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Investigation of filter temperatures and desorption of volatiles from carbon filters under different smoking regimes.

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Imperial Tobacco

Background

- Previous work carried out by C. Mueller

  Poster SSPT21

  - Loss of efficiency of carbon filter for the retention of volatiles in the last puffs during Canadian Intense (CI) smoking regime
  - Higher filter temperature in the last puffs

➔ Hypothesis : thermal desorption from the carbon filter might occur during CI and may not in ISO

From ISO to CI Smoking regimes

- Smoking parameters CI versus ISO

	ISO	CI
Puff volume	35 ml	55 ml
Puff duration	2 sec	2 sec
Puff flow rate	1,05 L/min	1,65 L/min
Puff frequency	60 sec	30 sec
Vent blocking	No	Yes 100%

Higher filter load
Higher flow rate
Higher filter temperature

➔ Experimental design focussed on temperature effects but additional phenomena to be taken into consideration

ISO and CI
Experimental set-up

1. **Evaluation of filter temperature**

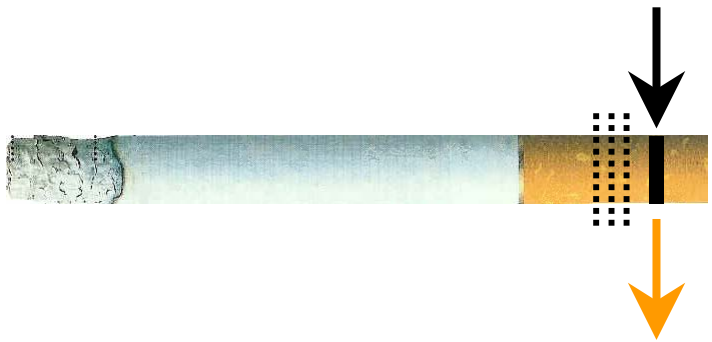
2. **Volatiles distribution between filter and vapour phase <u>with</u> the filter temperature effect**

3. **Volatiles distribution between filter and vapour phase <u>without</u> the filter temperature effect**

4. **Impact of filter temperature effect on the filter/vapour phase distribution**

Evaluation of filter temperature: experimental

A 7 mg ISO tar commercial cigarette (filter vent 38%)
modified by addition of 50 mg of carbon after the filter ventilation holes



Temperature measurement

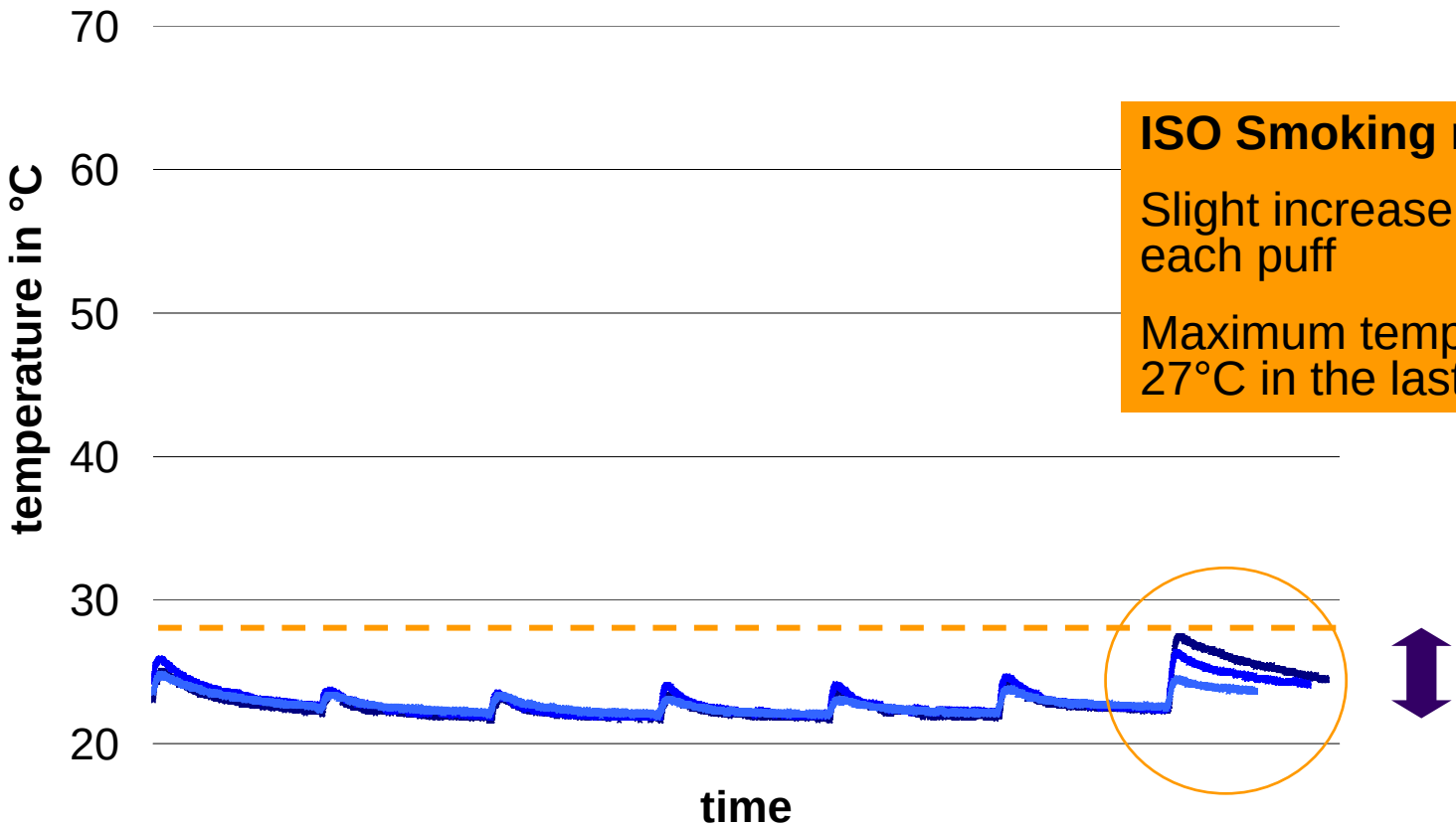
Experimental conditions

Probe in the middle of carbon section (axial and longitudinal)

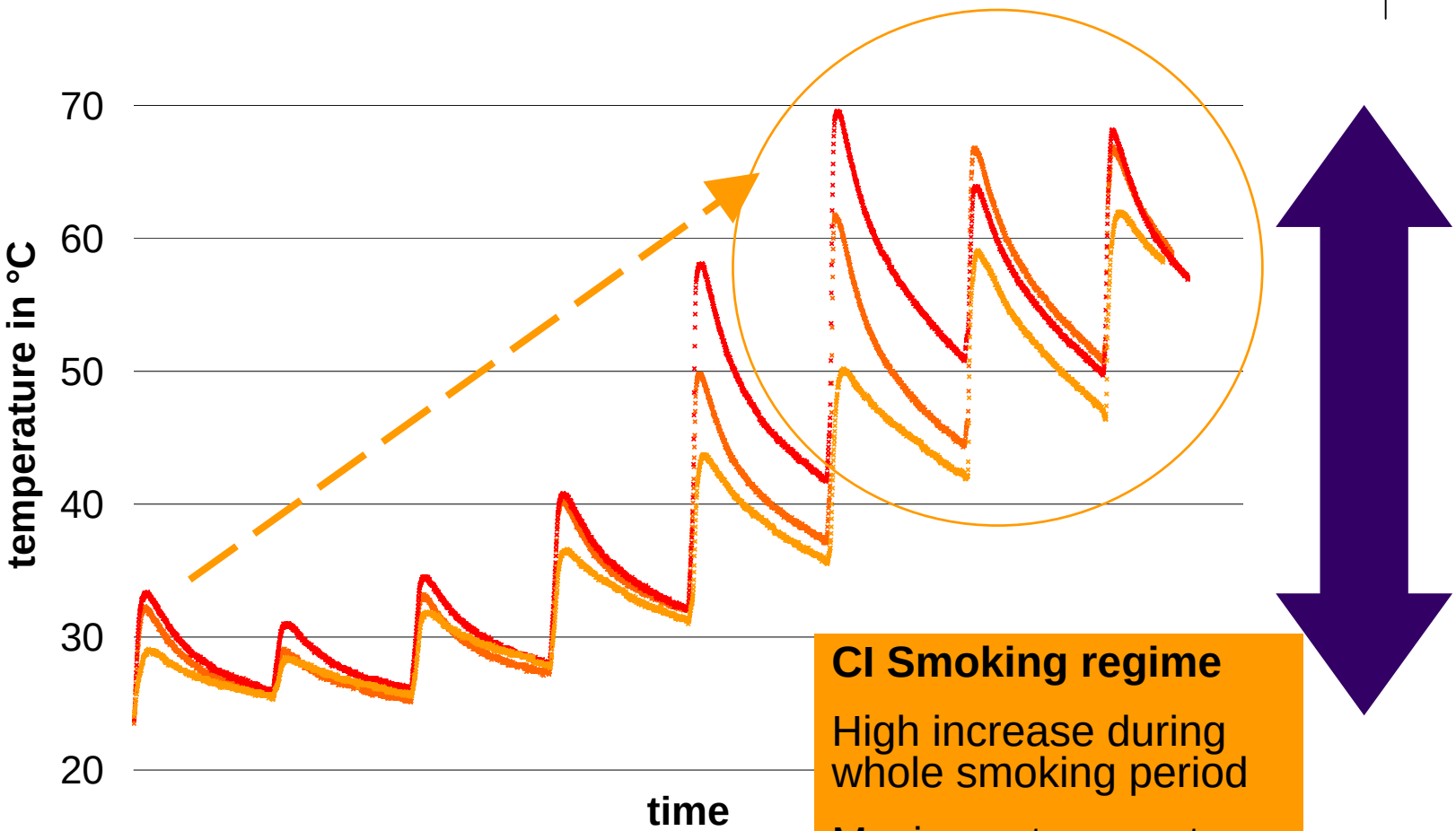
Linear smoking machine equipped with a digital recorder (Sodim) acquisition period 50 msec

3 replicates

Evaluation of filter temperature: ISO smoking



Evaluation of filter temperature: Canadian Intense smoking



CI Smoking regime

High increase during whole smoking period

Maximum temperature: 70°C in the last puffs

Evaluation of filter temperature: Summary

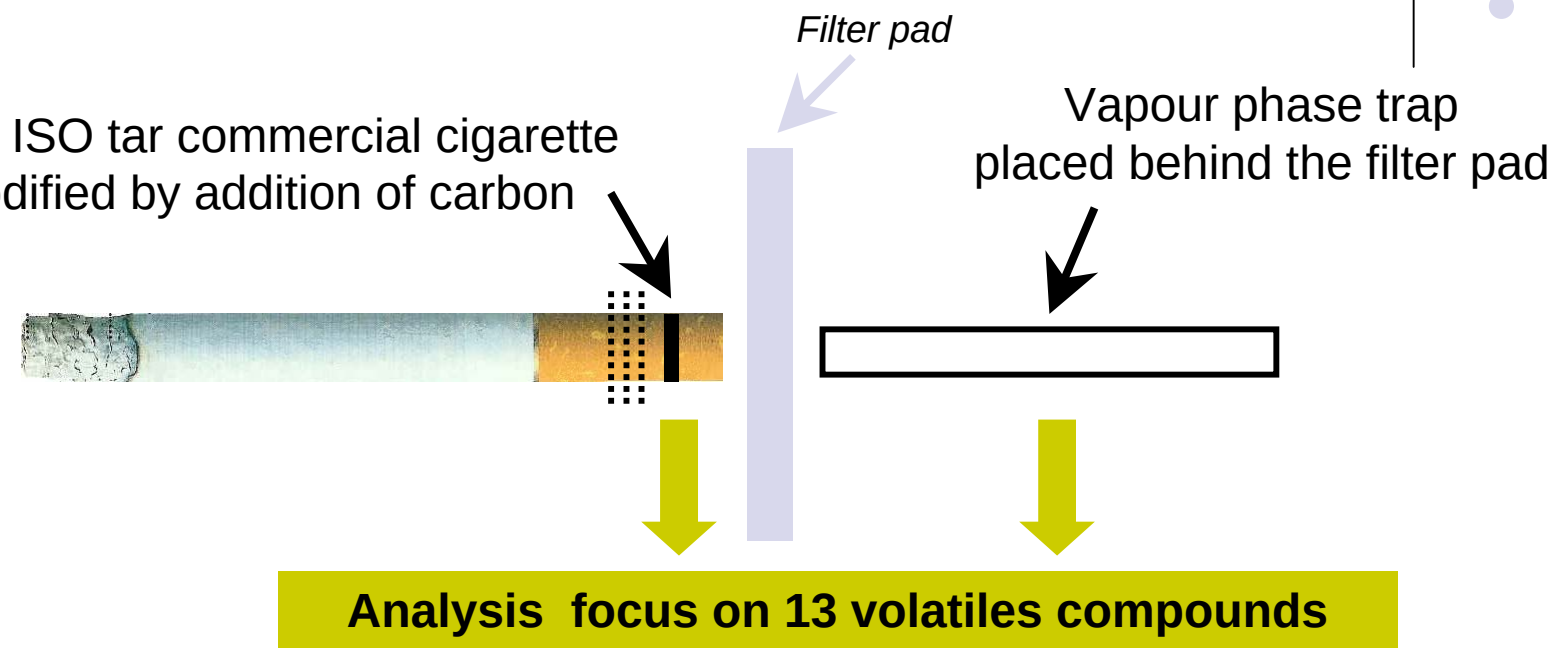
Differences in filter temperature according to the smoking regimes

- ISO
  - Constant
  - Slight increase only in the last puff
  - Maximum temperature ➔ 27°C

- Canadian Intense
  - High increase during the whole smoking period
  - Maximum temperature ➔ 70°C

Filter/vapour phase volatiles distribution with the filter temperature effect

Experimental



VOC : 1,3-butadiene; Isoprene; Acrylonitrile; Benzene.
Carbonyls : Acetaldehyde, Propionaldehyde, Acetone, Isobutyraldehyde, Butyraldehyde, Methyl Ethy Ketone (MEK), Crotonaldehyde.
Semi-volatiles : Toluene, Styrene.

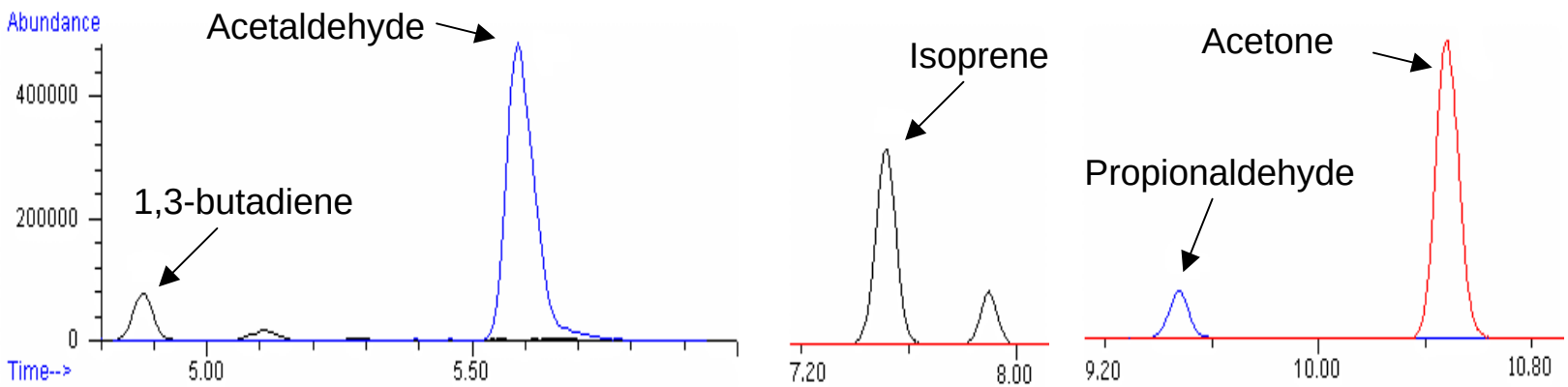
*Method limitation : **Acrolein** excluded (lack of specificity), **Formaldehyde** excluded (highly reactive compound), **Lower molecular weight** compounds excluded (not detectable)*

Filter/vapour phase volatiles distribution with the filter temperature effect

Volatiles analysis

Thermal desorption Gas Chromatography Analysis (TDS-GC/MS)

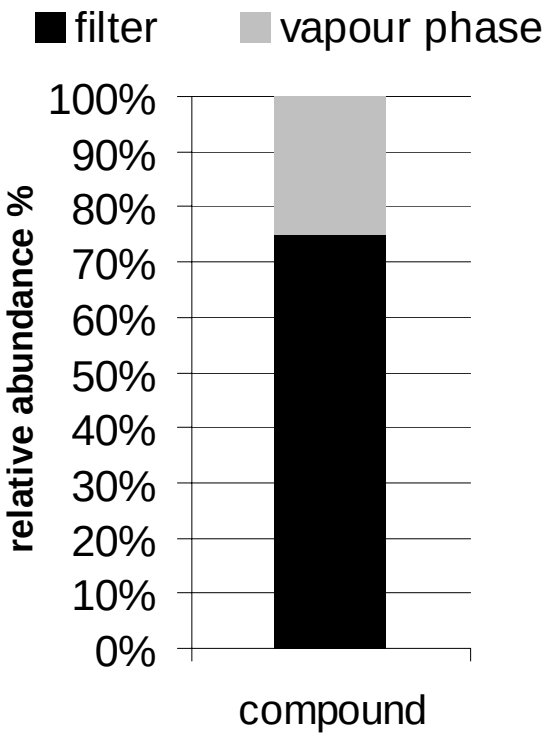
Experimental conditions : TDS-GC/MS Gerstel/Agilent system, RTX VMS column - multi ion monitoring acquisition -
Total desorption : 350°C for 5 min - 3 replicates



Filter/vapour phase volatiles distribution with the filter temperature effect

Results expression

Thermal desorption Gas Chromatography Analysis (TDS-GC/MS)



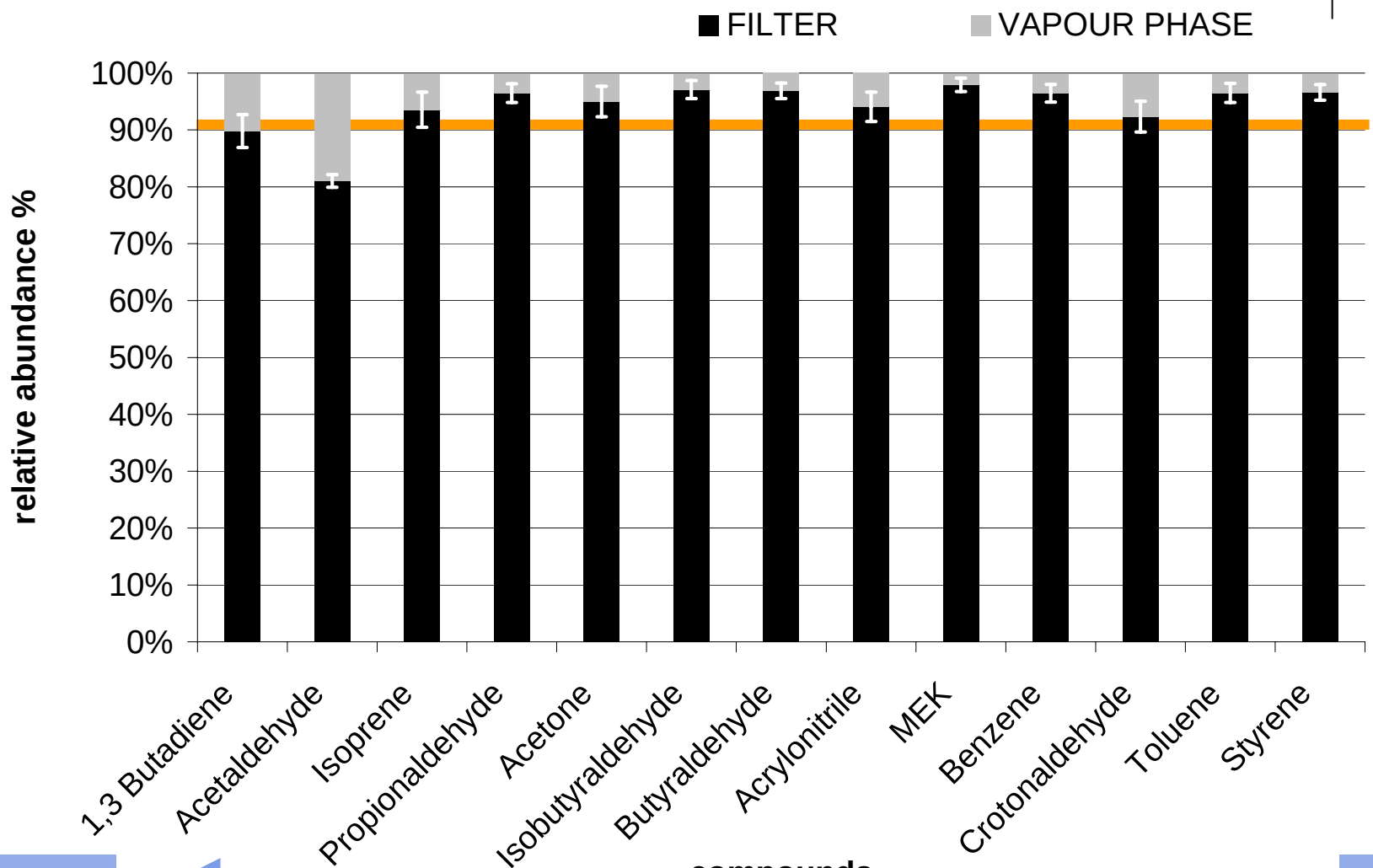
Results : Area response for each compound from the total desorption of the filter or the vapour phase trap

Expression : for each compound and each replicate, the relative distribution filter/vapour phase was calculated

100% corresponding to the sum of filter + vapour phase allowing comparison of different smoking regimes.

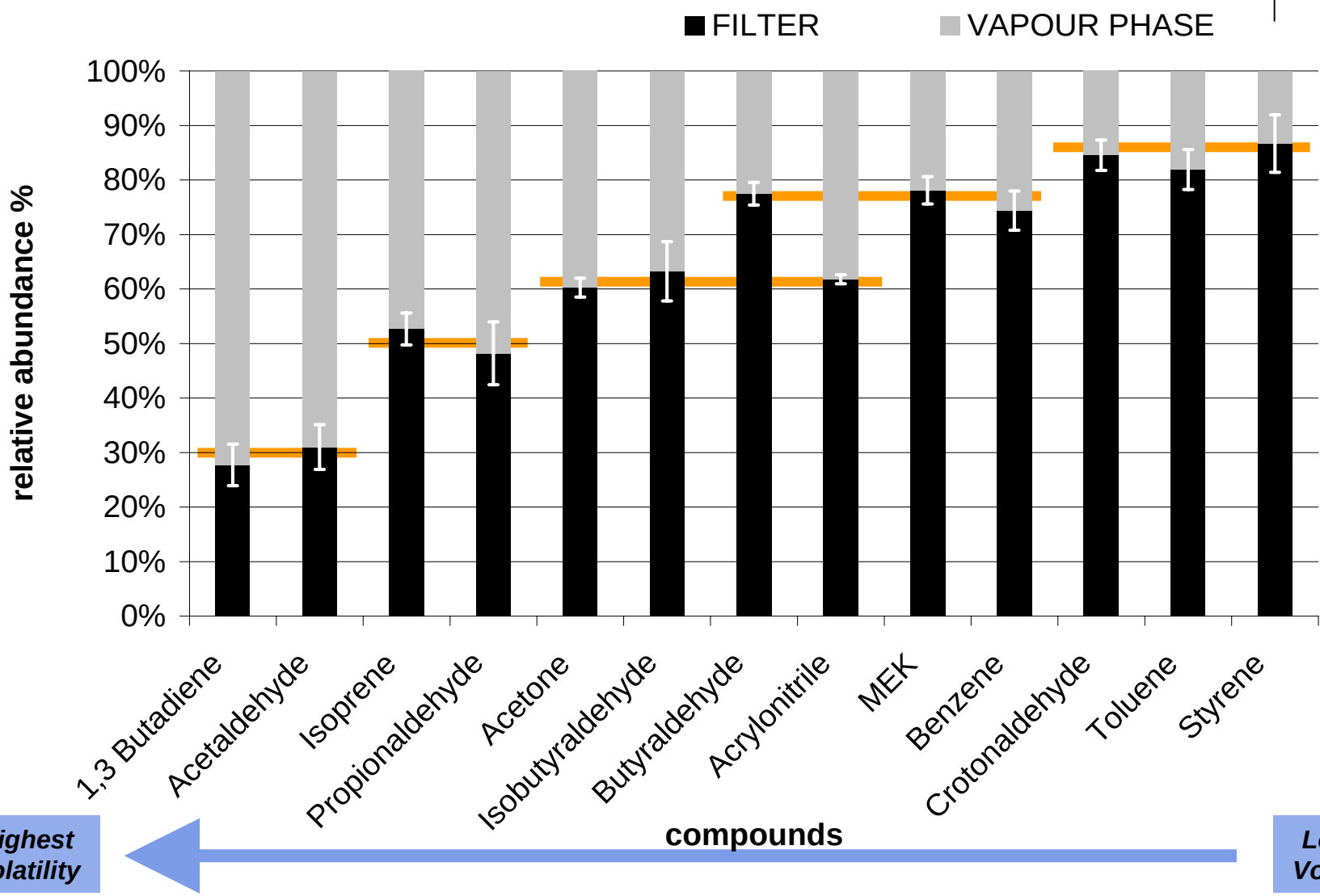
Filter/vapour phase volatiles distribution with the filter temperature effect

ISO smoking regime



Filter/vapour phase volatiles distribution with the filter temperature effect

CI smoking regime

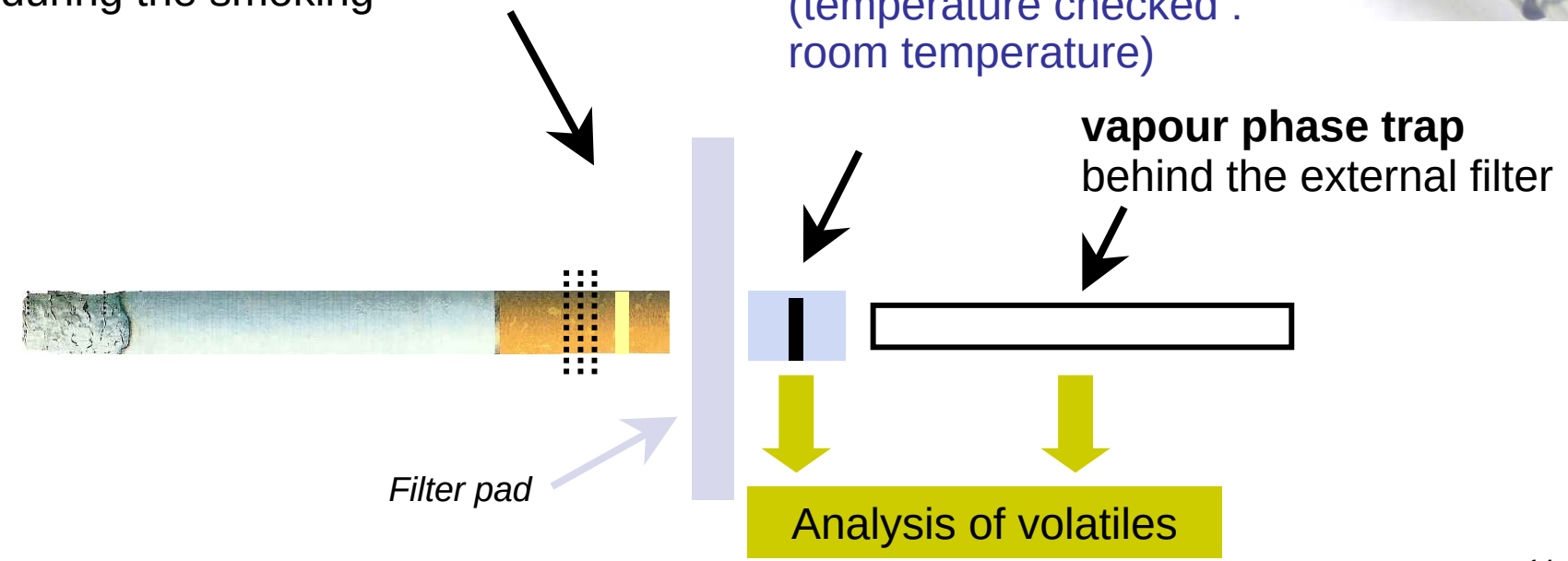


Filter/vapour phase volatiles distribution without the filter temperature effect

Experimental

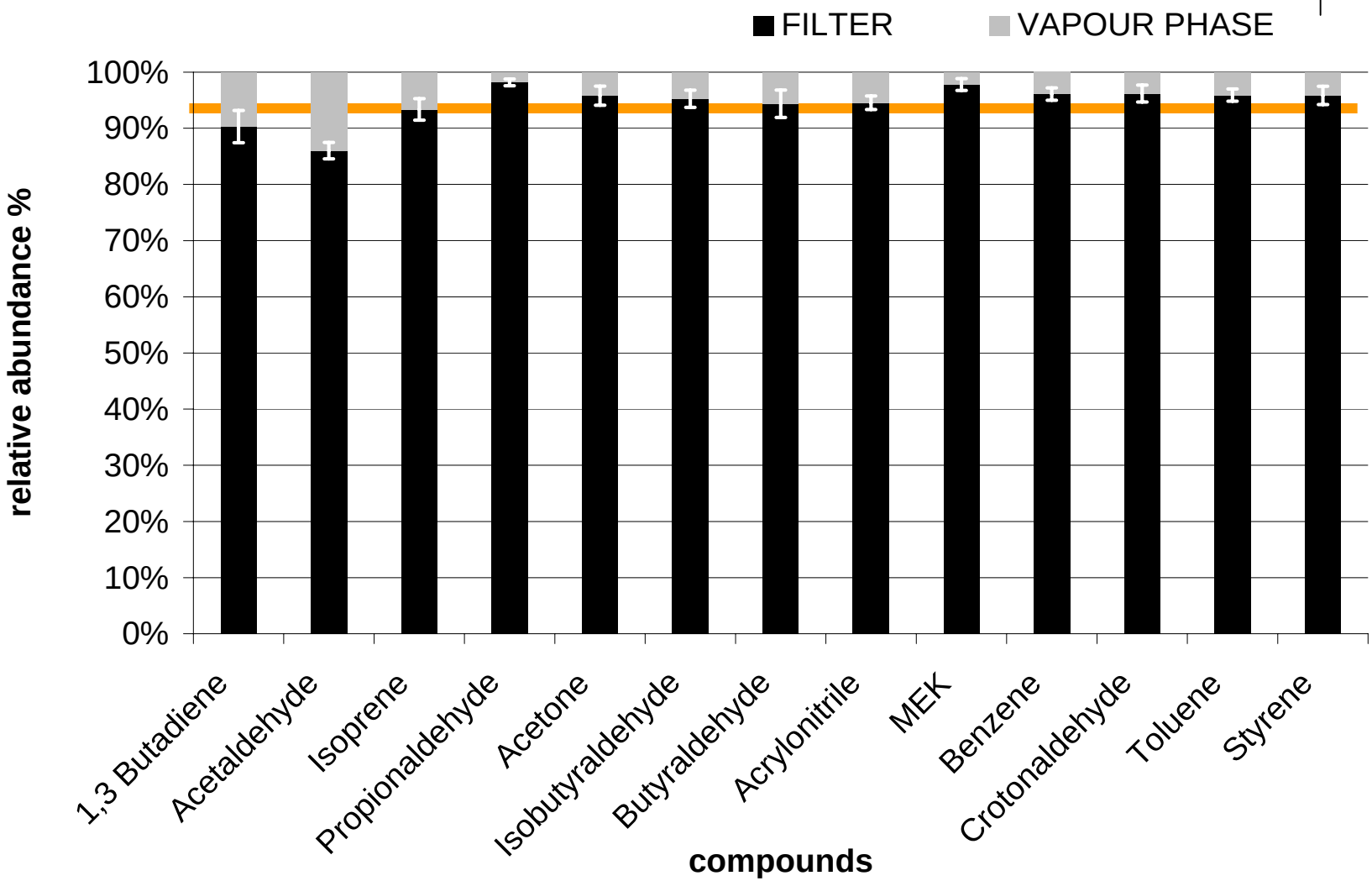
Same 7 mg ISO tar commercial cigarette modified by addition of 50 mg of **inert semolina** in order to maintain the pressure drop during the smoking

An 50 mg **external carbon filter** placed between the filter pad assembly and the entrance of the smoking machine syringe (temperature checked : room temperature)



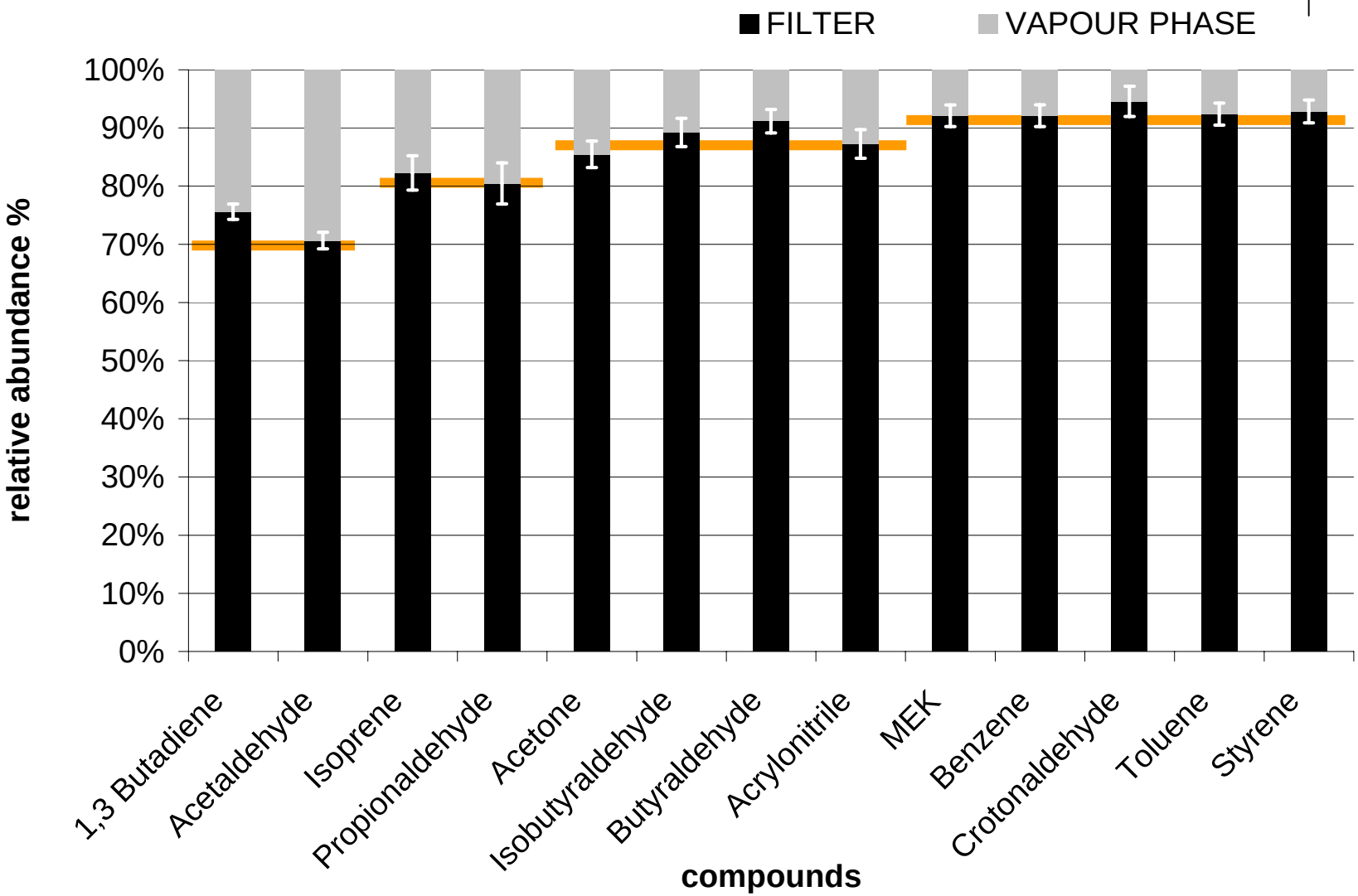
Filter/vapour phase volatiles distribution with the filter temperature effect

ISO smoking regime

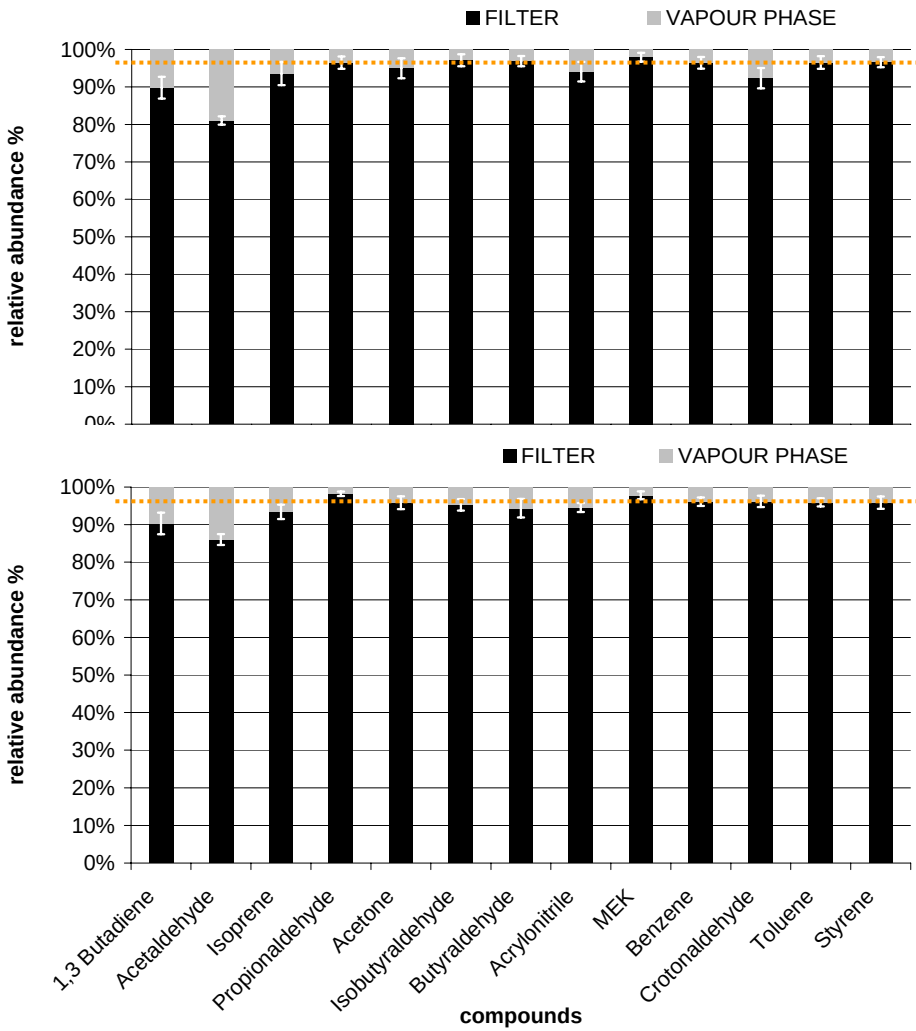


Filter/vapour phase volatiles distribution without the filter temperature effect

CI smoking regime



ISO smoking with/without filter temperature effect: summary

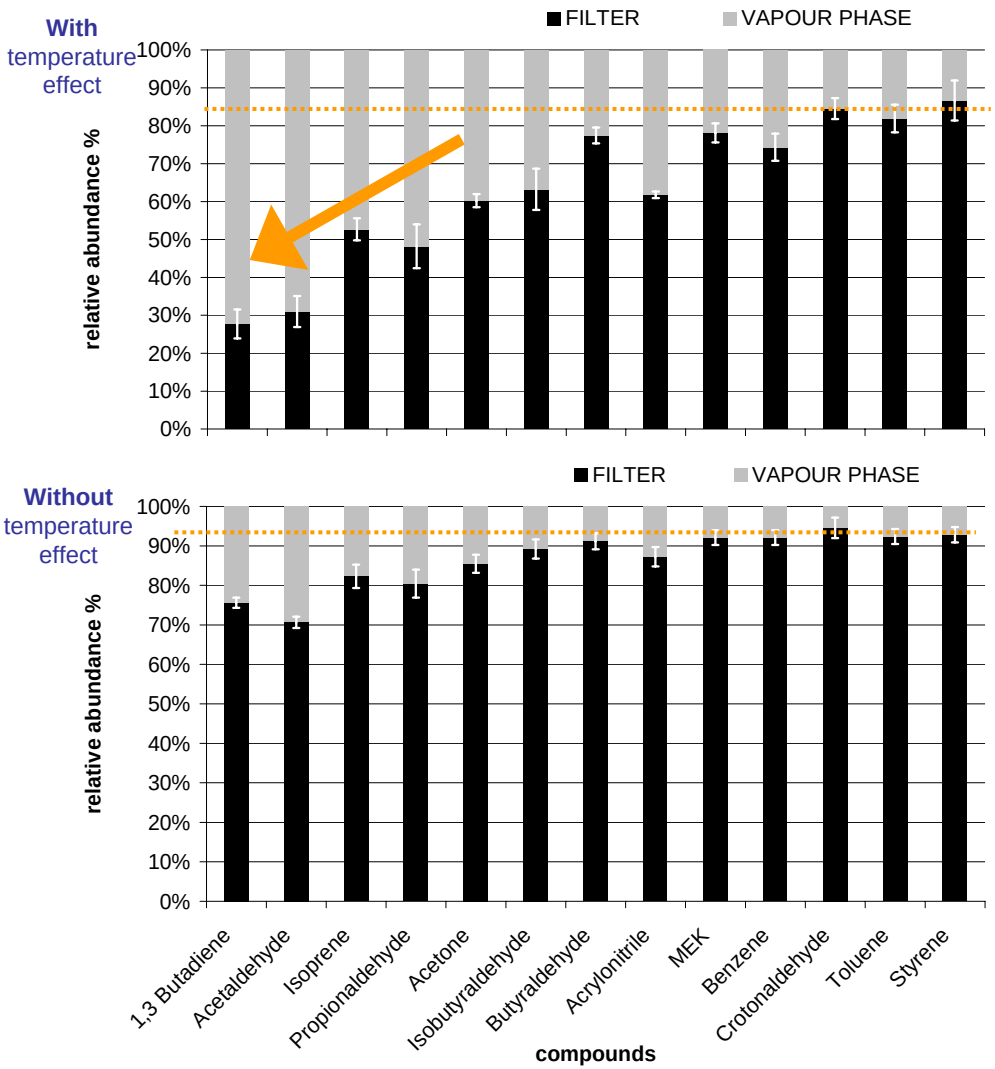


No major difference among volatiles distribution between filter and vapour phase whit or without temperature effect in ISO.

Temperature profile showed low temperature during the whole smoking period.

➔ **No temperature effect on carbon filter efficiency in ISO.**

CI smoking with/without filter temperature effect: summary



<u>Slight differences</u> between the maximum filter relative abundance (Cambridge filter pad in front of the external filter : filter load difference)

Huge differences between the filter relative abundance for the **highest volatility compounds.**

Temperature profile showed high temperature during the whole smoking period.

➔ **Temperature effect on carbon filter efficiency suspected in CI.**

Further investigations : Desorption estimation by TDS-GC/MS

Filter temperature effect on volatiles distribution: CI experimental

7 mg ISO tar commercial cigarette modified by addition of **semolina**

external carbon filter

Vapour phase trap

TDS-GC/MS Analysis in 2 steps

1

Analysis

thermal desorption until maximum occurring temperature

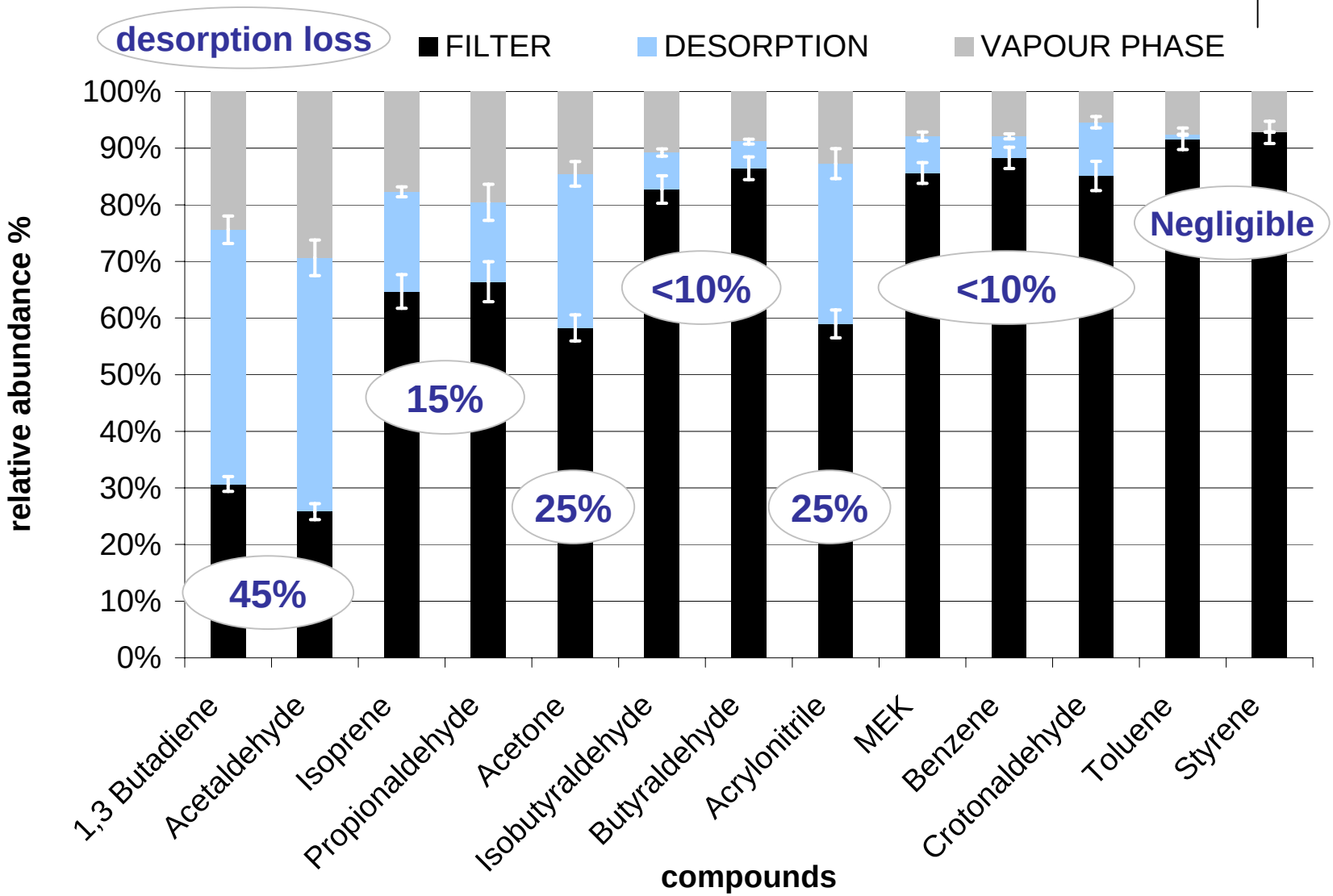
60°C/min up to 70°C during 6 sec

2

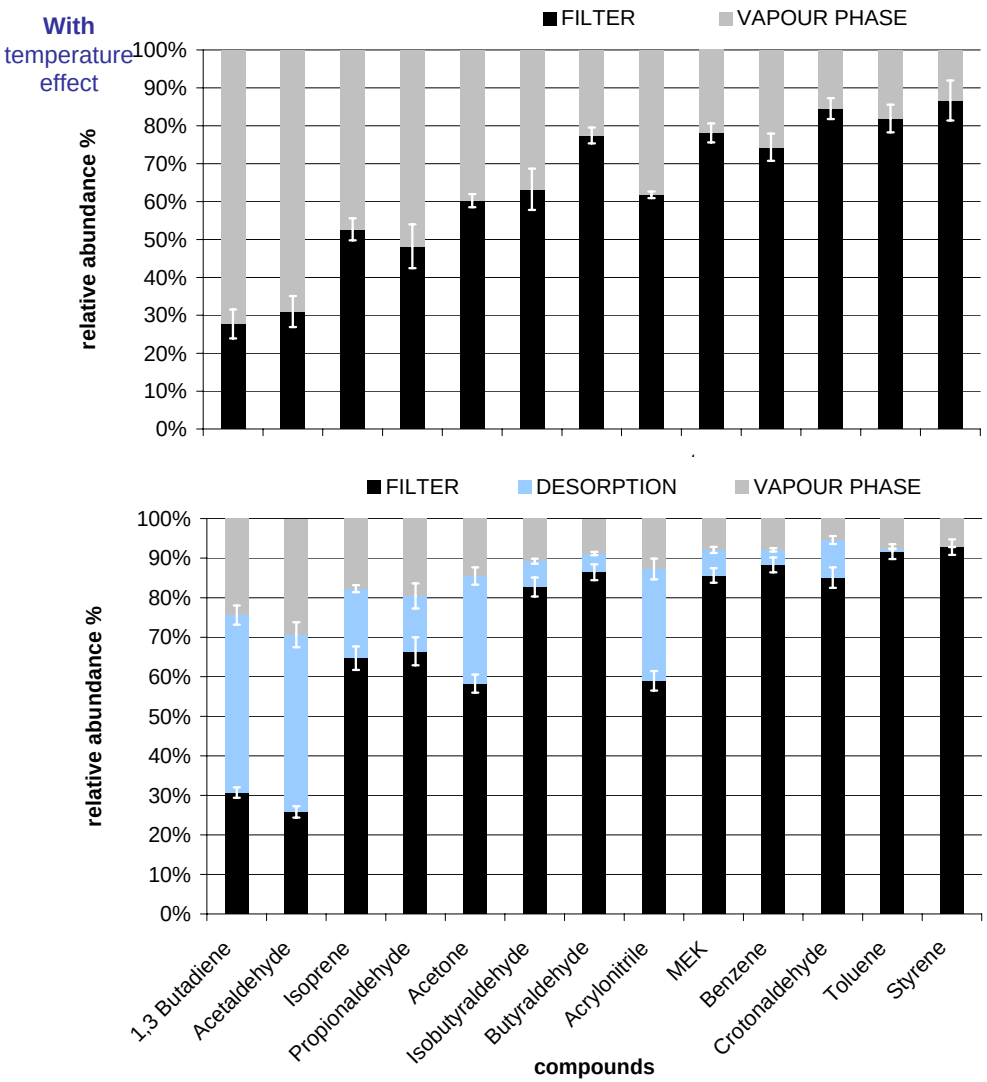
full desorption

350°C 5 min

Impact of filter temperature effect on the filter/vapour phase distribution
CI desorption simulation



CI smoking with filter temperature effect /TDS simulation : summary



Relative abundance of volatiles in the filter after desorption simulation in a good agreement with CI including temperature effect

Hypothesis :

Thermal desorption of volatiles from the filter to the vapour phase due to temperature effect

Higher temperature involved thermal desorption for the highest volatility compounds

Summary

Canadian intense regime involves **higher temperatures** than the ISO

In comparison with ISO an additional phenomena occurs related to temperature effect. It could **drastically reduce carbon filtration power for the highest volatility compounds**.

Thermal desorption estimation **shows reduction in carbon filter efficiency depending of the compounds from 45% to more than less 10%.**

Hypothetically, it might be a combination of both desorption and loss of adsorption due to filter temperature.

Blocking 100% filter ventilation does not allow the smoke cooling effect during the Canadian intense smoking period.

However, the Canadian regime may not well represent human smoking conditions.

Thank you for your attention