Exposure Indices for Painters Exposed to Toluene and Xylene at Low Concentrations

Key words: Exposure indices—Intraindividual—Painter—Toluene—Xylene—Low concentrations—Hippuric acid—Methylhippuric acid

It is important for health surveillance of workers who are exposed to harmful chemicals to keep their individual records of exposure levels. The measurement of the exposure level of toluene or xylene, which is widely used as thinner and degreaser, can be made in ambient air, exhaled air, blood or urine. To continue taking the data of the exposure levels in practice, analytical methods must be accurate, simple and economic. For the present, the time-weighted average concentration (TWA) of toluene or xylene, or the urinary metabolites hippuric acid and methylhippuric acid is recommended for the indices of the exposure levels because it is easy to sample and has established methods for analysis. Although there have been many reports on the exposure indices of toluene or xylene, most of them have been studied for the purpose of mass screening. Few reports have been concerned with the relationship between the exposure levels of the solvents and the intraindividual variation in urinary metabolites. This study was conducted to determine whether these metabolites can be used to monitor individual exposure levels at relatively low concentrations.

Four healthy male painters aged 23 to 50 were examined for ten or eleven days. They worked, outdoors or indoors, at wall grinding, basic and surface painting with oil and/or aqueous paints containing organic solvents, mainly toluene and xylene. They wore no gas masks during their work. Before they started working in the morning, diffusion samplers (3M MONITOR 3500) were attached to their collars for personal monitoring. The diffusion samplers were taken off at the end of the shift. The organic materials were desorbed from the diffusion samplers with carbon disulfide and analyzed for toluene and o-, m- and p-xylene by GC. The workers' urine was collected before work (pre-shift) and at the end of shift. The urine samples were filtered through 0.45 micrometer membrane filters then analyzed for hippuric acid and o-, m- and p-methylhippuric acid by HPLC. The observed values of the urinary metabolites were corrected for the creatinine concentrations determined by a conventional colorimetric method.

The exposure levels (TWA) of toluene and the concentrations of hippuric acid in the urine sampled at the end of shift are shown in Fig. 1. The exposure levels of toluene in individual workers were markedly different on different days, but were clearly lower than the TLV (100 ppm). The daily urinary levels of hippuric acid also varied greatly. There were no significant relationships between the individual exposure levels of toluene and the urinary levels of hippuric acid,
Fig. 1. Relationship between hippuric acid and toluene

- HA: hippuric acid in urine after work
- Toluene: TWA of toluene
- a day off

(a) K.H (aged 46)
(b) M.K (aged 23)
(c) S.M (aged 46)
(d) I.Y (aged 50)
EXPOSURE INDICES FOR PAINTERS

Table 1. Correlation coefficients between toluene and its urinary metabolite (hippuric acid) from workers exposed to toluene

<table>
<thead>
<tr>
<th>Cases</th>
<th>Number of samples</th>
<th>TWA of toluene (ppm)</th>
<th>Correlation coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>K.H</td>
<td>7</td>
<td>0—2</td>
<td>0.85*</td>
</tr>
<tr>
<td>M.K</td>
<td>9</td>
<td>0—6.7</td>
<td>0.01</td>
</tr>
<tr>
<td>S.M</td>
<td>10</td>
<td>0—4.8</td>
<td>0.54</td>
</tr>
<tr>
<td>I.Y</td>
<td>10</td>
<td>0—4.9</td>
<td>0.40</td>
</tr>
</tbody>
</table>

*p < 0.05

as shown in Table 1. The correlation coefficients were low except for one worker (K.H.) who showed a relatively high value (0.85).

It is generally accepted that hippuric acid in urine is recommended as the exposure index of toluene only when toluene exposure exceeds 50 ppm, since there are large interindividual differences seen in values from workers exposed to similar environmental concentrations of toluene. But at the same time, it is considered that a pre-shift sample of urine provides a baseline of hippuric acid arising from exogenous or dietary source, and that hippuric acid from dietary source is relatively constant. From these observations it was expected that urinary hippuric acid might serve as an index of individual exposure even at lower concentrations of toluene. But the present investigation revealed that hippuric acid in the pre-shift urine was not constant and had a wide range of intraindividual variations as shown in Table 2. Figure 2 shows the difference in the urinary level of hippuric acid before and after work, with the exposure level of toluene. The differences also have no relation to the TWA of toluene. Evidently, there is no definite baseline of hippuric acid in the individuals’ pre-shift urine. The present results indicate that hippuric acid in urine is not a suitable index of exposure to toluene, especially when individual exposure levels are monitored.

Figure 3 shows the exposure levels (TWA) of total xylenes and the concentration of total methylhippuric acids in the urine sampled at the end of the shift for the individual workers. Unlike the concentration of hippuric acid, the daily change in the concentration of methylhippuric acids in urine, followed approximately the same pattern as the xylene exposure levels. The correlation coefficients between them were high as shown in Table 3.

Table 2. Variation in the concentration of hippuric acid in pre-shift urine

<table>
<thead>
<tr>
<th>Cases</th>
<th>Number of samples</th>
<th>Mean (mg/g Cre.)</th>
<th>Standard deviation (mg/g Cre.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K.H</td>
<td>7</td>
<td>285</td>
<td>199</td>
</tr>
<tr>
<td>M.K</td>
<td>9</td>
<td>404</td>
<td>134</td>
</tr>
<tr>
<td>S.M</td>
<td>10</td>
<td>265</td>
<td>174</td>
</tr>
<tr>
<td>I.Y</td>
<td>10</td>
<td>456</td>
<td>313</td>
</tr>
</tbody>
</table>
Fig. 2. Difference in urinary hippuric acid between end of shift and pre-shift

- **Difference**: difference in urinary hippuric acid between end of shift and pre-shift (the value at end of shift minus the pre-shift value)
- **Toluene**: TWA of toluene
- **a day off**
Fig. 3. Relationship between methylhippuric acid and xylene

- **MHA**: methylhippuric acid in urine after work
- **Xylene**: TWA of xylene
- **a day off**
As methylhippuric acids are not normally present in the urine of workers not exposed to xylenes, there are good correlations between the concentration of methylhippuric acids in urine and the TWA of xylenes. The present results agree with this principle. Urinary levels of methylhippuric acids reliably reflect the exposure indices for xylenes, even for individual exposures at low levels.

**ACKNOWLEDGMENT**

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**REFERENCES**

2) NIOSH. NIOSH Manual of Analytical Method 1 2nd. 1977; No 127.
4) ACGIH. Documentation of the TLVs and BEIs 5th. 1986; CAS: 108-88-3.
6) ACGIH. Documentation of the TLVs and BEIs 5th. 1986; CAS: 1330-20-7.

**Table 3. Correlation coefficients between xylene and its urinary metabolite (methylhippuric acid) from workers exposed to xylene**

<table>
<thead>
<tr>
<th>Cases</th>
<th>Number of samples</th>
<th>TWA of xylene (ppm)</th>
<th>Correlation coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>K.H</td>
<td>7</td>
<td>0.1—0.8</td>
<td>0.82*</td>
</tr>
<tr>
<td>M.K</td>
<td>9</td>
<td>0—22.8</td>
<td>0.98**</td>
</tr>
<tr>
<td>S.M</td>
<td>10</td>
<td>0—2.1</td>
<td>0.93**</td>
</tr>
<tr>
<td>I.Y</td>
<td>10</td>
<td>0—15.6</td>
<td>0.92**</td>
</tr>
</tbody>
</table>

*p<0.05  **p<0.001

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