Permeation of a Straight Oil Metalworking Fluid Through Disposable Nitrile, Chloroprene, Vinyl, and Latex Gloves

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Accepted for publication in the Journal of Hazardous Materials
Aims

- Select rubber gloves for straight oil metalworking fluids (MWFs)
- Study collection solvent effects
Background

- Forsberg study, 1986
- Collection solvent: water, air, organic solvent
- Solid medium
- IR
MWFs

MWFs, also called cutting fluids or cutting oils

- Improve tool life
- Reduce workpiece thermal deformation
- Flush away chips from the cutting zone
- Improve surface finish

Independent lubricant manufacturers in US produced 92 million gallons of MWFs in 1990.
Four Major Classes of MWFs

1. Straight oil (neat oil) MWFs
2. Soluble oil (emulsifiable oil) MWFs
3. Semisynthetic MWFs
4. Synthetic MWFs
Exposure and Regulations

- Routes of exposure: Inhalation of aerosols, and dermal contact

- NIOSH REL
  - 0.4 mg/m³ for thoracic particulate mass
  - 0.5 mg/m³ for total particulate

- OSHA
  - Mineral oil mist: 5 mg/m³.
  - Particulates not otherwise regulated, total dust: 15 mg/m³; respirable fraction: 5 mg/m³

- ACGIH
  - Intend to have a new TLV of 0.2 mg/m³ TWA for “poorly and mildly refined” mineral oil used in metalworking, and 5 mg/m³ TWA for “pure, highly and severely refined mineral oils”
Health Risks

- Respiratory Disorders
- Cancer concern
- Dermatitis
Major Disposable Glove Materials

- Natural rubber
- Polyvinyl chloride rubber
- Chloroprene
- Nitrile rubber
- Polyethylene
## Gloves

<table>
<thead>
<tr>
<th>Glove Type</th>
<th>Descriptive Brand Name</th>
<th>Manufacturer (Address)</th>
<th>Monomer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrile</td>
<td>Kimberly-Clark Safeskin Blue Nitrile exam gloves (nitrile powder-free latex-free)</td>
<td>Kimberly-Clark (Roswell, GA)</td>
<td>Acrylonitrile/butadiene</td>
</tr>
<tr>
<td>Latex</td>
<td>Kimberly-Clark Safeskin Satin Plus powder-free latex exam gloves</td>
<td>Kimberly-Clark (Roswell, GA)</td>
<td><em>cis</em>-Isoprene</td>
</tr>
<tr>
<td>Chloroprene</td>
<td>SemperCare CRX by Sempermed chloroprene examination gloves (latex-free powder-free beaded)</td>
<td>Sempermed (Clearwater, FL)</td>
<td>Chloroprene</td>
</tr>
<tr>
<td>Vinyl</td>
<td>OAK Laboratory Handies Standard Weight vinyl gloves (nonallergenic latex-free powder-free recyclable single use)</td>
<td>Oak (Stow, OH)</td>
<td>Vinyl chloride</td>
</tr>
</tbody>
</table>
Permeation Experiments

ASTM F739-99a permeation method, with 1 inch permeation cells from Pesce Lab
Methods

- Duration: 8 hours
- Challenge: the straight oil MWF D4 (No challenge for controls)
- Collection: hexane and perfluorohexane
Methods: Gravimetry

- Evaporate final collection solutions in V-vials at 35°C under nitrogen flow (Evaporation method validated)

- Permeated D4 mass \( (m) \) determined after correcting for controls

- The time weighted permeation rate \( P_A = (m/A)/t \), where \( A \) is the exposed permeation area of the glove, and \( t \) is the duration of the permeation tests.
Amount of Glove Extractables by the Two Collection Solvents
Permeated Amounts of D4 Through the Gloves

<table>
<thead>
<tr>
<th>Glove Type</th>
<th>Time weighted permeation rate (µg/cm²/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloroprene</td>
<td>4.1 ± 0.5</td>
</tr>
<tr>
<td>Latex</td>
<td>13.6 ± 0.3</td>
</tr>
<tr>
<td>Nitrile</td>
<td>0.04 ± 0.08</td>
</tr>
<tr>
<td>Vinyl</td>
<td>0.3 ± 0.1</td>
</tr>
</tbody>
</table>
\( P_A \) with hexane collection was generally much larger.

The ranking of glove performance with either solvent was similar.
After 15 minutes, about 400 to 1000 µg/cm² of hexane back-permeated.

After 30 to 60 minutes, hexane concentration in the challenge chamber reached saturation (1.0 mg/mL).

Perfluorohexane was detected in the empty challenge chamber after 1 hour for one replicate, and after two hours in the other two replicates.

At the end of the 8-hour experiment, 0.5 µg/cm² of perfluorohexane had back-permeated.
Conclusions

- Hexane extracted more glove components than perfluorohexane, and increased the amounts and permeation rates of D4

- Perfluorohexane is a better collection solvent

- The ranking of performance of these four types of gloves were the same for both collection solvents

- Nitrile was the best glove for the straight oil MWF
Acknowledgement

• UCLA COEH
• ASPH/NIOSH S1891-21/21
• NIOSH OH03754
• NIOSH SC ERC Pilot Project 405950
• Robert N. Phalen, PhD, CIH
• Weng Kee Wong, PhD

Thank you!