Decontaminating Material

HD on concrete surface



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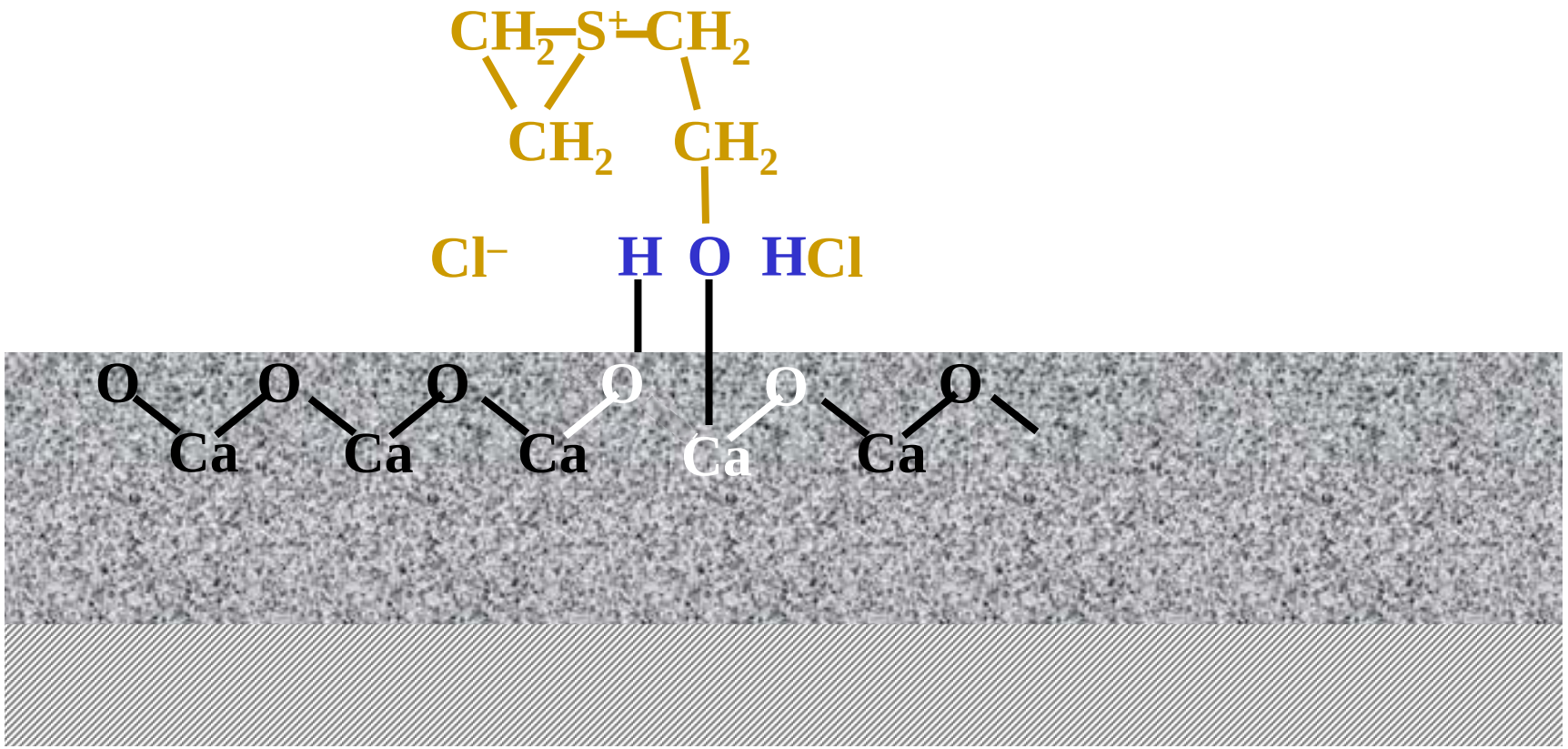

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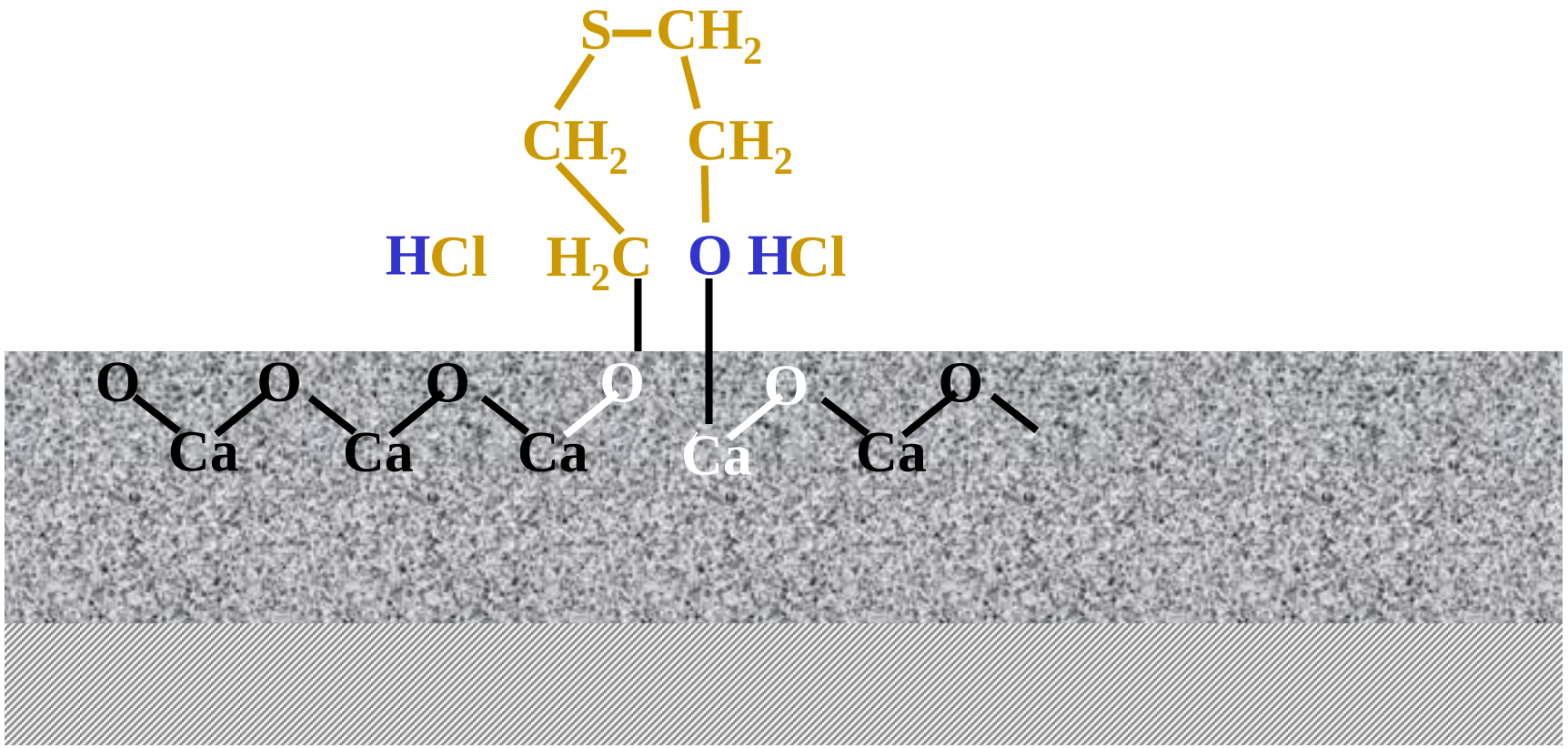

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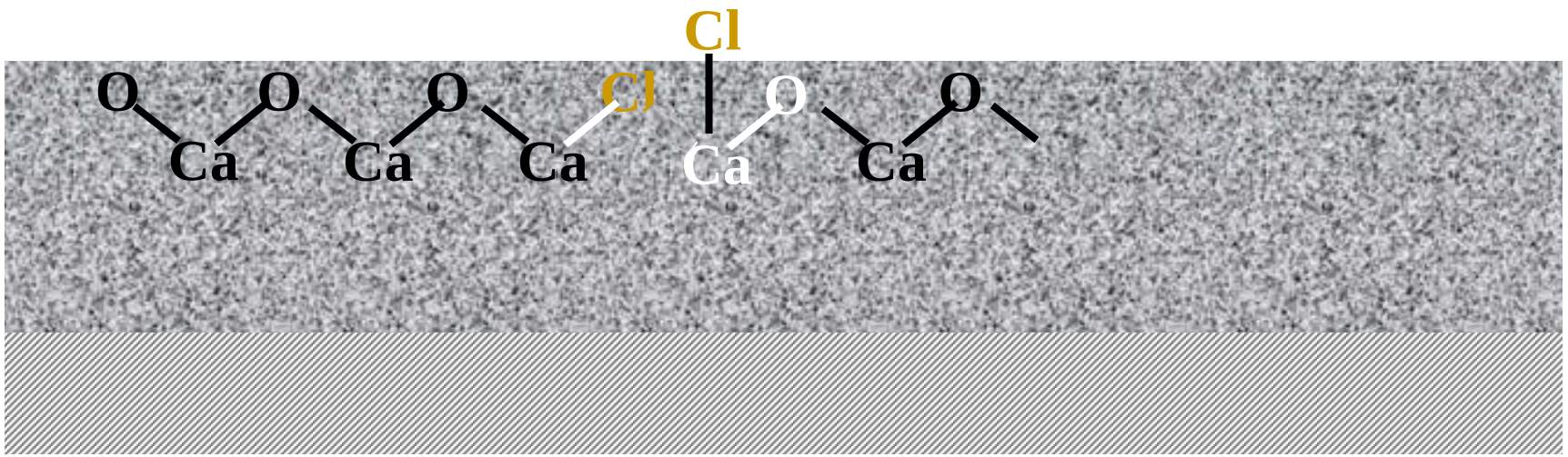
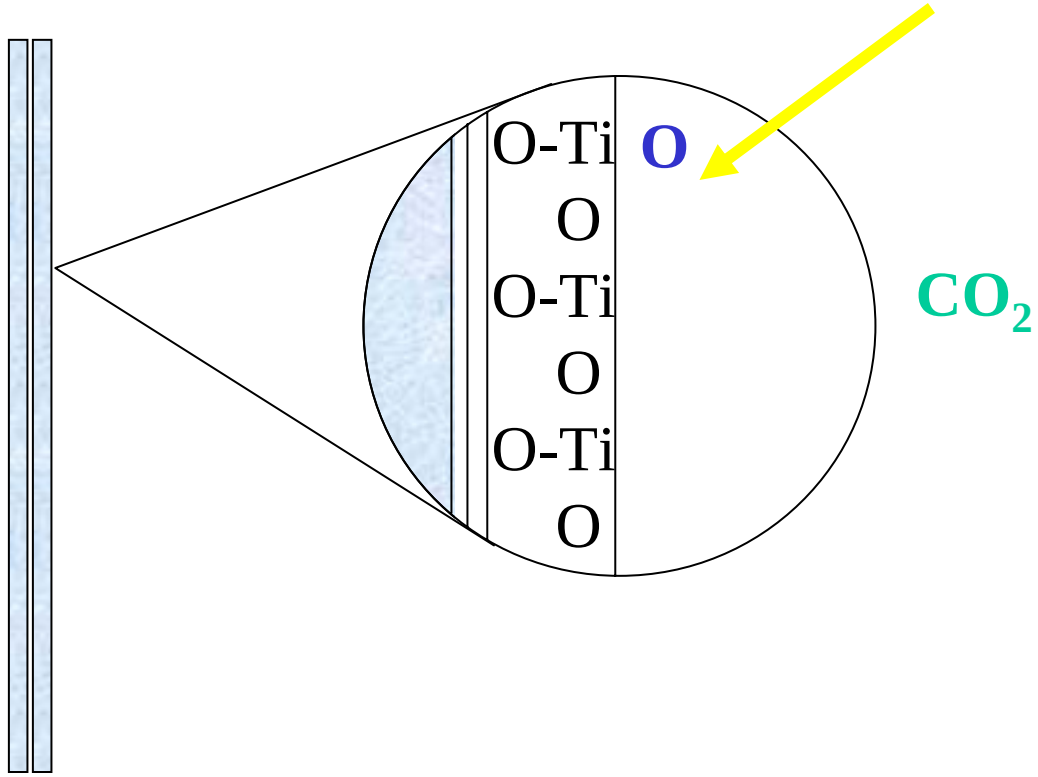


Commercially Available Self-Decontaminating Material

PHOTOCATALYTIC (SELF-CLEANING) GLASS:

Layered, composite material. Excludes most infrared.



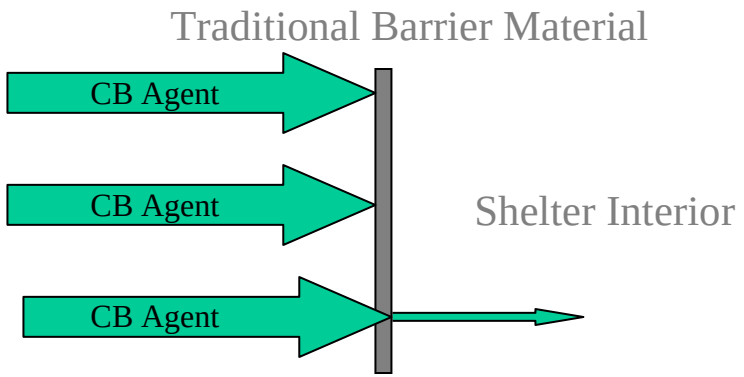
Technical Approach

“Impermeable” Barrier Materials

•All barrier materials will fail (72 hours for current systems)

•Hermetic isolation => environmental stress

•Better barrier materials => to higher costs

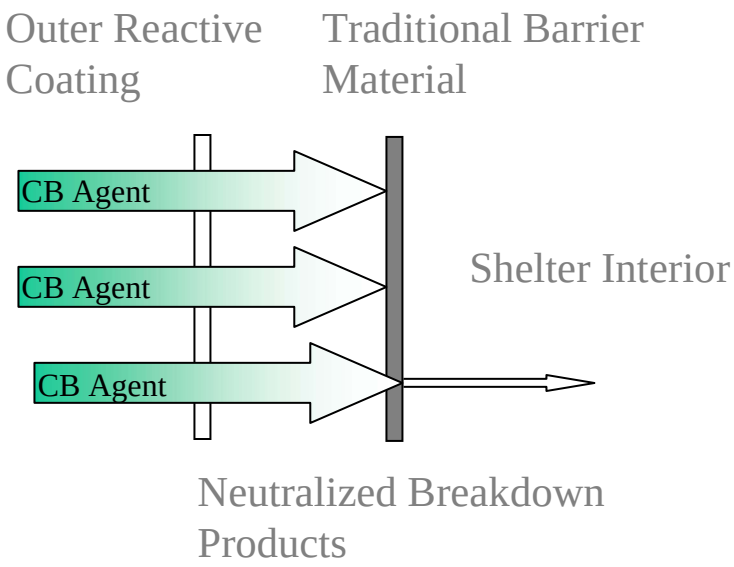


Reactive/Barrier Materials

•Neutralization products as the surface act as prophylactic

•Only neutralized products permeate through the reactive barrier component

•Shelter materials can now be made using less expensive barrier materials augmented with a reactive coatings



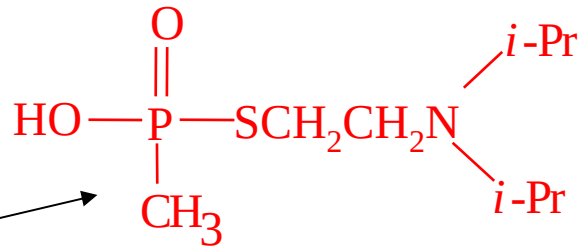
What We Have

Kills Bugs

- cell toxicity
- membrane disruption
- oxidation

Neutralize VX

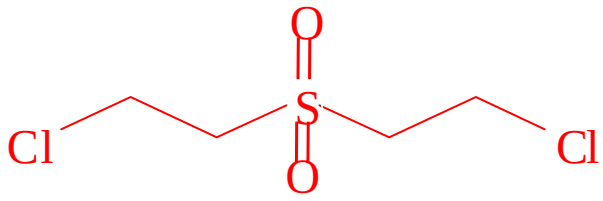
- oxidation
- hydrolysis
- nucleophilic attack



EA2192

Neutralize G-agents

- hydrolysis
- nucleophilic attack

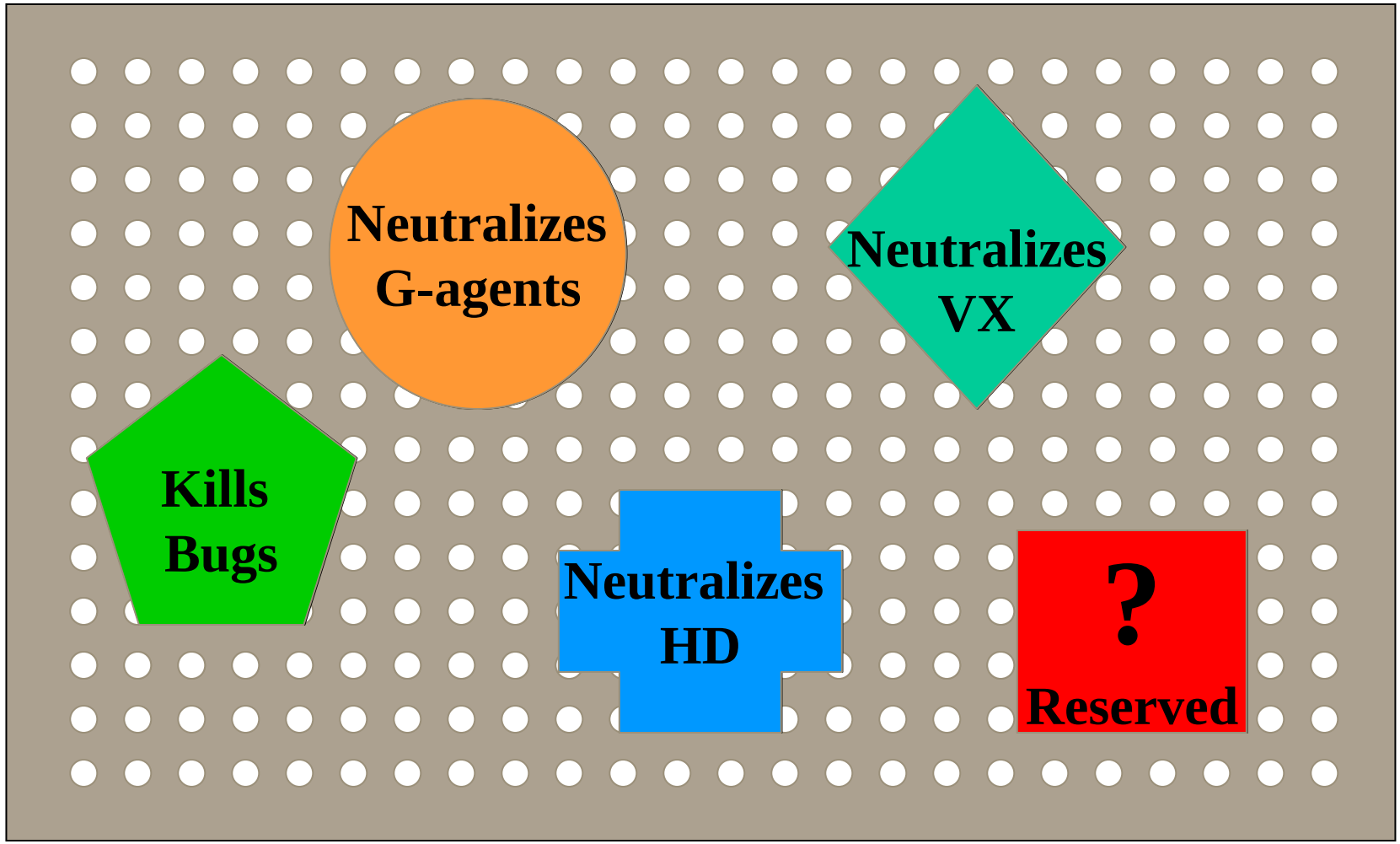


HD-Sulfone

- oxidation
- hydrolysis

Neutralize HD

What We Want


Neutralizes G-agents
Neutralizes VX
Kills Bugs
Neutralizes HD
?
Reserved

Reactive Monomer Criteria

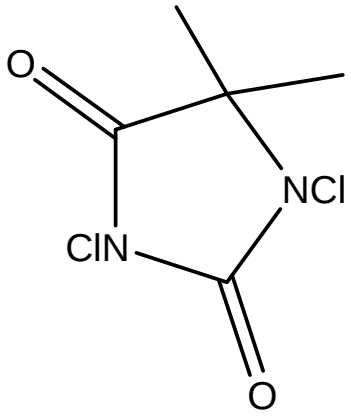
- Active against the things we're worried about
- Neutralization products relatively non-toxic
- Non-specific
- Catalytic or regenerable
- Contain sacrificial attachment functionality
- Mustn't significantly degrade each other or the polymer matrix

Reactive Monomer Selection

Weak oxidizers within a band of reactivity that targets specific functional groups

Chloramides

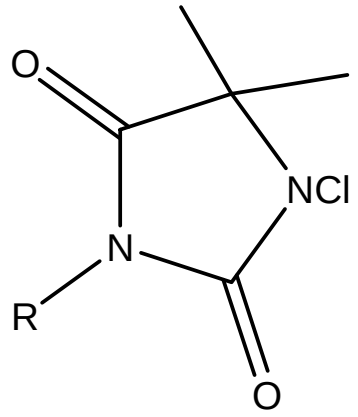
Chloramides

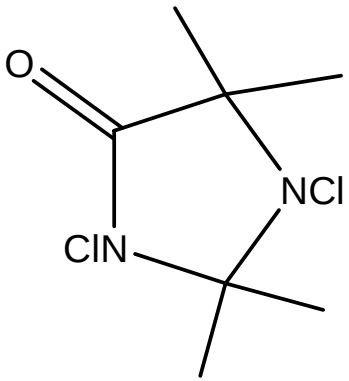


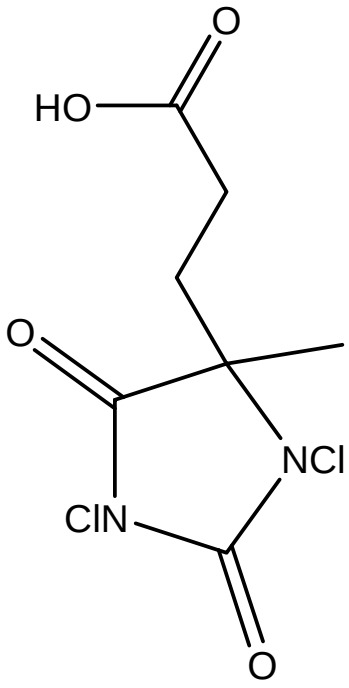
1,3-Dichloro-5,5-dimethyl-hydantoin

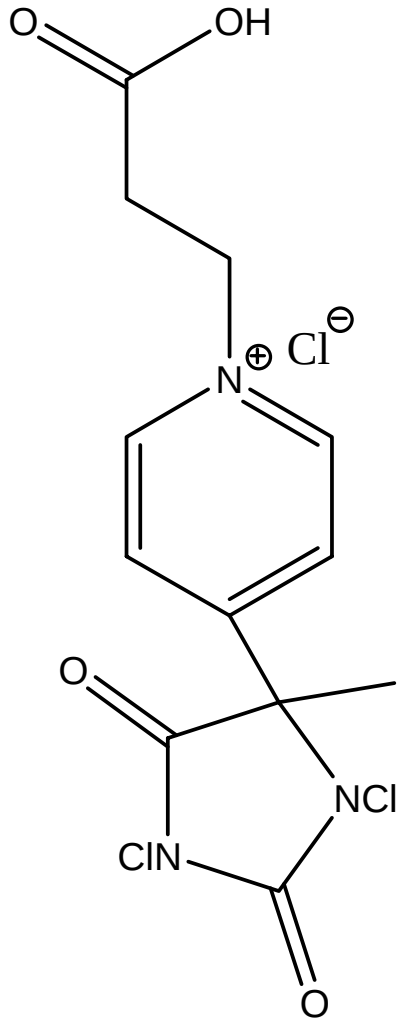
- CWA decontaminant (DANC, RH-195).
- Antibiotic
  - nonspecific
  - acts on contact
  - broad-spectrum
- $>N^-$ **Cl[+1]**
- Benign

Chloramides

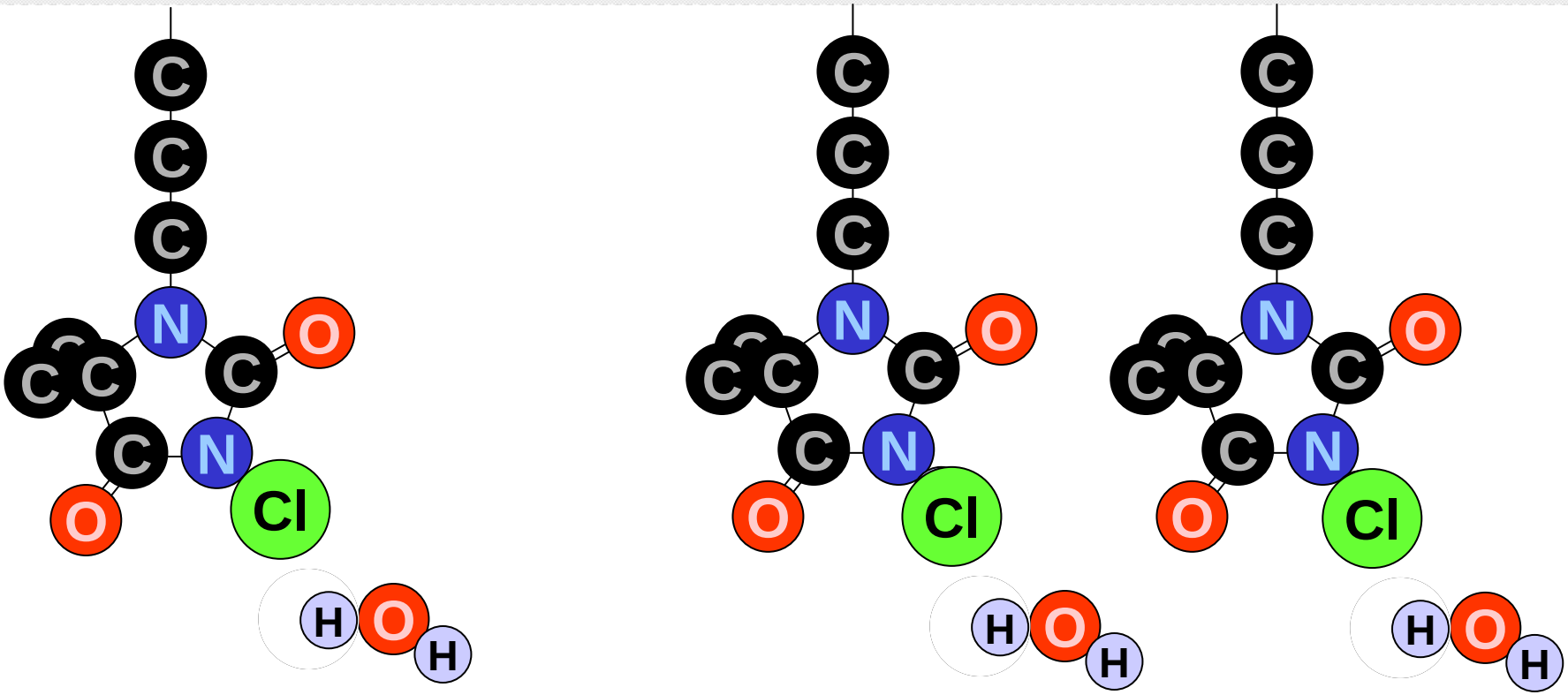








Chloramides of the World… Regenerate!



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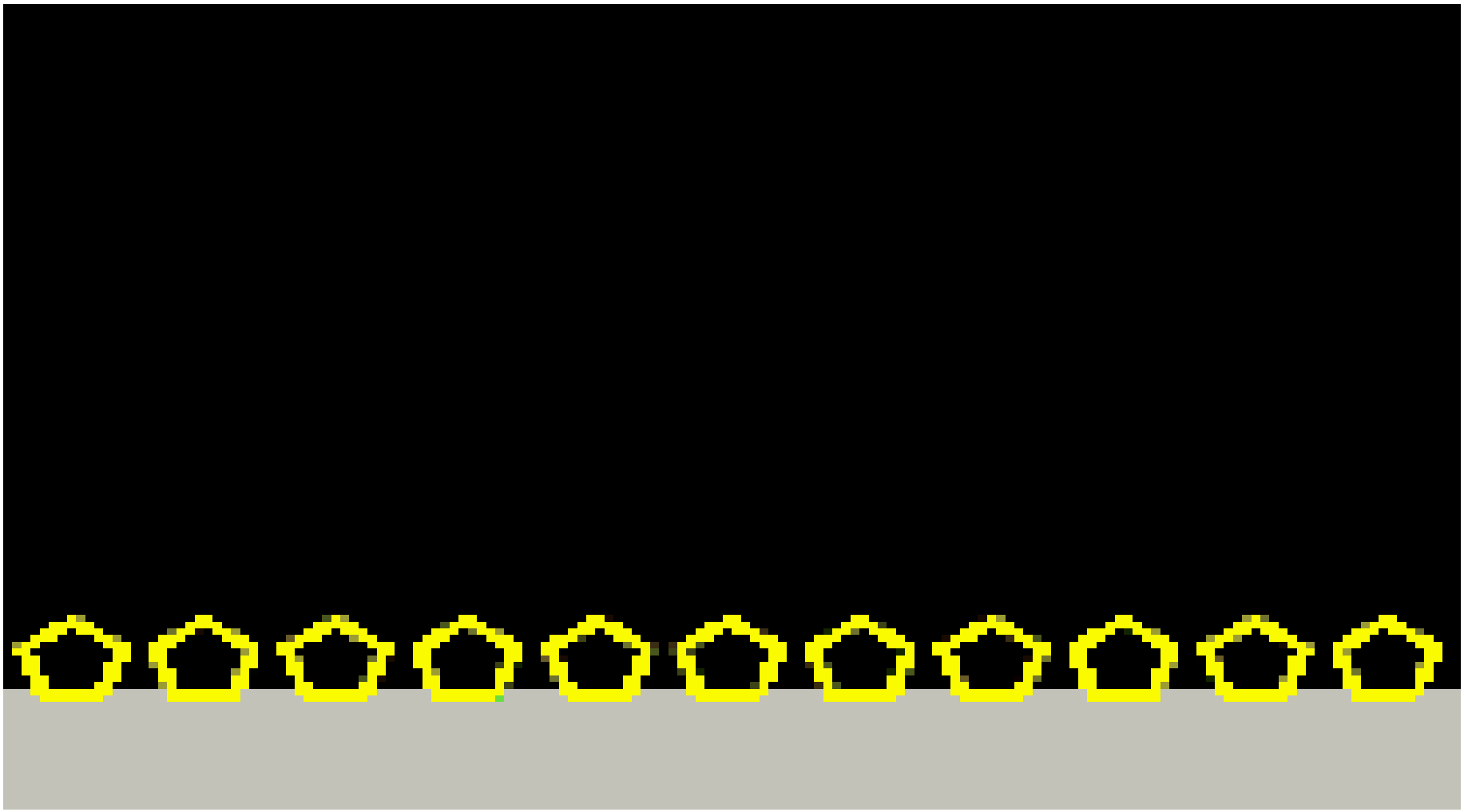
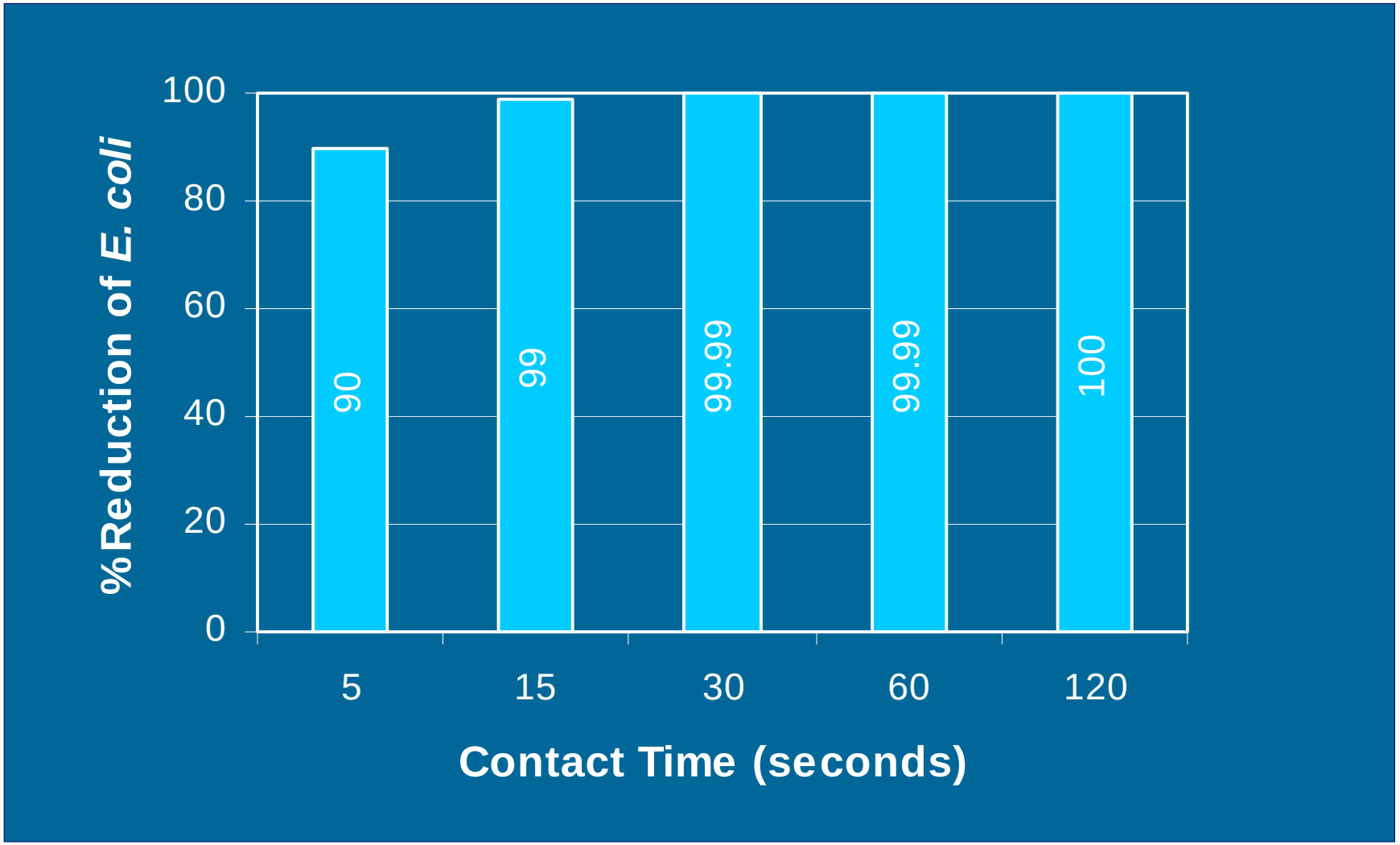
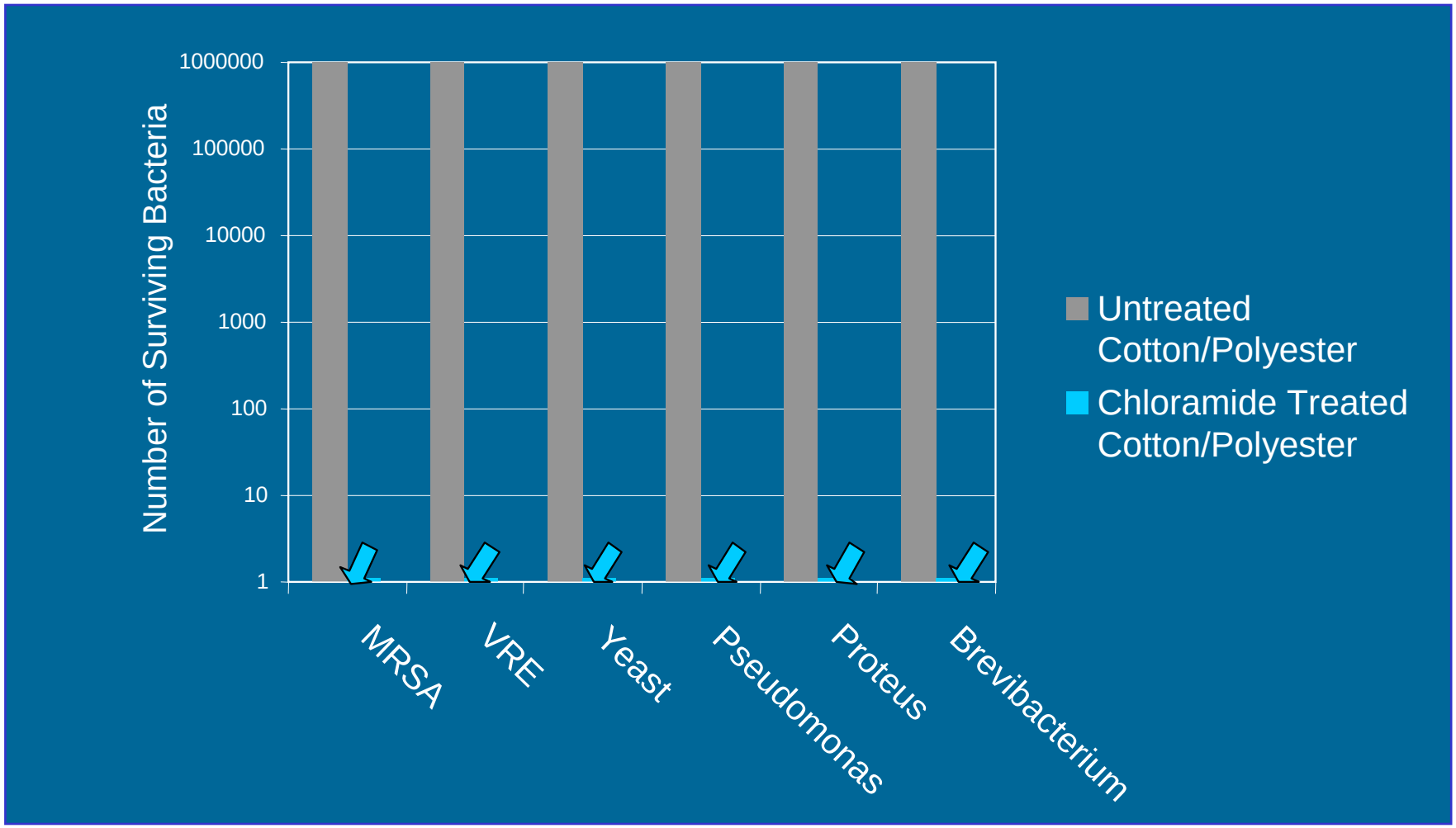


Chloramides Kill Bugs…



Indiscriminately!



After two minutes exposure

Including the Ones We Care About

Microorganisms	Disease
Escherichia coli	Gastroenteritis
Staphylococcus aureus	Abscesses, wound infection
Salmonella choleraesuis	Gastroenteritis
Shigella	Gastroenteritis
Candida albicans	Yeast, diaper rash
Brevibacterium	Diaper rash
Pseudomonas aeruginosa	Skin & lung infection
Tricophyton mentagrophytes	Fungus, Athlete's Foot & Jock Itch
Vancomycin resist. Enterococcus	Antibiotic resistant bacteria
Staphylococcus epidermidis	Foot odor

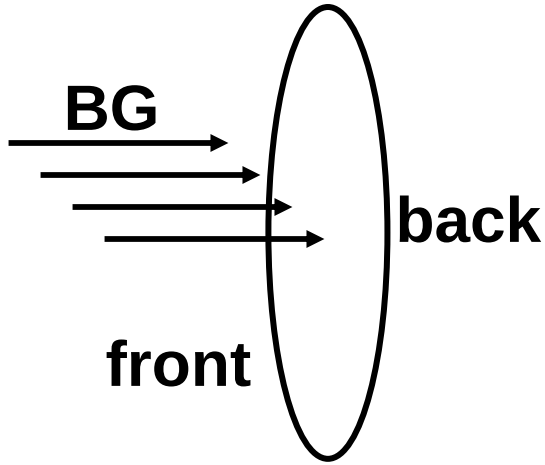
Including the Ones We Care About!

AEROSOL CHALLENGE TEST

BG Spores, 10 min flow

525-675K Spores, 1 hr Incubation

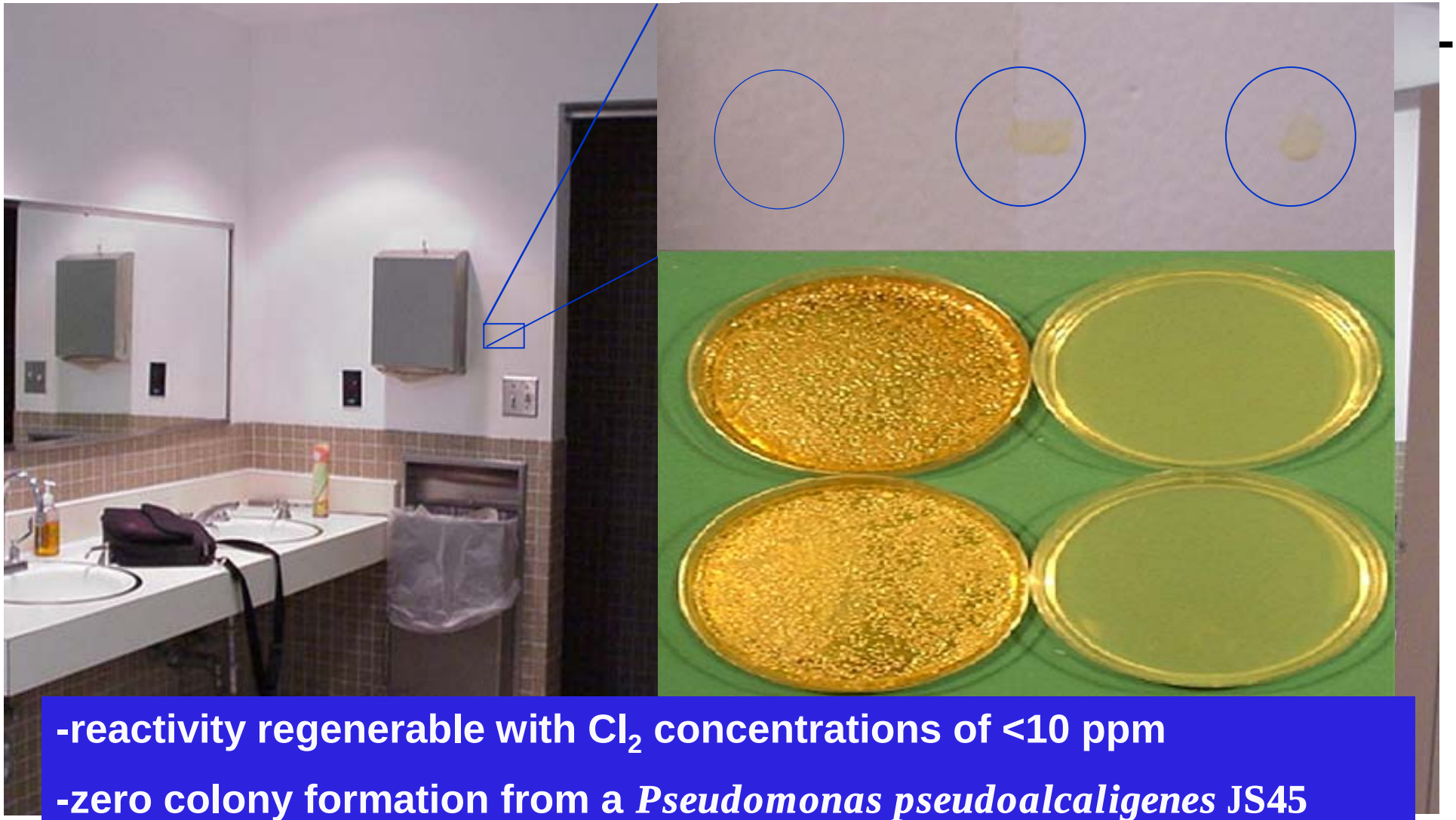
Plate Back Surfaces and Count



RESULTS

SAMPLE	Penetration (%)	Front (counts)	Back (counts)
Shell/Espun	3.0	36,000	1,150
Shell/Espun/Chloramine	2.7	29,000	720
Shell/Coated/Chloramine	9.6	1,610	0

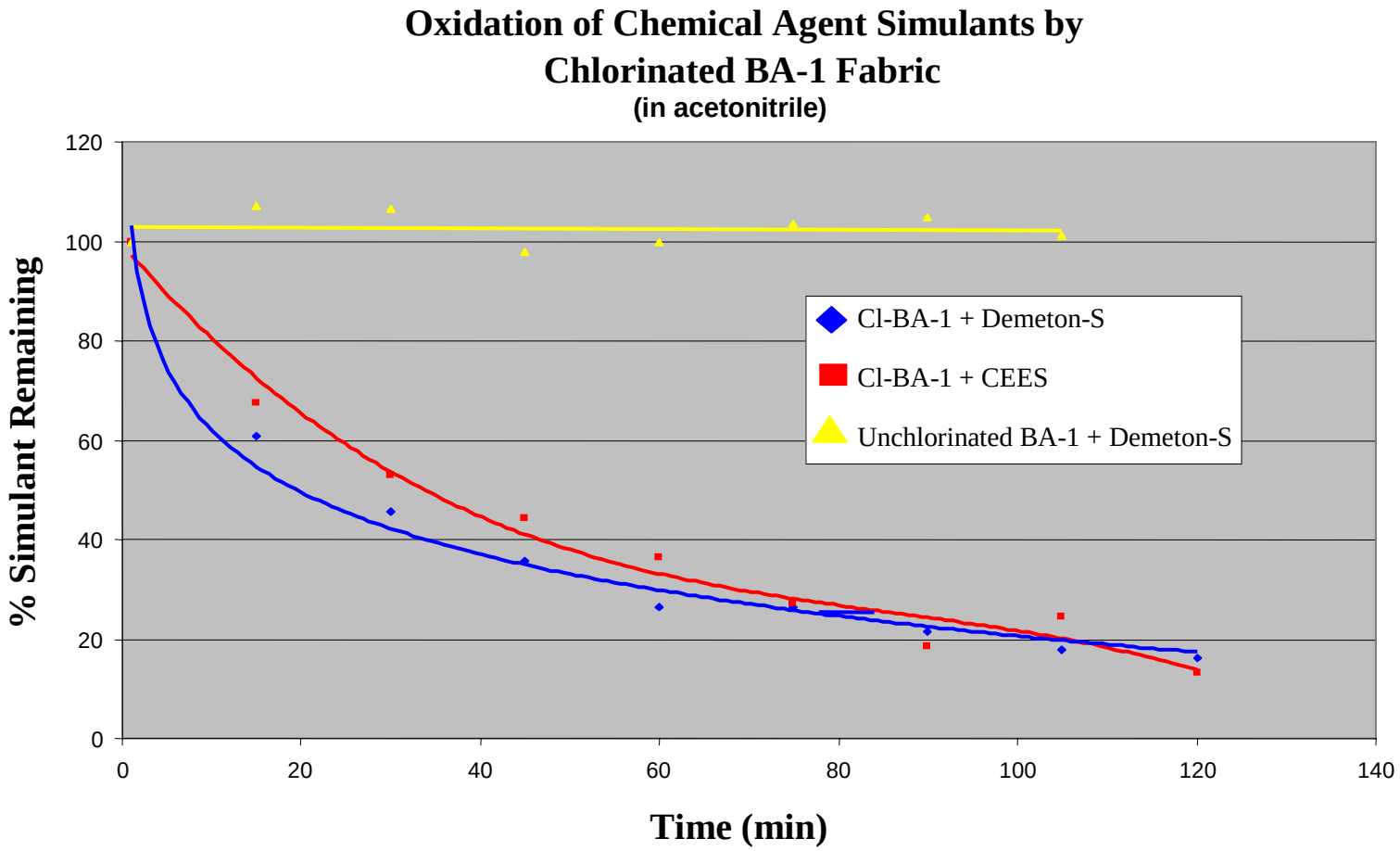
Practical Experiment



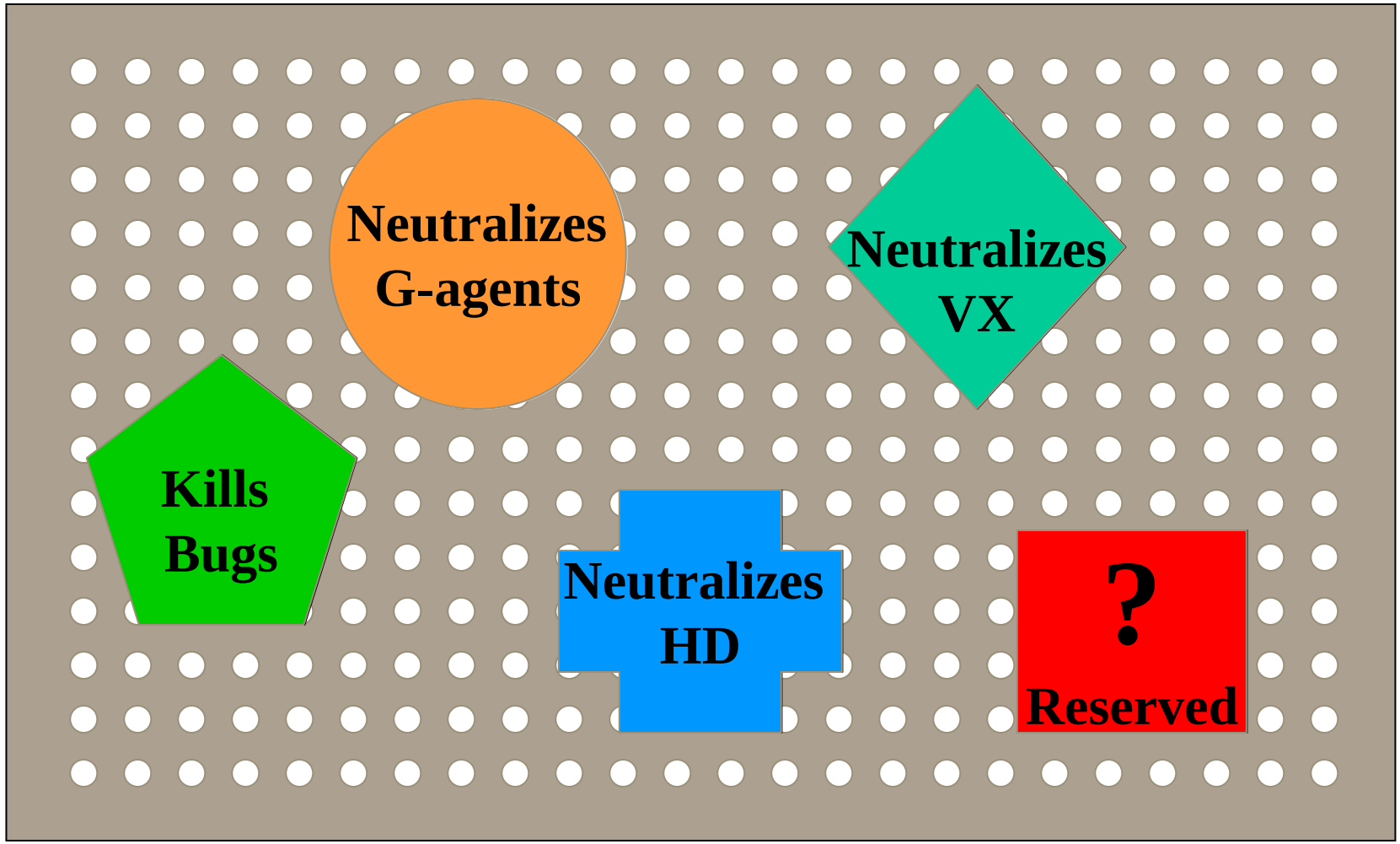
-reactivity regenerable with Cl_2 concentrations of <10 ppm

-zero colony formation from a *Pseudomonas pseudoalcaligenes* JS45 challenge after three, six, nine and twelve months w/o recharging

Chloramide Reactivity to Chemical Agent Simulants



What We Want

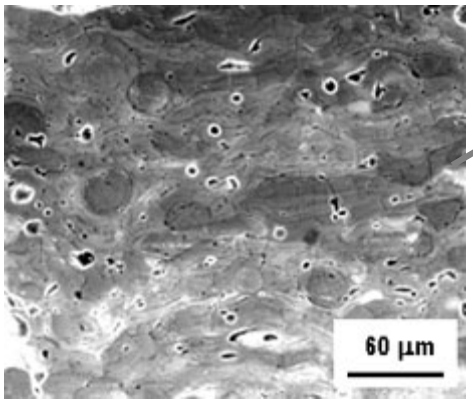

Neutralizes G-agents
Neutralizes VX
Kills Bugs
Neutralizes HD
?
Reserved

We’re Getting There

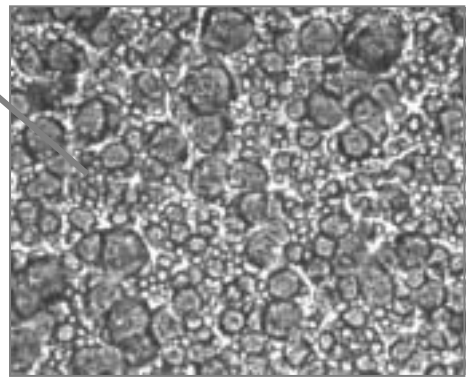
HOOC COOH

Reactive Coating Formulation

- COTS coatings were evaluated for desirable barrier characteristics, ease of application, cost, and compatibility with reactive monomers
- Waterborne, thermoplastic poly(vinylidine fluoride) coating systems were chosen primarily for its barrier properties and ease of incorporation of the reactive component
- Stable coating emulsions containing reactive nanoparticles were successfully formulated



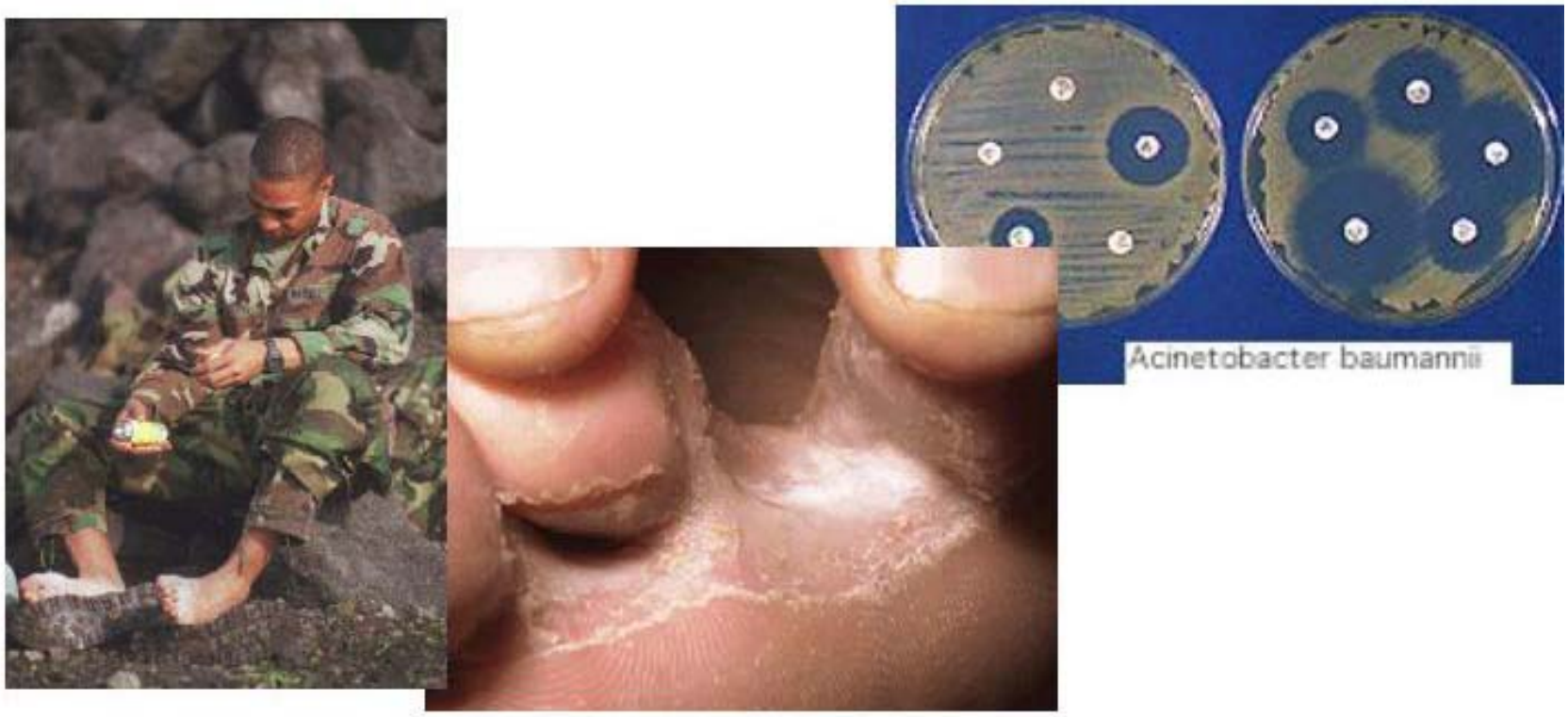
Reactive nanoparticle powder bound in breathable fluoropolymer coating.



Relevant Publications

- 1. Worley, S D; Li, F; Wu, R; Kim, J; Wei, CK; Williams, J F; Owens, J R; Wander, J; Bargmeyer, A M; Shirtliff, M E, 'A Novel *N*-Halamine Monomer for Preparing Biocidal Polyurethane Coatings,' submitted; *Surface Coatings International Part B, Coatings Transactions;* AFRL-ML-TY-TP-02-4629, Air Force Research Laboratory; Tyndall AFB, Florida (2002).
- 2. H. Lomasney and C Lomasney, National Science Foundation Phase I SBIR #1208081 Final Report "Cost Effective Production of Alumina Nanoparticles for Anti-Corrosive Coatings", Isotron Corporation (2002).
- 3. J. Lin, C. Winkelmann, S.D. Worley, J. Kim, C-I. Wei, U. Cho, R.M. Broughton, J.I. Santiago, J.F. Williams, J. Appl. Polym. Sci., in press.
- 4. 1. Kuhm, J O, "Acute Dermal Irritation Study In Rabbits,' *Treated Fabric (HTC) Final Report*; Laboratory Study NO. 5650-00; Oppts NO. 870.2500; 12 June 2000, Stillmeadow Incorporated; Sugar Land, Texas; Kuhm, J O, 'Acute Dermal Irritation Study In Rabbits,' *Control Fabric Final Report*; Laboratory NO. 5649-00; Oppts NO. 870.2500; 12 June 2000, Stillmeadow Incorporated; Sugar Land, Texas; Kuhm, J O, 'Acute Dermal Irritation Study In Rabbits,' *Activated Fabric (aHTC) Final Report*; Laboratory NO. 5652-00; Oppts NO. 870.2500; 12 June 2000, Stillmeadow Incorporated; Sugar Land, Texas; Kuhm, J O, 'Acute Dermal Toxicity Study In Rats,' *Activated Fabric (aHTC) Final Report*; Laboratory NO. 5651-00; Oppts NO. 870.1200; 12 June 2000, Stillmeadow Incorporated; Sugar Land, Texas; Kuhm, J O, 'Skin Sensitization Study In Guinea Pigs,' *Activated Fabric (aHTC) Final Report*; Laboratory NO. 5655-00; Oppts NO. 870.2600; 10 July 2000, Stillmeadow Incorporated; Sugar Land, Texas.

Applications



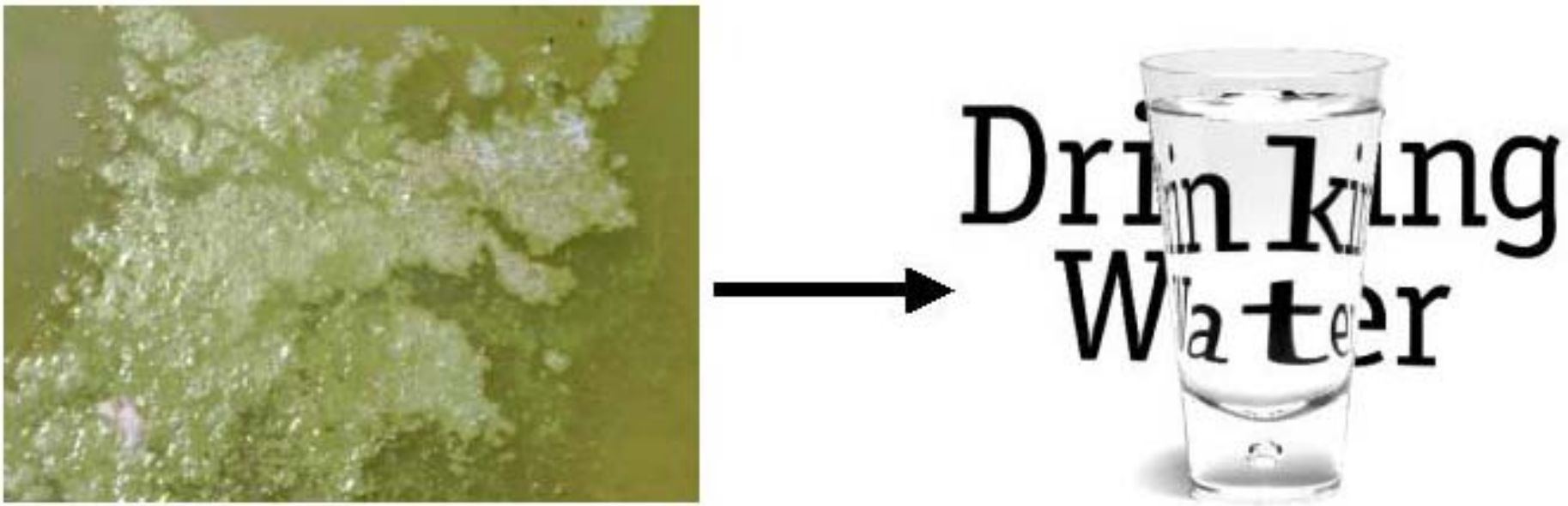
Infection Control

Applications



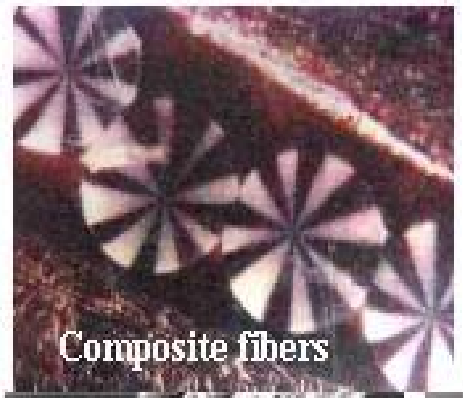
Biocidal coatings for food preparation areas and latrines

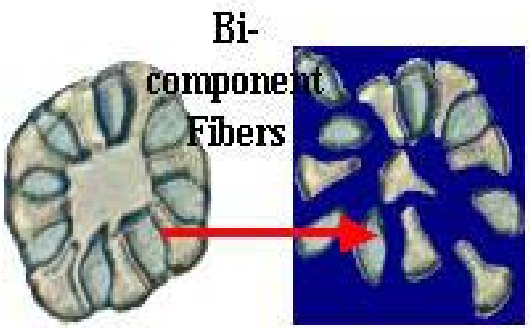
Applications

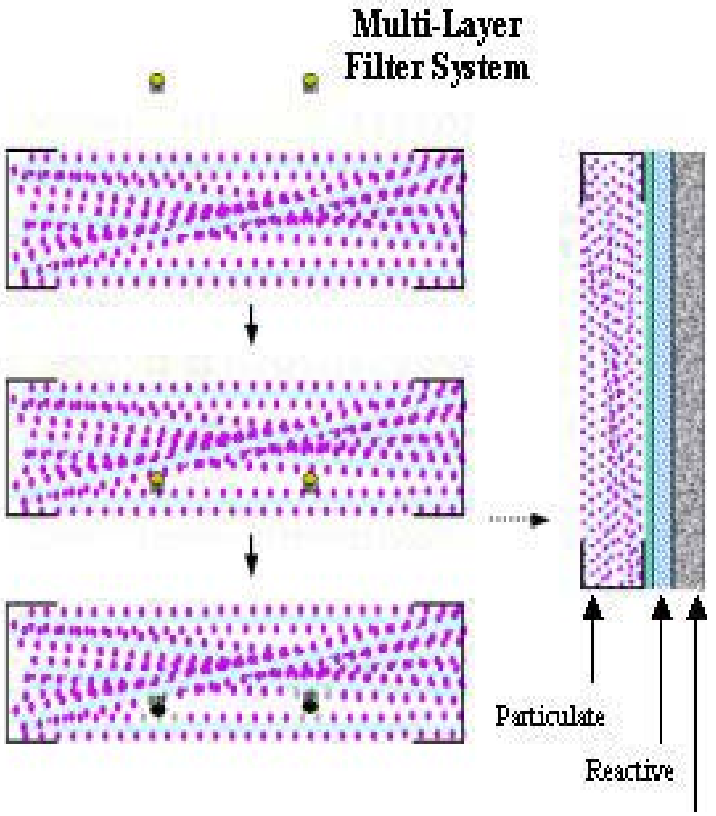


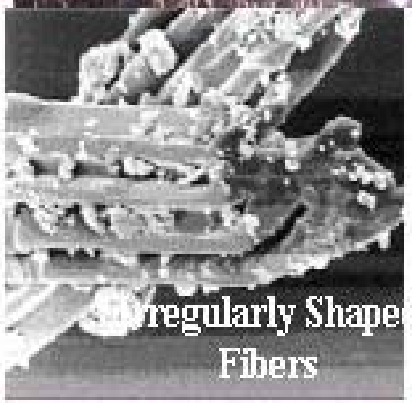
Reactive filtration for water purification

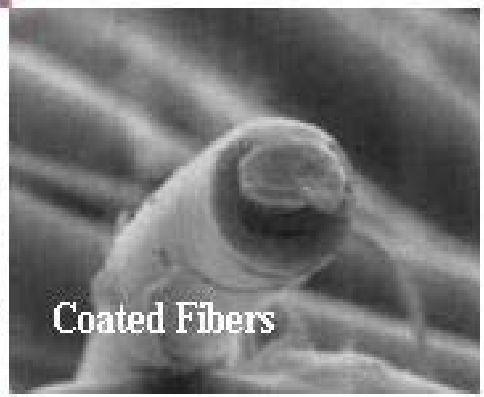
Applications









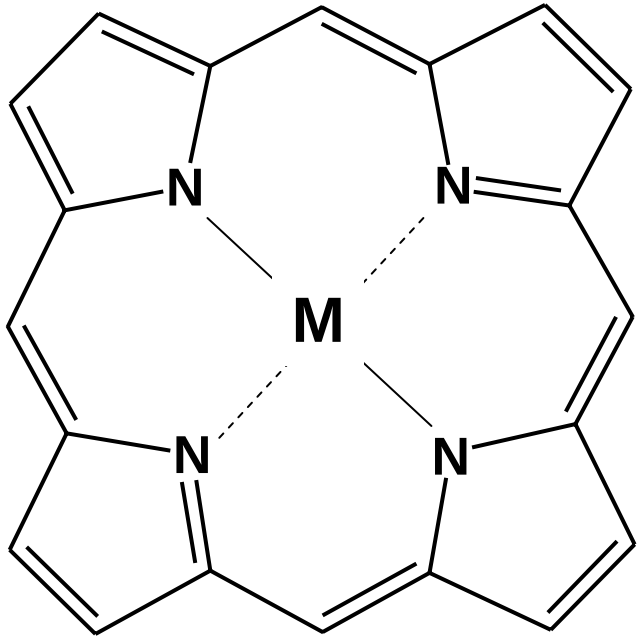


Reactive low pressure drop air-filtration media for collective and individual protection

Applications

Applications

Applications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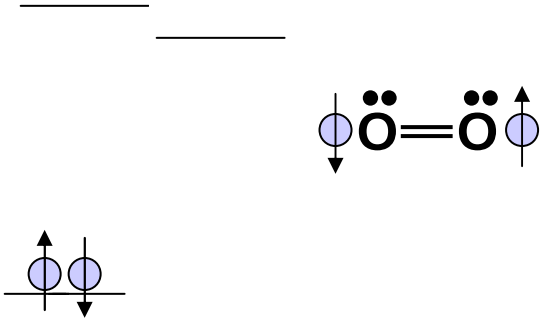
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