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

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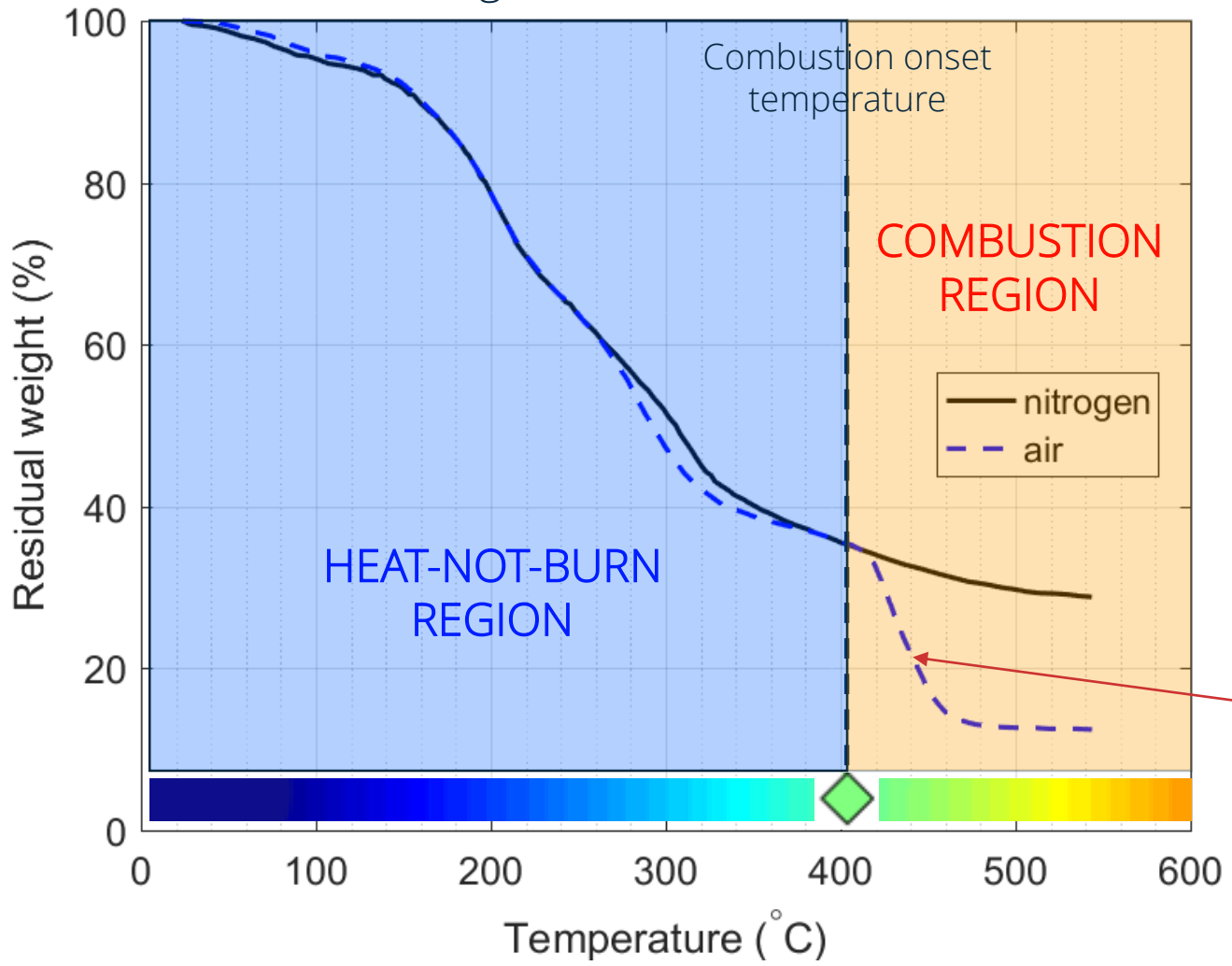
Outline

- Introduction
- Objective
- Method
- Results
- Conclusions
- Future work

Introduction: Heat-not-burn versus combustion

Thermal degradation of tobacco material



Combustion of the remaining char

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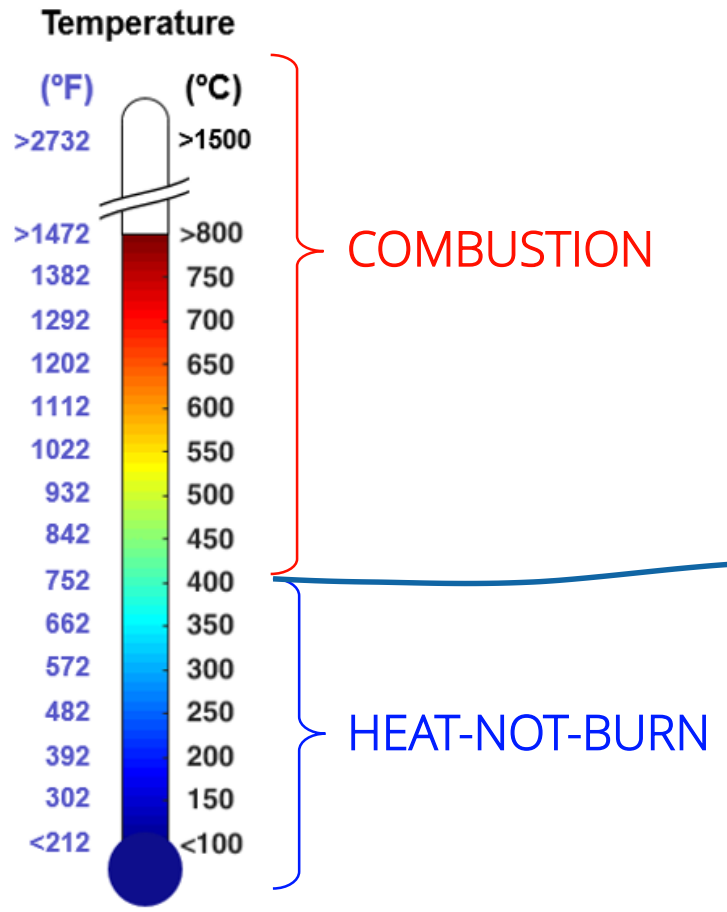
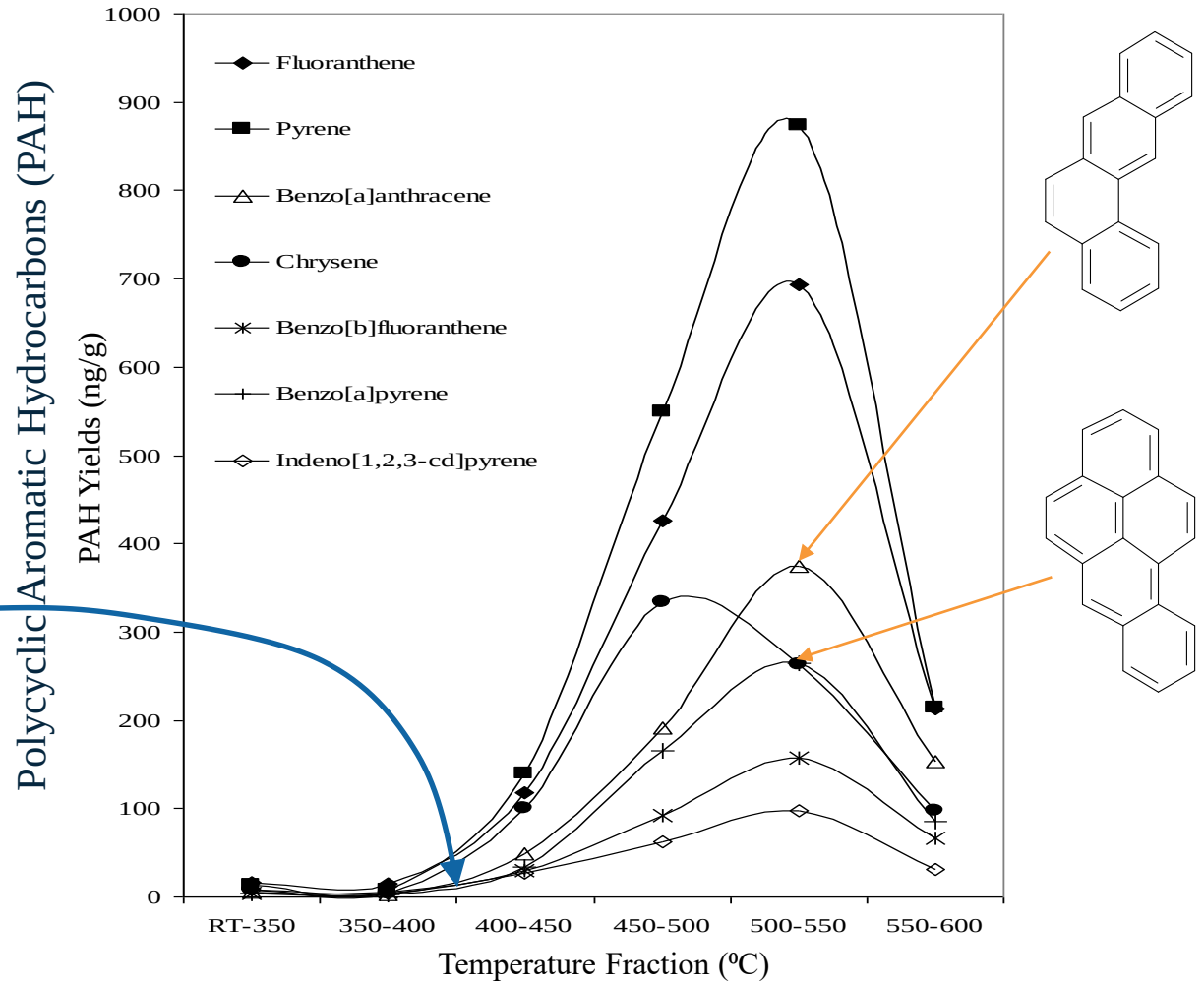
Barontini, F. et al. (2013) Volatile Products Formed in the Thermal Decomposition of a Tobacco Substrate. Ind. Eng. Chem. Res. 52: 14984−14997.

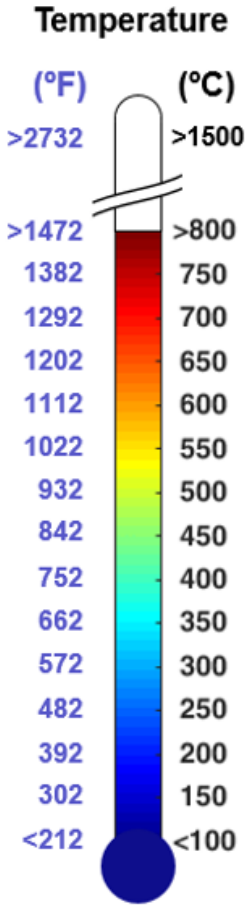
Introduction: Heat-not-burn versus combustion





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



COMBUSTION

HEAT-NOT-BURN

Smoke aerosols

Examples of smoke aerosols

\+ ASH

Non-smoke aerosols

Examples of non-smoke aerosols

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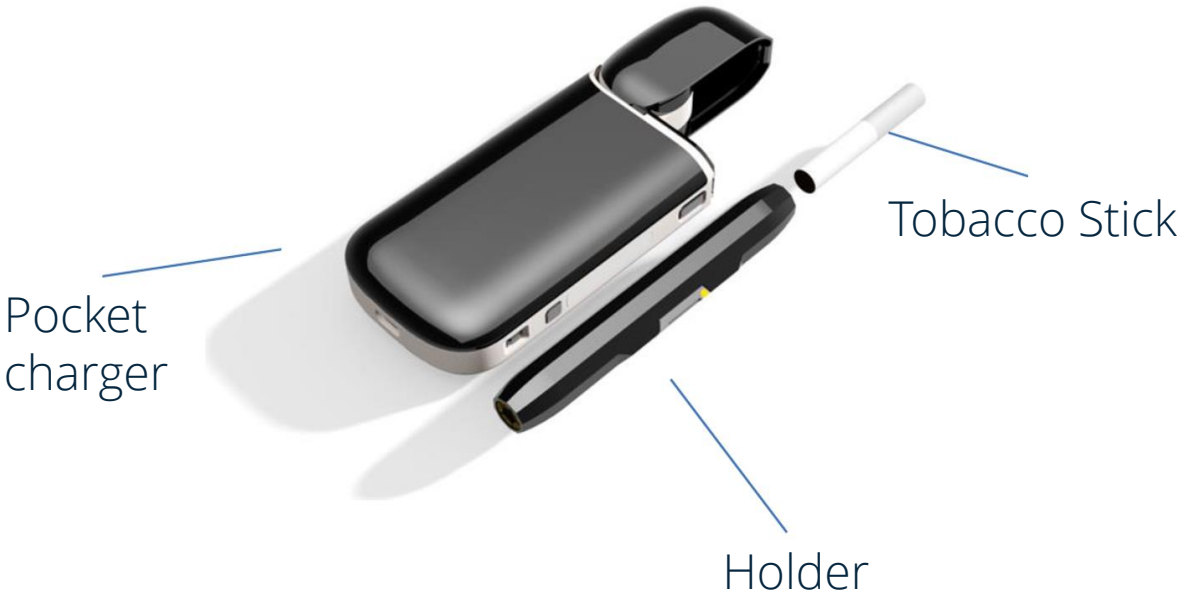
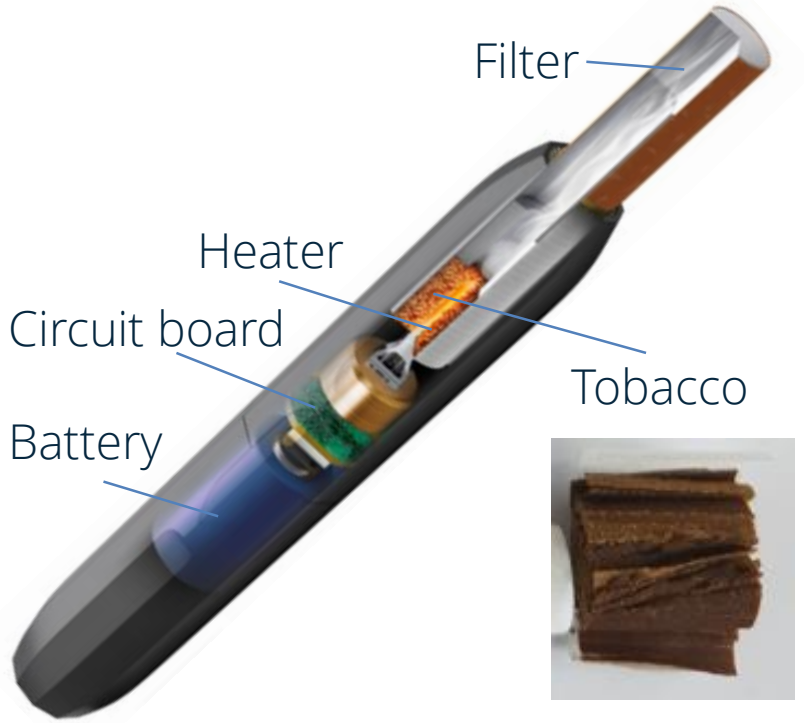
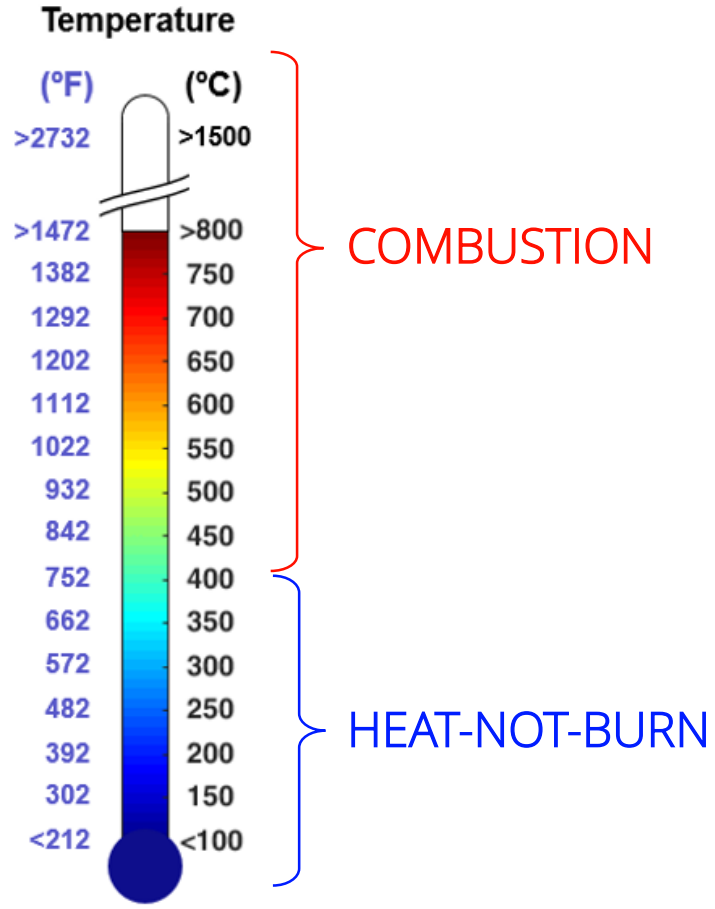
Introduction: Tobacco Heating System (THS) 2.2

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

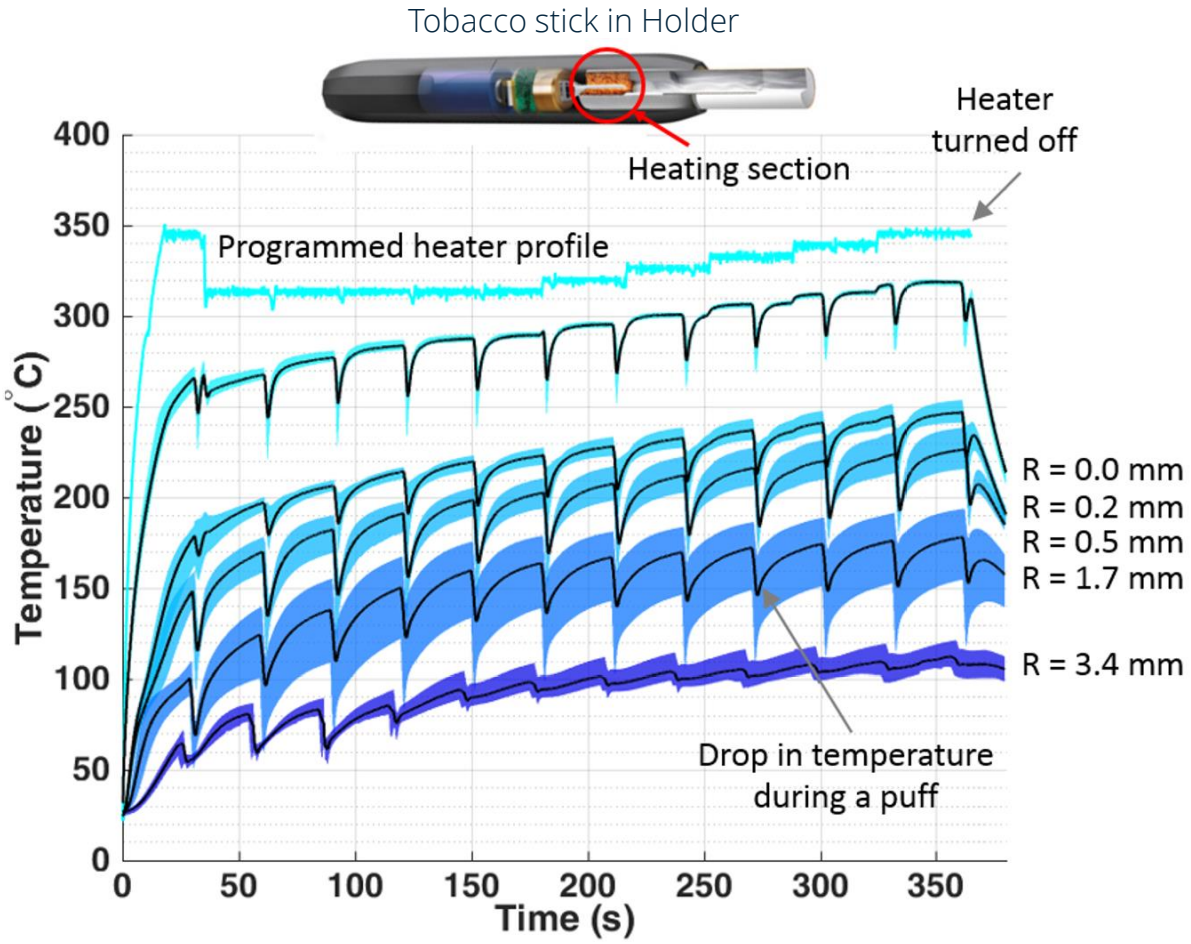




Introduction: Tobacco Heating System (THS) 2.2



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



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R = Radial position of thermocouple relative to the surface of the heater
HCI = 55 mL puff, 2 s puff duration, 30 s puff interval

Objective

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

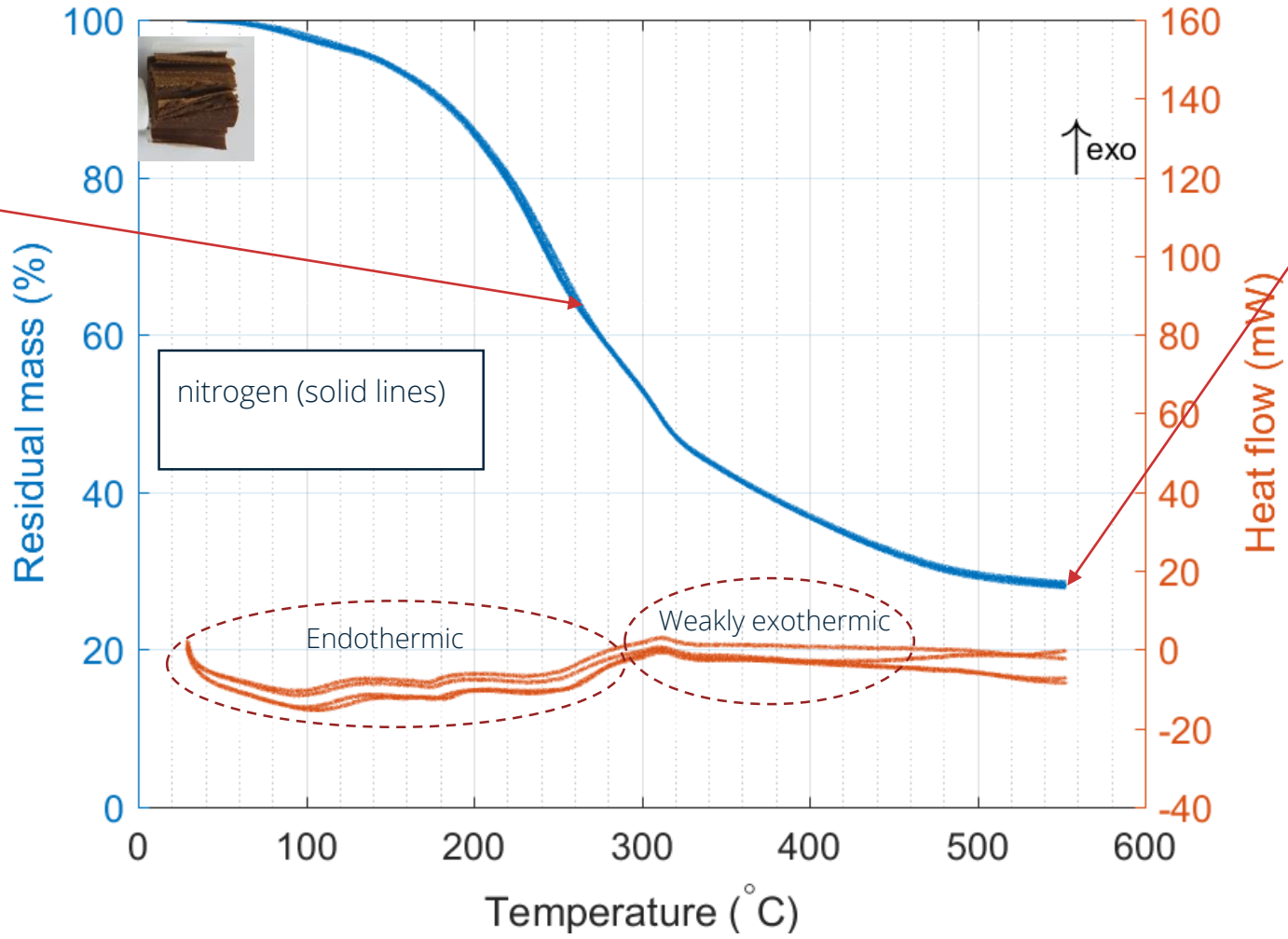
Method

- 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

Tobacco after heating up to **260 °C under nitrogen**

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



Tobacco after heating up to **550 °C under nitrogen**

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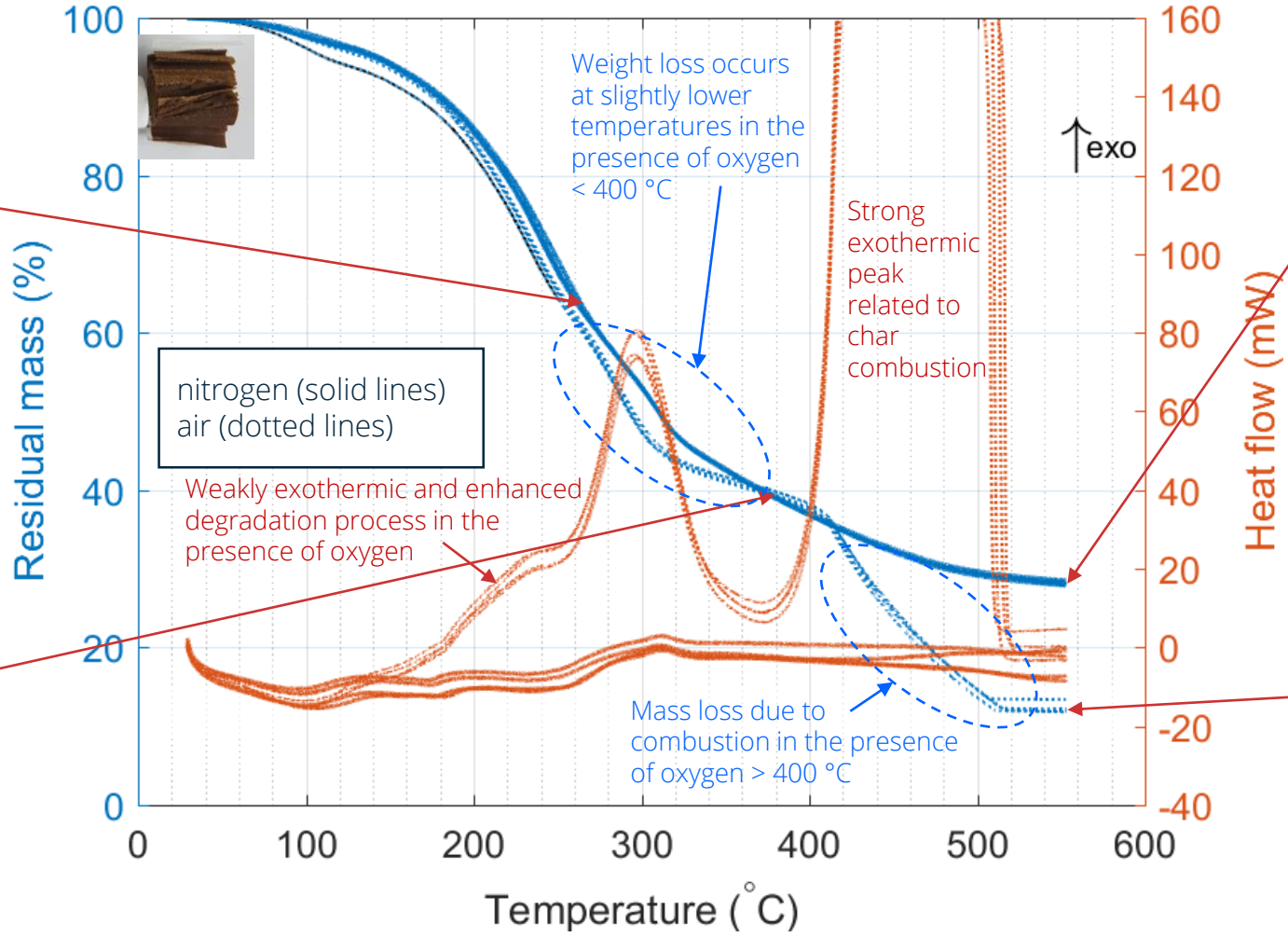
Results: THS 2.2 tobacco mass and heat evolution

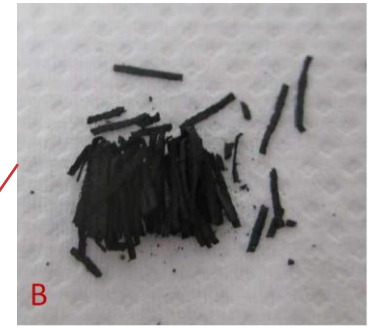
Tobacco after heating up to **260 °C under nitrogen**

Tobacco after heating up to **370 °C under air**

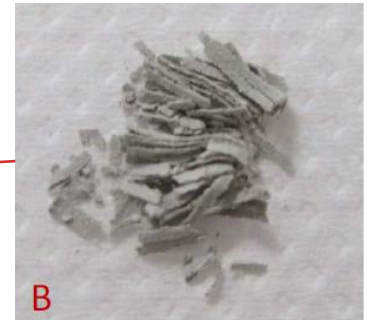
Mass loss and heat flow for 5 K/min heating rate



Tobacco after heating up to **550 °C under nitrogen**



Tobacco after heating up to **550 °C under air**



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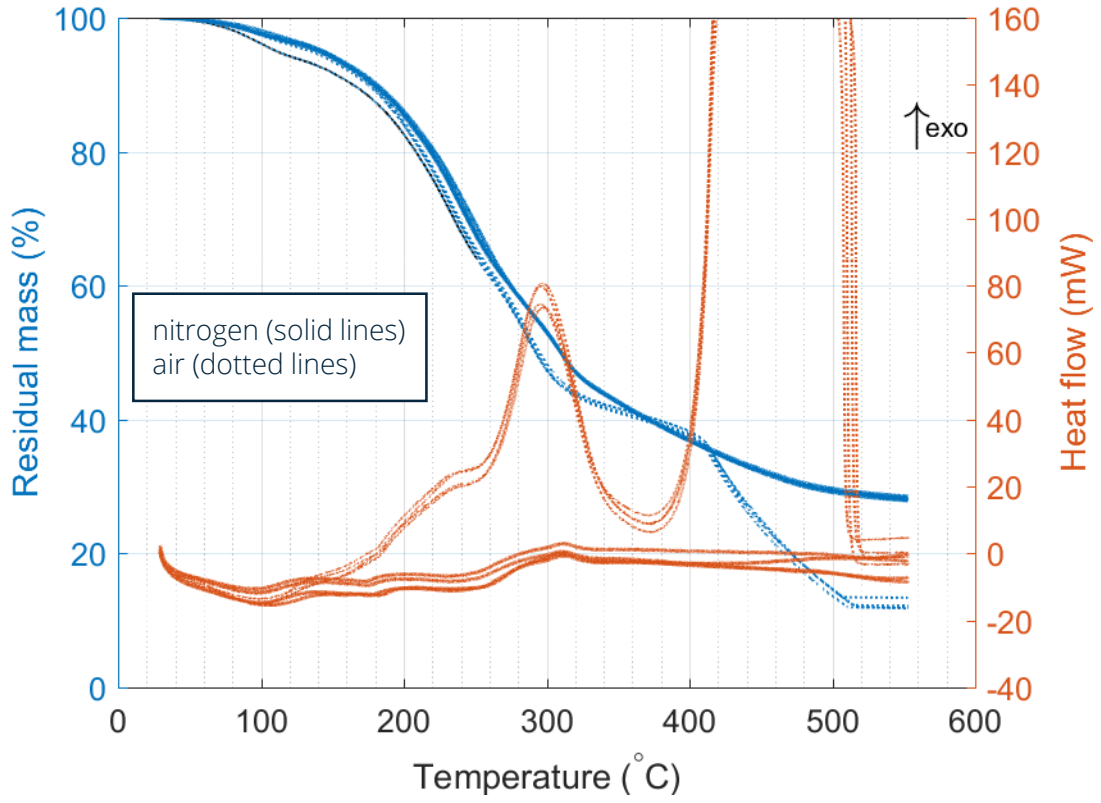
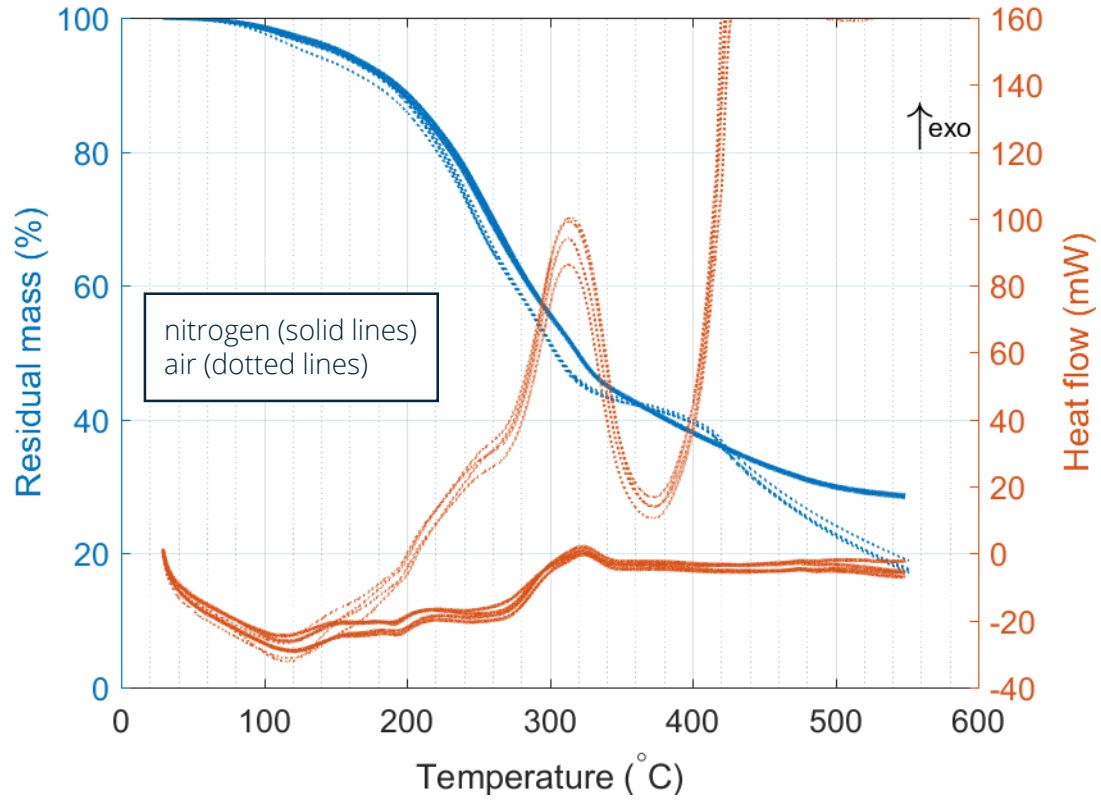
Results: THS 2.2 tobacco mass and heat evolution

Influence of heating rate on mass and heat evolution

5 K/min heating rate



10 K/min heating rate



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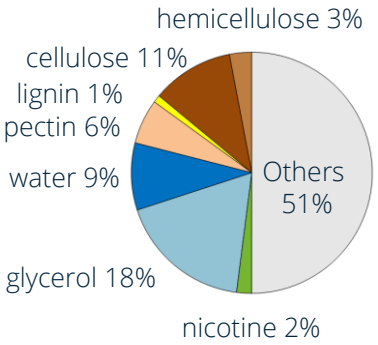
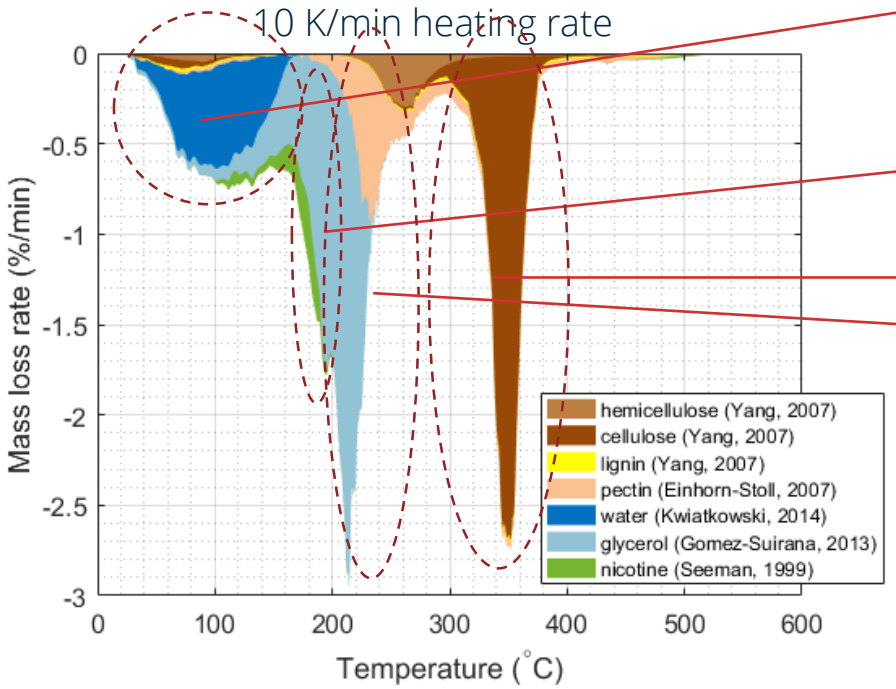
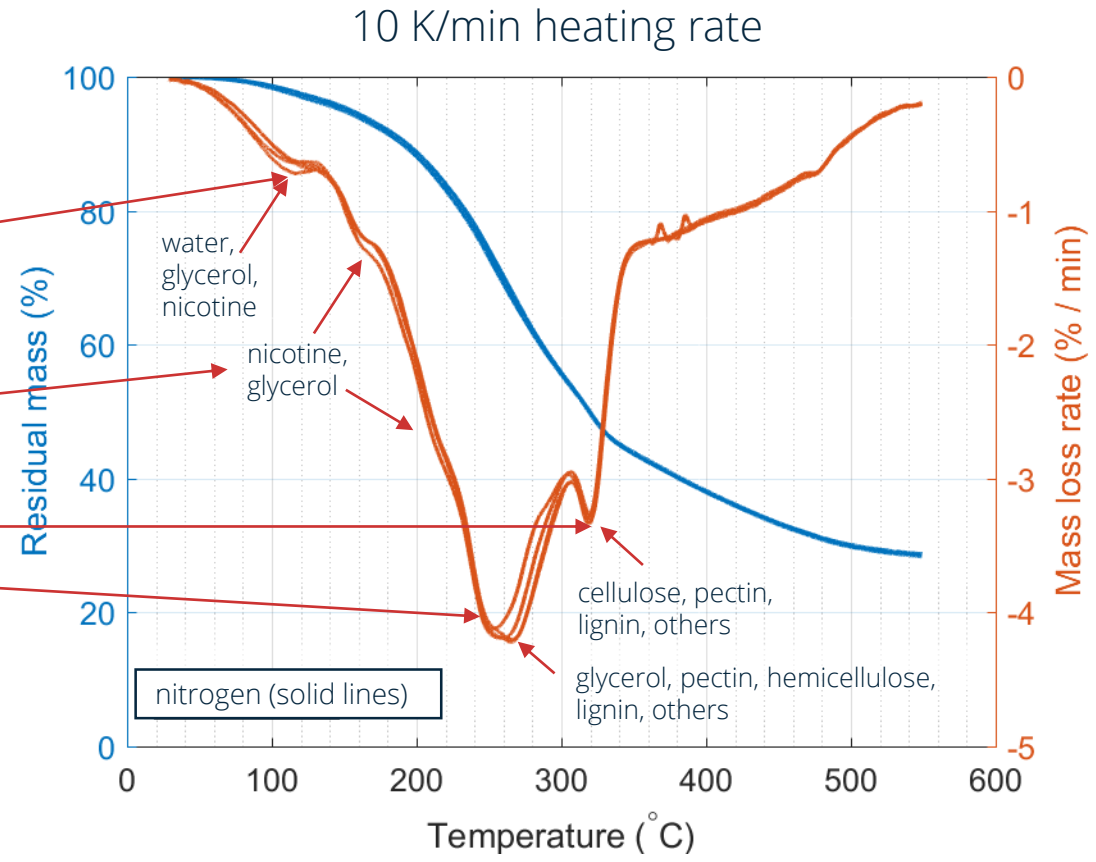
Results: identification of mass loss rate peaks

Tobacco composition







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- *Gómez-Siurana, A. et al. (2013) Thermochimica Acta, 573, 146– 157.*
- *Kwiatkowski, K. et al (2014) Journal of Physics: Conference Series, 530, 012015.*
- *Seeman, J.I. et al. (1999) Journal of Agricultural and Food Chemistry, 47, 5133-5145.*
- *Yang, H. et al. (2007) Fuel, 86, 1781–1788.*

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

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Thank you for your attention!

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