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Sampling gaseous compounds of heating essential oil using solid phase microextraction devices

Department of Occupational Safety and Hygiene

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Introduction
Essential oils, which are the metabolism by-product of aromatic herbs, and are mainly produced by evaporation, pressing and extraction by solvents or by supercritical procedures.

Introduction
Because of their very low molecular weights, essential oils are easily absorbed into human body through skin; or inhaled via the respiratory tract.

When the chemical compounds of essential oils excite the human nerve system, the release of neurotransmitters initiates several physiological effects, like excitation, calm, or relaxation, etc. (Kao and Hung, 2012).

Introduction
Aromatherapy is the therapeutic use of essential oils in massage, bath and inhalation of spray at specific dosages for purposes of recuperation, emotional balance and care of health.

Of all methods of using essential oils, thermal evaporation of essential oils via diffusers for diffusion of the aromatic molecules in the indoor atmosphere is most frequently used.

Introduction
Chiang et al. (2010) and Chiu et al. (2009) used Tedlar bags to collect samples of exhaust streams produced by heating five essential oils: lavender, lemon, rose, rosemary and tea tree.

Thermogravimetric analysis was used to maintain heating rates of 2–15°C/min to final temperatures of 190–300°C. The carbonyl compounds obtained under poorly ventilated conditions included formaldehyde, acetaldehyde, acetone and propylaldehyde at concentrations of 34–170 ppb.
When the final temperature of heating progress was 40°C, the VOCs were aromatic compounds, including toluene (around 1–3 ppm), 1,2,3-trimethylbenzene, 1,2,4-trimethylbenzene, p-diethylbenzene, and m-diethylbenzene (5–6 ppm).

Introduction
Su et al. (2007) diluted 300 μL quantities of three essential oils (lavender, eucalyptus and tea tree) in 50 mL water and then indirectly heated the three dilutions in glass dishes.

Experimental comparisons between two indoor environments: a bedroom (21.6 m$^3$, air exchange rate 1.8 hr$^{-1}$) and an office (28.2 m$^3$, air exchange rate 1.3 hr$^{-1}$).
The experimental results indicated that the concentrations of indoor air pollutants increased because of heating essential oils:

CO (1.48 vs. 0.47 ppm, hereinafter, values are given as heating concentration vs. background concentration), CO₂ (543 vs. 435 ppm) and total VOCs (0.74 vs. 0.48 ppm), which shows that heating essential oils reduces the air quality but does not substantially increases particulate matters.
The above studies of heated essential oils reported that concentrations of VOC by-products ranged from a few tens of ppb to thousands ppb.

To date, studies of essential oils have used different types of brands or purity of essential oils and have used distinct heating procedures, which have resulted in widely varying air pollutants and concentration distributions.

Introduction
This study effectively sampled trace VOCs by using a self-fabricated solid phase microextraction (SPME) device, needle trap samplers (NTS). The target essential oil was only tea tree oil, which was evaporated in three modes: free convection evaporation diffuser and thermal ceramic wicks. After sampling and analysis of VOC by-products, the extraction performances of NTS were compared to those of commercial SPME fiber samplers.

Introduction
Methods
Methods

- Free convection
  - 27°C, no heating

- Evaporation diffuser
  - 40°C, commercial diffuser with a 5-Watt bulb

- Thermal ceramic wick
  - 100°C, thermal ceramic wick for evaporating by electric power

Teflon bags

GC/MS
Methods

Diffuser with a 5-Watt bulb
Methods

Thermal ceramic wick
Adsorbent: 80–100 mesh divinylbenzene (DVB) particles
Methods

- Essential oils (different evaporation modes)
- 10-liter burning chamber
- 1.5 L/min Air
- Needle trap sampler
- PDMS SPME fiber
- Vent
- Valve
## Results & Discussions

Main air by-products of tea tree essential oil by different evaporation modes

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Free convection</th>
<th>Evaporation diffuser</th>
<th>Thermal ceramic wicks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylbenzene</td>
<td>2.7 ng (0.73 ng)</td>
<td>4.5 ng (1.20 ng)</td>
<td>5.6 ng (1.84 ng)</td>
</tr>
<tr>
<td>m/p-Xylene</td>
<td>3.2 ng (1.10 ng)</td>
<td>5.5 ng (1.44 ng)</td>
<td>6.8 ng (1.82 ng)</td>
</tr>
<tr>
<td>1,2,3-Trimethylbenzene</td>
<td>1.8 ng (0.57 ng)</td>
<td>3.3 ng (1.06 ng)</td>
<td>28.8 ng (9.79 ng)</td>
</tr>
<tr>
<td>1,2,4-Trimethylbenzene</td>
<td>4.2 ng (1.4 ng)</td>
<td>5.3 ng (1.83 ng)</td>
<td>21.6 ng (6.31 ng)</td>
</tr>
<tr>
<td>1,4-Diethylbenzene</td>
<td>1.6 ng (0.56 ng)</td>
<td>3.3 ng (1.24 ng)</td>
<td>28.6 ng (9.02 ng)</td>
</tr>
<tr>
<td>1,2,3-Trimethylbenzene</td>
<td>1.8 (0.57)</td>
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<td>1,2,4-Trimethylbenzene</td>
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</tr>
<tr>
<td>1,4-Diethylbenzene</td>
<td>1.6 (0.56)</td>
<td>3.3 (1.24)</td>
<td>28.6 (9.02)</td>
</tr>
<tr>
<td>Others</td>
<td>1.6 (0.56)</td>
<td>3.3 (1.24)</td>
<td>28.6 (9.02)</td>
</tr>
<tr>
<td>Acetone</td>
<td>3.6 (0.23)</td>
<td>11.8 (4.65)</td>
<td>18.4 (3.97)</td>
</tr>
</tbody>
</table>
NTS vs. SPME fiber

Free convection

Results & Discussions
Results & Discussion

NTS vs. SPME fiber

Evaporation diffuser

![Bar graph showing adsorption mass (ng) for various compounds: EB, m/p-Xylenes, 1,2,3-TB, 1,2,4-TB, and 1,4-D8. The graph compares NTS (solid bars) and SPME (open bars).]
Results & Discussions

**NTS vs. SPME fiber**

Thermal ceramic wicks

![Graph showing adsorption mass (ng) for different compounds (EB, m/p-Xylenes, 1,2,3-TB, 1,2,4-TB, 1,4-DB) comparing NTS and SPME fibers.](image)


Thanks for your attention!