

# Elastomeric Selectively Permeable Membranes For Chemical and Biological Protective Clothing

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# Report Documentation Page

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# •ADVANCED LIGHTWEIGHT CB PROTECTION PROGRAM (DTO CB-06a-12-D) WAS SUCCESSFULLY COMPLETED IN FY00, WHERE SPM UNIFORMS WERE PREFERRED OVER CURRENT CHEMICAL PROTECTIVE GARMENTS

## Accomplishments:

Developed and demonstrated SPM garments that are 50% lighter weight than any fielded garment with equivalent or better protection.

Integrated novel closure systems and demonstrated their effectiveness via MIST @ERDEC, @DPG

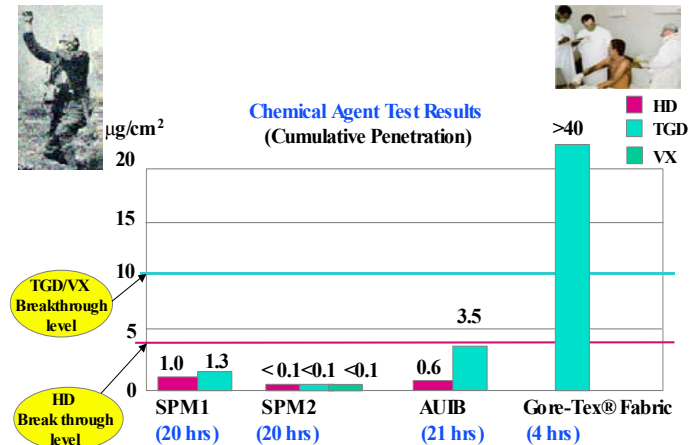
Conducted field-assessments for field durability and perception of comfort of prototype CB duty uniforms.

- Ft. Lewis, WA with the Maneuver Support Battle Labs (MSBL)
- Pohakuloa and Kaneohe Bases, Hawaii with the Marine Corps and Army MSBL

Transition to JPACE, JIG, SOF, and JCBE

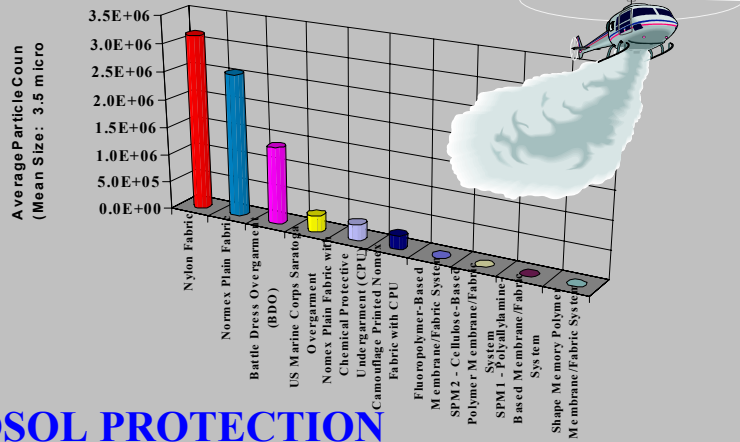
## Impacts:

- Reduced thermal stress
- Reduced logistics burden
- Increased CB agent protection
- Eliminated dependency on charcoal adsorbent



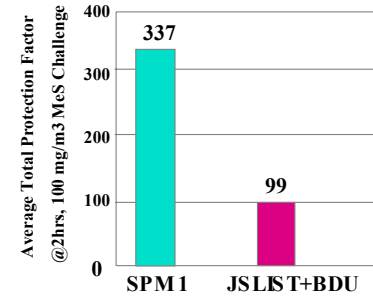
SPM1: Polyallylamine-Based SPM2: Cellulose-Based  
AUIB: Aircrew Uniform Integrated Battlefield (Carbon loaded foam + Gore-Tex fabric)

### Aerosol Penetration Through Various Fabrics



## AEROSOL PROTECTION

### DPG MIST Data



JSLIST: Joint Service Lightweight Integrated Suit Technology

SPM1: Polyallylamine-Based

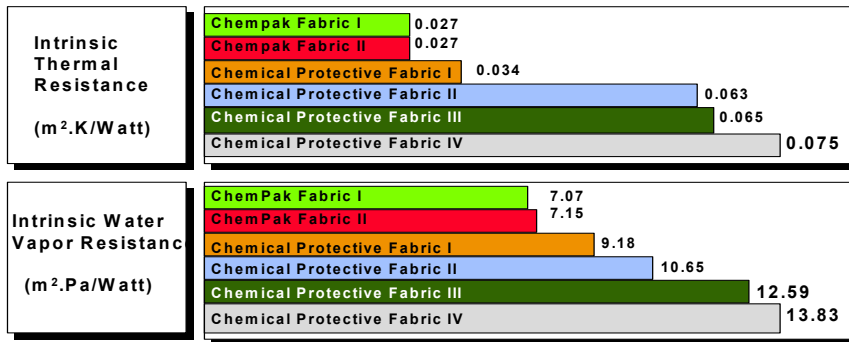
BDU: Battle Dress Duty Uniform

DPG: Dugway Proving Ground, Utah

MIST: Man-In-Simulant System Vapor Test

## VAPOR PROTECTION

### EVAPORATIVE COOLING POTENTIALS of SPMs vs. VARIOUS CB FABRIC SYSTEMS

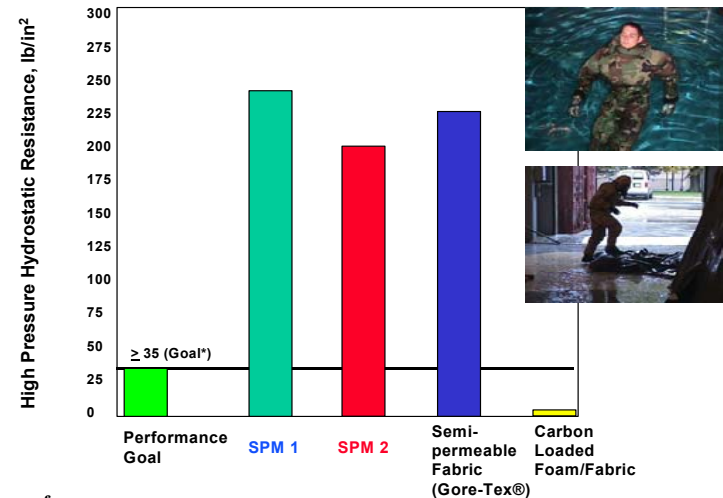


Chemical Protective Fabrics I-IV: Various CB Fabric Systems

## REDUCED HEAT STRESS

•Many Tests and Evaluation have been conducted to evaluate SPM fabrics; however, **NOISE AND SIZING REMAIN SIGNIFICANT BARRIERS TO OVERCOME.**

### High Pressure Hydrostatic Resistance



\*Being Waterproof

## LIQUID PROTECTION

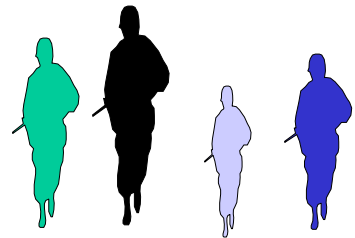
# Problems: Noise and Sizing



-Many variations of chemical protective clothing



-Many concerns (Costs, Weight, Logistic, Comfort, Mobility, etc.)



-Multiple sizes

## Material Concept:

Stretchable Perm-selective Membrane

Perspiration Moisture Vapor

Agent Vapor

Liquid

Aerosols

Shell Fabric

Liner Fabric

Skin

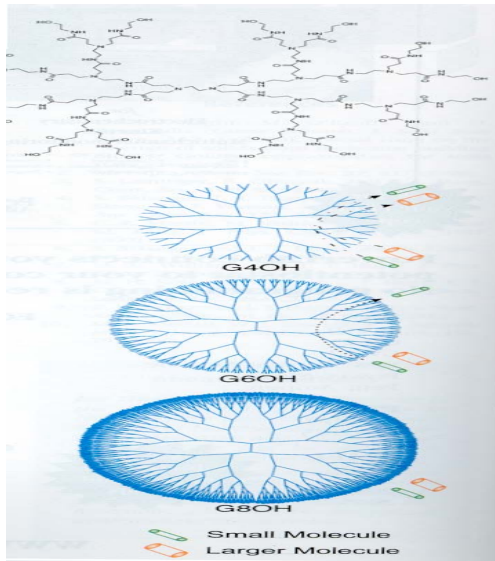
Body

Evaporative Cooling

## Capability/Enhancement:

- Reduce/Eliminate multiple size requirement
- Conformable Clothing
- Reduce logistic concerns, and improved operational readiness
- Reduced Noise when “being quiet” is important

# Technical Approach --- Prepare dendrimer containing membranes



**Blocking efficiency for dendrimers as a function of the density of the peripheral groups.**

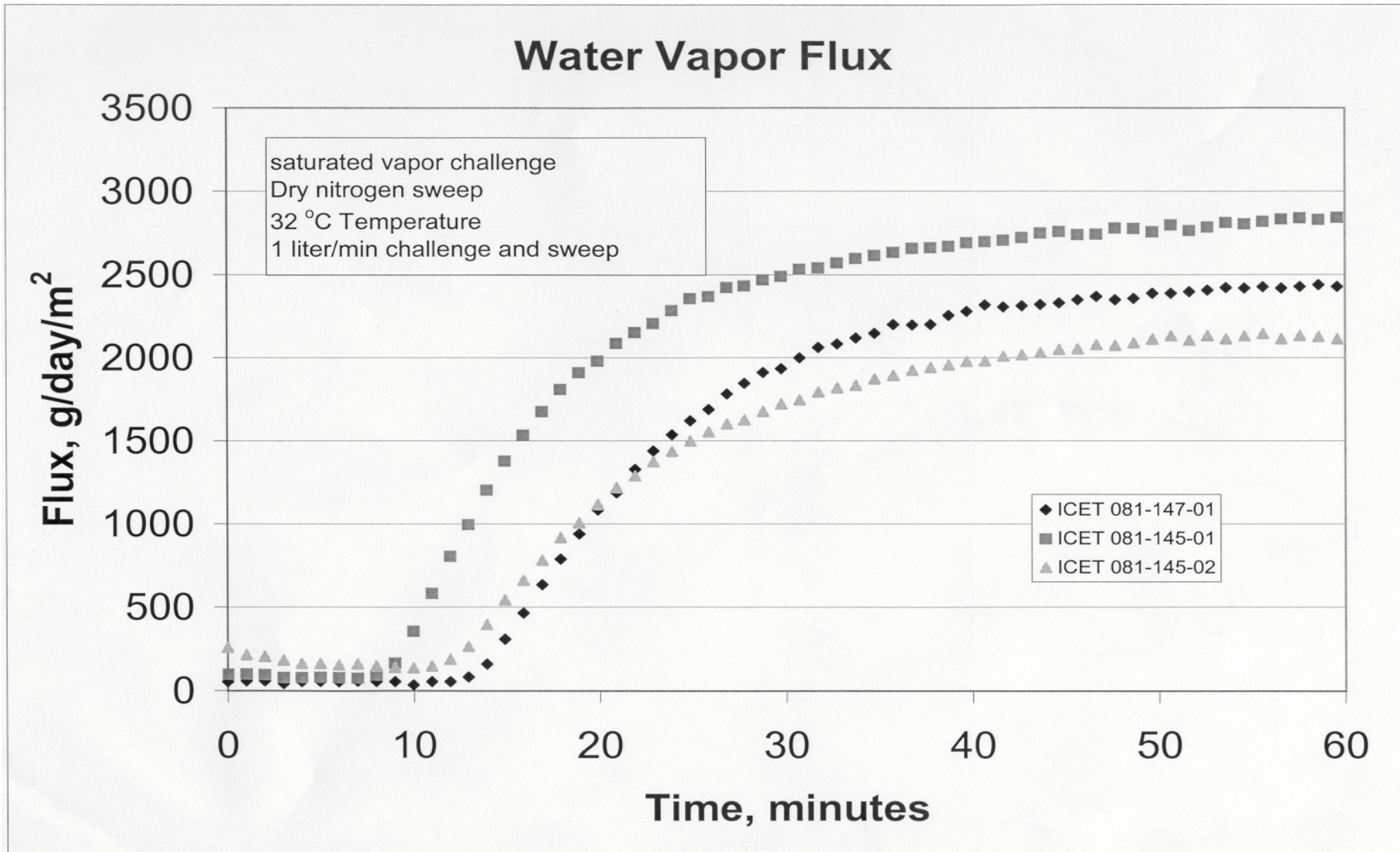


**Dendrimer Packing and Cross Linking shows reactive binding polymer molecules for further filtration efficiency**

# Experimental Results: Dendrimer containing membranes

Methods	MVTR (E96-BW) (g/m <sup>2</sup> /day)	TCE Permeation (E96-BW) (g/m <sup>2</sup> /day)	Special Notes
<b>Hytre/Noveon Membrane (Control – 2mil thick)</b>	<b>1,000 – 2,000</b>	<b>10,000 to 20,000</b>	<b>Elastomeric</b>
<b>1. Estane Coated with dendrimer</b>	<b>2,000</b>	<b>10,000</b>	<b>Elastomeric</b>
<b>2. Estane Cross linked dendrimers</b>	<b>19,000</b>	<b>2,000 – 3,000</b>	<b>Elastomeric</b>
<b>3. Incorporate dendrimers in ICET water based proprietary polymer</b>	<b>3,000</b> <b>WSPC: 2,000-2,800</b>	<b>0</b> <b>WSPC: 0 after 3 hrs</b>	<b>Elastomeric</b>
<b>4. Self-assembled dendrimer</b>	<b>3,000</b> <b>WSPC: 2,000-2,500</b>	<b>0</b> <b>WSPC: 0 after 3 hrs</b>	<b>Not elastomeric</b>
<b>5. PU dispersions mixed with ICET proprietary polymer</b>	<b>To be done</b>	<b>To be done</b>	<b>Elastomeric</b>

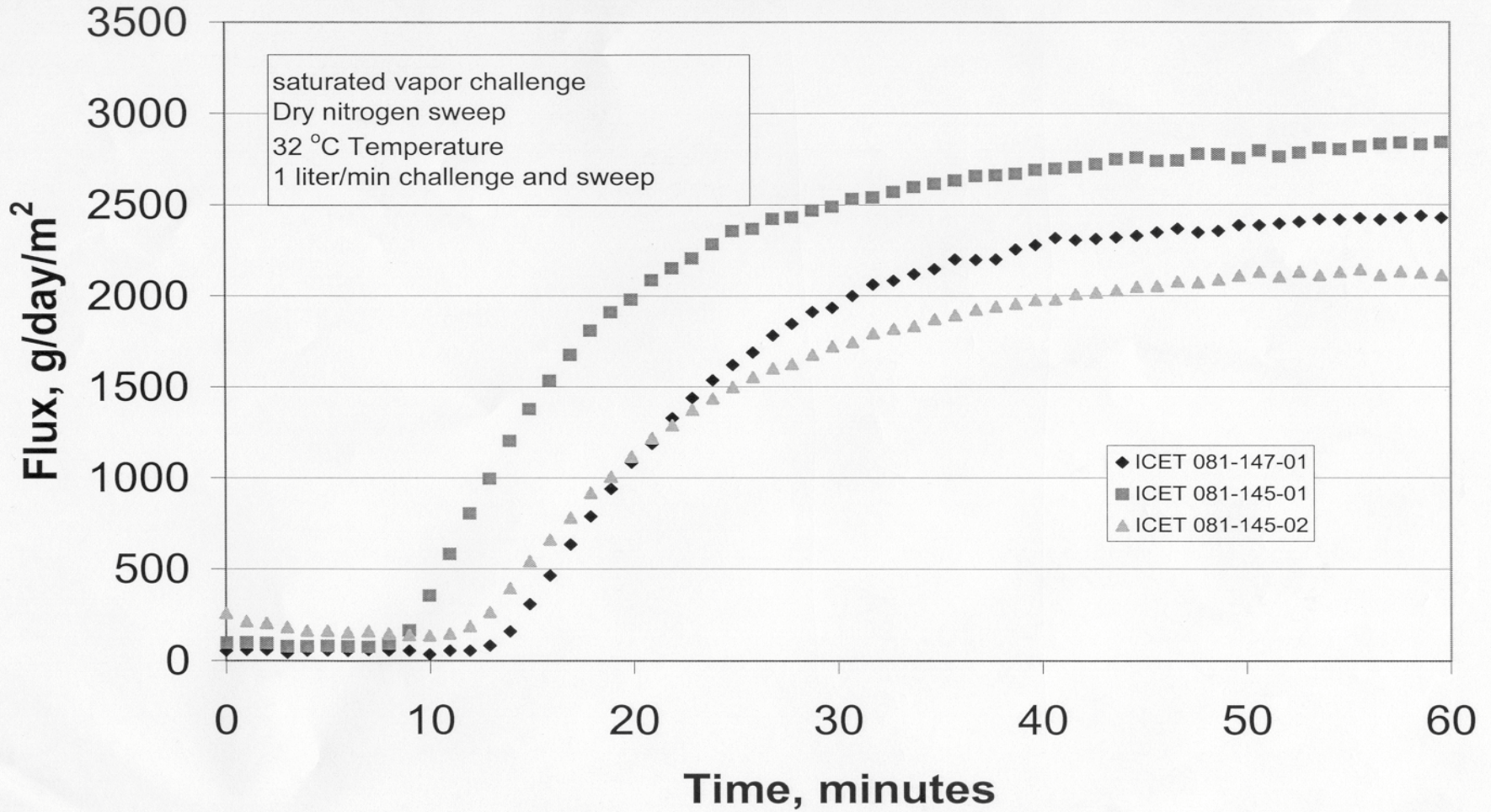
# Natick's Water/Simulant Permeation Cell (WSPC) Test Results



**Method 3. Incorporate dendrimers in ICET water based proprietary polymer**

# Water/Simulant Permeation Cell (WSPC) Test Results

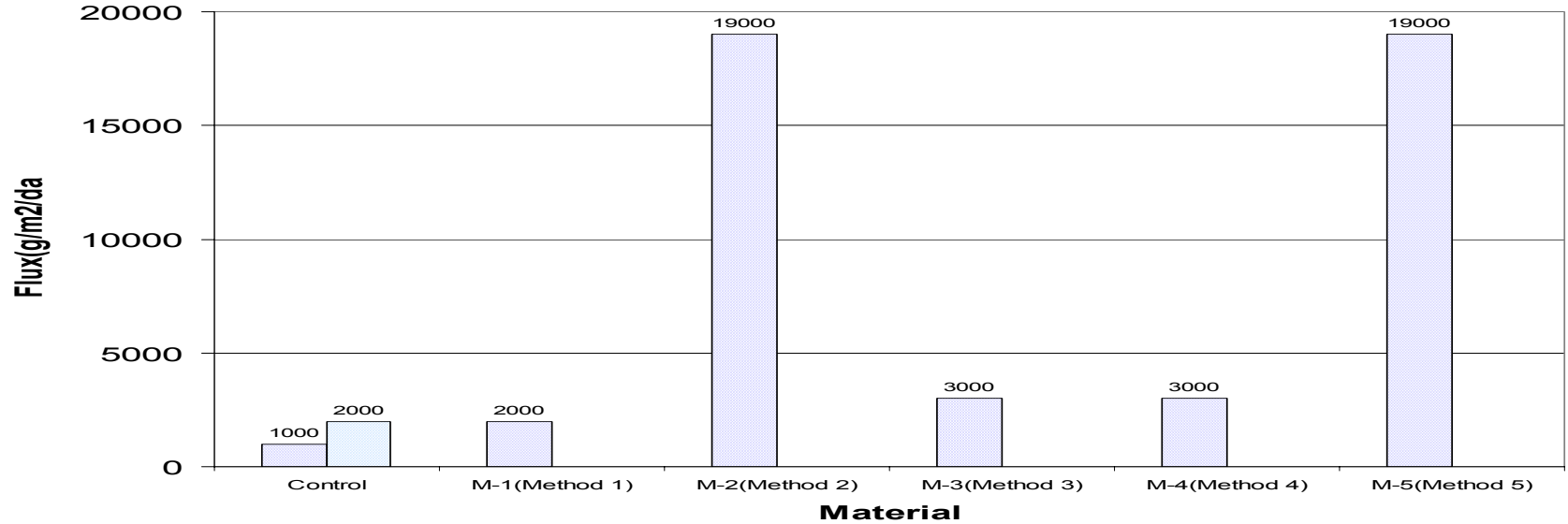
## Water Vapor Flux



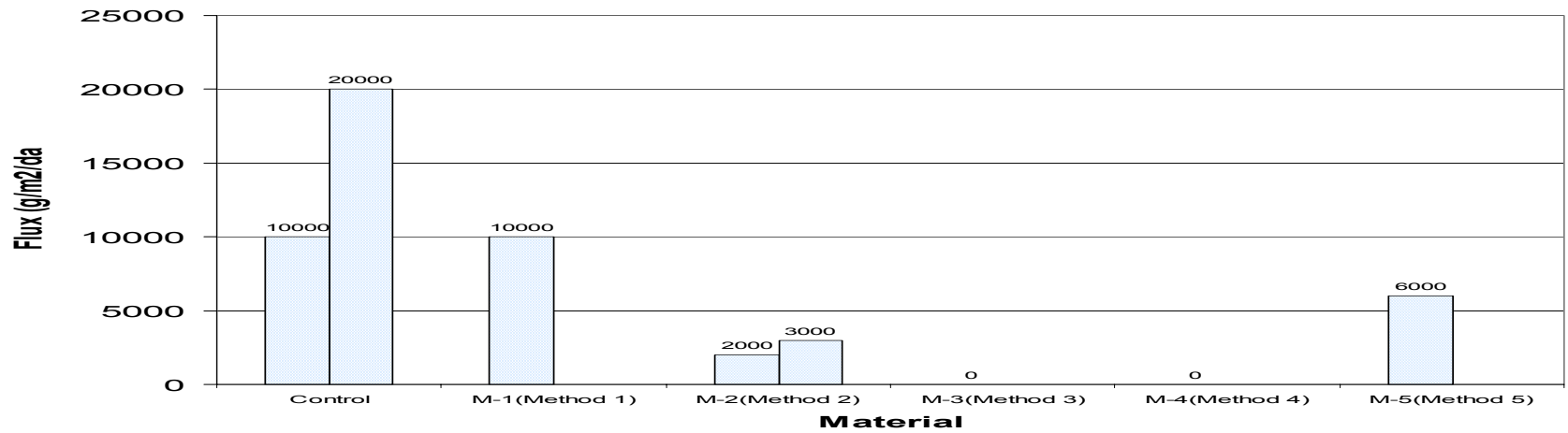
Method 4. Self-assembled dendrimer

# Static Permeation Test Results

## Static Moisture Vapor Permeation Data (E96-BW)



## Static TCE Vapor Permeation Data (E96-BW)



# **Discussions:**

**Dendrimers are highly hydrophilic and viscous materials. They are very expensive**

**The direct coating on elastomers through anchoring by surface interactions resulted in coatings that never cured.**

**Direct incorporation of dendrimers into polymeric dispersions results in tough but flexible membranes.**

**Using optimal cross-linking of a thin coating appears to overcome this difficulty while dramatically improving the moisture vapor permeation and dramatically reducing cost of the eventual commercial products.**

***This could be a preferred way for optimization for achieving better perm-selectivity.***

## **Conclusions:**

- **Extremely thin coating of cross-linked dendrimer were achieved on water vapor Permeable polyurethane elastomers.**
- **Such coatings improve water vapor transport properties significantly while maintaining resistance to organic vapors.**
- **Further optimization work are underway with ICET, Inc. to develop elastomeric SPMs for resistance to both polar and non-polar molecules.**

## **Recommendations:**

- **Follow on work will be on developing dendritic polymers cross-linked coatings where the cross linking agent is flexible PEO segments with reactive end groups on water vapor permeable polymer materials such as TPU latexes modified with ICET fillers and formulations**

# **Acknowledgments:**

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