NEXT GENERATION PRODUCTS

Chemical characterisation of a ceramic wick e-vapour product aerosol reveals marked reductions in toxicant levels when compared to cigarette smoke

CORESTA Congress October 13-17th, 2024

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Figure 1: blu 2.0 device and pod

INTRODUCTION

Imperial Brands understands that smoking is a cause of serious disease in smokers including lung cancer, heart disease and emphysema. The greatest risk of smoking related diseases comes from burning tobacco and inhaling smoke containing around 7,000 chemicals. While science suggests that nicotine is addictive and not risk-free, Public Health experts worldwide have concluded that it is the toxicants in cigarette smoke generated by burning tobacco, and not nicotine, which is the primary cause of smoking-related disease. Tobacco Harm Reduction (THR) refers to strategies designed to reduce the health risks associated with tobacco smoking. Next Generation Products (NGP), like E-Vapour Products (EVP), deliver nicotine without burning tobacco so have the potential to play a role in THR. The most recent iteration of pod-based e-vapour products (EVP), utilise a ceramic-based wick as opposed to a standard cotton wick. As a new product, it is important to assess the construction of the EVP wick products heating performance and resulting aerosol composition. The aim of this research was to characterise and compare EVP aerosol and tobacco smoke for 52 toxicants, to assess the harm reduction potential of EVP compared to cigarettes. Some of the analytes that were reviewed have been identified by public health authorities as chemicals associated with causing diseases in smokers and have been published on lists such as WHO and FDA[1, 2, 3].
These analytes included carbonyls, phenolics, tobacco specific nitrosamines, polyaromatic amines, polycyclic aromatic hydrocarbons and heavy metals. All chemical analyses were performed in an ISO 17025 accredited laboratory and all methods have undergone internal validation.

METHODS

Test Articles
- 1R6F Reference Cigarette (University of Kentucky)
- Commercially available EVP, blu 2.0 Classique Original Tobacco flavour 1.6% Nicotine (EU Market variant) see Figure 1

Smoke/Aerosol Generation
Test product aerosol/smoke was generated using the following regimes (Table 1):

Sample	Puffing Regime	Puff Volume (ml)	Puff Duration (Seconds)	Puff Interval (Seconds)	Vent Blocking	Puff Profile
1R6F Reference cigarette	ISO 20778	55	2	30	Yes	Bell shaped
EVP	ISO 20768	55	3	30	N/A	Square shaped

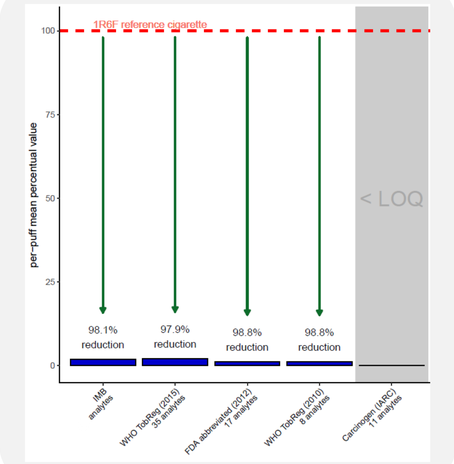
- For 1R6F reference cigarette, between 8.3 and 10.5 puffs were taken in replicates of 3.
- For the EVP, 50 puffs were taken for each block, with 3 blocks taken (150 puffs total).

Analytical methods:
EVP aerosol collected mass (ACM)/ 1R6F total particulate matter (TPM) was trapped on a Cambridge filter (CF) pad using a rotary machine. The mass of the filter pad including the holder of the smoking machine was determined before and after use. The mass of the collected particulate phase per stick is the ACM/ TPM.
Nicotine – the particulate phase of the aerosol/ smoke was trapped on a CF pad and extracted with 2-Propanol. Analysis was carried out using GC-flame ionization detection (FID).
Tobacco Specific N-nitrosamines (TSNAs) - the collected ACM/ TPM CF was extracted with water/methanol. This was analysed using liquid chromatography (LC) and tandem mass spectrometry (MS/MS).
Gas phase - the vapour phase of the aerosol/ smoke was collected in a Tedlar bag located after the CF pad. The sample is separated by gas chromatography (GC) and detected by mass spectrometry (MS).
Heavy Metals – the whole unfiltered aerosol/ smoke was collected by two in row impingers, filled with a solution of nitric acid. Extracts were then analysed by induction coupled plasma (ICP)-MS.
Benzo(a)pyrene (BAP) – the collected ACM/TPM CF was extracted by cyclohexane. Part of the extract was concentrated and cleaned using solid phase extraction (SPE) with n-hexane as eluent. The eluate was concentrated and diluted by cyclohexane, and analysed by GC-MS.
Carbonyls – whole aerosol and gas phase was passed through directly two in-row impingers containing DNPH (2,4-Dinitriphenylhydrazine) solution in acetonitrile to trap all carbonyls as hydrazones. The solution was stabilised and analysed using reversed phase high phase liquid chromatography (HPLC)-diode-array detector DAD.
Aromatic Amines – the collected ACM/ TPM CF was extracted with 5% hydrochloric acid, neutralised and the aromatic amines are extracted using n-hexane. The extract was treated with PFPA (Pentafluoropropionic acid anhydride) followed by a SPE and quantified by GC-MS.
Phenols - the collected ACM/ TPM CF was extracted with 1% acetic acid in water. An aliquot was filtrated, diluted and analysed using reversed phase ultra-high phase liquid chromatography (UHPLC) fluorescence detector.
Semi-Volatiles - following collection, the CF and the whole aerosol/smoke trapped with an impinger of Methanol at -70°C (dry-ice/isopropanol) were extracted and injected together in a specific GC-MS system.
Ammonia – the aerosol/smoke condensate was trapped using electrostatic trapping in addition to an impinger containing diluted sulfuric acid. Ammonium is transformed in a coloured complex and analysed using a continuous flow analyser.

RESULTS

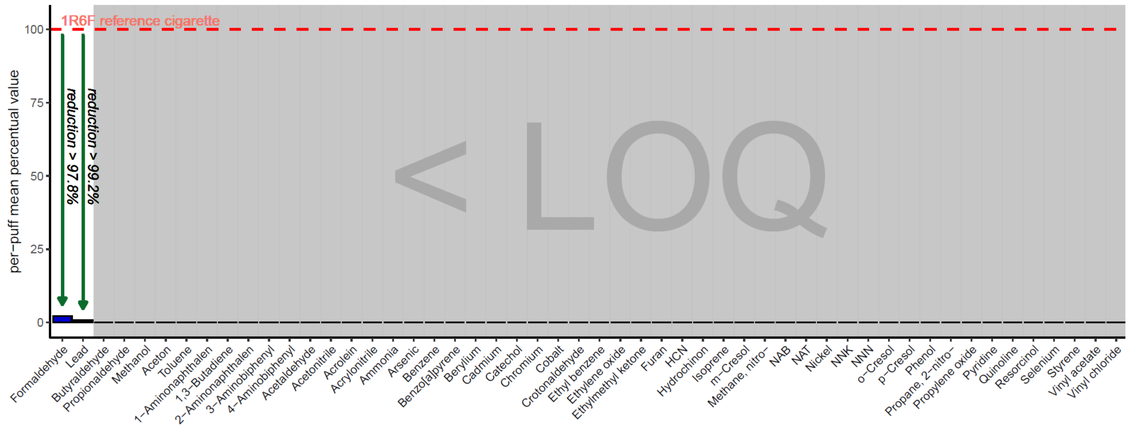
- The average ACM for the blu 2.0 was 5mg/puff, whereas the 1R6F cigarette delivered 4.2mg/puff TPM.
- The average per puff levels of nicotine for the blu 2.0 device was 0.07mg/puff, whilst the 1R6F cigarette delivered 0.2mg/puff nicotine.
- The blu 2.0 EVP delivered 1.68mg/puff propylene glycol, 2.65mg/puff glycerol and 0.57mg/puff water.
- When collated into analyte lists suggested by public health authorities (specifically WHO, FDA and IARC), there were toxicant decreases of 97.9 – 99.9% in the blu 2.0 aerosol when compared to 1R6F smoke. See Figure 2.
- In contrast to the 1R6F cigarette smoke, the majority of analytes in the EVP aerosol were below the limit of quantification (n=50/52). Formaldehyde and Lead were quantified in the EVP aerosol, but at substantially reduced levels when compared to the 1R6F smoke, with reductions of 97 and 99% respectively. These reductions in analytes are in keeping with published results for other iterations of EVP[4, 5, 6].
- Out of the eight heavy metals (Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Nickel and Selenium) which were analysed, only Lead was present at quantifiable levels in blu 2.0 aerosol. However, this was not a consistent result with it being detected only in the 3rd replicate of the 51 – 100 puff block (7.9ng/50 puffs).

Figure 2: Comparison of toxicant levels between blu 2.0 aerosol and 1R6F cigarette smoke using regulatory analyte lists



NOTE: Nicotine, CO, NO and Mercury were not included in the regulatory analyte lists

Figure 3: Toxicant levels in blu 2.0 aerosol relative to 1R6F reference cigarette smoke



CONCLUSIONS

Here we present data comparing the toxicant levels of a ceramic wick e-vapour product to that of a combustible reference cigarette.

Of the toxicants assessed in the blu 2.0 aerosol, 50 out of the 52 analytes were below their respective limits of quantification.

The two analytes that were quantified were Formaldehyde and Lead but were present in aerosol at substantially lower levels when compared to reference cigarette smoke levels.

When collated into analyte lists suggested by public health authorities, there were toxicant decreases between 97.9 – 99.9% in the blu 2.0 aerosol when compared to 1R6F smoke.

The results presented here require further substantiation via integrated pre-clinical and clinical assessments.

However, the initial dataset confirms this iteration of pod-based EVP delivers nicotine with a marked reduction in toxicants associated with causing tobacco-related disease, and therefore has the potential to make a meaningful contribution to THR.

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