Controlled aerosol release to heat tobacco: product operation and aerosol chemistry assessment

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INTRODUCTION

Heating instead of burning tobacco has the potential to significantly reduce the levels of combustion-derived toxicants in the final aerosol. A number of ways to deliver controlled aerosol by heating tobacco have been described in patents and there are also commercially available tobacco-heating products (THPs) in some markets around the world, for example, Revo, Ploom and iQOS. These THPs use different heating methods and have markedly different heating temperature profiles.

Here, we describe a patented novel THP, which is based on utilising the energy of a heated aerosol stream from a battery-heating coil, much like an electronic cigarette (or e-cig). In operation, the aerosol stream passes through a bed of blended cut tobacco by a puffing flow. This poster presents an overview of its operation and examples of the aerosol chemistry, compared with a commercial e-cig and the 3R4F research reference cigarette.

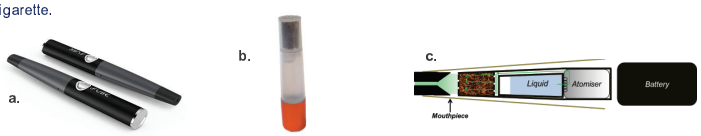

Figure 1. *(a) THP device exterior - Features a Li-ion rechargeable battery and single voltage output. (b) THP pod – Disposable cartomiser with e-liquid formulation and tobacco plug. (c) Schematic of THP with hybrid e-cig and tobacco disposable pods - The e-liquid aerosol generated at the coil passes through the tobacco to release tobacco sensory characteristics.*

AEROSOL TEMPERATURE

The aerosol temperature of the e-cig aerosol stream pre- and post-transit of the tobacco plug, measured using thermocouples, is shown in Figure 2. The temperature of the e-cig aerosol, before reaching the tobacco, had an average maximum of 35ºC, cooling to an average maximum of 32ºC after the tobacco plug. The temperature difference implies an energy exchange that heats the tobacco to a small degree. Thus, an e-cig formulation used in this manner can heat the tobacco to just above ambient conditions.

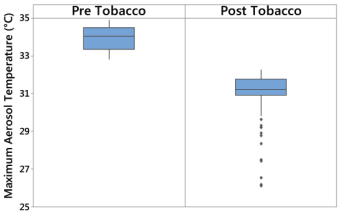

Figure 2. *Maximum aerosol temperature measured before and after tobacco plug for puffs 16-40 (puffing regime 80 mL / 3 s / 30 s).*

AEROSOL DELIVERY

Typical aerosol emission was generated using a puffing regime of 80 mL puff volume, 3 second puff duration and 30 seconds inter-puff duration. Under these puffing conditions:

- THP cartomiser longevity = 225 puffs
- Aerosol collected mass = 3.0 - 3.5 mg/puff
- Nicotine delivery = 20 - 40 µg/puff* (Figure 3)

*e-liquid formulation nicotine contents 1.86mg/mL

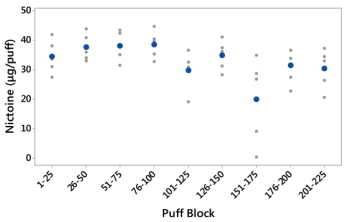

Figure 3. *Nicotine delivery over the lifetime of the cartomiser.*

AEROSOL CHEMISTRY DATA

- Aerosol emission levels were measured for 113 compounds of interests (COIs), identified for their toxicological properties by researchers and regulatory agencies (for example, the Health Canada, IARC, and FDA's HPHC lists). They were measured at Labstat International ULC (262 Manitou Dr, Kitchener, ON N2C 1L3, Canada) for the three products:
  - Reference cigarette (Kentucky 3R4F) - puffing regime 55mL-2s-30s - Canadian Modified
  - E-cig (cartomiser, e-liquid with a blended tobacco flavour) - puffing regime 55mL-3s-30s - 200 puffs (2 blocks of 100) (3.6 volts)
  - THP (unflavoured e-liquid and plug of blended cut tobacco) - puffing regime 55mL-3s-30s - 200 puffs (2 blocks of 100) (3.6 volts)
- 91 of the 113 compounds for both the THP and e-cig were below the level of quantification for both puff blocks of 100 puffs.
- Figure 4 shows aerosol emission levels for 29 compounds, displayed as *per puff* reductions relative to 3R4F and in four different chemical classes. A higher number represents a greater reduction in a target compound. At least 98% reductions per puff were recorded for both the THP device and the e-cig aerosol emissions compared to 3R4F. The results showed that some aldehydes, semi-volatile compounds and phenolic compounds were present in the aerosol. Only very small amounts of TSNAs were found in the aerosol. In most cases, the levels of reduction were indistinguishable between the e-cig and the THP product. Further development in analytical techniques are needed in order to ascertain whether some of the toxicants in the THP were from the tobacco portion. Judging from the fact that similar levels of reduction were found across these different classes of compounds, the tobacco was unlikely to be a major contributor to these emissions.

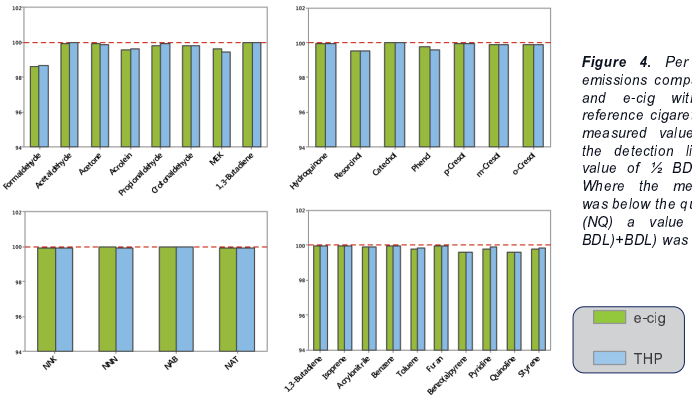

Figure 4. *Per puff aerosol emissions comparing the THP and e-cig with the 3R4F reference cigarette. Where the measured value were below the detection limit (BDL), a value of ½ BDL was used,. Where the measured value was below the quantitation limit (NQ) a value of ((½ NQ-BDL)+BDL) was used.*

CONCLUSIONS

- **A tobacco heating product using an e-cig aerosol as the method of heating the tobacco is described. The maximum temperature the tobacco plug was exposed to was 35ºC.**
- **Extensive chemical analyses of the THP aerosol emissions were conducted, guided by both e-cigarette and cigarette toxicant lists.**
- **Aerosol emissions of the THP closely resembled those of an e-cigarette.**

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Abstract

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This work describes a patented novel tobacco heating product, which is based on utilising the energy of a heated aerosol stream from a battery heating coil, much like an electronic cigarette (or e-cig). In operation, the aerosol stream passes through a bed of blended cut tobacco by a puffing flow. A transient and dynamic energy exchange between the aerosol and the tobacco bed occurs which drives off tobacco flavour components into an otherwise e-cig aerosol. The resulting aerosol composition is dominated by the parent e-cig formulation by mass, but with a sensorially elevated tobacco flavour profile, which is distinctively associated with the tobacco blend used. As the aerosol contains tobacco flavour constituents released by thermal elution, we classify the product as a tobacco heating product (THP).

The aerosol chemistry data obtained showed that this mechanism of tobacco heating produced similar classes and levels of toxicants as the parent e-cig. Improved analytical capabilities are required to distinguish whether some toxicants found were originated from the tobacco. Tobacco flavours in the aerosol was confirmed by a consumer sensory panel, and again improved analytical method would be needed to detect some sensorially potent yet very low levels of tobacco flavour compounds. Nicotine concentrations within the aerosol were shown to originate from the e-liquid formulation. Microbial activities within the moist tobacco during use were found to be constant for up to 4 weeks. Detailed aerosol chemistry data from this product will be presented against those obtained from an e-cig, and a reference cigarette (3R4F).

Acknowledgements

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