



PMI SCIENCE
PHILIP MORRIS INTERNATIONAL

Air Quality assessment during indoor use of the Tobacco Heating System 2.2

THS 2.2. is commercialized under the IQOS brand name

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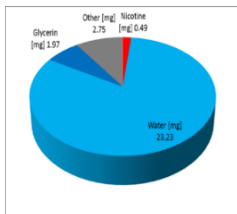
Japan Society for Environment Chemistry

June, 7-9. Shizuoka (Japan)

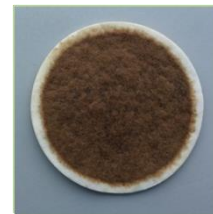
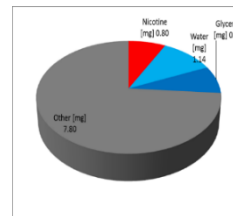
PMI heat not burn Tobacco Heating System vs. lit-end cigarette



Tobacco Heating System



Lit-end cigarette



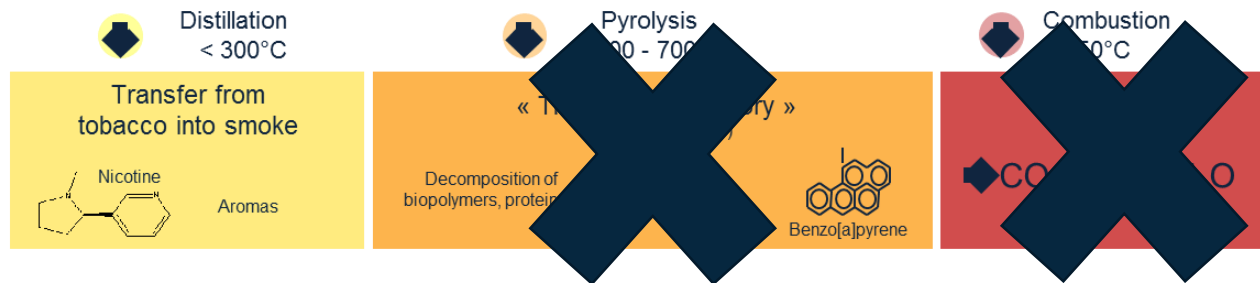
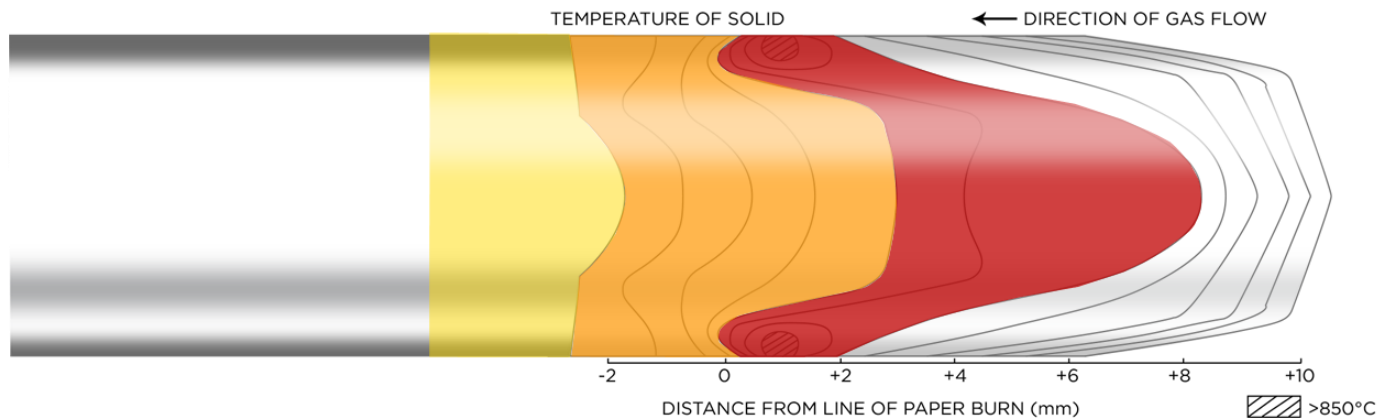
- Heating maintains the tobacco temperature below combustion, which creates an aerosol* with a very different composition compared to cigarette smoke
 - Main constituents are water, glycerin and nicotine
 - The concentrations of Harmful or Potentially Harmful Compounds (HPHCs) concentrations are reduced on average by 90 to 95% compared with a 3R4F standard reference cigarette.
- The mainstream aerosol* is generated when a puff is drawn → no sidestream**

*: an aerosol is a mixture made up of liquid droplets suspended within a gas

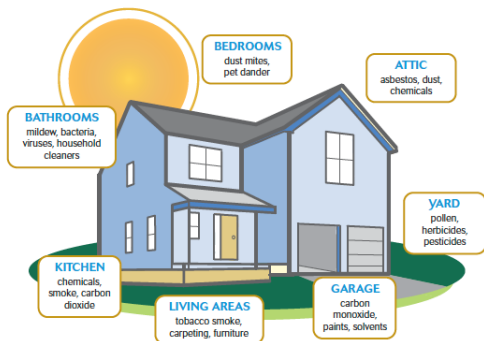
** : sidestream is related to tobacco smoke that is emitted from the lit end of a cigarette or cigar



Impact of the temperature on the formation of toxicants



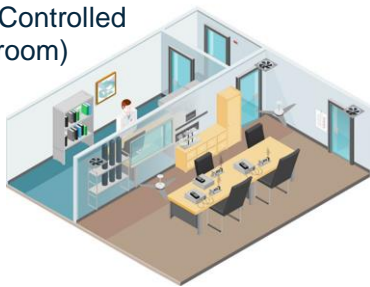
Why exploring Indoor Air Quality ?



- Indoor air quality (IAQ) relates to the health and comfort of building occupants.
- Several parameters contribute to IAQ.
- Presence and level of certain pollutants in the air can be precisely measured
- WHO guidelines for indoor air quality has established limits of exposure for nine pollutants
- For RRP's, the aerosol exhaled by the user will be the only source of polluting substances
- ➔ How do THS 2.2 contribute to IAQ?
- ➔ Is there any Environmental Tobacco Smoke (ETS*) when using THS 2.2?
- *: ETS also named second hand smoke is a mixture of sidestream smoke and exhaled smoke

How to simulate an environment and assess the impact of a product on IAQ?

Environmentally Controlled Room (IAQ room)



Quality Management System (ISO17025)



Model environment

| Environments | Ventilation Rate [m³/h] | Air changes [per hour] | Design Occupancy [m²/person] | Total number of test items |
|-----------------|-------------------------|------------------------|------------------------------|----------------------------|
| Residential I | 121 | 1.68 | 8 | 12 |
| Residential II | 87 | 1.20 | 8 | 12 |
| Residential III | 37 | 0.5 | 8 | 12 |
| Office | 156 | 2.16 | 8 | 16 |
| Hospitality | 555 | 7.68 | 4.8 | 32 |



Adult Volunteer Panelists

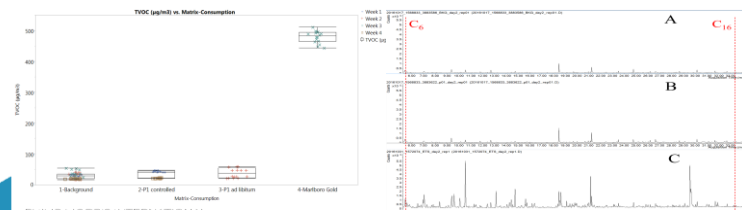
Assessing the impact of a product use on indoor air quality requires strict control over many elements

| Category | Compounds |
|--|--|
| ISO measurement standards for ETS (ISO Norms 15989, 2001; 18144, 2005; 18145, 2005; 11454, 1997) | ESP gravimetric [µg/m³] LTPA-THAP [µg/m³] PMA-acetate [µg/m³] Solvent [µg/m³] 3-Ethylpyridine [µg/m³] Nicotine [µg/m³] |
| ISO measurement standard for TVOCs (ISO 15000-6, 2011) | Total Volatile Organic Compounds (TVOC) [µg/m³] |
| Carbonyls | Acetaldehyde [µg/m³] Acetone [µg/m³] Crotonaldehyde [µg/m³] Formaldehyde [µg/m³] |
| Volatile Organic Compounds (VOCs) | Acrylonitrile [µg/m³] Benzene [µg/m³] 1,3-Butadiene [µg/m³] Isoprene [µg/m³] Toluene [µg/m³] |
| Tobacco-specific N-nitrosamines (TSNAs) | N-nitrosanornicotine (NNN) [ng/m³] 4-methylnitrosamino-1-(3-pyridyl)-1-butene (NNN) [ng/m³] Catechol [µg/m³] Hydroquinone [µg/m³] |
| Phenols | Phenol [µg/m³] |
| Product-specific compounds: aerosol formers | Glycerin [µg/m³] Propylene Glycol [µg/m³] |
| Inorganics | Carbon monoxide [ppm] Nitrogen oxide (NO) [ppb] Nitrogen oxides (NOx) [ppb] |

Indoor air contaminants (PMI-IAC 25)



Technical expertise



PHILIP VORRIS INTERNATIONAL

Study design & report



Dedicated methods

IAQ room & simulated environments



Temperature ($23 \pm 3^\circ\text{C}$) & pressure controlled
Humidity monitored (40-56 RH%)

Air change: 0.5 to 12.2 per hour

Ventilation: 37 to 879 m^3/h

Air filtration (dust, microparticles, VOCs)

Low-emission / washable furniture

Fans to homogenize air

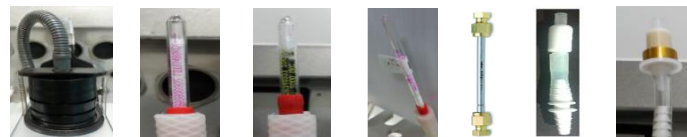
Environmental specifications according to CEN Standard (EN 15251:2007)

| Environments | Ventilation Rate [m^3/h] | Air changes [per hour] | Design Occupancy [m^2/person] | Total number of test items |
|------------------------|--|------------------------|---|----------------------------|
| Residential I | 121 | 1.68 | 8 | 12 |
| Residential II | 87 | 1.20 | 8 | 12 |
| Residential III | 37 | 0.5 | 8 | 12 |
| Office | 156 | 2.16 | 8 | 16 |
| Hospitality | 555 | 7.68 | 4.8 | 32 |

Collection: 26 pumps with mass flow controller – online analyzers for gases



Offline: Trapping system & analysis: chemical class / compound specific



Selection of targets

| Category – (Norm) -[unit] | Constituents | Rationale for selection |
|---|---|--|
| ISO measurement standards for ETS (ISO Norms 15593, 2001; 18144, 2003; 18145, 2003; 11454, 1997) - [$\mu\text{g}/\text{m}^3$] | 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) - [$\mu\text{g}/\text{m}^3$] | Total Volatile Organic Compounds (TVOC) | Air quality marker |
| Carbonyls - [$\mu\text{g}/\text{m}^3$] | <u>Acetaldehyde, Acrolein, Crotonaldehyde, Formaldehyde</u> | Relevance for air quality |
| Volatile Organic Compounds (VOCs) - [$\mu\text{g}/\text{m}^3$] | <u>Acrylonitrile, Benzene, 1,3-Butadiene, Isoprene, Toluene</u> | Relative abundance in THS2.2 aerosol (i.e. the most abundant) |
| Tobacco-specific Nitrosamines (TSNAs) - [ng/m^3] | N-nitrosonornicotine (NNN) 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK) | Carbonyls, VOCs, TSNAs: part of the FDA list of HPHCs |
| Product-specific compounds: aerosol formers- [$\mu\text{g}/\text{m}^3$] | Glycerin, Propylene Glycol | Product-specific markers |
| Inorganics (CO [ppm], NO [ppb], NO _x [ppb]) | <u>Carbon monoxide</u> , Nitrogen oxide, Nitrogen oxides | Gas-phase tobacco smoke non-specific markers Gas-phase combustion marker |

How to measure the impact of THS 2.2 on IAQ?

| 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, THS 2.2 used according to study protocol | | End of the sessions | Start of the analysis |



Background (BKG)
How people contribute
to indoor air pollution



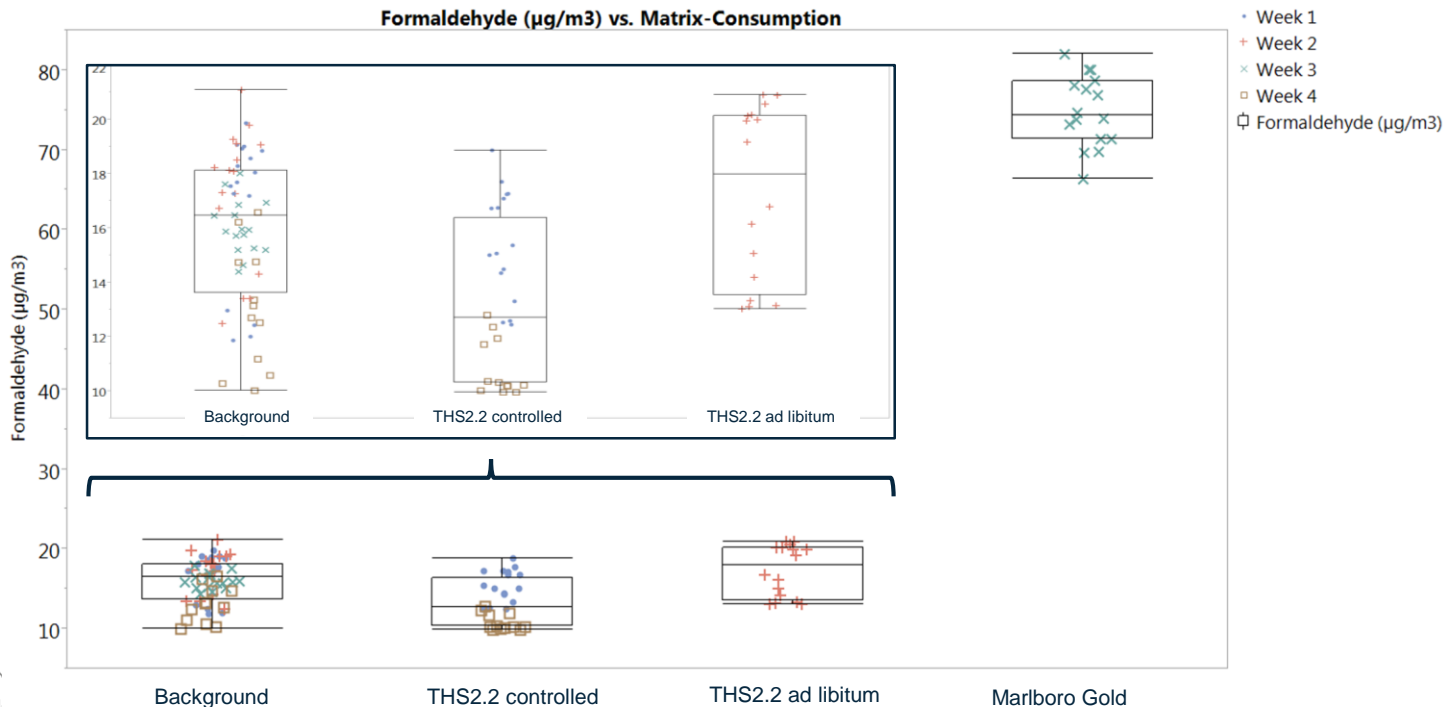
Environmental Aerosol (EA)
How product contributes
to indoor air pollution



- 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)

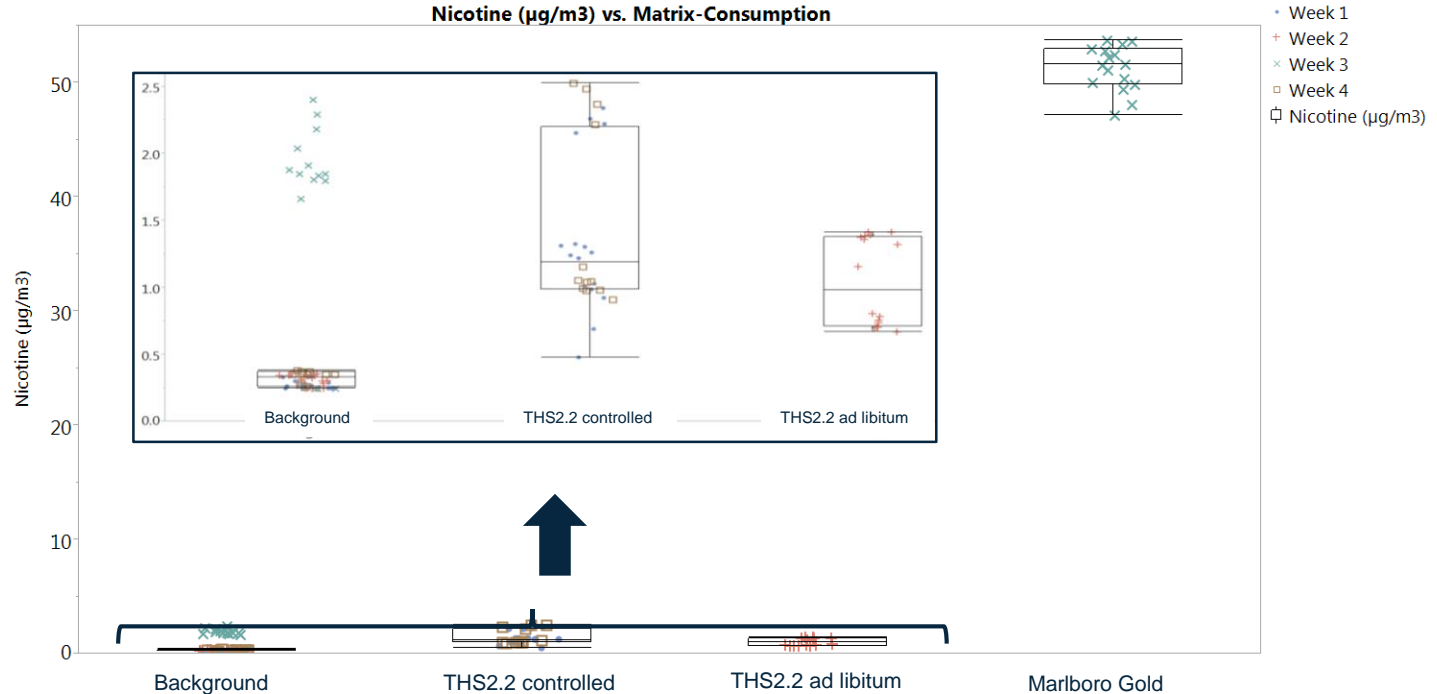
Example of comparison: Formaldehyde – residential III

Formaldehyde is an IAQ marker, non-specific marker of ETS. **MHLW: 100 $\mu\text{g}/\text{m}^3$**



Example of comparison: Nicotine – residential III

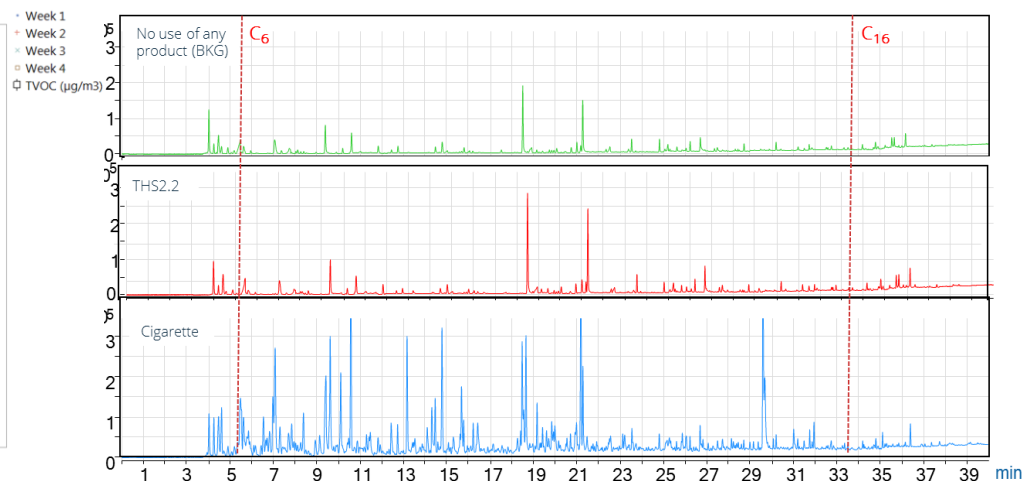
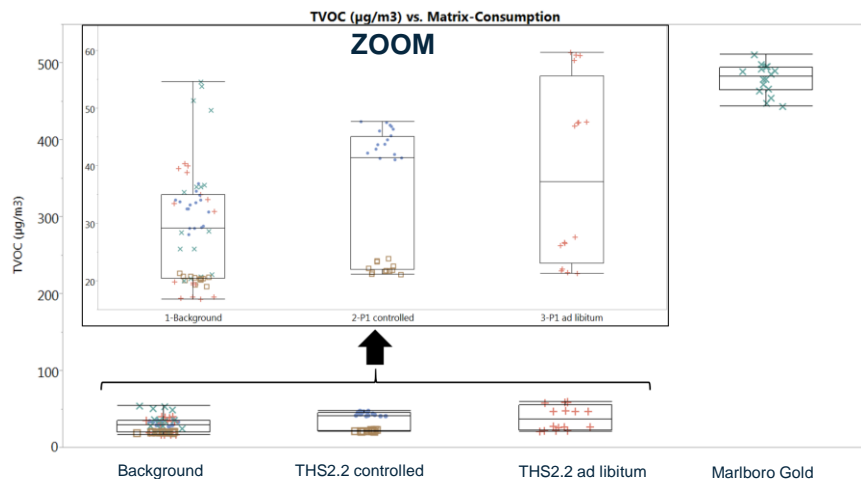
Nicotine (ISO 18145:2003) is higher for THS 2.2 compared with background but significantly lower compared with the cigarette. **EU: 500 µg/m³.**



How much is THS 2.2 environmental aerosol different from background air?

TVOC (ISO16006-2011) provides a broader view of chemical composition (bp 69-287°C).

LWRL: $2\mu\text{g}/\text{m}^3$. MEXT: $400\mu\text{g}/\text{m}^3$

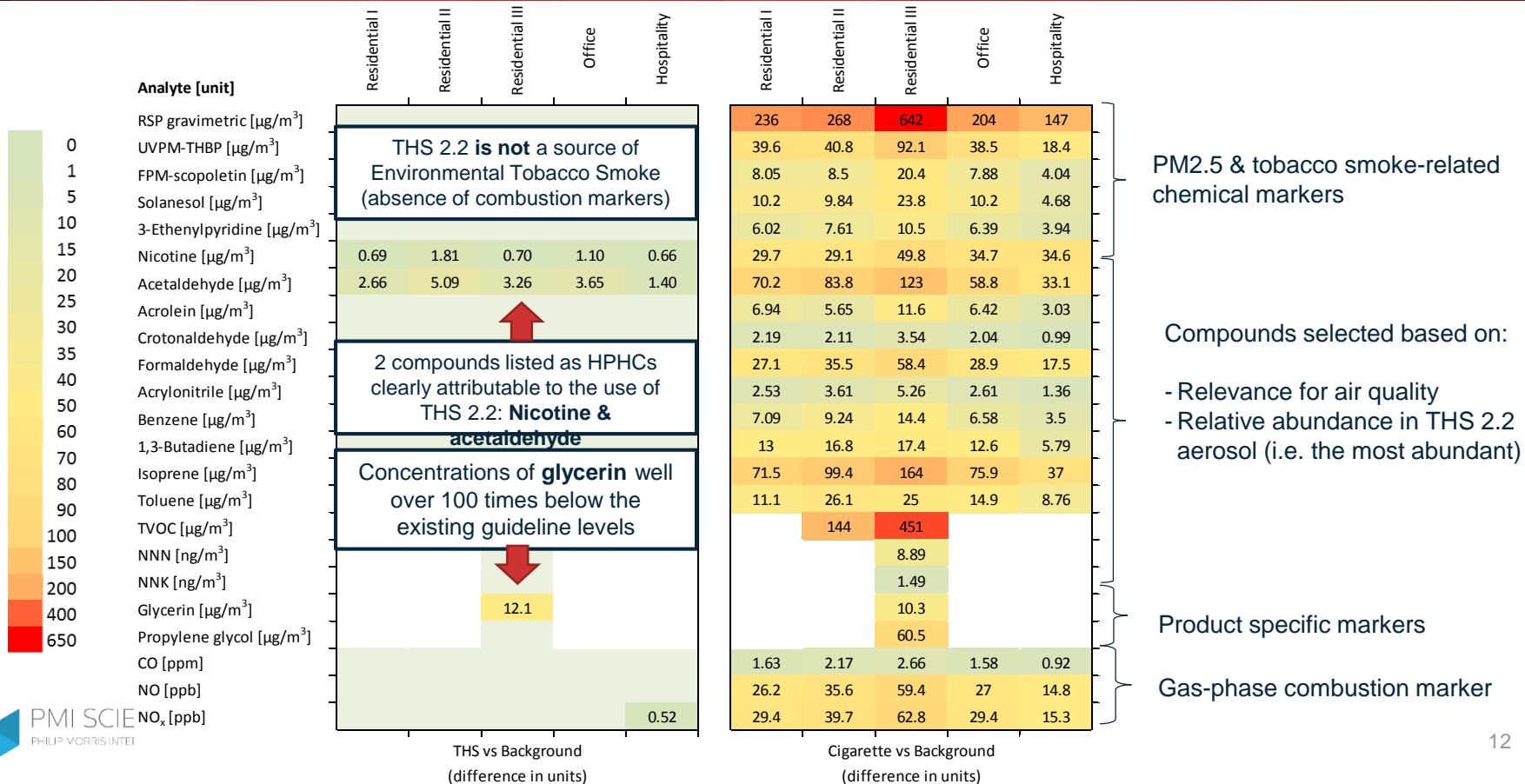


BKG & P1 chemical compositions are highly comparable in contrast to the cigarette (TVOC value for well above guideline level).

Peaks above LWRL: 4-9 for BKG, 4-10 for THS 2.2, 73-87 for cigarette



Table of results

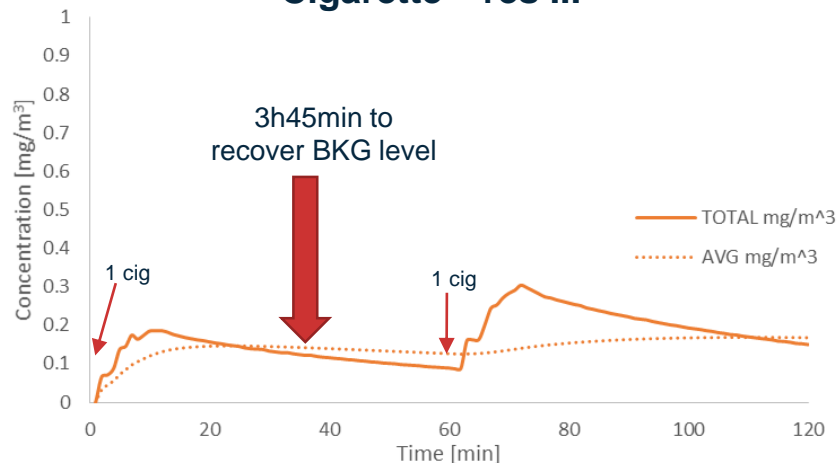


Aerosol vs smoke evolution in indoor environment

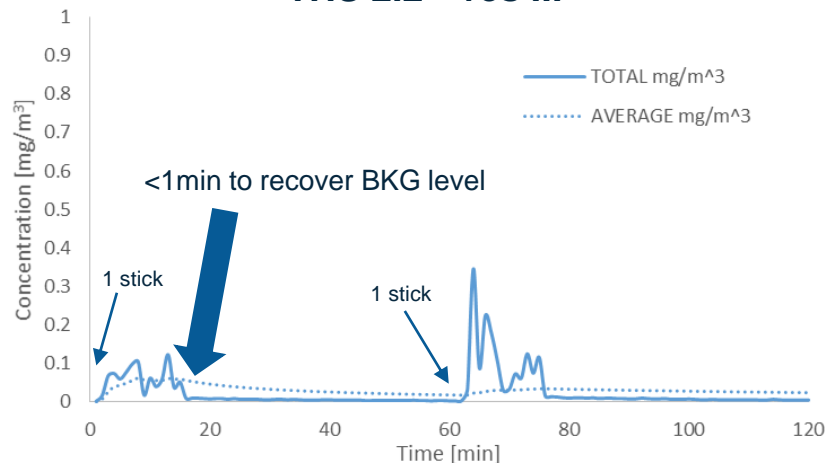
- Portable Dust Track measures suspended particulate matter on real time → lifetime of aerosol vs smoke
- THS 2.2 aerosols is constituted of liquid droplets, evaporating very fast when introduced in an indoor air environment.



Cigarette – res III

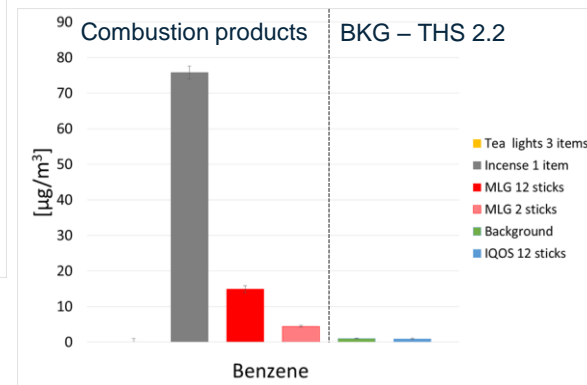
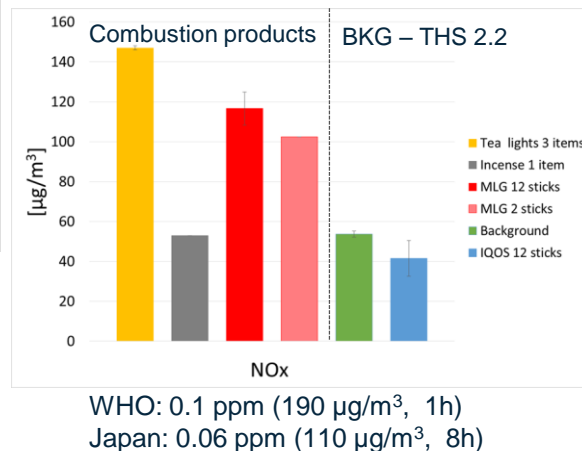
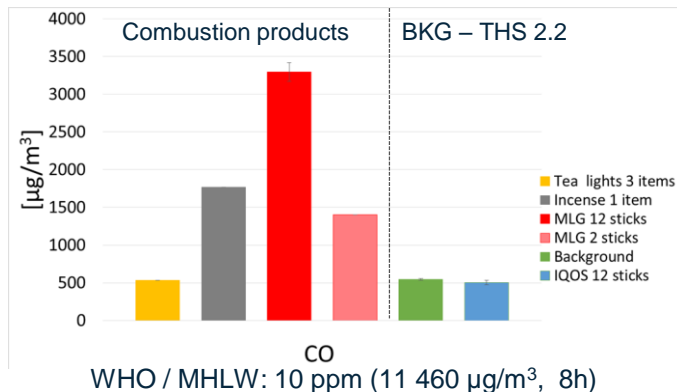


THS 2.2 – res III



Combustion vs heating

Complete and incomplete combustion are a source of contamination as noxious particulate matter and gases. These phenomena can occur in any product based on combustion



Combustion products (tea lights, incense, cigarette). 2-hours collection, 0.5 air change. 16 constituents measured (PM2.5 markers, VOCs, carbonyles, TVOC, gases)

Wrap-up

- Indoor air quality study, under extreme conditions (low air change / high consumption) performed with THS 2.2 simulating residential category shows that:
- Markers of combustion **are absent** in Environmental Aerosols of THS 2.2
- THS 2.2 **does not emit** Environmental Tobacco Smoke (ETS)
- Of the measured compounds only two Harmful and Potentially Harmful Compounds, **nicotine and acetaldehyde**, were found in air following the use of THS 2.2. **Glycerin** was found at very low concentrations. The measured levels, however, are orders of magnitude below the maximum exposure levels as defined in existing air quality guidelines.

Using THS 2.2 indoors has no negative impact on the overall air quality