CHEMICAL AND BIOLOGICAL BARRIER MATERIALS FOR COLLECTIVE PROTECTION

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### Report Documentation Page

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OVERVIEW

- **PURPOSE**
  - Educate

- **BACKGROUND**
  - Brief History of CB Barrier for Collective Protection

- **TECHNOLOGY DEVELOPMENT AREAS**
  - Near-Term Solution
  - Mid-Term Solution
  - Long-Term solution

- **WHAT NEXT?**
  - Collaborative Effort
ColPro Shelters
* Heavy
* Cumbersome
* High Logistic Burden
* Very Expensive

Barrier Materials
* Butyl Rubbers
* Chlorinated Aliphatics
* Fluorinated Polymers

Characteristics of a Barrier Material
Permeability of a “Challenge Agent”

VS.
* Thermal Stability
* Flame Resistance
* Ease of Decontamination
* Longevity
* Leakage Points
* Weight
* Durability (Flexibility, Abrasion, Crackle)
* Cost

DEGREE OF PROTECTION?
NO BARRIER IS PERFECT

**Threat Permeability**
- Polarity
- Chemical Structure
- Size of Molecule
- Driving Force (Concentration)
- Temperature

**Properties of Barrier Film**
- Material
- Thickness
- Inertness
- Condition

**SEVERAL COMPONENTS**

- Base Material or Substrate
  - *Provides Physical Properties
- Impermeable Barrier
  - **Provides CB Protection**
M51
1st ColPro Shelter System
-1960’s

✓ Neoprene/Dacron®/Tedlar®

Effective Barrier Material?

✓ YES
100 minutes for Mustard (HD)
200 minutes for GB (Sarin)
M51 DEFICIENCIES

✓ Logistically Burdensome
  - 5,700 lbs.
  - Took 5 persons 30+ minutes to erect
  - Needed generator/blower to run 24/7

✓ Material Flaws
  - Expensive $$$
  - Difficult to weld/bond
  - Heavy
  → Tedlar®
    * Flex Cracking (Folding, Cold)
    * Abrasion
  × Dedicated Vehicle
WHAT NEXT?

1980’s Investigation

*Need New CB Material

*2 Areas Investigated
✓ Outer Shelter Skin
✓ Inner Liner Material

CANDIDATE MATERIALS

✓ Butyl Nylons
✓ Teflon®/Kevlar®
✓ Tedlar®/Vinyl coated Dacron®
✓ Teflon®/Nomex®
✓ Polyester/Tedlar®/Kevlar®
CHARACTERISTICS

- CB Resistance
- Flammability
- Weight
- Flexibility
- Durability
- Manufacturability
- Cost
- Decontamination
SUPERIOR QUALITY

- CB Resistance
- Weight
- Mechanical Properties
- Decontaminable
- Heat-Sealable

HOWEVER...

$$$ High Cost $$$

*Manufacturing
*Material

Chemical and Biological Protective Shelter (CBPS)
M28 LINER MATERIAL

- Secret Service
  *M20
  Adopted for GP shelters

  M28

Over Pressured Liner

Material

- PVDC or Saranex Barrier Film
- HDPE Scrim
- LDPE Coating (Protect Barrier)

Lightweight  Inexpensive Solution

*Increased
- Weight
- Packing Volume
- Deployment Time
2 OPTIONS AVAILABLE

Teflon®/Kevlar®
* Superior Protection
* Lightweight
* Decontaminable
* Flame Resistant

HOWEVER...

$$EXPENSIVE$$

PVDC/PE (M28)
* Inexpensive
* Provide CB Protection for GP Shelters

HOWEVER...

* Increase Weight
* Increase Deployment Time
* Increase Packing Volume
* Not Decontaminable

OR
Joint Science and Technology Panel for CB Defense

Investigate/Develop Next Generation CB Material

GOAL

- Lightweight Composite Material
- UV/Flame Resistant
- Increased Durability
- Improved Permeation Properties
- Decreased Cost (Material & Manufacturing)
MITIGATE RISK

Incremental Improvements

3 Pronged Approach

* Near-Term Solution
  - Fluoropolymer Coating/Lamination of GP Fabrics

* Mid-Term Solution
  - Nanotechnological Enhancement of Polymers
  - Low-Temperature Processible Fluoropolymers

* Long-Term Solution
  - Self-Decontaminating Barrier Materials
**NEAR-TERM SOLUTION**

Improving Barrier Properties of General-Purpose Fabric

Polyester with PVC Coating
*Apply Coating or Laminate

**Duracote Corporation**
- Various Laminates
- Very Promising Results

**TCE Simulant**
Typical GP Fabric = 17,000 g/d/m²

**BUT...Delamination**

Tetrachloroethane (TCE) Permeation Through Laminated GP fabric
CB Barrier Coatings
For
GP Shelter Fabric

* Low cost
* Water Soluble
* Environmentally safe
* Easy to apply
Goal: Transition in 2-4 yrs.

Current Programs

* Nanocomposite Films
* Low-Temperature Processible Fluoropolymers
**Background**

- Novel patented nanotechnology is based on the use of minute levels (1-5%) of chemically inert inorganic fillers that exhibit a platelet nanostructure.

- Adjustment of chemistry and processing conditions allows nanofillers to self-assemble (stack up) through the thickness of the plastic sheet and parallel to the plane of the barrier film.

- High aspect ratio creates a tortuous path for the diffusing chemical species.

- Increased distance = Increased time for diffusion through thickness of the plastic.
Accomplishments

✓ Synthesized several nanocomposite films that have shown up to 5X improvement in barrier to CB simulants compared to unfilled barrier films

✓ Layered silicates act as a passive flame retardant
  ➔ Act as a barrier to the flame by the formation of a ceramic or glassy layer on the surface of the polymer
  ➔ High gas barrier also prevents oxygen from feeding the flame, thus starving the fire
**LIVE AGENT TESTING**

*Developed a multi-layer laminate system that achieved greater than 24-hour exposure to liquid HD mustard chemical agent with NO penetration*

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CURRENT EFFORTS:

Scaling up Technology → Prototype Shelters

✓ Non-Decontaminable Barrier Liner Material

✓ Decontaminable High Barrier CB Outer Skin Fabric
LOW-TEMP PROCESSENTIBLE FLUOROPOLYMERS

ARAMIDS (KEVLAR®, NOMEX® etc.)

- High Strength
- Light Weight
- BUT…

*High Cost

Needed to Survive the High Temperature During Manufacturing

Low-Temperature Fluoropolymer = Lower Cost Substrate
Work From building blocks

Create:
* Void Free Fabric Substrate
* CB Resistant Barrier

- Low Cost
- Lightweight
- Decontaminable
Elongation at Break (23°C)
ASTM D638 Type D dogbones

- Not aged (control)
- 24 hr D2
- 24 hr Clorox
CURRENT EFFORTS:

✔️ Have equipment in place and have completing a limited production run

Production?
Improving:
Efficiency
Quality
Consistency of entire process
LONG-TERM SOLUTION

Self-Decontaminating Barriers
Incorporating
Catalytically Reactive Membranes

*Newly funded program with Ventana Research

TECHNOLOGY WATCH

✓ Academia
✓ Industry
✓ Government
✓ Foreign Military
CONCLUSION

2 Currently available Options

→ Kevlar/Teflon
→ M28 Liner (PVDC/PE)

Mitigate Risk
※ Near-Term Solution※
Coated/Laminated Barrier Fabric
※ Mid-Term Solution※
Integrating Nanocomposites into Commodity Polymers
※ Long-Term Solution※
Low-Temperature Processible Fluoropolymers
Self-Decontaminating Barrier Materials Incorporating Catalytically Reactive Membranes

➢ Need to work together to bridge technology gaps and identify novel solutions
THANK YOU

Questions?