Characterising key thermophysical processes in a novel tobacco heating product THP1.0(T)

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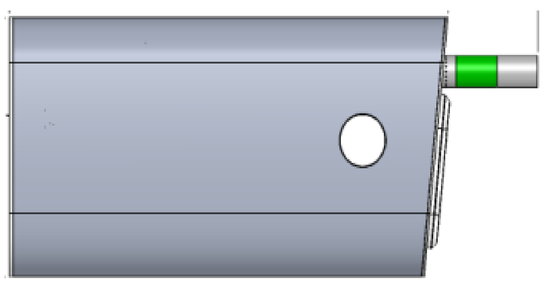
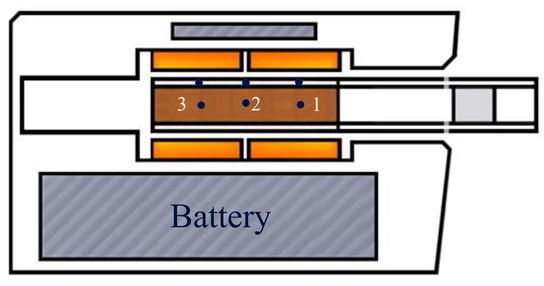
INTRODUCTION

Heating instead of burning tobacco has the potential to significantly reduce the levels of combustion-derived toxicants. Among commercial tobacco heating products (THPs), different heating methods (charcoal source vs battery-powered heater) and heating temperature profiles have been applied. In this work we describe 5-step approach to characterise a novel tobacco heating product THP1.0(T) to demonstrate that it works by heating and not combusting tobacco.

TOBACCO HEATING PRODUCT: THP1.0(T)

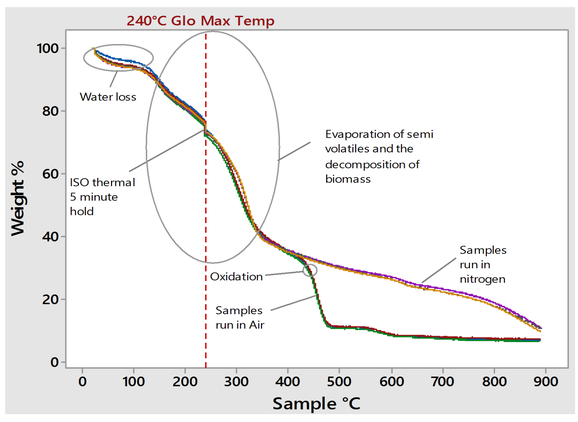
This is a novel tobacco heating product, designed to heat tobacco below 250˚C. It works by a user inserting a superslim tobacco consumer rod into a heating device (known as glo™), which is powered by a rechargeable battery in the same housing. The tobacco rod has approx 250 mg reconstituted and cut tobacco, with added ca. 14.5% (dwb) glycerol as the main aerosol agent. The control product was Ky3R4F research reference cigarette. All samples were tested under at 22˚C (± 3˚C) and 60%RH (±3%)





ASSESSMENT 1 - Thermogravimetric Analysis (TGA)

Combined paper wrapper and reconstituted tobacco material were heated by a Perkin Elmer Pyris 1 TGA at 5˚C/min in air and N_2, holding at 240˚C for 5 min, then up to 900˚C.

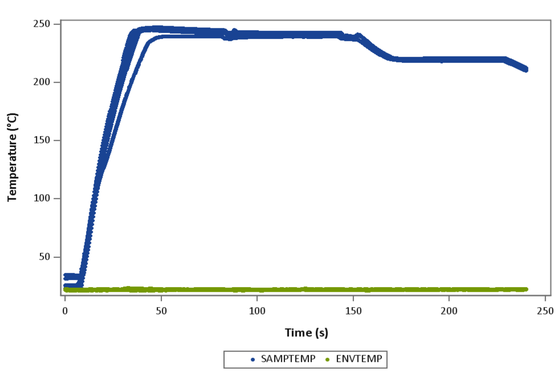


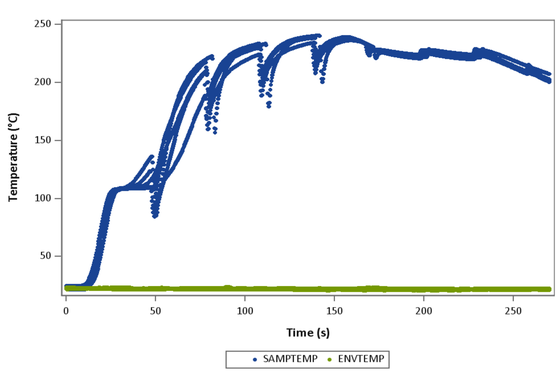
The thermal events identified:

- Moisture release, up to 100˚C
- Glycerol evaporation, up to 240˚C
- Initial tobacco flavour and cellulosic decomposition to 350˚C
- Oxidation and char combustion >400˚C

ASSESSMENT 2 - Device Heater and Tobacco Rod Temperature

Temperatures were measured using K-type fine thermocouples located under three representative lengths of the heater and tobacco rod, puffed under Health Canada intense puffing parameters. Temperatures profiles from position 1 are shown below – both the heater temperature and tobacco rod temperature remained <250˚C throughout the heating session.





ASSESSMENT 3 – Levels of Combustion Markers in Aerosol

Labstat International ULC was commissioned to quantify the levels of CO, CO_2, NO and NOx in the aerosol produced from THP1.0(T), the consumable tobacco rod alone when it was mis-used as a cigarette, and 3R4F mainstream smoke – these markers were markedly reduced in the aerosol of THP1.0(T).

Marker	THP1.0(T) (8 puffs)	Misused Tobacco Rod (5.1 puffs)	3R4F (10.3 puffs)
CO (mg/stick)	**NQ** (<0.233)	**14.4** (±0.4)	**32.0** (±0.9)
CO_2 (mg/stick)	**2.4** (±0.14)	**29.6** (±1.0)	**85.1** (±4.0)
NO (µg/stick)	**10.1** (±0.4)	**75.3** (±3.9)	**495** (±16)
NO_x (µg/stick)	**12.0** (±0.4)	**90.0** (±5.1)	**555** (±18)

ASSESSMENT 4 – Levels of WHO TobReg9 Toxicants in Aerosol

Labstat International ULC was commissioned to quantify the levels of a range of emissions produced from THP1.0(T). Table below compares the levels of TobReg9 in THP1.0(T) and 3R4F under HCI regime – the significant reductions in TobReg9 toxicant levels from THP1.0(T), especially those associated with initial decomposition of leaf composition, indicate an absence of tobacco combustion.

TobReg 9	THP1.0 (T) Emission*	THP1.0 (T) Formation Mechanism	3R4F Cigarette Emission#	3R4F Cigarette Formation Mechanism
Acetaldehyde (µg/stick)	111 (±8)	Initial degradation of carbohydrates	2200 (±103)	Decomposition of carbohydrates by pyrolysis
Acrolein (µg/stick)	2.22 (±0.52)	Same as above with trace glycerol breakdown	157 (±9)	Decomposition of carbohydrates and leaf polymers; from glycerol if added
Benzo(a)pyrene (ng/stick)	NQ (<0.354)	Minor transfer from tobacco	12.9 (±1.3)	Decomposition of leaf terpenoids and transfer of contaminants
Benzene (µg/stick)	NQ (<0.056)	Not detected	78.6 (±4.6)	Decomposition of leaf polymers with C6-ring moieties, above 300˚C
1,3-Butadiene (µg/stick)	BDL (<0.029)	Not detected	108 (±4)	Similar mechanisms as benzene with thermal cracking involving tobacco char
CO (mg/stick)	NQ (<0.223)	Significantly reduced as compared to cigarette smoke	32.0 (±0.9)	Combustion of tobacco, pyrolysis and char reaction
Formaldehyde (µg/stick)	3.29 (±0.30)	Initial decomposition of sugars	54.1 (±6.0)	Decomposition of sugars and cellulose
NNN (ng/stick)	24.7 (±2.5)	Thermal transfer	263 (±12)	Transfer and pyrosynthesis
NNK (ng/stick)	6.61(±0.86)	Thermal transfer	281 (±16)	Transfer and pyrosynthesis

*8 puffs taken per stick. #Average of 10.4 puffs taken per stick.

ASSESSMENT 5 – Physical Integrity of Tobacco Rod Post Use

The overall thermal degradation of the tobacco rod was evaluated by visual inspection. Cigarette smoking resulted in complete destruction of the tobacco rod and the formation of ash. Puffing with THP1.0(T) caused discolouration but the stick's physical structure was kept and no ash was formed.

CONCLUSIONS

- We applied a 5-step thermophysical and thermochemical assessment on a novel THP1.0(T) product
- This assessment approach provides a comprehensive yet practical characterisation of THP thermophysics irrespective of the heating mechanism applied
- The evidence showed that the aerosol from this product was mainly formed by evaporation under heating; no combustion occurred, no ash was generated during and post use

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