Nicotine and other potentially harmful compounds in "nicotine-free" e-cigarette liquids in Australia

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Awareness and use of e-cigarettes is increasing in Australia.[1] The thousands of available e-liquids contain various excipients, nicotine, flavourings, and other additives. There is little to no regulation of their manufacture, and potentially dangerous ingredients and incorrect nicotine levels have been identified.[2] Of particular concern is the frequency with which nicotine is detected in e-liquids labelled "nicotine-free".[2] E-liquids containing nicotine cannot legally be sold in Australia,[3] but inaccurate labelling means that users may unwittingly inhale this addictive substance, or retailers may sell incorrectly labelled nicotine-containing e-liquids to willing customers. The aim of our investigation was to assess the chemical composition of a range of e-liquids available in Australia, focusing on nicotine and other potentially harmful compounds. Formal ethics approval was not required for this study.

We purchased ten "nicotine-free" e-liquids of a variety of brands and flavours, online and over the counter from Australian suppliers. None disclosed ingredient information beyond vague reporting of the excipient mix and the absence of nicotine. E-liquids were analysed quantitatively by gas chromatography–mass spectrometry (GC-MS) in a commercial laboratory (Supporting Information).

Apart from the excipient and nicotine, sixteen known chemicals were identified; a further seven could not be identified with our methods (Box). The propylene glycol/glycerine excipient accounted for 91.4–98.8% (mean, 96.3%; SD, 3.1%) abundance, based on peak areas in GC-MS chromatograms. Nicotine was detected in six e-liquids; the levels in three (1.3, 1.4, 2.9 mg/mL) were comparable with those of commonly available low dose nicotine e-liquids. The fact that nicotine was present has important implications for addiction and health, and reflects its use in the e-cigarette liquid manufacturing process.[4]

Of the other chemicals we detected, 2-chlorophenol, classified as acutely toxic by the Globally Harmonized System of Classification and Labelling of Chemicals, was identified in all e-liquids. Probably an excipient contaminant, 2-chlorophenol is commonly used in insecticides, herbicides, and disinfectants. There is no

Chemical composition of ten e-liquids purchased in Australia (percentage abundance, based on peak areas in gas chromatography–mass spectrometry chromatograms)

Flavour	Excipient	Nicotine	Hexa-decanoic acid	Octa-decanoic acid	1,2,3-butanetriol	2-chloro-phenol	2-amino-octanoic acid	Unknown #1	Others
Blueberry*	92.8%	ND	0.03%	0.05%	0.04%	0.24%	4.44%	0.06%	Triacetin, benzyl alcohol
Cigar*	96.4%	ND	0.07%	0.12%	ND	0.47%	0.53%	0.06%	Glycine, isoeugenol, vanillin, ethylvanillin, unknowns #5, #6, #7
Flue-cured tobacco*	98.7%	0.09%	ND	ND	0.16%	0.24%	0.58%	0.08%	Unknown #2
Tobacco*	99.5%	0.14%	ND	ND	0.09%	0.21%	ND	0.06%	—
Tobacco†	98.2%	0.29%	0.20%	ND	ND	0.30%	0.61%	0.13%	Tetradecanoic acid
Vitamin B†	98.9%	ND	0.04%	0.07%	ND	0.13%	0.18%	0.06%	Triacetin, glycine
Tobacco§	91.4%	0.05%	0.05%	0.17%	ND	0.22%	8.01%	0.06%	—
Menthol§	91.9%	ND	0.17%	0.13%	ND	0.25%	0.76%	0.14%	Triacetin, propionic acid, menthol, glycine, unknowns #3, #4
Classic lemon cheesecake‡	97.6%	0.13%	0.05%	0.03%	ND	0.19%	1.77%	0.09%	Anisaldehyde
Double apple‡	97.2%	0.05%	1.70%	0.20%	0.18%	0.32%	ND	0.06%	Propionic acid, benzyl benzoate

ND = not detected (below detection limit). Country of origin: * Australia; † China; ‡ United States; § unknown.

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See Editorial, p. 000.

Safework Australia exposure standard for 2-chlorophenol, but it is known to be a respiratory and dermal irritant. Similar chemicals (eg, 2,4-dichlorophenol) have been identified in canola oil as pesticide residue.[5] Glycerine is a by-product of biodiesel production, often manufactured from canola oil. Other substances we often detected were 2-amino-octanoic, hexadecanoic, and octadecanoic acids. 2-Amino-octanoic acid is a metabolite occasionally found in mammalian blood, urine, and faeces; its presence may indicate contamination by biological substances during manufacture. Hexadecanoic and octadecanoic acids are relatively benign for humans, and are commonly used in foodstuffs, soaps, and detergents, but it is not known whether they affect health when heated and inhaled. Most other substances were flavours (anisaldehyde, menthol, vanillin, ethylvanillin), flavouring precursors (isoeugenol), or solvents (triacetin, benzyl alcohol). These chemicals are common e-cigarette liquid ingredients, and are generally regarded as safe for ingestion or dermal exposure, but their effects on health when heated, aerosolised, and inhaled are unknown.

Acknowledgements: We acknowledge funding from the Australian Competition and Consumer Commission, Health Department of Western Australia, and from the National Health and Medical Research Council (APP1128231).

Competing interests: No relevant disclosures.

Received: 22 May 2018, Accepted: 9 October 2018 ■

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Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article.