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

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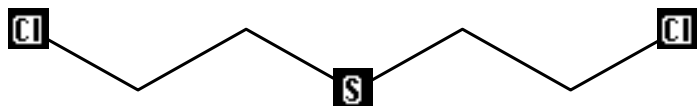
3M Occupational Health & Environmental  
Safety Division

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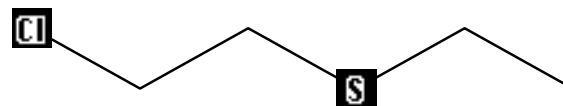
# Background

- 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

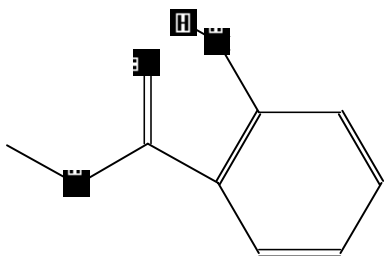
# Mustard and simulants



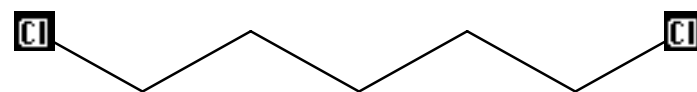
sulfur mustard HD  
bis(2-chloroethyl)sulfide



half-mustard (CEES)  
2-chloroethyl ethyl sulfide



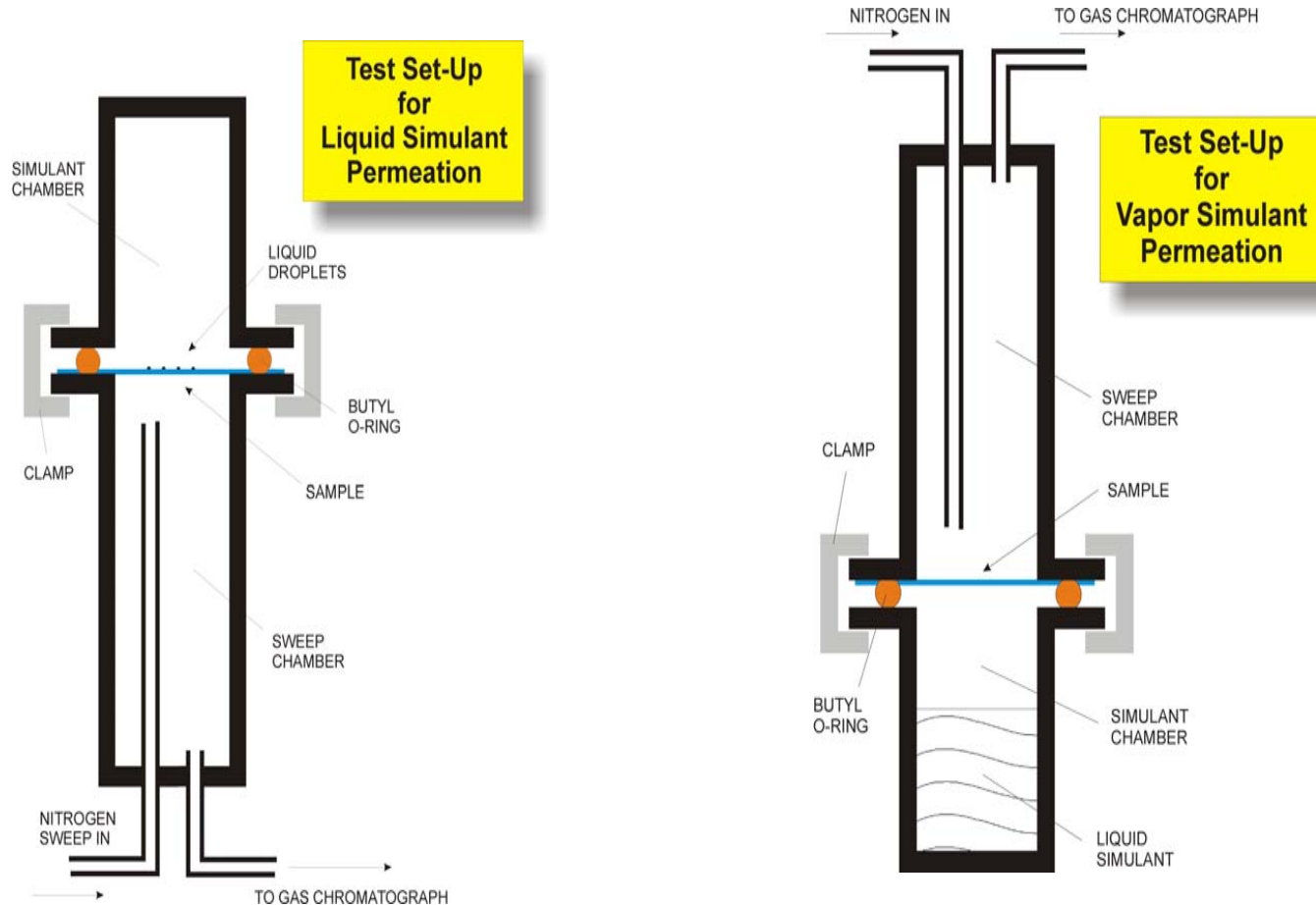
methyl salicylate



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

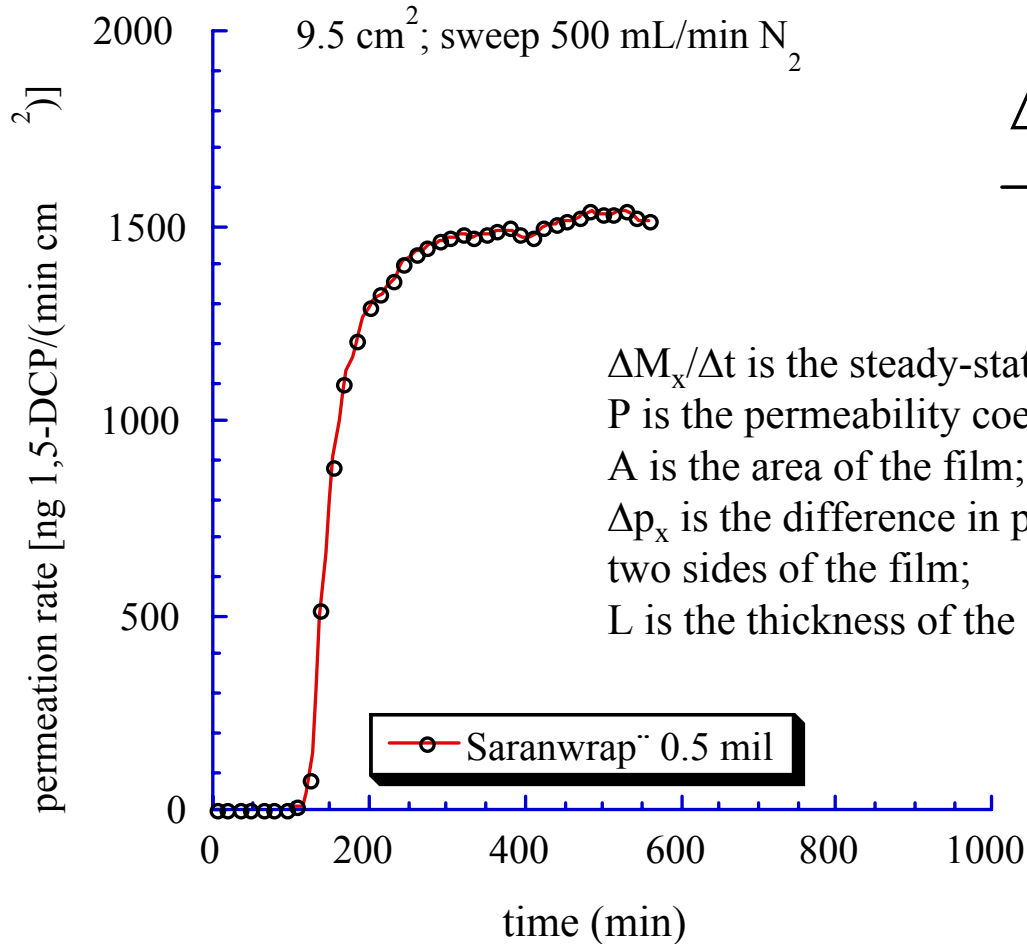


# 1,5-dichloropentane permeation rate

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)

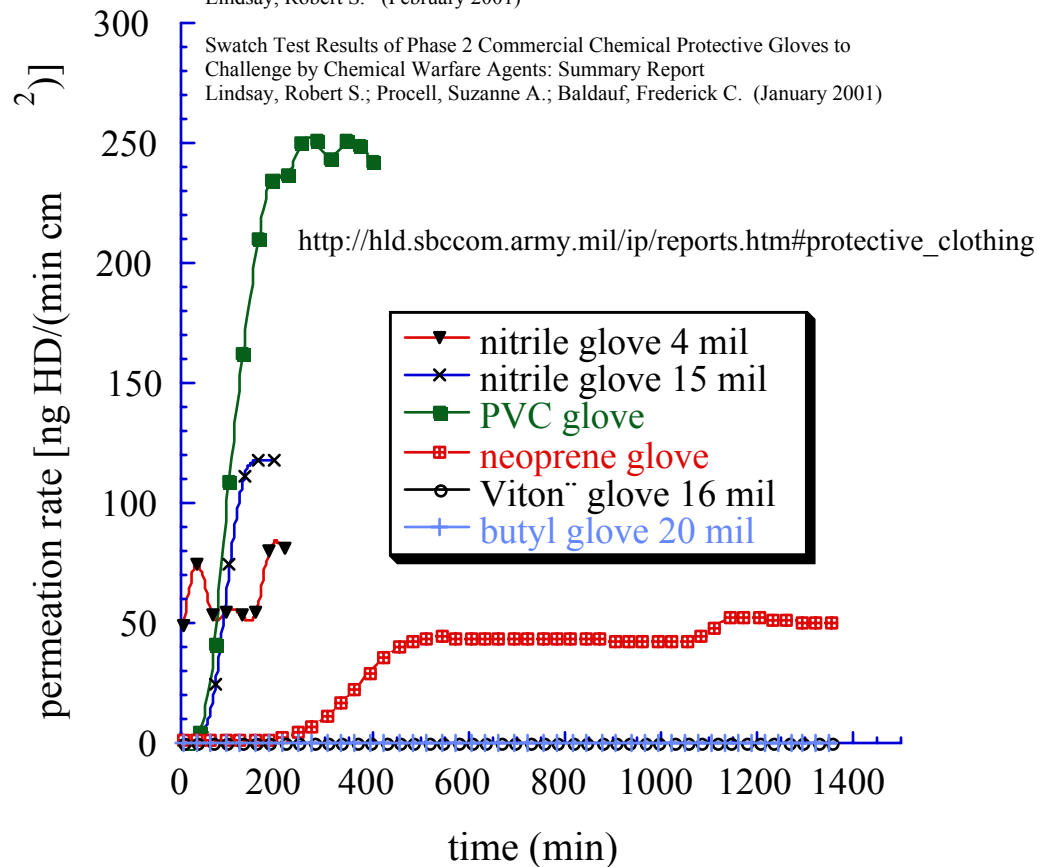
(original data recalculated to obtain permeation rate vs time plot)

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)

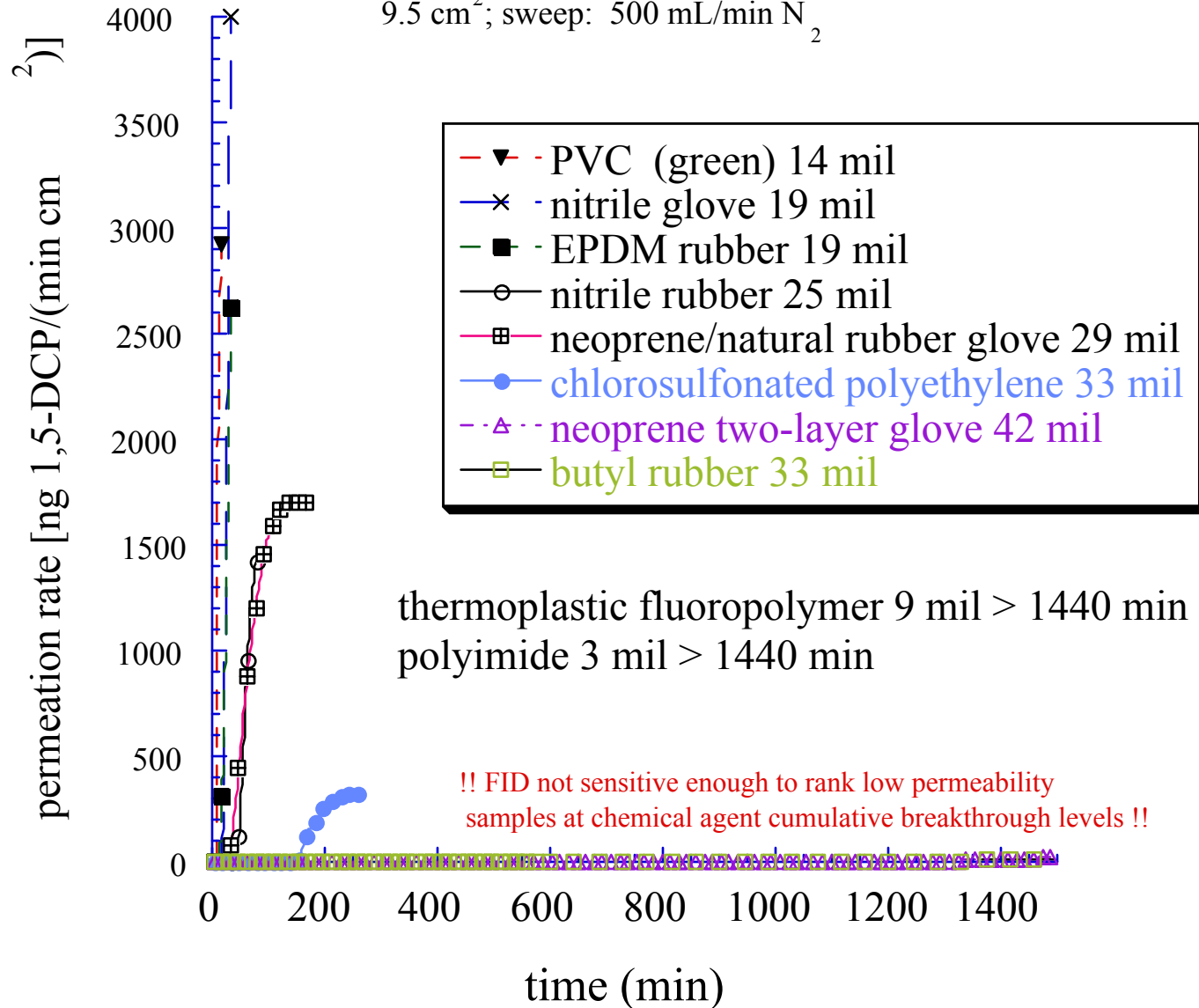


# 1,5-dichloropentane permeation rate

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 mL/min  $\text{N}_2$

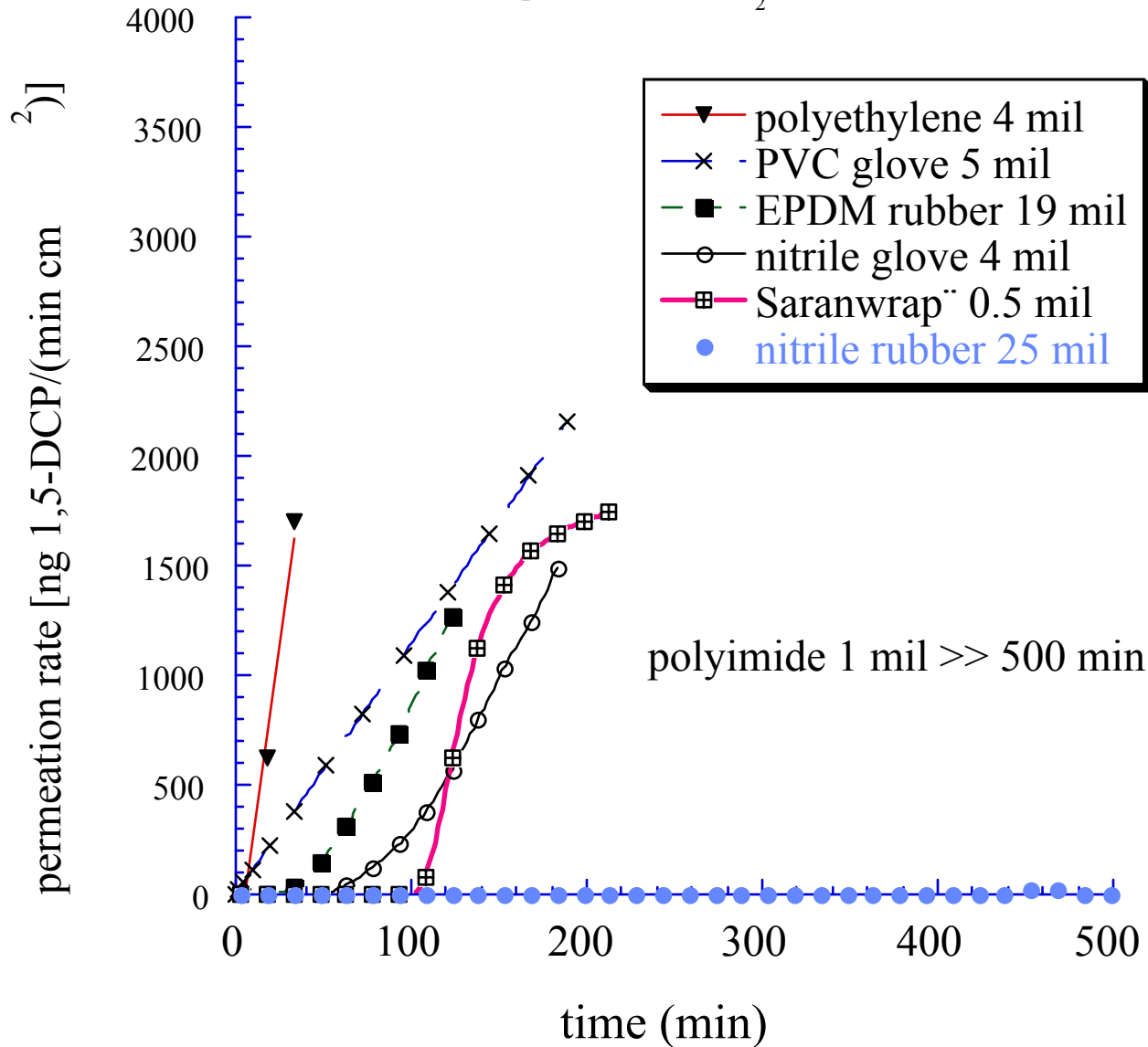


# 1,5-dichloropentane permeation rate

static vapor permeation

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

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



# 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