Metals - solubility in, and transfer from, a prototype e-liquid to aerosol using the CORESTA e-cigarette reference device

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Introduction

Work presented at the CORESTA Congress (Edinburgh 2024)[1] demonstrated that 12-18% of nickel measured in an e-liquid in a non-commercial device was transferred to the aerosol. Is this a representative transfer % for metals? For this study pure samples of 10 metals were individually submerged in a modified CORESTA prototype e-liquid for 4 weeks at 40°C/75% RH. The levels of each metal in the e-liquid was then measured before the CORESTA reference device was used to collect an aerosol sample on an acid washed quartz filter pad. The level of metal in the aerosol was measured to calculate % transfer.

Methodology

Metals + e-liquid

Arsenic, cadmium, chromium, iron, copper, tin, lead, zinc, silver, nickel (all >99.8% pure).

E-liquid – CORESTA prototype B, tobacco flavour modified with nicotine 2%, benzoic acid (0.6Meq) lactic acid (0.6Meq).

Figure 1. CORESTA reference device

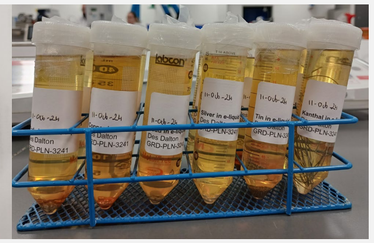

Figure 2. e-liquids + metals

Approx 2 g metal + 50 g e-liquid stored 4 weeks at 40°C/75% RH, shown in Figure 2.

E-Aerosol

Liquids were filled into the CORESTA reference device and samples collected within 2 hours of filling.

CORESTA reference device used (Figure 1), 4mL tank, single puff block of 15 or 30 puffs, 12W VWM mode with a 1.8 Ohm resistance coil added. A new coil was used for each sample.

Aerosol collected onto acid washed quartz filter pads.

Analysis was conducted at a third-party laboratory using ICP-MS (8800, Agilent Technologies, UK).

Results

Metals in e-liquids

Table 1 presents the concentrations of each of the metals in the e-liquid pre and post submersion.

Table 1. Concentrations of metals in e-liquid pre and post submersion

Starting E-liquid (mg/kg)	Metal	Stored e-liquid (mg/kg)
0.07	As	**70.8**
<LOQ	Cd	**96.2**
0.01	Cr	**0.01**
<LOQ	Cu	**5.18**
0.02	Fe	**12.7**
<LOQ	Pb	**92.1**
<LOQ	Ni	**0.23**
<LOQ	Ag	**0.11**
<LOQ	Sn	**0.79**
0.01	Zn	**234**

Transfer to aerosol

T-tests were performed on vaped blank e-liquid and metals samples to determine if there was any statistical difference between the blank and the sample (95% confidence interval), see Figure 3 and Figure 4 as examples.

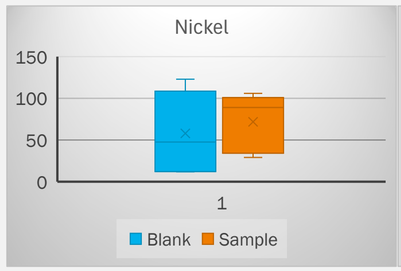

Figure 3. Nickel – Blank vs e-liquid sample

p= 0.604
(No significant difference)

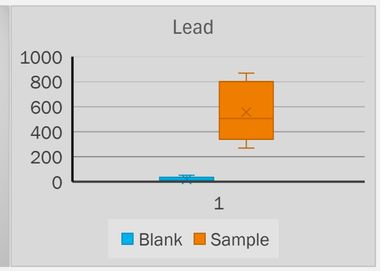

Figure 4. Lead – Blank vs e-liquid sample

p= 0.008
(Significant difference)

Results

Transfer rates

For the metals where there was a statistical difference between the blank and the sample, transfer rates were calculated, results are presented in Table 2 and Figure 5.

Table 2. Summary of % transfer to aerosol

Metal	Conc. in e-liquid (mg/kg)	ACM (mg)	Amount measured on pad (ng)	Theoretical amount on pad (ng) (based on 100% transfer)	Transfer %
As	70.8	134.7	9622	9538	**100.9**
Cd	96.2	134.2	354.5	12906	**2.7**
Pb	92.1	131.0	557.6	12066	**4.5**
Sn	0.79	131.0	10.6	102.9	**10.4**
Zn	234	140.3	1273	32830	**3.8**

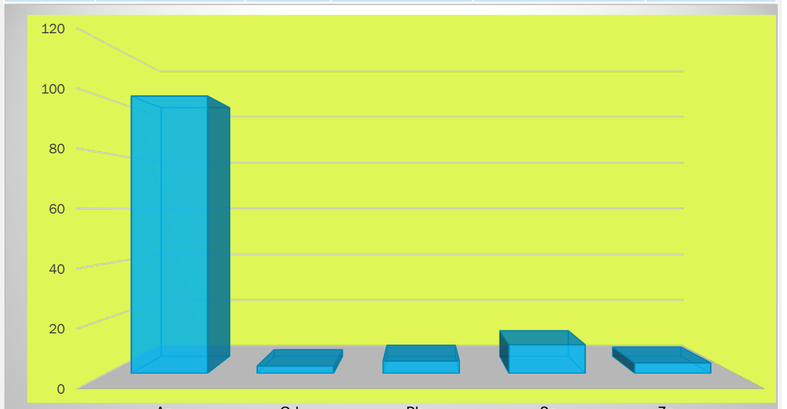

Figure 5. % Transfer of metals from e-liquid to e-aerosol

Conclusion

Transfer rates for metals from e-liquid to aerosol have been shown to vary between metals with use of the described CORESTA reference device. Consideration of the transfer rates for different metals could aid in the design of future collaborative studies when considering the concentrations of metals required at the start of the study.

Acknowledgements
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References
1. CORESTA Congress 2024, Dalton D D, ST64 – An approach to the determination of metals in the emissions from e-cigarettes

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