INDOOR AIR CHEMISTRY - An exploratory study on e-cigarette shows no negative impact on indoor air quality

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Introduction and Objectives

Electronic Vapor products (commonly referred as electronic cigarettes, e-cigarettes) do not produce sidestream aerosol and the only source of aerosol constituents in the indoor environment is exhaled aerosol.

The goal of this exploratory study was the assessment of the impact on Indoor Air Quality (IAQ) of the aerosol produced by a selection of rechargeable and refillable tobacco-flavored e-cigarettes in an environmental controlled room. The Indoor Air Chemistries (IAC) of e-cigarettes were compared to the IAC of background air.

Brand name	Type	Nicotine content in e-liquid [mg/mL]	Nicotine content in mainstream aerosol [µg/puff] **
Solaris KS	Rechargeable	20	30.6
Nicolites	Rechargeable	16	48.6
Vivid	Refillable	18	70.5

***: CORESTA smoking regime: 55 mL puff volume for 3 sec, square shape puffing profile, 30 sec between puffs, group of 50 puffs, to achieve a constant delivery with battery recharging every 50 puffs*

Study Design & Methods

- Environmental conditions set according to EN 15251:2007. Vaping: each 40 min for 10 min (without restraint during vaping) per panelist. The ventilation rate selected for Residential II corresponds to a normal level of expectation and should be used for new buildings and renovations

Model Environment	Ventilation [m^3/h]	Air change [L/h]	# of vapers	E-cig/pers/h	E-cig/h
Residential II	87	1.20	2	1.5	3

- Products: Solaris KS, Nicolites, Vivid, Background (BKG).
- Panelists: non-smokers for background, adult e-cig and dual users for vaping sessions.
- Eight markers (ETS markers, Indoor Air Quality markers, specific analytes)

ISO norm/method reference	Analytes
ISO 15593, 2001	RSP gravimetric
ISO 18145, 2003	3-ethenylpyridine, nicotine
Carbonyl compounds	acetaldehyde, acrolein, crotonaldehyde, formaldehyde
Aerosol formers	glycerin, propylene glycol
ISO 16000-6, 2011; ISO 16017-1, 2000	Total Volatile Organic Compounds (TVOC) as toluene equivalent

- Three repetitions of each session performed on three separate weeks.
- Four hours collection, five trapping systems.

RSP

Nicotine
3-Ethenylpyridine

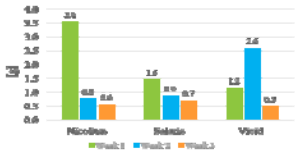
Carbonyles

Aerosol Formers

TVOCs

Results and Discussion

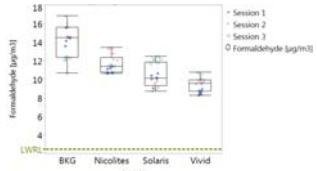
Consumption of e-liquid



Large differences between the consumed e-liquids during the sessions were measured and were explained by the different vaping behaviour of panellists
Normalized values showed a factor up to 6 for e-liquid consumption.
E-liquid consumed influenced indoor air concentrations for the major e-liquid constituents (Aerosol Formers, nicotine)

Indoor Air Concentrations: formaldehyde

Carbonyls: Formaldehyde

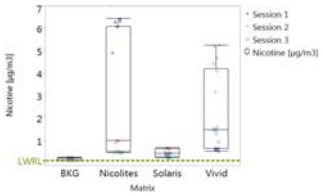


No statistical increase of formaldehyde above background levels when using e-cigarettes. Same observation was done for acetaldehyde.
The measured medians for formaldehyde were ranking between 9.6 and 11.4 µg/m^3 and the ones for acetaldehyde were ranking between 5.1 and 8.7 µg/m^3 in e-cigarette environmental aerosols.

Results and Discussion

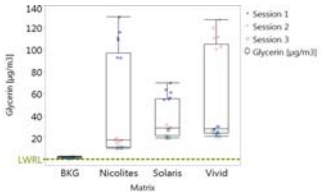
Indoor Air Concentrations: nicotine, glycerin

Nicotine



Statistical increase of nicotine above background levels when using e-cigarettes. Concentrations strongly influenced by vaping behavior.
Median levels of nicotine are at least two orders of magnitude lower than EU indicative occupational exposure limit of 500 µg/m^3 (Commission Directive 2006/15/EC)

Aerosol Formers: Glycerin



Statistical increase of glycerin above background levels when using e-cigarettes. Concentrations correlated with e-liquid consumption.
Median levels of glycerin are at least two orders of magnitude lower than guideline levels of 10 000 µg/m^3 (ACGIH, 2001)

Analytes levels (median and first and third quartile, Q1-Q3) obtained environmental aerosols after background subtraction.

Analyte	Solaris KS $_{adjusted}$ * (-)**	Nicolites $_{adjusted}$ * (-) **	Vivid $_{adjusted}$ * (-) **
RSP gravimetric [µg/m^3]	-	-	-
3-Ethenylpyridine [µg/m^3]	-	-	-
Nicotine [µg/m^3]	0.221 (0.0761-0.411)	0.791 (0.305-5.57)	1.28 (0.444-3.67)
Glycerin [µg/m^3]	26.5 (21.2-52.1)	15.6 (9.78-90.3)	25.7 (22.0-99.8)
Propylene glycol [µg/m^3]	20.7 (13.0-24.0)	204 (90.1-1381)	143 (34.7-503)
Acetaldehyde [µg/m^3]	-	-	-
Formaldehyde [µg/m^3]	-	-	-
TVOC[µg/m^3](toluene equivalent)	-	-	-

Analytes levels (median and first and third quartile, Q1-Q3) obtained for e-cigarettes environmental aerosols after background subtraction. "-": the value is equivalent to background value for e-cigarettes

The statistical evaluation of the results showed that the concentrations in background and environmental aerosol of tested e-cigarettes could be considered as equivalent for five of the eight analytes (RSP-gravimetric, 3-ethenylpyridine, acetaldehyde, formaldehyde and TVOC expressed as toluene equivalent).

Conclusions

Nicotine, glycerin and propylene glycol levels were higher in indoor air compared to background levels in all studied brands.
Under the simulated 'residential category II' environmental condition, the measured median levels of nicotine, glycerin and propylene glycol in indoor air following e-cigarettes use were considerably lower than the few guideline values that exist for these compounds. Indeed the guideline levels are at least 50 times above the maximum median levels for all tested brands and well over 100 times above the maximum median levels in most cases.
Guideline levels: nicotine: 500 µg/m^3 (Commission Directive 2006/15/EC), glycerin: 10 000 µg/m^3 (ACGIH, 2001), propylene glycol: 10 000 µg/m^3 (AIHA, 2011)

In summary, under the simulated 'residential category II' environmental condition and on the measured indoor air quality parameters, no negative impact on the overall indoor air quality was observed when using e-cigarettes in an indoor environment.

ABBREVIATIONS: ACGIH: American Conference of Governmental Industrial Hygienists, AIHA: American Industrial Hygiene Association, IAC: Indoor Air Chemistry, TVOC: Total Volatile Organic Compounds, BKG: background, EC: European Commission, EU: European Union

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