

Air quality assessment during indoor use of the Tobacco Heating System THS 2.2

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Introduction and Objectives

Philip Morris International's (PMI) heat-not-burn Tobacco Heating System 2.2 (THS 2.2), commercialized under the name IQOS[®], uses an electronically controlled mechanism to precisely heat specially designed tobacco sticks at operating temperatures well below combustion (less than 350°C). As a result, the generated aerosol is composed of mainly water, glycerin and nicotine while the levels of harmful and potentially harmful constituents are significantly decreased compared to cigarettes smoke (Schaller et al. 2016). In order to address public health concerns about possible presence of polluting substances during indoor use of heated tobacco products, which may present an exposure source to potential bystanders, a study was designed using a dedicated controlled room (Indoor Air Quality room, IAQ room, Figure 1) and applying ventilations conditions recommended to simulate environment representative for residential buildings with natural ventilation ("Residential category III"; EN 15251:2007, Table 11).

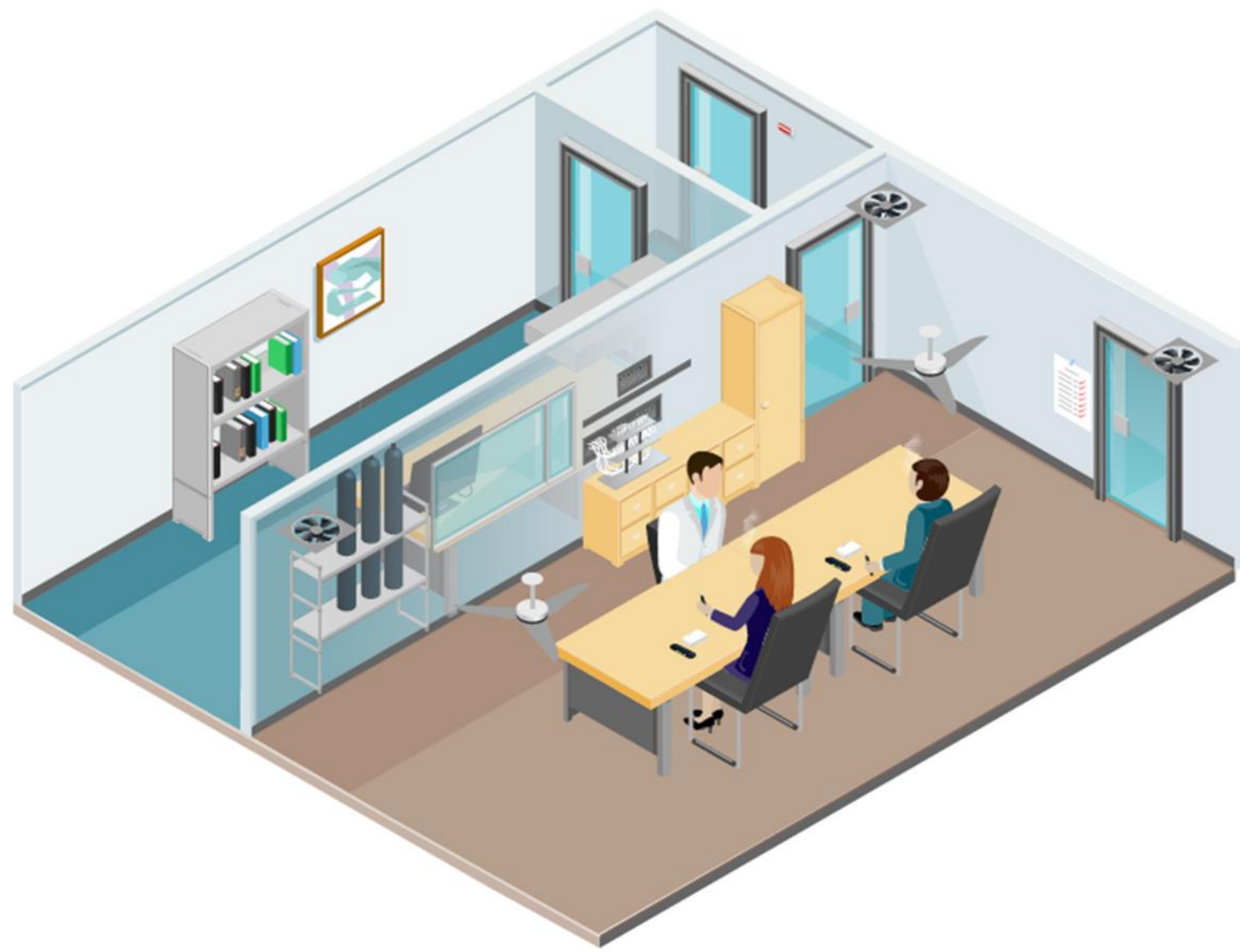


Table 1: Ventilation conditions (EN 15251:2007)

Category used for specification	Ventilation m³/h	Air change 1/h
Office	156	2.16
Hospitality	555	7.68
Residential I	121	1.68
Residential II	87	1.2
Residential III	37	0.5

Figure 1: Graphical representation of the IAQ room (72.3 m³, 24.1 m²) during the experiments with THS 2.2.

Methods

Table 2: Study design.

9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00
Preparation of the room	People present in the room not using any product	Break Room ventilated	Same people, product used according to study protocol	End of the sessions	Start of the analysis		

Background (BKG)
How people contribute to indoor air pollution

Environmental Aerosol (EA)
How product contributes to indoor air pollution

- Experiments were executed in an environmentally controlled room (IAQ room, Figure 1) with a ventilation set at 0.5 air changes/h and occupant density of 8 m²/person (two Panelists and one PMI staff member)
- Adult experienced IQOS users for the THS 2.2 sessions, e-cigarette users for the e-cigarette sessions, and cigarette smokers for the Marlboro Gold sessions were recruited by an external company
- THS 2.2 were used under predetermined conditions (2 hours, 6 sticks/hour, 12 sticks in total)
- E-cigarettes were used under predetermined conditions (2 hours, 6 vaping sessions of 10 min/hour, 12 vaping sessions in total)
- Positive control: Marlboro Gold (2 hours, 6 cigarettes/hour, 12 cigarettes in total)
- Background session (2 hour) with the same volunteers as for the product session before each THS 2.2, e-cigarette or Marlboro Gold session (Table 2)
- Indoor air concentrations of constituents were determined (Table 3) using ISO-17025 accredited methods (Mottier et al. 2016)

Table 3: List of constituents analyzed during the study and rationale for selection*.

Category - (Norm) -[unit]	Constituents	Rationale for selection
ISO measurement standards for ETS (ISO Norms 15593, 2001; 18144, 2003; 18145, 2003) - [µg/m³]	RSP gravimetric, UVPM-THBP, FPM-scopoletin, Solanesol, 3-Ethenylpyridine, Nicotine	PM2.5 & tobacco smoke related particulate matter markers Gas-phase tobacco smoke specific markers
ISO measurement standard for TVOCs (ISO 16000-6, 2011) - [µg/m³]	Total Volatile Organic Compounds (TVOC)	Air quality marker
Carbonyls - [µg/m³]	Acetaldehyde, Acrolein, Crotonaldehyde, Formaldehyde	Relevance for air quality: Relative abundance in THS 2.2 aerosol (i.e., the most abundant)
Volatile Organic Compounds (VOCs) - [µg/m³]	Acrylonitrile, Benzene, 1,3-Butadiene, Isoprene, Toluene	Carbonyls, VOCs: part of the FDA list of HPHCs
Phenols - [µg/m³]	Catechol, Hydroquinone	
Tobacco-specific Nitrosamines (TSNAs) - [ng/m³]	N-nitrosornicotine (NNN), 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK)	TSNAs: tobacco smoke specific markers, part of the FDA list of HPHCs
Product-specific compounds: aerosol formers - [µg/m³]	Glycerin, Propylene Glycol	Product-specific markers
Inorganics (CO [ppm], NO [ppb], NO _x [ppb])	Carbon monoxide, Nitrogen oxide, Nitrogen oxides	Gas-phase tobacco smoke non-specific markers and combustion marker

*Constituents forming part of FDA list of HPHCs are underlined.

Data evaluation:

When concentration is equivalent between BKG and product-use sessions: **NO IMPACT ON IAQ.**

When concentration is different between BKG and product-use sessions: **THE IMPACT IS THE DIFFERENCE BETWEEN BKG AND PRODUCT SESSION.**

Concentrations are compared to existing air quality guidelines (e.g. WHO, EU, MOH).

References

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Abbreviations

ACGIH: American Conference of Governmental Industrial Hygienists; EA: environmental aerosol; EU: European Union; FPM: Fluorescence Particulate Matter; HPHC: Harmful and Potentially Harmful Constituents; MOH: Ministry of Health Japan; NNN: nicotine-derived nitrosamine ketone; NNN: N-nitrosornicotine; OSHA: US Occupational Health and Safety Administration; PM1: Particulate Matter <1 µm; PM2.5: Particulate Matter <2.5 µm; PMI: Philip Morris International; RSP: Respirable Suspended Particles; THS: Tobacco Heating System; TVOC: Total Volatile Organic Compounds; UVPM-THBP: Ultraviolet Particulate Matter-2,2',4,4'-tetrahydroxybenzophenone; VOC: Volatile Organic Compounds; WHO: World Health Organization

Results

Illustration of the evaluations are presented on Figure 2 and Figure 3.

Nicotine:

- specific marker of Environmental Tobacco Smoke, environmental aerosol (EA) of THS 2.2 and e-cigarettes
- mainstream aerosol of THS 2.2 (Health Canada Intense): 1.32 ± 0.16 mg/stick (mean ± CI_{95%})
- mainstream aerosol of e-cigarette Solaris[®] (Coresta regime, 100 puffs): 46.6 µg/puff
- guideline upper limit values: 500 µg/m³ (8h; OSHA), 500 µg/m³ (8 hours, occupational exposure EU)

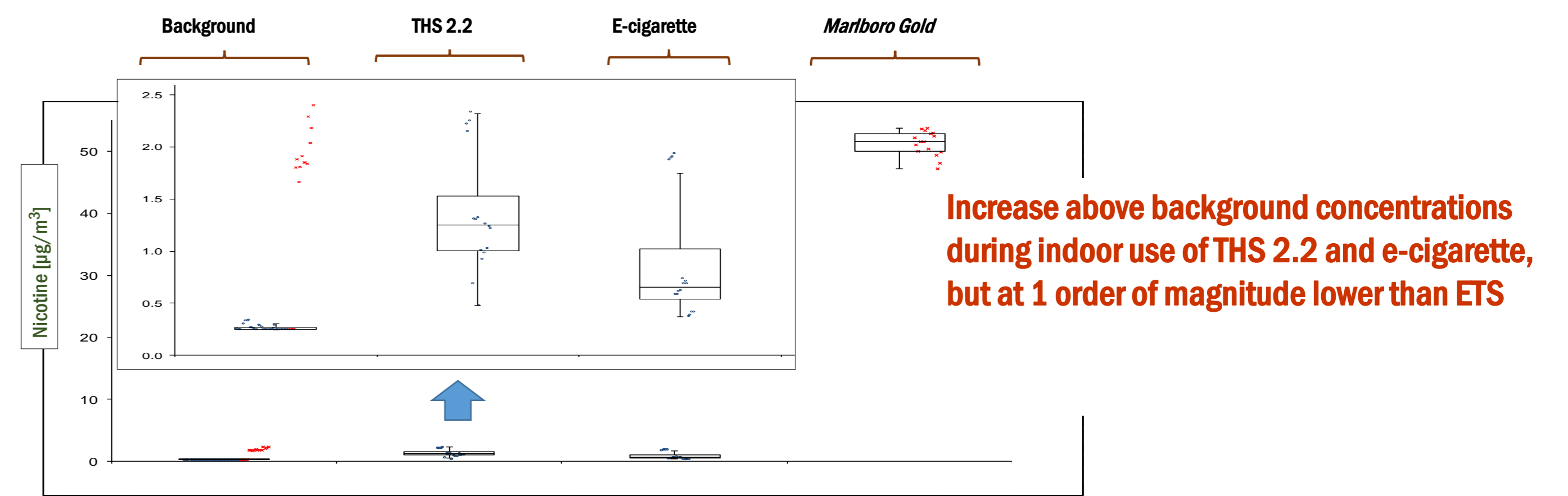


Figure 2: Comparison of data for nicotine measurements.

Total Volatile Organic Compounds:

View of chemical composition (bp 69-287°C), IAQ marker: 400 µg/m³(MOH, Japan)

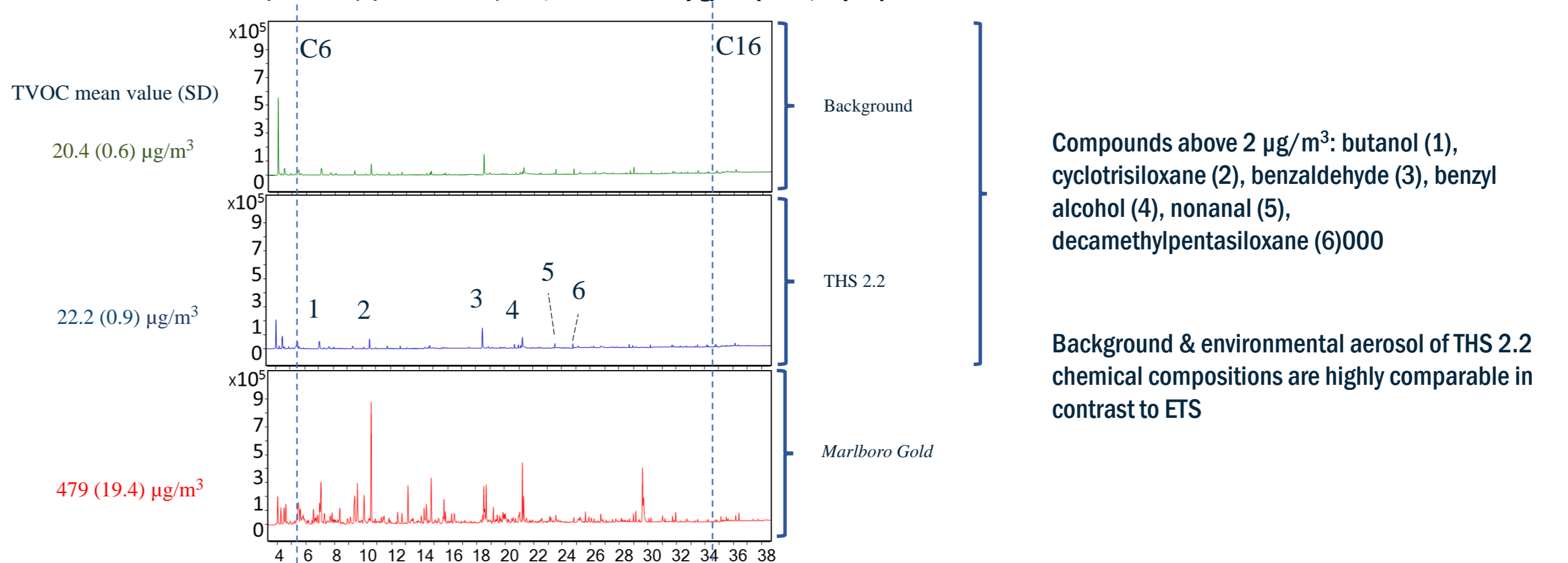


Figure 3: Total Volatile Organic Compounds (TVOC) chromatograms.

The study evaluated the indoor impact of THS 2.2 under typical high load conditions for a residential environment:

- high consumption rates for THS 2.2 and cigarettes (6 sticks/hours, total of 12 sticks for 2 hours session). The results are summarized in Table 4.

One e-cigarette Solaris[®] was also tested during another study, and results were added as comparison in Table 4.

Table 4: Comparison of the summary results of the THS 2.2 and e-cigarette study.

Analyte [unit]	Residential III ventilation condition	THS 2.2 vs Background	e-cigarette vs Background (difference in units)	Marlboro Gold vs Background
RSP gravimetric [µg/m³]	nm	631	nm	687
PM1 & PM2.5 [µg/m³]	nm	92.5	nm	20.3
UVPM-THBP [µg/m³]	nm	20.3	nm	23.9
FPM-scopoletin [µg/m³]	nm	10.2	nm	49.8
Solanesol [µg/m³]	nm	49.8	nm	122
3-Ethenylpyridine [µg/m³]	1.08	0.56	12.4	3.5
Nicotine [µg/m³]	5.55	10.2	58.9	58.9
Acetaldehyde [µg/m³]	nm	5.15	14.2	16.9
Acrolein [µg/m³]	nm	14.2	16.9	164
Crotonaldehyde [µg/m³]	nm	16.9	164	25.2
Formaldehyde [µg/m³]	nm	25.2	25.2	445
Acrylonitrile [µg/m³]	nm	58.9	445	1.43
Benzene [µg/m³]	nm	445	1.43	8.86
1,3-Butadiene [µg/m³]	nm	1.43	8.86	7.34
Isoprene [µg/m³]	nm	8.86	7.34	30.4
Toluene [µg/m³]	nm	7.34	30.4	2.55
TVOC [µg/m³]	8.83	35.6	55.5	58.5
NNN [ng/m³]	nm	55.5	30.4	60.9
NNK [ng/m³]	nm	30.4	60.9	nm
Glycerin [µg/m³]	nm	60.9	nm	nm
Propylene glycol [µg/m³]	nm	nm	nm	nm
CO [ppm]	nm	nm	nm	nm
NO [ppb]	nm	nm	nm	nm
NO _x [ppb]	nm	nm	nm	nm

THS 2.2 is not a source of Environmental Tobacco Smoke (absence of combustion markers)

2 compounds listed as HPHCs clearly attributable to the use of THS 2.2: Nicotine & acetaldehyde

Concentrations of glycerin well over 100 times below the existing guideline levels

*The data are background subtracted; THS 2.2: numerical value not shown if the concentration of the constituent in air is not increased above background

Conclusions

The evaluation of the study results indicated that in comparison to background air, only three compounds could be attributed to the use of THS 2.2:

- nicotine (1.08 µg/m³),
- acetaldehyde (5.55 µg/m³),
- and glycerin (8.83 µg/m³),

with levels much lower than maximum exposure levels defined in existing air quality guidelines (nicotine: 500 µg/m³ (OSHA); acetaldehyde: 140 µg/m³ (OEHA); glycerine: 10 000 µg/m³ (ACGIH)). Markers of combustion were absent in environmental aerosols of THS 2.2.

ETS markers were not increased above background levels confirming the conclusions of previous studies:

- indicating that THS2.2 is not a source of ETS (Mitova et al. 2016).
- Moreover the EA concentrations from THS 2.2 are in the same order of magnitude as EA of e-cigarettes (not published)

Therefore we can conclude that the chemical composition of the background air and air during use of THS 2.2 were highly similar. In light of the above, and comparing our results with existing air quality guidelines, it can be concluded that under the studied experimental conditions there is **no negative impact on the overall Indoor Air Quality when using THS 2.2.**