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Collective Protection Directorate

CHEMICAL AND BIOLOGICAL BARRIER MATERIALS FOR COLLECTIVE PROTECTION

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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

BACKGROUND

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?

CHEMICALLY PROTECTIVE BARRIER

NO BARRIER IS PERFECT

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

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

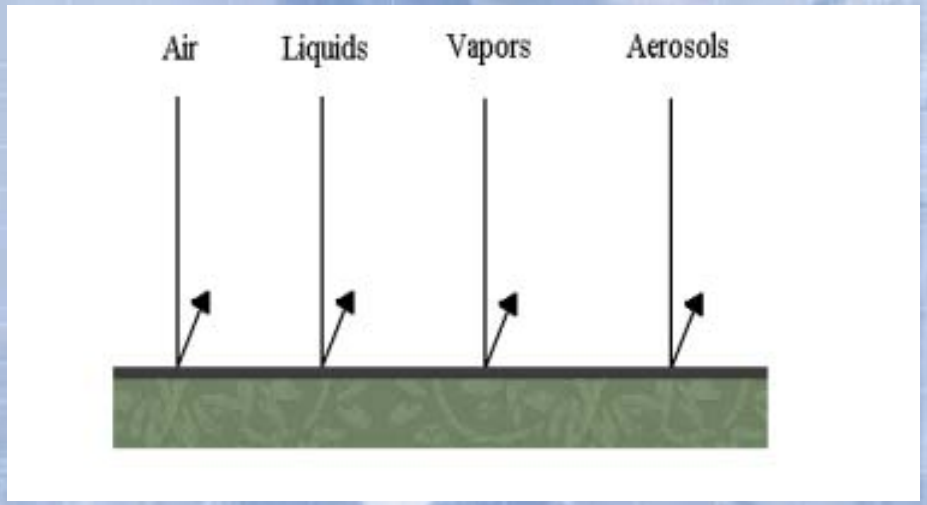
SEVERAL COMPONENTS

→Base Material or Substrate

*Provides Physical Properties

→Impermeable Barrier

**Provides CB Protection



HISTORY

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 Collective Protective Shelter

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®**

TEFLON®/KEVLAR®

⌘ CHARACTERISTICS ⌘

- ✓ CB Resistance
- ✓ Flammability
- ✓ Weight
- ✓ Flexibility
- ✓ Durability
- ✓ Manufacturability
- ✓ Cost
- ✓ Decontamination

TEFLON®/KEVLAR®

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…

$$EXPENSIVE$$

OR

PVDC/PE (M28)

* Inexpensive
*Provide CB Protection for GP Shelters

HOWEVER…

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

TECHNOLGY DEVELOPEMENT

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

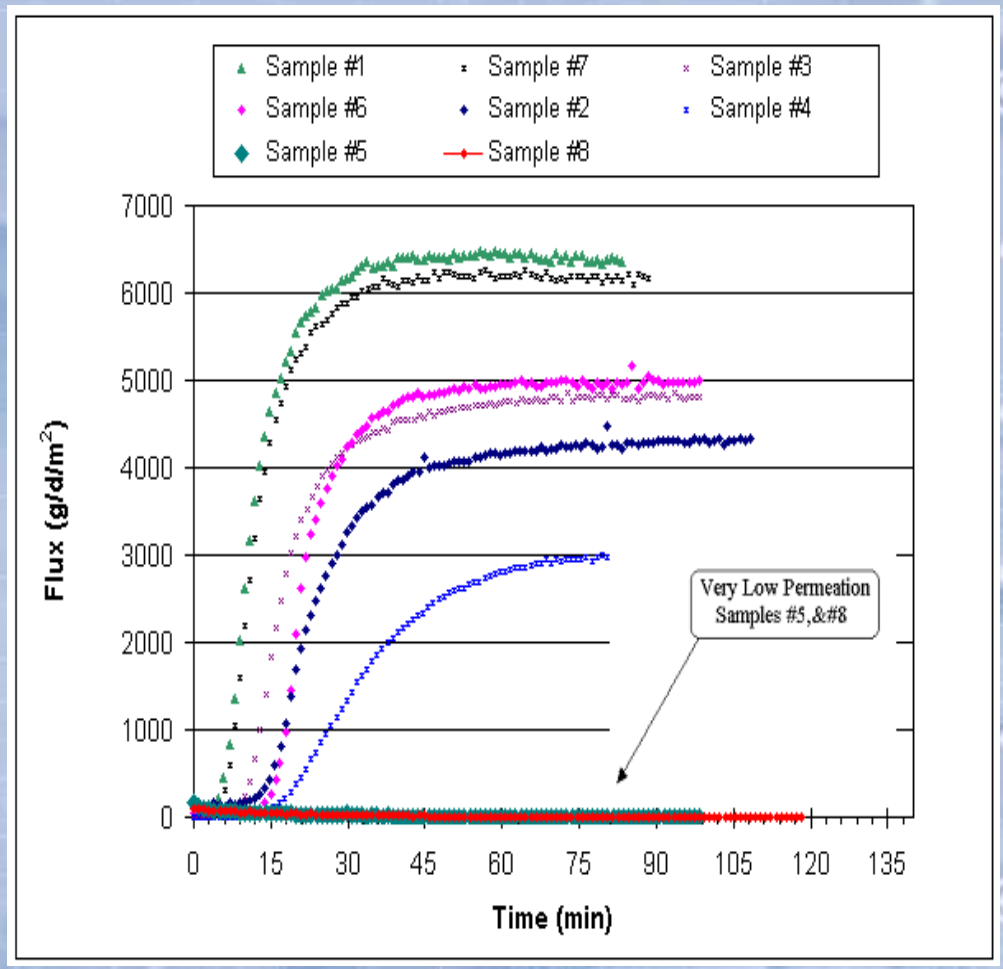
Improving Barrier Properties of General-Purpose Fabric

Polyester with PVC Coating
***Apply Coating or Laminate**

<u>Duracote Corporation</u>
- **Various Laminates**
- **Very Promising Results**

<u>TCE Simulant</u>
Typical GP Fabric= 17,000 g/d/m^2

BUT…Delamination



Tetrachloroethane (TCE) Permeation Through Laminated GP fabric

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VENTANA RESEARCH

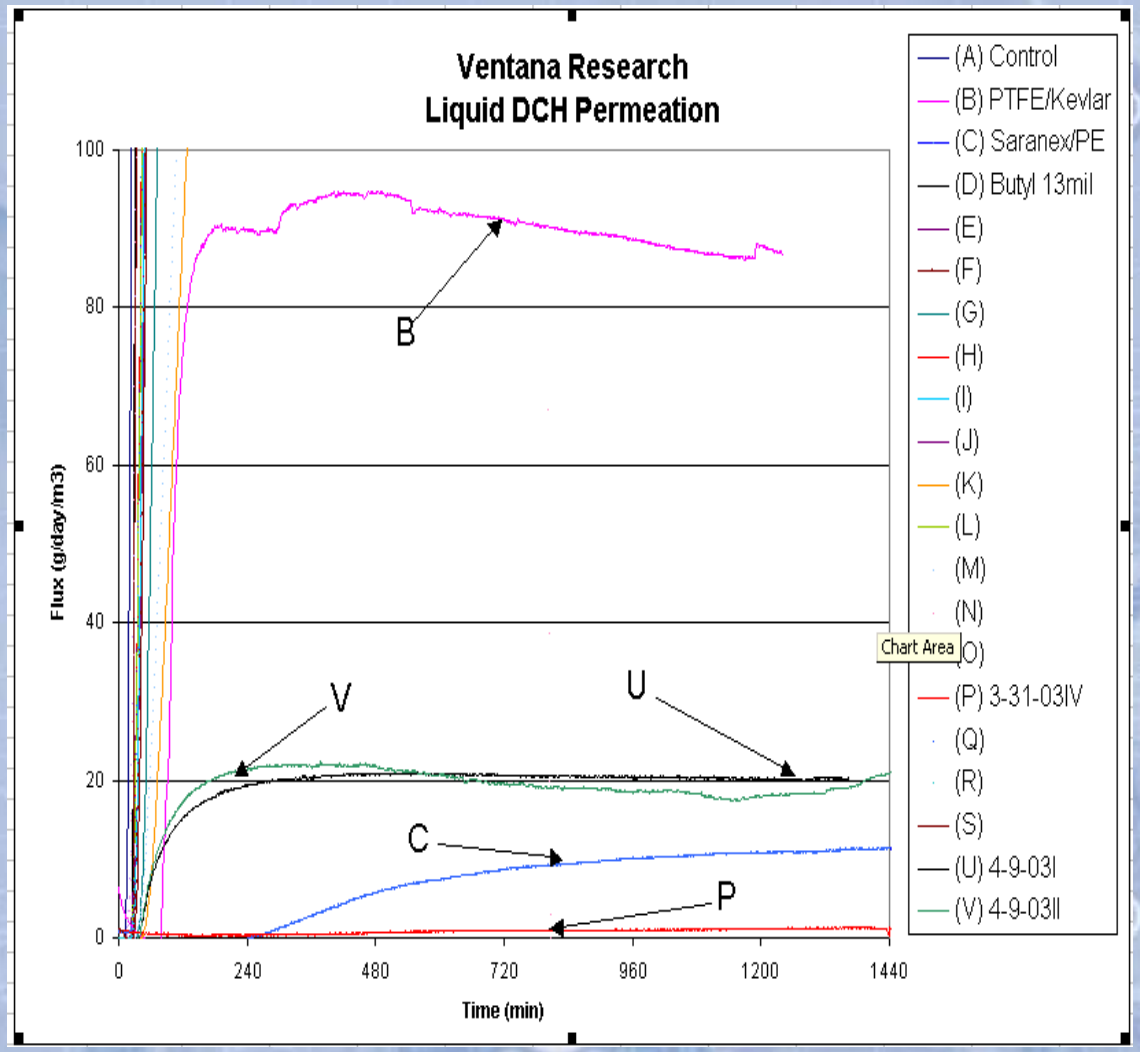
CB Barrier Coatings For GP Shelter Fabric

*Low cost

*Water Soluble

*Environmentally safe

*Easy to apply



MID-TERM SOLUTION

Goal: Transition in 2-4 yrs.

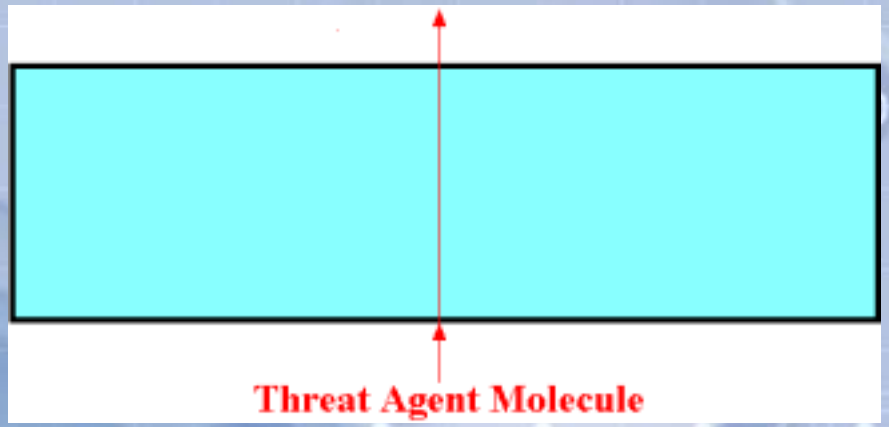
Current Programs

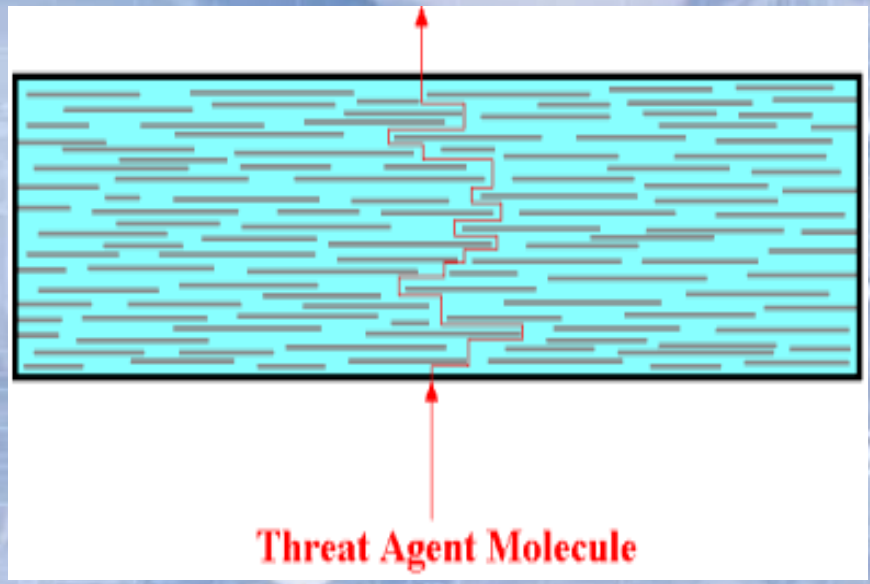
- **Nanocomposite Films**
- **Low-Temperature Processible Fluoropolymers**

NANOCOMPOSITE FILMS

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 ration creates a tortuous path for the diffusing chemical species
  - Increased distance = Increased time for diffusion through thickness of the plastic



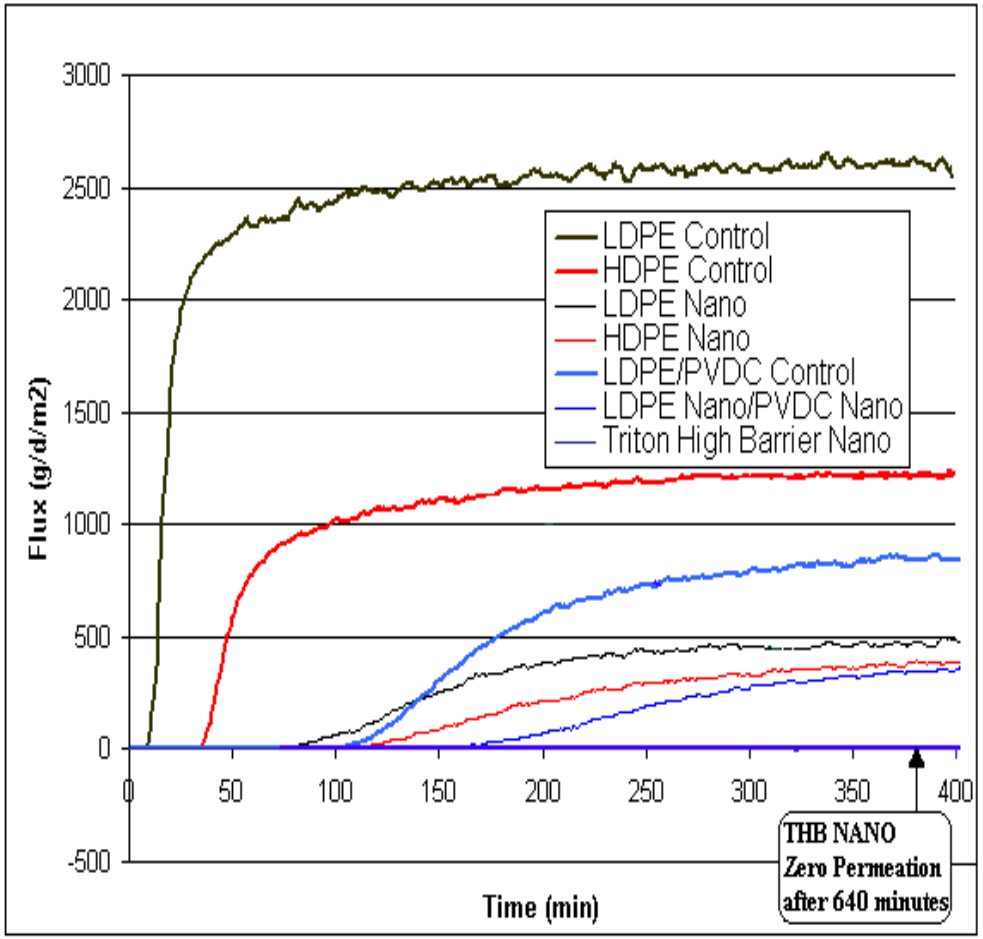


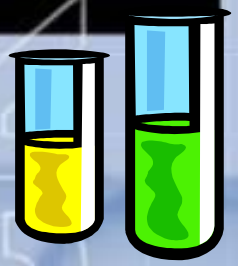
TRITON SYSTEMS INC.

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

Sampling Intervals (Hours from Start) (µg/cm²)										
Agent	Sample	(0-2)	(2-4)	(4-6)	(6-8)	(8-12)	(12-24)	(24-48)	(48-72)	Cumulative
HD	Neat	ND	ND	ND	ND	ND	ND	0.1	0.15	0.25
	TSI Barrier Film	ND	ND	ND	ND	ND	ND	ND	0.2	0.2
GB	Neat	ND	ND	ND	ND	ND	0.00016	0.00036	0.00037	.00089
	TSI Barrier Film	ND	ND	ND	ND	ND	ND	ND	ND	ND

CURRENT EFFORTS:

Scaling up Technology→ Prototype Shelters

- ✓Non-Decontaminable Barrier Liner Material
- ✓Decontaminable High Barrier CB Outer Skin Fabric

LOW-TEMP PROCESSIBLE 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

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FEDERAL FABRIC-FIBERS INC.

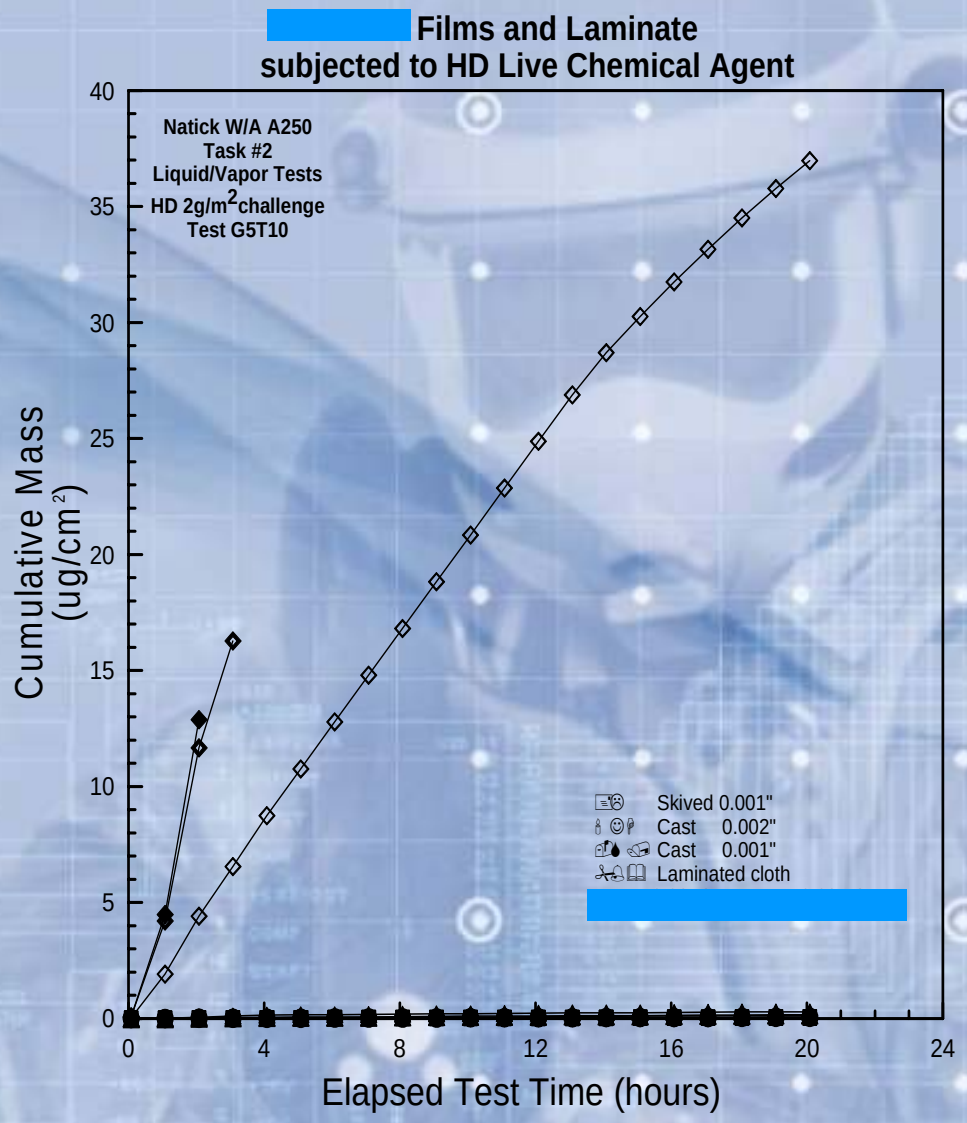
Work From building blocks

Create:

*Void Free Fabric Substrate

*CB Resistant Barrier

- ➔ Low Cost
- ➔ Lightweight
- ➔ Decontaminable



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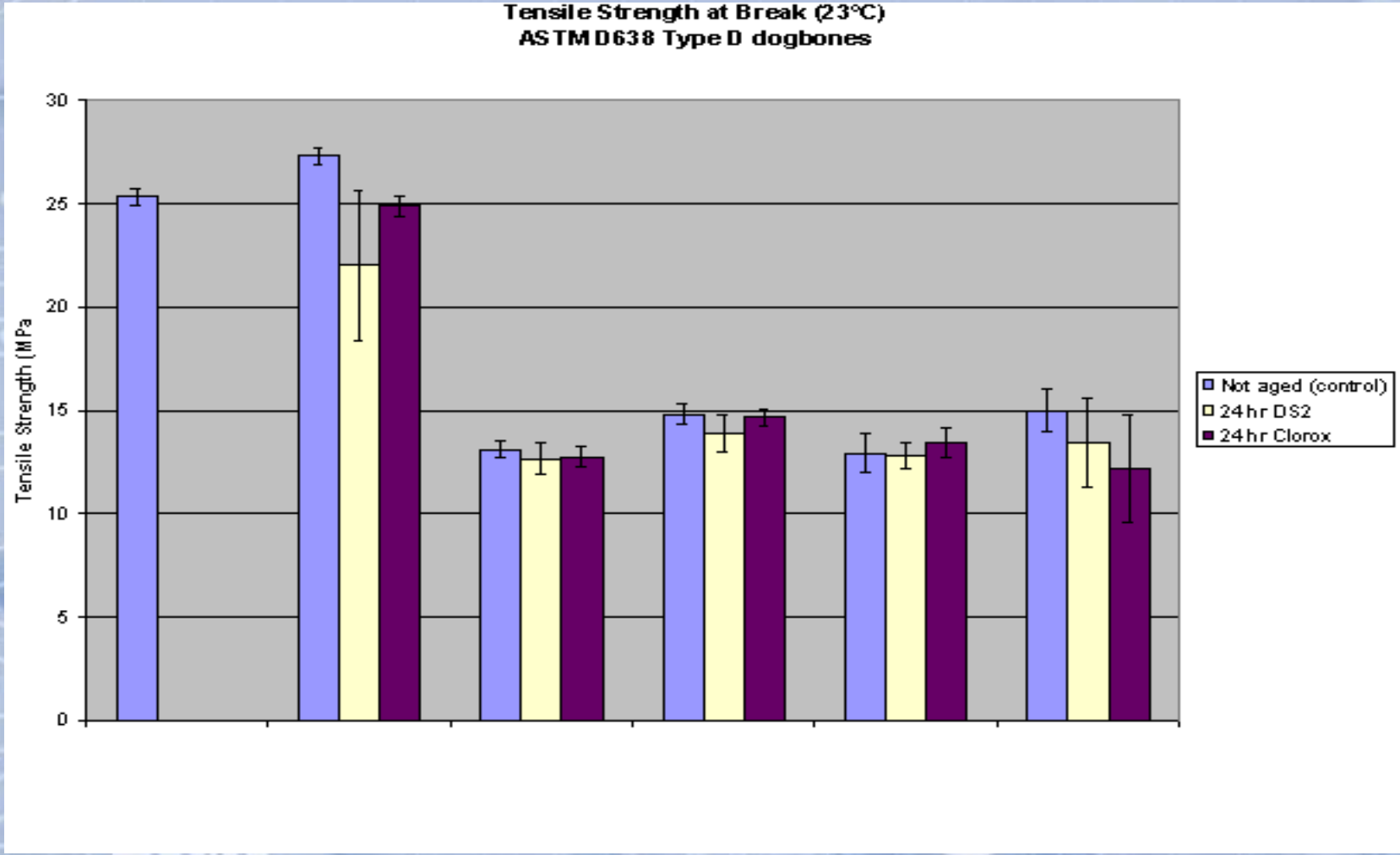

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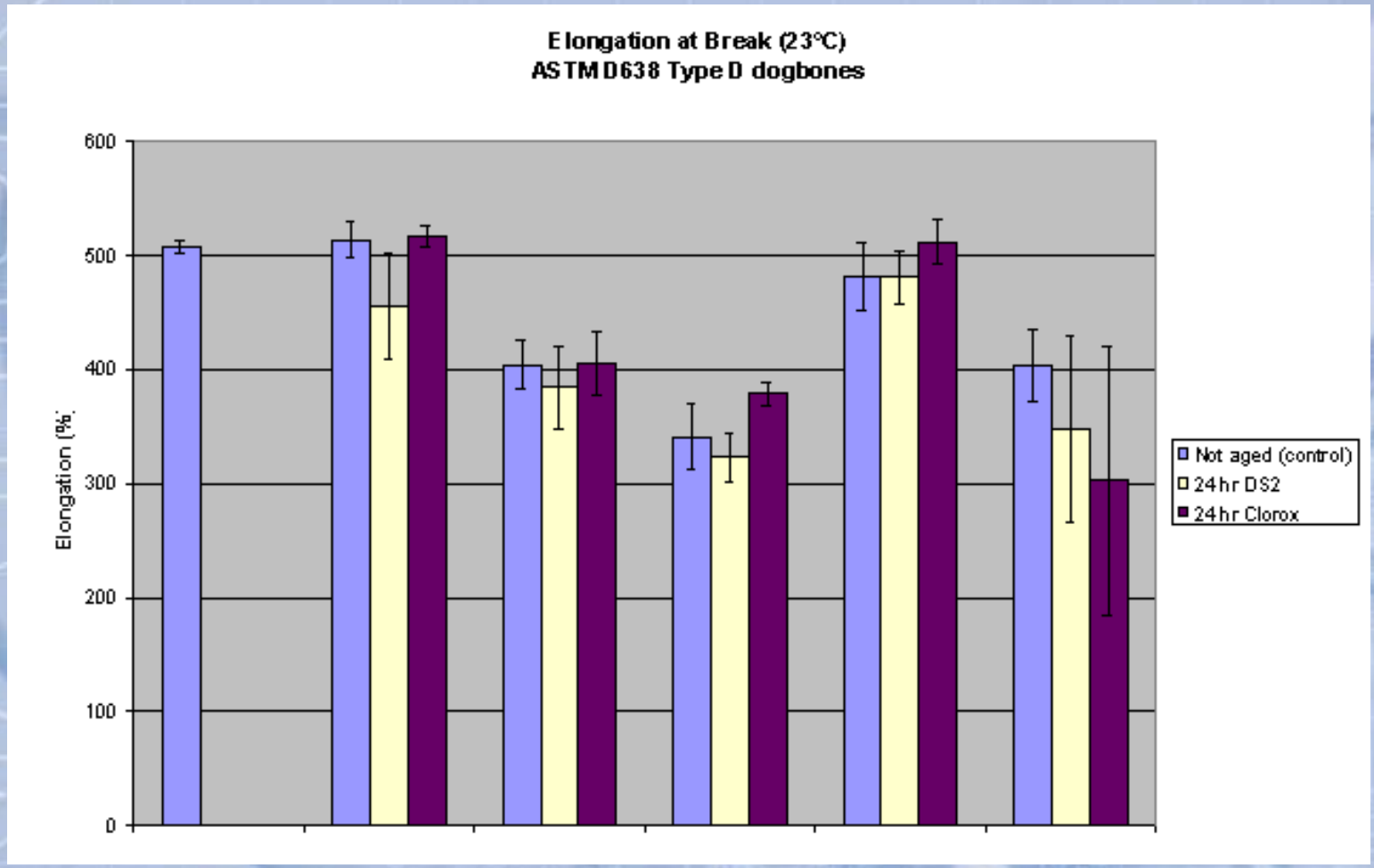

FEDERAL FABRIC-FIBERS INC.

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

Low-Temperature Processible Fluoropolymers

※Long-Term Solution※

Self-Decontaminating Barrier Materials Incorporating Catalytically Reactive Membranes

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

THANK YOU

Questions?