Simultaneous sampling and analysis of indoor air infested by Cimex lectularius L. (Hemiptera: Cimicidae) with solid phase microextraction, thin film microextraction and needle trap device

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Introduction & Theory

Air in a room infested by Cimex lectularius L. (Hemiptera: Cimicidae) was sampled simultaneously by three different sampling devices including solid phase microextraction (SPME) fiber coatings, thin film microextraction (TFME) devices, and needle trap devices (NTDs) and then analyzed by gas chromatography-mass spectrometry (GC-MS).

The results presented in the current study illustrate comprehensive characterization of infested indoor air samples through the use of three different non-invasive SPME formats and identification of novel components comprising *C. lectularius* pheromone, therefore, promising future alternatives for use of potential synthetic pheromones for detection of infestations.

thermodynamic theory of SPME

$$n_e = (K_{fs} \cdot V_f \cdot V_s \cdot C_o) / (K_{fs} \cdot V_f + V_s)$$

i: $K_{fs} \cdot V_f \ll V_s$

ii: $\downarrow K_{fs}$

on-site applications & negligible depletion conditions

$$n_e = K_{fs} \cdot V_f \cdot C_o$$

sample volume independent

n_e: mass extracted at equilibrium;

K_{fs}: fibre coating/sample matrix distribution constant of analyte;

V_f: coating volume;

V_s: sample volume;

C_o: concentration of analyte;

A: surface area of extraction phase;

dn/dt: extraction rate;

D_s: diffusion coefficient;

δ: thickness of boundary layer;

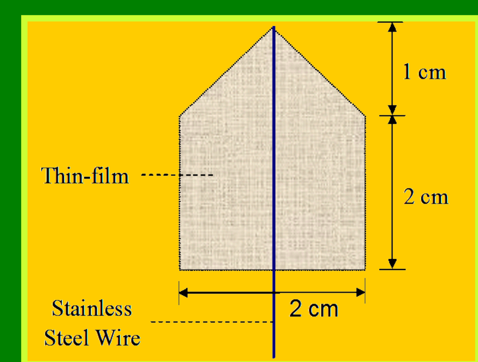
$(b\text{-}a)$: extraction phase thickness;

t_e: equilibrium time

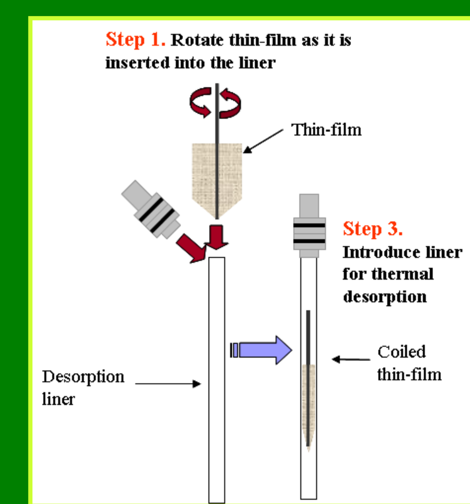
$\uparrow V_f$	$n_e = K_{fs} V_f C_o$	$\uparrow$ sensitivity
$\uparrow A$	$d_n / d_t = (D_s A / \delta) C_o$	$\uparrow d_n / d_t$
$\downarrow (b\text{-}a)$	$t_e = [3 \delta K_{fs} (b\text{-}a)] / D_s$	$\downarrow t_e$

SPME Devices & Sampling Conditions

thin film microextraction device; TFME

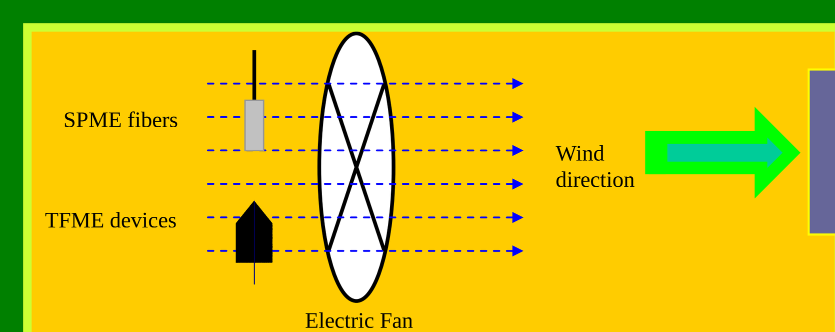


sample introduction



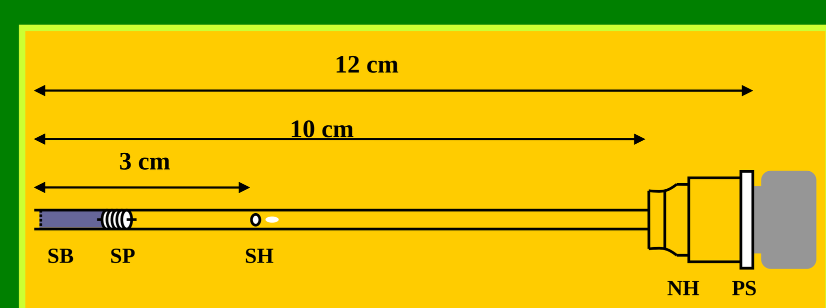
sampling method for TFME devices & SPME coatings

extraction time 3.5 hr



sampling indoor air by providing agitation

needle trap device; NTD

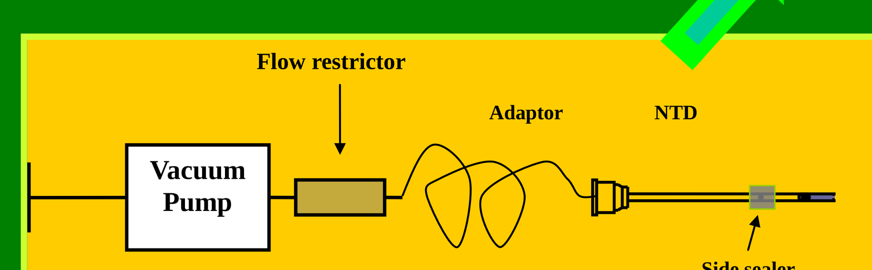


SB sorbent;
SP spiral plug;
SH side hole;
NH needle head;
PS PTFE sealer

sampling method for NTD devices

extraction time 20 min

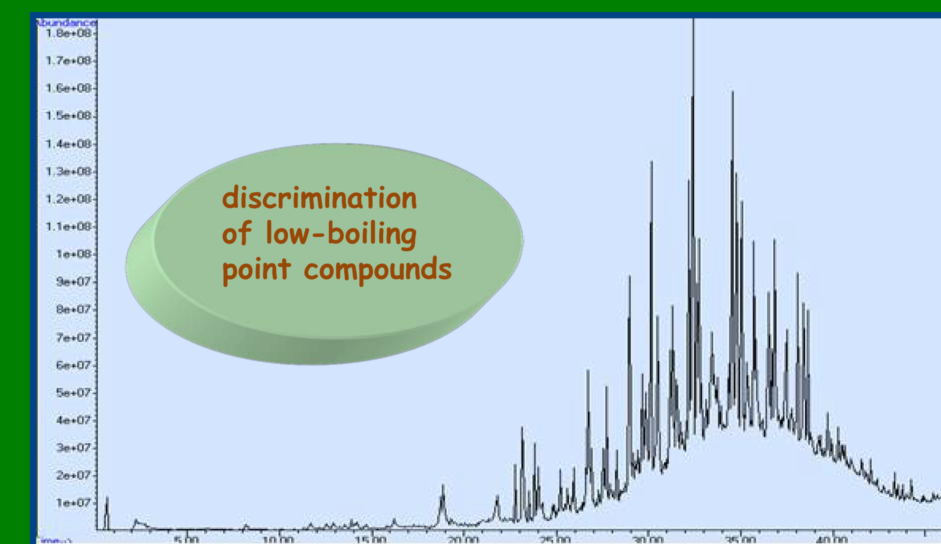
sampling indoor air by providing active sampling



Results & Discussion

performance of TFME devices

TIC chromatogram;
highly infested air sample



performance characteristics

# of peaks tentatively identified: 22;

poor retention capacity of PDMS membrane;

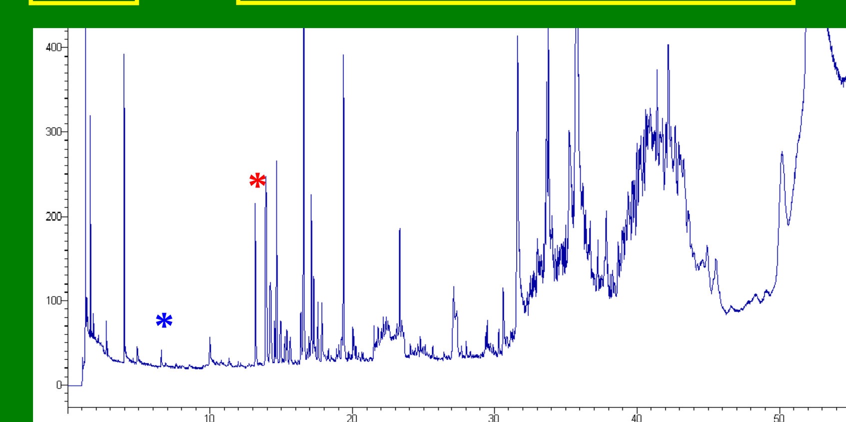
volatile analyte losses due to prolonged times between sampling & GC-MS analysis;

suitable for more biased & targeted screening studies involving high boiling point components

performance of SPME & NTD devices

TIC chromatograms;
highly infested air sample

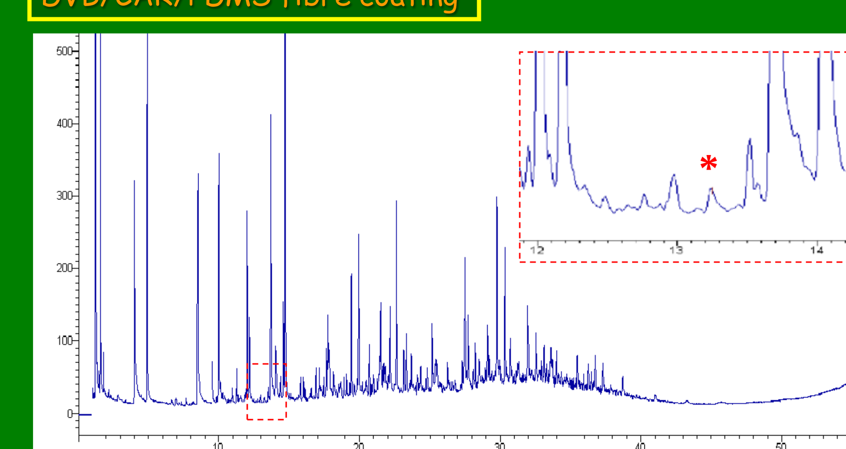
NTD



(*E*)-2-hexenal & (*E*)-2-octenal

two major components of C. lectularius alarm pheromone

SPME
DVB/CAR/PDMS fibre coating



(*E*)-2-octenal

↑ fibre coating/sample matrix distribution constant

Results & Discussion - *continued*

performance characteristics

compound name	SPME	NTD	TFME
(*E*)-2-hexenal	x	√	x
3-carene	√	x	x
D-limonene	√	x	x
2-ethylhexanol	√	x	x
(*E*)-2-octenal	√	√	x
nonanal	√	√	x
L-menthol	√	x	x
alpha-terpineol	√	x	x
2-decen-1-ol	x	√	x
decanal	√	x	x
(*E*)-cinnamaldehyde	x	√	x
tridecane	√	√	x
tetradecane	√	√	x
longifolene	√	x	x
pentadecane	√	√	x
diethyl phthalate	√	√	x
cedrol	√	x	x
heptadecane	√	√	√
pentadecanal	x	√	x
tetradecanoic acid	x	√	x
pentadecanoic acid	x	√	x
hexyl cinnamic aldehyde	x	x	√
octadecane	√	x	√
isopropyl myristate	√	x	√
galaxolide	√	x	√
7-methyl-*Z*-tetradecen-1-ol acetate	x	x	√
2-methylhexadecan-1-ol	x	x	√
dibutyl phthalate	√	x	√
ethyl hexadecanoate	x	x	√
isopropyl palmitate	√	x	√
8-octadecenal	x	x	√
methyl 4-hydroxyoctadecanoate	x	x	√
Z-5-methyl-6-heneicosen-11-one	x	x	√

suitable for **volatile** & **semivolatile** analytes:

non-particulate bound & have **high Kfs** values (mid-elution region)

→ **SPME**

suitable for sampling of analytes from **access-restricted areas & narrow openings**;
suitable for **unbound & particulate-bound analytes**

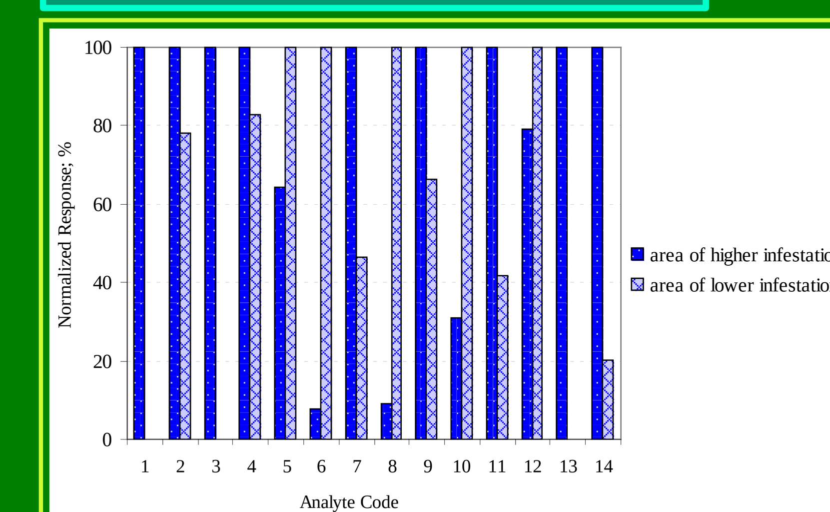
→ **NTD**

RSD (n=3); %

SPME
1.4% (alpha-terpineol) to 26.1% (3-carene)

TFME
1.2% (2-methylhexadecan-1-ol) to 10.1% (hexyl cinnamic aldehyde)

biomarkers of infestation



1) D-limonene,
2) 2-ethylhexanol,
3) (E)-2-octenal,
4) nonanal,
5) L-menthol,
6) alpha-terpineol,
7) decanal,
8) tetradecane,
9) longifolene,
10) pentadecane,
11) hexadecane,
12) diethyl phthalate,
13) cedrol,
14) heptadecane

Conclusions

This study illustrated the comparison of performance characteristics of SPME, TFME & NTD devices in sampling of *C. lectularius* infested indoor air samples, pheromone characterization & detection of biomarkers of infestation.

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