Dynamic properties of exhaled e-cigarette aerosol vs. conventional cigarette smoke

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Introduction

- Growing discussion amongst public health organizations and the scientific community as to whether particles exhaled following the use of e-cigarettes has potential implications for indoor air quality and bystanders.

- There is little data available on the dynamic properties of exhaled e-cigarette aerosols and how they differ to those emitted when a conventional cigarette is smoked (i.e. smoke exhaled + side-stream smoke).
Cig-a-like e-cigarette device

- Microprocessor: controls heater and light
- Sensor: detects when smoker takes a drag
- Heater: vaporises liquid and nicotine
- Cartridge: holds nicotine dissolved in propylene glycol
- LED Lights: up when the smoker draws on the cigarette
- Battery
- Steam aspiration

Caponnetto et al., Journal of Medical Case Reports, 2011, 5:585
Aim of the study

- To investigate the spatial and temporal variations of exhaled aerosols following the use of an e-cigarette and a conventional cigarette in a room under controlled environmental conditions.

- To assess the second-hand exposure of a bystander to
  - aerosols in the exhaled air of a volunteer vaping an e-cigarette;
  - aerosols in the exhaled air of a volunteer smoking a conventional cigarette, as well as in the side-stream emissions.
Experimental setup

Exhaust air to outdoor
Supply air from outdoor
Filter F7
Air exhaust diffuser
Mixing air supply diffuser
Activated charcoal filter
Filter H13
T
V
Temperature measurement
VOCs measurement

TSI NanoScan SMPS
Fast Mobility Particle Sizer Model 3091
Heated dummy (bystander)
Activated charcoal filter
Filter H13
Temperature measurement
VOCs measurement

2.8 m
0.3 m
3.6 m
3.6 m
Exhaust air
Exhaust air to outdoor
Supply air

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Parameters

- **Products:** - cig-a-like e-cigarette (Puritane),
  - conventional cigarette (Marlboro Gold).

- **Volunteers:** 3.

- **Distance between volunteer and bystander:** 0.5, 1.0, 2.0 m.

- **Ventilation rate:** 0, 1, 2 ACH (air changes per hour).

- **Experiments:** - 1 puff every 30 sec during 3 min
  - Stay in the exposure chamber during 5 minutes after the last puff
  - Volume and puff duration, volume of inhalation during the puff up to the volunteer
Particle number concentration during vaping

**Frequency:** 1 puff every 30 sec.

**Duration of the experiment:** 3 min.

E-cigarette
Volunteer 1
Ventilation intensity: 2 ACH
Distance 1.0 m
At a short distance, the particle concentration increases and comes back to background values in < 10 sec.

At a large distance, e-cigarette shows a smaller mode due to evaporation (size shrink), conventional cigarette has a more stable size distribution.
**Inter-comparison between products**

- At a short distance, no significant difference between products.
- At a large distance, the peak size of particles from e-cigarettes shrunk from 150 to 30 nm due to evaporation.
In general, important difference among volunteers in terms of total particle concentration, sometimes also in terms of size distributions.
Influence of the ventilation rate

- No significant impact of ventilation rate on particle concentration and size distribution during puffs.
Influence of the distance between the volunteer and the bystander

- Important decrease of the particle concentration with the distance.
- For e-cigarette, shrink of the particle size (evaporation) at large distance.
- For conventional cigarette, size distribution stable with distance.
Particle concentration after successive puffs

Average particle concentration 2-3 minutes after the last puff

[Graph showing particle concentration over time with a peak around 16:08 and a decline afterwards.]
Decay rates

For e-cigarette, the particle concentration is already back to background levels <1 min after the last puff, even without ventilation.

- 0.3% per min
- 2.9% per min
- 5.6% per min
Conclusion

- Very fast variation of the particle concentration during the use of e-cigarettes and conventional cigarettes.

- Particles exhaled after the use of e-cigarettes were in the range 100-150 nm, shrank rapidly down to 30-40 nm due to evaporation of volatile compounds, and disappeared 10-15 seconds after the puff, transferring into the gas phase.

- Conventional cigarette particles were larger (150-200 nm) and much more stable than those from e-cigarettes. The removal of these particles was much longer, and depended on the ventilation rate in the room.
Thanks for your attention!

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