Carbonyls Partitioning in Heated Product (HP) Aerosol

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Introduction

Carbonyl compounds can be formed when substrates are heated, and are a key class of compound to assess in the emissions of heated products. A study has been carried out to determine the partitioning of selected carbonyl compounds between the vapour and particulate phases of the aerosols produced by tobacco and rooibos-based substrates used in commercially available heating products. In addition, the same methodology has been used to assess the same carbonyls in cigarette smoke for comparison. In the literature,[1,2,3] it is reported that 30-40% of formaldehyde in cigarette smoke is in the particulate phase. For acrolein and acetaldehyde, 93% and 98% are reported respectively in the vapour phase. The results from this study may assist when considering strategies to reduce carbonyls in emissions in HP.

Methodology

Test Articles

Three heated products (HPs) and one cigarette were assessed in this study, as per Table 1.

Table 1. HP and cigarette samples

HP Samples	Cigarette
Reconstituted rooibos	1R6F reference
Tobacco lamina	
Tobacco recon/lamina blend	

Methodology

In this study, the particulate and vapour phases were collected and analysed separately, to quantify the distribution of carbonyl compounds in each phase of the aerosol. A schematic of the method is shown in Figure 1.

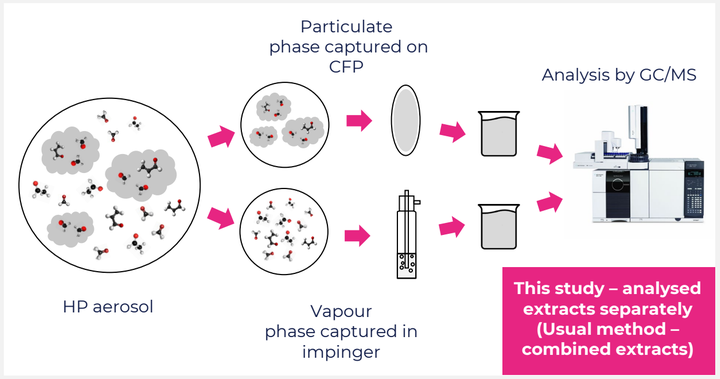

Figure 1. Schematic of collection method of particulate and vapour phase fractions

The HP samples were puffed using glo™ Pro devices, using CRM 101 puffing regime.[4] The cigarettes were smoked at both the ISO[5] and ISO Intense[6] regimes. Laboratory conditions were 22°C and 60%RH.[7] In total, 18 carbonyls were analysed, with a specific focus on formaldehyde, acrolein and acetaldehyde as these appear on the TobReg 9 list of 9 key toxicants proposed by the WHO for mandated lowering in cigarettes.[8]

Results

Partitioning of carbonyls in HP aerosol

Of the three carbonyls of interest, formaldehyde was the only one found to partition between the vapour and particulate phase. Acrolein and acetaldehyde are almost exclusively in the vapour phase for all samples.

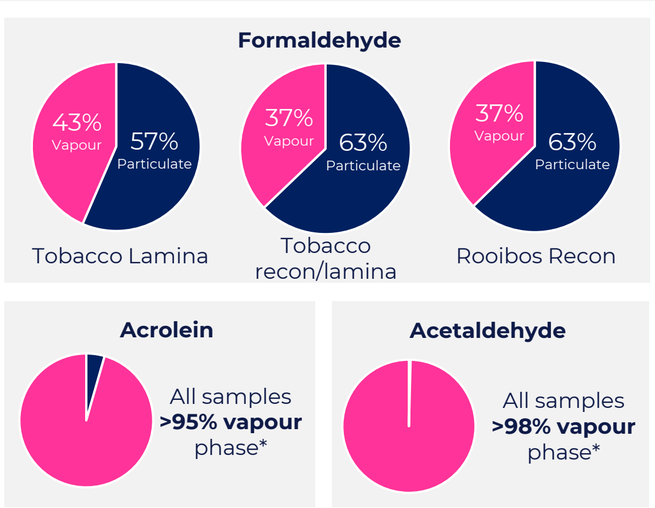

Figure 2. Partitioning of formaldehyde, acrolein and acetaldehyde in three heated product samples
*Particulate phase values reported are LOQ values

Of the remaining 15 carbonyls analysed, the following three partitioned almost exclusively in the particulate phase; glycolaldehyde, acetoin* and methylglyoxal. Nine carbonyls** partitioned almost exclusively in the vapour phase, and outcomes for the remaining three*** were below the limit of quantification for the method.

*Acetoin showed some partitioning for the tobacco substrates only, with 84% in the particulate phase. For Rooibos, 100% was in the particulate phase.

**Crotonaldehyde, acetone, butyraldehyde, 2,3-pentanedione, 3-buten-2-one, 2,3-butanedione, isobutyraldehyde, propionaldehyde, methyl ethyl ketone

***Glyoxal, 2,3-heptanedione, 2,3-hexanedione

Partitioning of carbonyls in 1R6F reference cigarette smoke

The data from this study differs from some literature reported values for formaldehyde, with our data suggesting the majority of formaldehyde is found in the particulate phase of cigarette smoke. Our acrolein and acetaldehyde partitioning values are however similar to those reported in the literature.

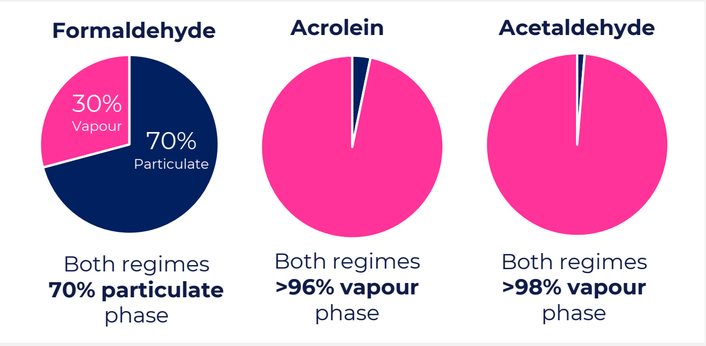

Figure 3. Carbonyls partitioning in 1R6F cigarette smoke, data for both ISO and Health Canada Intense smoking regimes summarised.

The partitioning of the remaining 15 carbonyls analysed in 1R6F cigarette smoke were broadly in line with that observed for the HP samples. Two of the vapour phase carbonyls showed a small fraction in the particulate phase – 2,3-pentanedione and 2,3-butandione.

Conclusion

This study has shown that carbonyls partitioning is broadly similar between HP aerosol and cigarette smoke, across the 18 carbonyls tested.

Acrolein and acetaldehyde were both found to partition predominantly in the vapour phase of both heated product aerosol and cigarette smoke and align with values reported in the literature.

Our results suggest the majority of formaldehyde is found in the particulate phase of heated product aerosol, with slight differences seen between substrate types.

A similar result was found for formaldehyde in cigarette smoke, which is not in agreement with some previous literature values. This could be due to differences in cigarette samples and / or sampling methodology. In addition, several factors could influence partitioning, such as temperature and humidity.

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