Toxicological assessment of aerosols emitted by three cannabis inhalation methods: joints, vaporizers, and Electronic Non-Nicotine Delivery Systems (ENNDS)

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Abstract
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Introduction

- Cannabis users are increasingly interested in safer alternative inhalation methods than joints and reduce their exposure to toxicants.
- This includes cannabis vaporizers and cannabis extract vaping using an electronic non-nicotine delivery system (ENNDS).
- Very few studies investigated the toxicological profiles of these alternatives in laboratory conditions.
- No published data on the filter efficiency to reduce toxicants in joint emissions.

Objectives

- Compare the toxicological profile of cannabis aerosols emitted by vaporizers and ENNDS to cannabis smoke (without tobacco) by quantifying the concentrations of 91 compounds.
- Compare the Δ^9-tetrahydrocannabinol (Δ^9-THC) delivery efficiencies between the electronic devices and joints
- Evaluate the influence of the heating system type for vaporizers, and of devices and e-liquids for ENNDS on emissions.

Devices and products tested

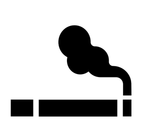
Tab1. Characteristics of the three selected cannabis vaporizers

	FX* by Wolkenkraft	Air II by Arizer	Mighty* by Storz & Bickel
Type of heating	Convection	Combination of convection conduction (hybrid system)	Combination of convection conduction (hybrid system)
Time to heat up	20 – 30 s	60 – 90 s	60 s
Temperature ranges	170 – 220°C	50 – 220°C	170 – 210°C
Herb capacity (chamber volume)	Up to 400 mg	100 – 200 mg	Up to 300 mg

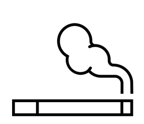
Tab2. Characteristics of the five selected ENNDS

	OBY by Aspire	Endura T20-S by Innokin[1]	Nautilus X by Innokin[1]	Vape Pen by Noïd.Lab	Cable Pen by Yeitaeso
Coil	OBY Pod	Prism S	Aspire PockeX	Noïd.Lab	No information
Resistance	1.2 Ω	0.8 Ω	1.2 Ω	1.5 Ω	No information
Activation	Draw activated	Button activated	Button activated	Draw activated	Button activated
Reservoir capacity	2 mL	2 mL	2 mL	0.55 mL	0.55 mL

Joints (without tobacco)



Without filter



With filter (cellulose + active carbon) Hybrid Supreme Filters (30 mm long, 6.4 mm diameter)

Tab3. Composition of the six e-liquids tested

	e-liquid #1	e-liquid #2	e-liquid #3	e-liquid #4	e-liquid #5	CBD extract
Type of cannabis extraction	Solvents	Supercritical CO_2	Solvents	Solvents	Solvents	Solvents
Percentage of cannabis extracts[1]	5.4%	-[2]	5.4%	5.4%	-	100%
Percentage of glycerol (VG)	18.9%	30%[3]	0%	20%	20%	0%
Percentage of propylene glycol (PG)	0%	70%[4]	100%	80%	80%	0%
Percentage of polyethylene glycol (PEG)	37.8% PEG400 18.9% PEG300 18.9% PEG200	0%	0%	0%	0%	0%
Δ^9-THC content	4.21%[4]	<1%[4]	8.8%[5]	11.5%[5]	0%	<0.2%[5]
CBD content	1.4%[4]	3.15%[4]	0.13%[5]	0.14%[5]	10%[5]	62%[5]
Viscosity	High	Low	Low	Low[6]	Low	High

Cannabis extract consists of a mixture of cannabinoids and terpenes.
Confidential information.
Percentage of cannabis extracts was not taken into account.
Δ^9-THC content was calculated as total Δ^9-THC = (Δ^9-THCA-A x 0.877) + Δ^9-THC; CBD content was calculated total CBD = (CBD-A x 0.877) + CBD.
Content quantified by the company.
Poor solubility of cannabis extracts.

Study design

We quantified the following chemical families in emissions (3 replicates):

- Cannabinoids (7 compounds)
- Aldehydes (13 compounds)
- Volatile organic compounds (20 compounds)
- Phenolic compounds (7 compounds)
- Polycyclic aromatic hydrocarbons (16 compounds)
- Aromatic amines (8 compounds)
- Metals (20 compounds)

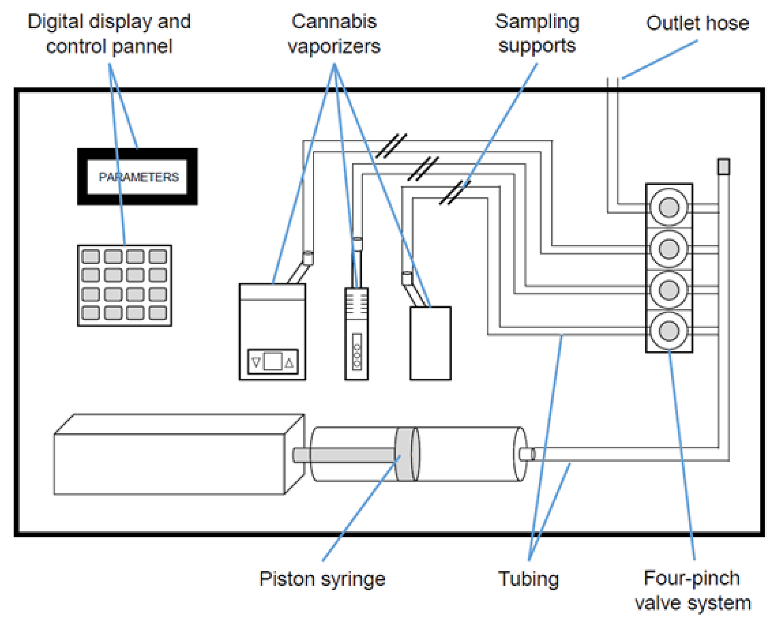


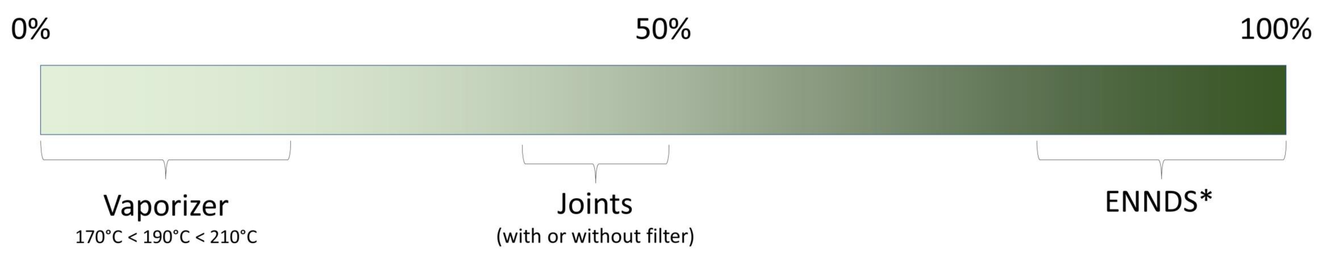
Fig1. Schema of the smoking machine

Tab4. Smoking regimes used for each tested cannabis products to generate emissions

Cannabis products	Smoking regime	Puff volume	Puff duration	Puff interval
Joints	HCI standard	55 mL	2 s	30 s
Cannabis vaporizers	Adapted CORESTA	80 mL	3 s	30 s
ENNDS	Adapted CORESTA	80 mL	3 s	30 s

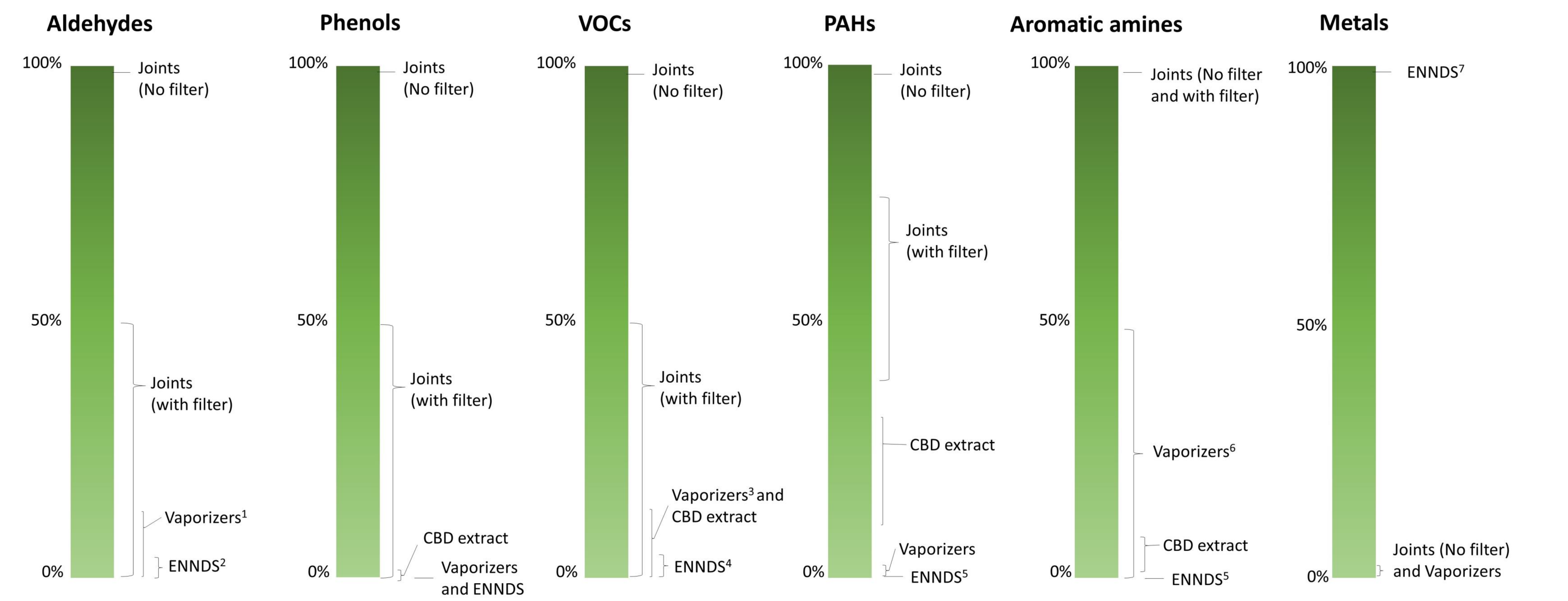
Three replicates per tested devices and products

Results



* A decarboxylation of Δ^9-THCA-A and CBD-A to Δ^9-THC and CBD is needed during the manufacturing of the e-liquids, the vaporization process in ENNDS was not sufficient to perform this transformation.

Fig2. Δ^9-THC delivery efficiencies



[1] Only **Acetaldehyde** and **Butyraldehyde** were quantified, concentrations increased with heating T°C.
[2] Only **Acetaldehyde** and **Formaldehyde** were quantified. High concentrations with viscous e-liquids and CBD extract.
[3] Only **Glycidol** and **1,3-propanediol** were quantified, concentrations increased with heating T°C.
[4] Only **Glycidol** were quantified and **ethanol** when used in e-liquid. High concentrations with viscous e-liquids.
[5] High concentrations were quantified with viscous e-liquids.
[6] **Aniline** and **1-aminonaphthalene** concentrations were quantified at the highest heating T°C.
[7] Only **Aluminium** (Al), **Nickel** (Ni) and **Copper** (Cu) concentrations were above LOQs but remained low.

Fig3. Emission comparison between cannabis vaporizers, ENNDS, and joints with and without filters for each chemical family

Discussion – Conclusion

- Cannabis users may benefit from cannabis vaporizers or ENNDS as alternative to joints, due to reduction of exposure to toxicants.
- Choice of e-liquids containing Δ^9-THC and of ENNDS devices must be made to avoid overheating.
- Further studies on real puffing regime use are needed to confirm these results obtained in laboratory conditions.
- Addition of filter to joints reduce toxicant concentrations without changing the toxicological profile.