Thermal decomposition behavior of the tobacco material used in a heated tobacco product

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Outline

• Introduction
• Objective
• Method
• Results
• Conclusions
• Future work
Introduction: Heat-not-burn versus combustion

Thermal degradation of tobacco material

Combustion of the remaining char

Introduction: Heat-not-burn versus combustion

McGrath, T. E. et al. (2007) Formation of Polycyclic Aromatic Hydrocarbons from Tobacco: the “Link” between Low Temperature Residual Solid and PAH Formation, Food and Chemical Toxicology, 45, 6, 1039-1050
Introduction: Heat-not-burn versus combustion

Smoke aerosols
Examples of smoke aerosols

Non-smoke aerosols
Examples of non-smoke aerosols

Temperature

(combustion)

>2732 >1500
>1472 >800
1382 750
1292 700
1202 650
1112 600
1022 550
932 500
842 450
762 400
662 350
572 300
482 250
392 200
302 150
<212 <100

COMBUSTION

HEAT-NOT-BURN

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Introduction: Tobacco Heating System (THS) 2.2

- THS 2.2 heats tobacco to temperatures below 350 °C to avoid combustion and to produce a nicotine-containing, non-smoke aerosol.

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Introduction: Tobacco Heating System (THS) 2.2

Temperature in THS 2.2 during use under Health Canada Intense (HCl) puffing regimen

R = Radial position of thermocouple relative to the surface of the heater

HCl = 55 mL puff, 2 s puff duration, 30 s puff interval

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To better understand the underlying thermochemical processes occurring in the THS 2.2 tobacco material when heated in the Holder, we aimed to:

• Determine the onset temperature for combustion of the tobacco material

• Establish evaporation and thermal degradation characteristics of the tobacco material and to relate them to main tobacco material constituents
Method

- Thermogravimetry - Differential scanning calorimetry measurements of THS 2.2 tobacco material using a LABSYS evo simultaneous thermal analysis
- Nitrogen and air atmospheres
- Temperature range: 25 °C - 550 °C
- Two constant heating rates (5, 10 K/min)
- Four replicates
- Measurements carried out by SETARAM Instrumentation, France
Results: THS 2.2 tobacco mass and heat evolution

Mass loss and heat flow for 5 K/min heating rate

- Tobacco after heating up to 260 °C under nitrogen (A)
- Tobacco after heating up to 550 °C under nitrogen (B)

Residual mass (%) vs. Temperature (°C)

- Endothermic
- Weakly exothermic

Heat flow (mW) vs. Temperature (°C)

Nitrogen (solid lines)

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**Results: THS 2.2 tobacco mass and heat evolution**

Tobacco after heating up to 260 °C under nitrogen

Tobacco after heating up to 370 °C under air

Tobacco after heating up to 550 °C under nitrogen

Mass loss and heat flow for 5 K/min heating rate

- Weight loss occurs at slightly lower temperatures in the presence of oxygen < 400 °C
- Strong exothermic peak related to char combustion
- Weakly exothermic and enhanced degradation process in the presence of oxygen

Mass loss due to combustion in the presence of oxygen > 400 °C

nitrogen (solid lines)

air (dotted lines)

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Results: THS 2.2 tobacco mass and heat evolution

Influence of heating rate on mass and heat evolution

5 K/min heating rate

10 K/min heating rate

Residual mass (%) vs. Temperature (°C)

Heat flow (mW)

nitrogen (solid lines)
air (dotted lines)

nitrogen (solid lines)
air (dotted lines)
Results: identification of mass loss rate peaks

Tobacco composition

- cellulose
- lignin
- pectin
- water
- glycerol
- nicotine
- Others

10 K/min heating rate

- Mass loss rate (%/min)
- Temperature (°C)

- Residual mass (%)
- Temperature (°C)

10 K/min heating rate

- mass loss rate
- Temperature

- residual mass
- Temperature

References:
Conclusions

• Thermal degradation of the THS 2.2 tobacco material below 400 °C involves a combination of endothermic and weakly exothermic processes that can be attributed to evaporation or degradation of individual constituents in the tobacco material.

• Combustion of the THS 2.2 tobacco material occurred above 400 °C, only in the presence of oxygen (evidenced by a strong exothermic peak, mass loss and ash formation).

• Thermal degradation of THS 2.2 tobacco below 400 °C was largely unaffected by the presence of externally supplied oxygen, with only a slight shift in mass loss towards lower temperatures and a change from a mostly endothermic to a weakly exothermic degradation chemistry.

• Water, glycerol, and nicotine evaporation accounts for the majority of the mass loss from the tobacco material below 200 °C.

• The thermal degradation chemistry of the tobacco material in THS 2.2 during use under the HCI puffing regimen shows a net endothermic behavior and absence of combustion.
Future work

Extensive characterization of the thermochemical decomposition kinetics of the THS 2.2 tobacco material and its individual components, with the aim of developing a detailed thermochemical degradation kinetics model for the tobacco material, predictive of mass and heat evolution as well as volatilization and potential formation of degradation products.
Thank you for your attention!

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