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Use of a surface emissions trap for improving the indoor air quality by efficient exposure reduction

Lennart Larsson\textsuperscript{a*}, Pawel Markowicz\textsuperscript{a} and Johan Mattsson\textsuperscript{b}

\textsuperscript{a}Dept of Laboratory Medicine, Lund University, Sölvegatan 23, 22362 Lund, Sweden
\textsuperscript{b}cTrap Ltd, Scheelevägen 15, 22362 Lund, Sweden

Abstract

A new product, the surface emissions trap (cTrap), a device developed to stop and bind emissions effectively while having virtually no resistance to water vapor, was installed on a PVC flooring in a school with IAQ complaints. After the installation air concentrations of 2-ethylhexanol decreased rapidly and staff and students reported a considerably improved perceived IAQ. The amounts of 2-ethylhexanol adsorbed on the cTrap cloth 13 months after installation corresponded to only 1.03\% of its adsorption capacity. Installing the cTrap may constitute a cost-efficient and effective way of restoring the indoor air quality e.g. following water damage of a building.

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* Corresponding author. Tel.: +46 46725167879; fax: +46 46189117.
\textit{E-mail address:} lennart.larsson@med.lu.se
1. Introduction

Unsatisfactory indoor air quality may be due to emissions e.g. of volatile organic compounds (VOCs) from moist building construction parts. For example, 2-ethylhexanol and n-butanol may be formed due to alkaline hydrolysis of PVC flooring and glue applied on a concrete floor [1]. Both long- and short-term exposure to VOC emissions can result in eye, nose, and throat irritation, allergic reactions, headaches, fatigue etc. A wide range of devices for removing gaseous pollutants indoors such as portable air cleaners, gas-phase filters etc. are commercially available.

Here we describe the performance of a new device, the surface emissions trap (cTrap), developed for reducing VOC emissions from building material surfaces indoors, the goal being to prevent such emissions from reaching individuals residing inside the building. The cTrap is a laminate with two protective sheets of nonwoven polyester fabric surrounding an adsorption layer and a hydrophilic polymer sheet. The device is applied directly at the source of the emissions (floor, walls, ceiling, over cavities etc).

2. Materials and Methods

A school built in the 1970:s, with a long history of complaints on IAQ among the pupils and the school staff, was studied. A cTrap prototype (cTrap Ltd, Lund, Sweden) was attached on the existing PVC flooring, by using a double sided adhesive tape, in a classroom (30 m²). The cTrap cloth, with one adsorption and one polymer layer, adsorbs only from the adsorption layer side; hence the device was applied with the adsorption layer facing the floor; over the device was laid a laminate flooring. Because of the unsatisfactory perceived air quality in the room was not in use since several months. The ventilation was 2-2.5 air exchanges per hour. Air samples as well as samples of the cTrap cloth were taken from the floor (immediately replaced with new pieces of cTrap) at different time periods for measuring the amounts of 2-ethyl-1-hexanol in the air and adsorbed on the cTrap cloth, respectively. Tenax TA tubes were used for passive air samplings for 1 week and sent to IVL (Stockholm, Sweden) for thermal desorption and GC-MS analysis. The cTrap cloth pieces (approximately 3 cm², n=4) were extracted by using dichloromethane following GC-MS, as described elsewhere [2, 3]. In total, approximately 500 m² of cTrap was installed in the school building directly on the PVC flooring and subsequently covered by a laminate flooring.

3. Results and Discussion

The results are illustrated in Table 1. Decreased air concentrations of 2-ethyl-1-hexanol, from 6-7 µg/m³ to 2 µg/m³, were found two months after the cTrap had been applied; the concentrations of 2-ethyl-1-hexanol in the installed cTrap rose from 0 (unused cTrap) to 280.3 µg/g after 13 months of use. Air concentrations of total VOCs (TVOCs) were 58-127 µg/m³.

Table 1. Air concentrations of total VOCs (TVOCs) and 2-ethyl-1-hexanol, and amounts of 2-ethyl-1-hexanol extracted from cTrap, at different time periods after installation of the device.

<table>
<thead>
<tr>
<th>Time</th>
<th>TVOCs [µg/m³]</th>
<th>2-Ethyl-1-hexanol</th>
<th>Adsorbed amounts [µg/g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>before applying cTrap</td>
<td>127</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>1 week after application</td>
<td>95</td>
<td>7</td>
<td>17.0</td>
</tr>
<tr>
<td>2 months after application</td>
<td>72</td>
<td>2</td>
<td>68.6</td>
</tr>
<tr>
<td>8 months after application</td>
<td>119</td>
<td>2</td>
<td>150.6</td>
</tr>
<tr>
<td>13 months after application</td>
<td>58</td>
<td>2</td>
<td>280.3</td>
</tr>
</tbody>
</table>

The fact that the air concentration of 2-ethyl-1-hexanol did not decrease immediately after the cTrap had been applied on the floor may be due to absorption of the compound in the ceiling or walls, diffusing from these surfaces back into the air after the floor emissions had been stopped. This so-called sink effect, where building materials act as buffers for VOCs, has been described [4, 5]. The odor problems in the studied school disappeared shortly (a few
days) after application of the cTrap and the room could again be used as before the air quality complaints. Interestingly, this improvement in the perceived air quality was noticed well before the air concentrations of 2-ethyl-1-hexanol had started to decrease indicating that the problems were caused by substances other than 2-ethyl-1-hexanol. The amounts of 2-ethyl-1-hexanol in the cTrap cloth pieces taken under the laminate flooring increased from 17.0 (one week after installation) to 280.3 (13 months after installation) µg/g in a linear manner ($R^2=0.9975$) suggesting a constant emission of 2-ethyl-1-hexanol from the floor.

The cTrap has previously been shown to be able to efficiently reduce a range of small and larger VOCs including alcohols, aldehydes, ketones, terpenes, aromatic hydrocarbons, sulfides [2, 3]; as well as formaldehyde (a common emission product from building materials used indoors) and 2-chloroanisole (from moist impregnated wood) (data not shown). Recently, it has also been found that the cTrap is efficient against radon and odors from cigarette smoke (data not shown). The device may represent a convenient, health-effective and environment-friendly way of improving indoor air in cases when the problems are due to emissions from surfaces of the building indoors. Further studies should include an unbiased evaluation of the perceived the air quality in buildings following cTrap installation.

4. Conclusion

Emissions of VOCs (including odors) from a surface may be stopped efficiently by applying the cTrap cloth on the surface. In the present study, attaching the cTrap on a PVC flooring in a school with air complaints led to a dramatic improvement in the perceived air quality and decreased 2-ethyl-1-hexanol air concentrations. The device may constitute a useful means of restoring the indoor air quality after water damage.

5. Acknowledgements

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6. References