Dermal, inhalation and internal exposure to 1,6-HDI and its oligomers in car body repair shop workers and industrial spray painters

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Introduction

• Highly reactive N=C=O group
• Present in polyurethane products
• Low molecular weight allergens
• Important cause of occupational asthma
• Uncertainties exposure – response
  – Relevant exposure
  – Mechanisms
  – Health endpoints
Epidemiological study

- Population (n=600-800)
  - Car body repair shops
    - Spray painters: HDI + oligomers
    - Welders: Thermal degradation products
  - Industrial painting companies
    - Spray painters: HDI + oligomers
Exposure assessment

- **Compound:**
  - Monomers, oligomers, thermal degradation products
  - Vapor - aerosol
  - Several analytical methods

- **Route:**
  - Inhalatory
  - Dermal (no quantitative methods)

- **Pattern:**
  - Variability high
  - PPE use

- Actual total exposure received unknown
Study aims

- Develop method for dermal exposure
- Compare task based exposure with urinary metabolites in spray painting environments
## Study design

<table>
<thead>
<tr>
<th></th>
<th>Car body repair shops</th>
<th>Industrial painting companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Companies</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td><strong>External exposure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhalation - dermal</td>
<td>68</td>
<td>27</td>
</tr>
<tr>
<td>Tasks</td>
<td>Mixing, spraying,</td>
<td>Mixing, spraying, rolling/brushing, assisting</td>
</tr>
<tr>
<td></td>
<td>cleaning spray gun, welding</td>
<td></td>
</tr>
<tr>
<td>Biomonitoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workers</td>
<td>47</td>
<td>12</td>
</tr>
<tr>
<td>Urine samples</td>
<td>243</td>
<td>56</td>
</tr>
</tbody>
</table>
Exposure assessment

Inhalation exposure
- Sampling: Impinger
- Reagent: Di-n-butylamine (DBA) in toluene
- Analysis: LC-MS

Dermal exposure
- Sampling: Nitril rubber gloves submerged into reagent after sampling
- Reagent: DBA in toluene
- Analysis: LC-MS
Inhalation exposure

car body repair shops

HDI

Oligomers
Dermal exposure

car body repair shops

Percentage above LOD

HDI Oligomers

Concentration (μg/2 gloves)
Inhalation exposure
industrial painting companies

Percentage above LOD

Spray painting
Rolling/brushing
Mixing
Assisting

HDI

Concentration (µg/m³)

10⁶
10⁵
10⁴
10³
10²
10¹
10⁰
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶

Oligomers
Dermal exposure
industrial painting companies

Percentage above LOD

Spray painting  Mixing  Assisting

Spray painting  Rolling/brushing  Mixing  Assisting

HDI  Oligomers

Concentration (μg/2 gloves)
Determinants dermal exposure

Odds ratio’s for the presence of detectable dermal exposure

<table>
<thead>
<tr>
<th></th>
<th>Car body repair shops (n=6)</th>
<th>Industrial painting companies (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gloves vs no gloves</td>
<td>0.22 (0.09-0.57)</td>
<td>-*</td>
</tr>
<tr>
<td>Inhalation exposure level (µg/m³ NCO)**</td>
<td>1.34 (0.97-1.84)</td>
<td>0.97 (0.68-1.38)</td>
</tr>
</tbody>
</table>

* No OR calculated since all workers used gloves
** OR for a 10-fold increase in inhalation exposure levels
External exposure

• Inhalation exposure
  • Oligomers >> HDI
  • Spray painting >> mixing, cleaning spray gun

• Dermal exposure
  • Oligomers>>HDI
  • Spray painting ~ mixing, cleaning spray gun
Biomonitoring HDA

• Urinary metabolite of HDI
• Exposure through all routes
• Method:
  • Sampling: 24h Urine spot samples
  • Metabolite: Hexamethylene di-amine (HDA)
  • Analysis: GC-MS
Biomonitoring

A: Car body repair shop: Activities involving paint

- Spray painting n=15
- Handling paint n=1

B: Car body repair shop: Welding

Spray painting n=15
Handling paint n=1
Welding n=8
Biomonitoring

C: Car body repair shop: Other tasks
- HDA in urine (mg/gK)
- Activities involving paint n=7
- Other tasks (not shown) n=5

D: Industrial paint company: Activities involving paint
- HDA in urine (µg/gK)
- Activities involving paint n=7
- Other tasks (not shown) n=5

Other tasks n=23
## HDA over the measurement day

<table>
<thead>
<tr>
<th>Time interval</th>
<th>% above LOD</th>
<th>OR (95% CI) detectable samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-8 AM</td>
<td>18</td>
<td>-</td>
</tr>
<tr>
<td>8-12 AM</td>
<td>17</td>
<td>1.06</td>
</tr>
<tr>
<td>0-3 PM</td>
<td>11</td>
<td>1.03</td>
</tr>
<tr>
<td>3-6 PM</td>
<td>23</td>
<td>2.06*</td>
</tr>
<tr>
<td>6-12 PM</td>
<td>27</td>
<td>1.92</td>
</tr>
<tr>
<td>0-8 AM next day</td>
<td>24</td>
<td>1.97</td>
</tr>
</tbody>
</table>

* p<0.05

→ Fraction of detectable HDA significantly raised during the day
Internal exposure (HDA)

• 25% of spray painters
  – Inter person variability
  – No clear association with PPE use

• Also other workers
  – Different source HDA
  – Earlier exposure (longer half life oligomers)
  – Bystander exposure
Conclusions

• Exposure
  – Dermal exposure successfully measured
  – Dermal and inhalation exposure present
  – Mainly (spray) painters

• Internal exposure
  – Non spray painters may receive considerable doses