1. Introduction

- Electronic cigarette (e-cigarette) aerosol is considered by a number of public health bodies to provide reduced exposure to toxicants and carcinogens compared to conventional cigarette smoke, as it delivers nicotine and flavour without burning tobacco.

- While recent studies show that e-cigarette aerosol is chemically simpler when compared to cigarette smoke [2,3], comprehensive analytical assessments of many widely available products are limited.

- In this study, two commercially available myblu™ e-liquids (1.6% nicotine, tobacco flavour; 1.6% nicotine, menthol flavour) in a myblu™ pod-system e-cigarette [Figure 1] were analysed and compared to published data for cigarette smoke (1).

- A total of 55 chemical emissions were characterised. The myblu™ products were analysed for the four principal e-liquid ingredients (nicotine, propylene glycol, glycerol and water) as well as 51 further constituents of public health interest (carbonic, phenolic, volatile organic compounds [VOCs], metals, tobacco-specific nitrosamines [TSNAs], polyamines and nicotine) and polycyclic aromatic hydrocarbons [PAHs] (3).

- The additional constituents include those on the FDA Harmful or Potentially Harmful Constituents (HPHCs) list of chemicals in cigarette smoke it considers cause or could cause harm to smokers (4).

2. Analytical Methods

- The e-cigarettes were pulled in two separate 50 puff blocks using the CORESTA Recommended Method CRM81 (puffing regime: 55mL/sec/30sec; square wave) [5]. Five replicates were measured for each e-liquid type. All analyses were conducted by Entropy Analytical LLC, Durham, North Carolina, USA. The methods used by the analysis laboratory are summarised in Table 1.

3. Reduced Formation of Toxicants of Public Health Interest

- The average aerosol collected mass for each e-liquid tested was approximately 10 mg/puff. The myblu™ 1.6% nicotine tobacco flavour aerosol delivered on average 650 µg puff propylene glycol, 337 µg puff glycerol and 868 µg puff water; the myblu™ 1.6% menthol flavour aerosol delivered on average 3187 µg puff propylene glycol, 536 µg puff glycerol and 499 µg puff water. See e-liquid compositions in Figure 1.

- The nicotine yield for the tobacco flavour variant was 150 µg/puff and for the menthol flavour variant was 125 µg/puff, correspondingly, this was 33% and 44% lower than the 285 µg/puff nicotine yield published for the cigarette (1).

- Of the 51 toxicants analysed, eight were observed at quantifiable levels, including formaldehyde, acetaldehyde and acrolein (<0.9% reduction vs. conventional cigarette); manganese and selenium (average 82% reduction vs. cigarette); and NNK, N2T and NN2 (<99% reduction vs. conventional cigarette). See Table 2. Analyte class data summarised in Figure 2.

- The total analyte yield was <1 µg/puff of toxicants tested for the myblu™ aerosols (range 0.96-0.97 µg/puff), which is 99% less than the 381 µg/puff quantified and published for cigarette smoke (1).

Table 2. Analytical characteristics of myblu™ e-cigarette aerosols and comparison with conventional cigarette smoke (µg/puff)

<table>
<thead>
<tr>
<th>Analyte Class</th>
<th>Compound</th>
<th>Mainstream (µg/puff)</th>
<th>Myblu™ 1.6% Tobacco (µg/puff)</th>
<th>Reduction vs. Conventional Cigarette (M-LOQ)</th>
<th>Myblu™ 1.6% Menthol (µg/puff)</th>
<th>Reduction vs. Conventional Cigarette (M-LOQ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Amine</td>
<td>nicotine</td>
<td>&gt;LOQ</td>
<td>0.92 ± 0.02</td>
<td>&lt;1% (0.0005)</td>
<td>0.70 ± 0.01</td>
<td>&lt;1% (0.0005)</td>
</tr>
<tr>
<td>Phenol</td>
<td>phenol</td>
<td>&gt;LOQ</td>
<td>0.03 ± 0.02</td>
<td>&lt;1% (0.0005)</td>
<td>0.03 ± 0.02</td>
<td>&lt;1% (0.0005)</td>
</tr>
<tr>
<td>Phenol</td>
<td>anisole</td>
<td>&gt;LOQ</td>
<td>0.08 ± 0.02</td>
<td>&lt;1% (0.0005)</td>
<td>0.01 ± 0.01</td>
<td>&lt;1% (0.0005)</td>
</tr>
<tr>
<td>Phenol</td>
<td>benzene</td>
<td>&gt;LOQ</td>
<td>1.33 ± 0.02</td>
<td>&lt;1% (0.0005)</td>
<td>0.79 ± 0.01</td>
<td>&lt;1% (0.0005)</td>
</tr>
<tr>
<td>Phenol</td>
<td>toluene</td>
<td>&gt;LOQ</td>
<td>23.0 ± 2.0</td>
<td>&lt;1% (0.0005)</td>
<td>19.3 ± 2.1</td>
<td>&lt;1% (0.0005)</td>
</tr>
<tr>
<td>Aromatic Hydrocarbons</td>
<td>naphthalene</td>
<td>&gt;LOQ</td>
<td>&gt;LOQ</td>
<td>&gt;LOQ</td>
<td>&gt;LOQ</td>
<td>&gt;LOQ</td>
</tr>
<tr>
<td>Aromatic Hydrocarbons</td>
<td>acenaphthene</td>
<td>&gt;LOQ</td>
<td>&gt;LOQ</td>
<td>&gt;LOQ</td>
<td>&gt;LOQ</td>
<td>&gt;LOQ</td>
</tr>
<tr>
<td>Sterols</td>
<td>cholesterol</td>
<td>&gt;LOQ</td>
<td>&gt;LOQ</td>
<td>&gt;LOQ</td>
<td>&gt;LOQ</td>
<td>&gt;LOQ</td>
</tr>
</tbody>
</table>

4. Conclusions

- The aim of this study was to determine the composition of e-cigarette aerosols with respect to the principal e-liquid ingredients and a range of toxicants (including NHPCs) for which cigarette smoke is routinely tested and data have been published [1]. Here we report a comprehensive aerosol chemistry study for two commercially available myblu™ flavourings in a myblu™ pod-system e-cigarette device.

- Testing of the myblu™ aerosols indicates low or no detectable levels of the toxicants tested. Overall the e-cigarettes yielded <1 µg/puff of the toxicants tested compared to the reported cigarette yield of 381 µg/puff. Of the 51 toxicants tested, eight were detected in the e-cigarette aerosols but at substantially lower levels (see Table 2) than reported in cigarette smoke (1).

- These data are consistent with other studies that have found no quantifiable levels of tested toxicants or extremely low levels of measurable constituents relative to cigarette smoke [1,2,6,7].

- Findings from several recent clinical studies indicate smokers who have switched to e-cigarettes have significantly lower exposure to carcinogens and toxicants found in cigarette smoke, with reductions largely indistinguishable from complete smoking cessation or use of licensed nicotine replacement products [6,9,10].

- The results obtained in the aforementioned studies and in the present work demonstrate that high quality e-cigarettes and e-liquids offer the potential to substantially reduce exposure to carcinogens, toxicants and smokers who use such products as alternatives to cigarettes.

- The findings of the present study with the myblu™ products are highly informative. Future research studies planned in preclinical in vitro studies, clinical biomarker studies, and population studies to generate a body of evidence to assess the harm reduction potential of myblu™ products compared to conventional cigarettes.

References


[8] NAB, N2T, N2K.

[9] LOQ, LOD.