

Permeation Characteristics of Some  
Common Polymers Against the Mustard  
Simulant 1,5-Dichloropentane

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# Background

- Sulfur mustard (HD) is one of the most penetrating chemical agents through polymers
- Need screening methods for selecting potential PPE materials of construction for expensive and time-consuming agent testing
- Also need tool for checking PPE systems for areas susceptible to rapid permeation



# Mustard and simulants



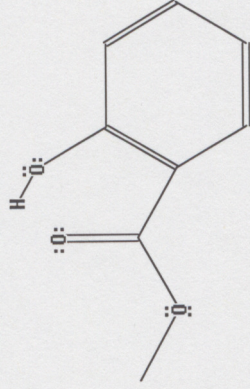
sulfur mustard HD

bis(2-chloroethyl)sulfide



half-mustard (CEES)

2-chloroethyl ethyl sulfide



methyl salicylate

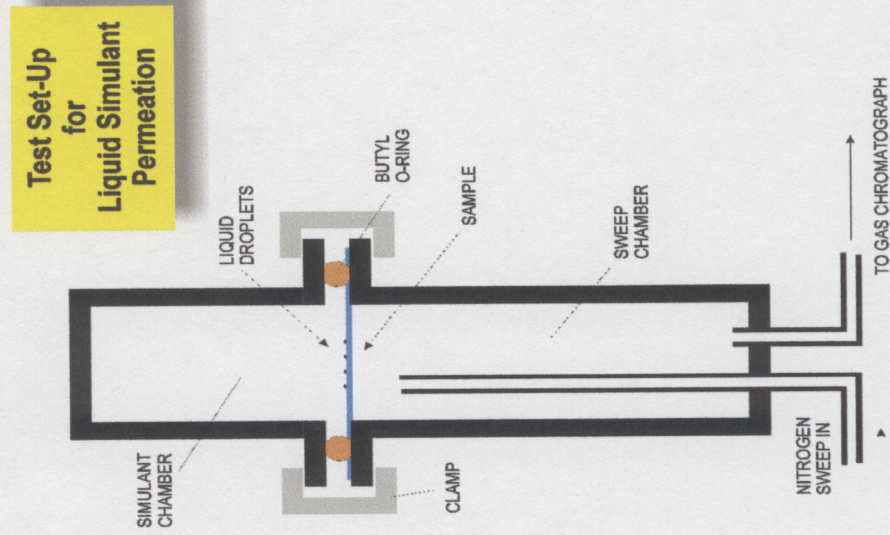
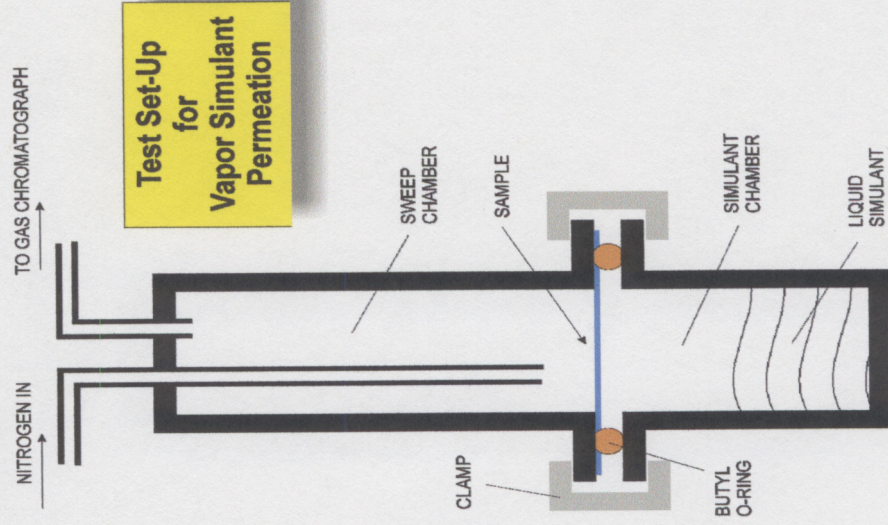


1,5-dichloropentane (DCP)

- Preferably use low toxicity simulant that can be detected at low concentrations with simple equipment



# Permeation cell



- Constructed from modular high-vacuum piping, flanges, and clamps (R. Padiyath)



# Gas chromatograph with FID and gas sampling valve



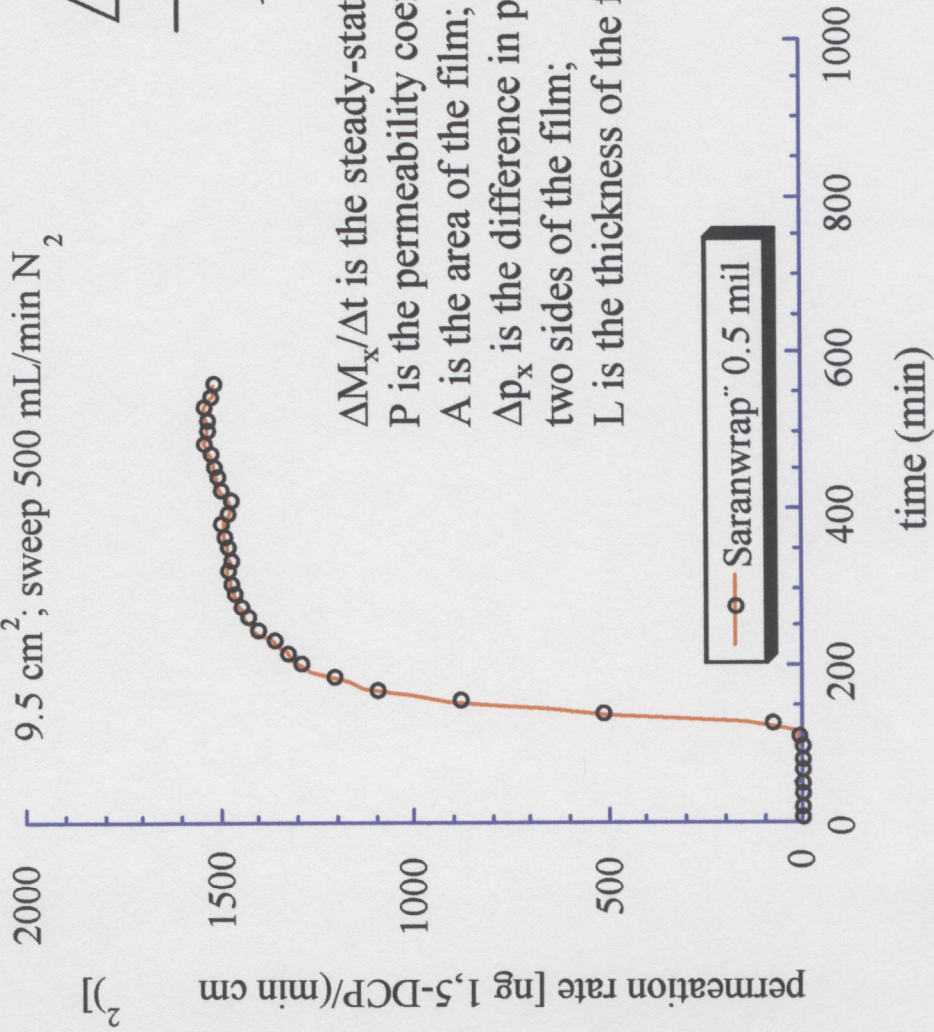


1,5-dichloropentane permeation rate

static vapor permeation

saturated 1,5-dichloropentane vapor (~1000 ppm)

9.5 cm<sup>2</sup>; sweep 500 mL/min N<sub>2</sub>



$$\frac{\Delta M_x}{A \Delta t} = \frac{P \Delta p_x}{L}$$

$\Delta M_x / \Delta t$  is the steady-state permeation rate;

P is the permeability coefficient;

A is the area of the film;

$\Delta p_x$  is the difference in pressure of the permeant on the two sides of the film;

L is the thickness of the film



- A perfect HD simulant would have the same value of P as HD
- Based on limited information,  $P_{\text{DCP}}$  seems larger than  $P_{\text{HD}}$
- Still, even if the magnitude of P differs, using DCP as a simulant would be useful if  $P_{\text{DCP}}$  varies in the same way as  $P_{\text{HD}}$  for various polymers



- Polymer samples from a variety of sources were used in this work.
- Permeation performance may be strongly affected by sample history/processing
  - crosslink density (for elastomers)
  - molecular weight
  - fillers, plasticizers, processing aids
  - Thickness
- No general judgment about the performance of any polymer type should be drawn from this data



# SBCCOM mustard data (glove permeation)

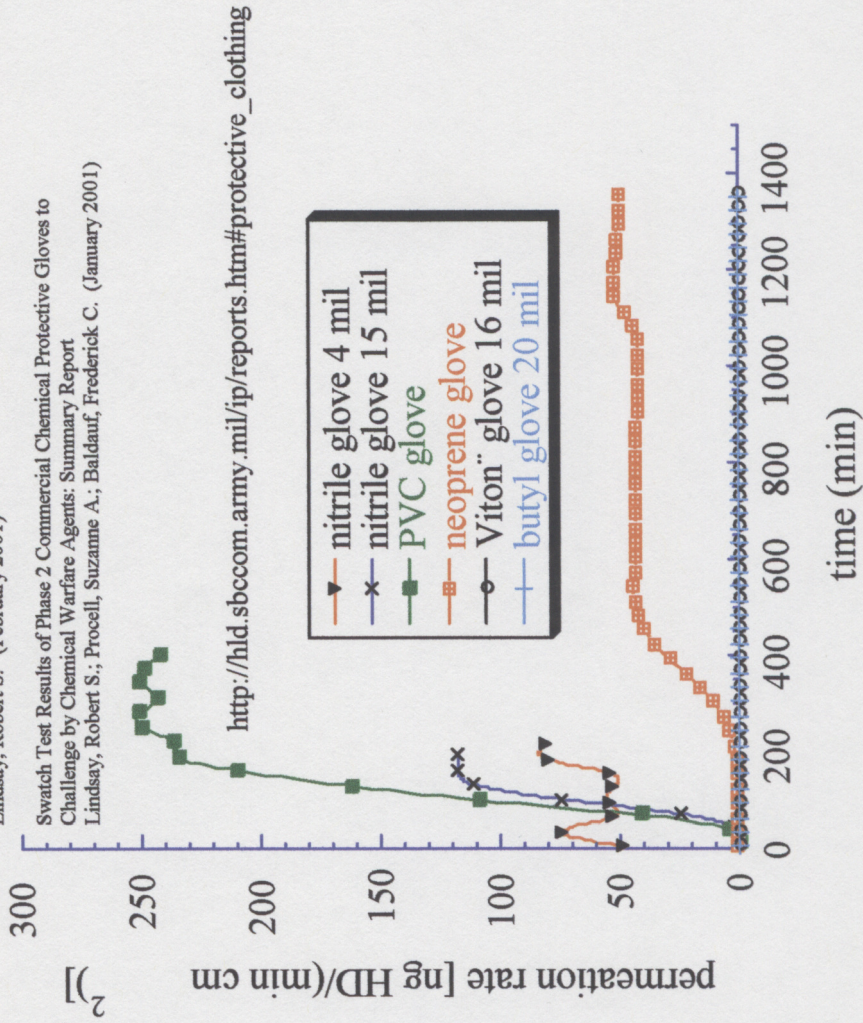
(original data recalculated to obtain permeation rate vs time plot)

HD permeation rate through glove swatches (palm)  
(liquid challenge/vapor permeation) @ 10 g HD/m

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Test Results of Commercial Chemical Protective Gloves to Challenge by  
Chemical Warfare Agents: Summary Report  
Lindsay, Robert S. (February 2001)

Swatch Test Results of Phase 2 Commercial Chemical Protective Gloves to  
Challenge by Chemical Warfare Agents: Summary Report  
Lindsay, Robert S.; Procell, Suzanne A.; Baldauf, Frederick C. (January 2001)



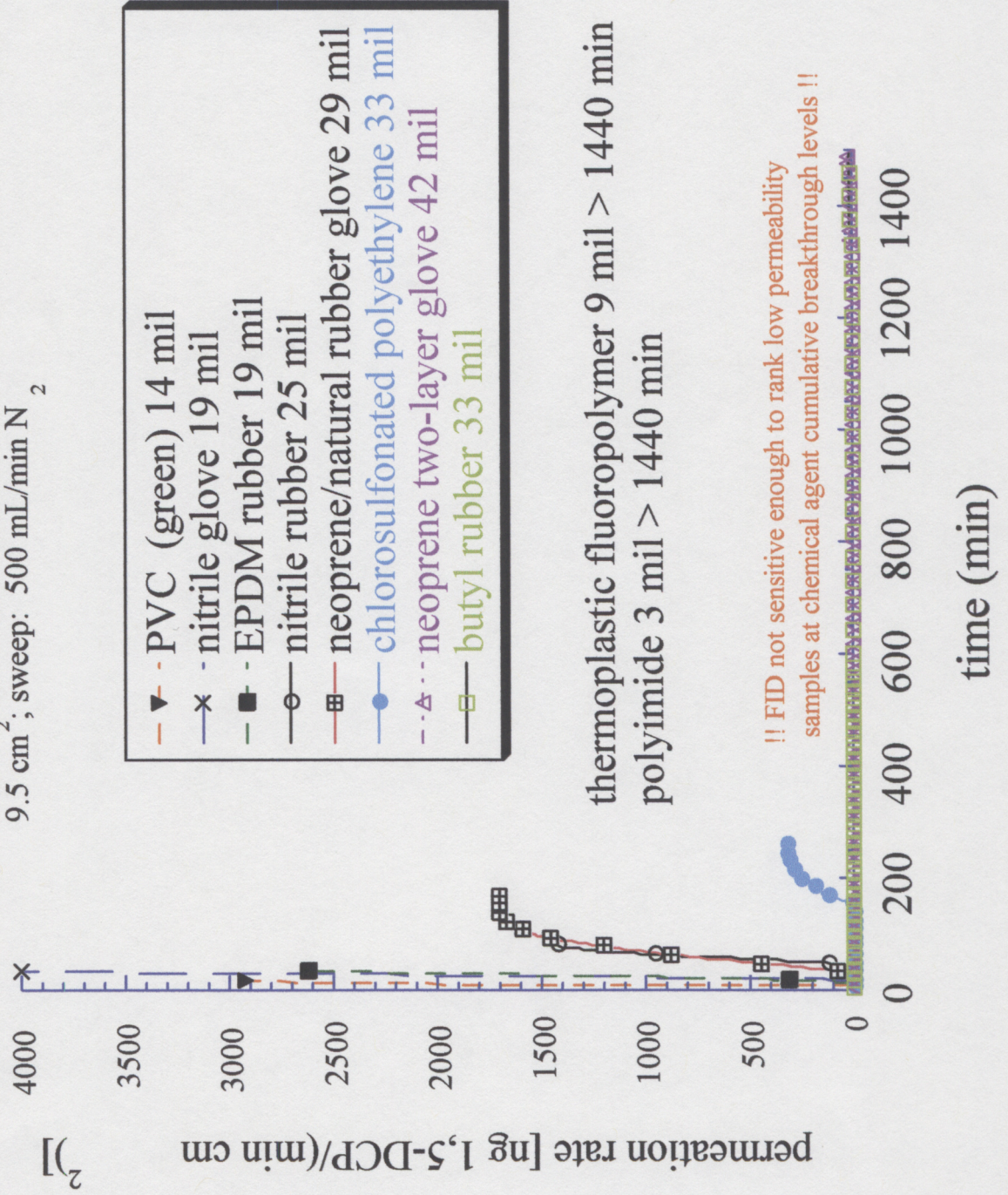


# 1,5-dichloropentane permeation rate

static liquid permeation

3 drops 1,5-DCP each 4  $\mu\text{L}$  ( $\sim 12 \text{ g/m}^2$ )

$9.5 \text{ cm}^2$ ; sweep:  $500 \text{ mL/min N}_2$









# Conclusions

- Limited data indicate that permeation testing using 1,5-dichloropentane may be useful in screening polymers for resistance to permeation by HD
- Most useful in excluding candidate materials - not in differentiating between good performers
- Results from permeation testing using simulants need to be confirmed by live agent testing