INTRODUCTION

Electronic nicotine delivery systems (ENDS or e-cigarettes) are a new type of product rapidly gaining popularity with adult cigarette smokers. They are typically cigarette shaped battery-powered electronic devices (Figure 1) which produce a condensation aerosol containing glycerol or propylene glycol (PG) or a mixture of each with water and nicotine. Menthol and other flavours may be included in some formulations. The e-cigarettes exist in a diverse regulatory landscape. This ranges from bans, or regulation as consumer, tobacco or licensed medical products. The use of e-cigarettes has generated wide debate over issues such as ingredient purity, output content and consistency, indoor use, and usage intent, whether as a cessation aid or as a means of harm reduction.

This poster illustrates some initial particle size and concentration measurements for a series of e-cigarettes and compares these data versus tobacco smoke data. The data show good reproducibility of output from some of the latest generation of devices. However, this process has highlighted the need for the development of standard measurement protocols as regulatory oversight develops.

EXPERIMENTAL – MEASUREMENT

Aerosol from e-cigarettes was measured by laser diffraction (LD: Spraytec, Malvern, UK) and electrical mobility (EM: DMS-500, Cambustion, UK). Smoking profiles were square wave, of 50, 55 and 80 mL volume, of 3s duration at 30s intervals. A 3s sample addressed lag-time issues in this type of e-cigarette due to actuation of the flow sensor and the heating coils, as reported by Ingebrethsen et al., 2012: Inhal Toxicol. 24: 976-984. Cigarette smoke measurements were conducted by EM only with a sine-wave profile of 55 mL puffs of 2s duration at 30s intervals as a reference.

RESULTS – e-cigarette versus cigarette

Mobility data for volume median diameter (VMD) and particle concentration are shown in Figure 3 and Figure 4 respectively for e-cigarette A versus a reference cigarette (University of Kentucky 3R4F). Ten puffs from each of 3 devices were measured with 55 and 80 mL square wave puffs of 3s duration at 30s intervals. An ANOVA main effects plot for the e-cigarette data is shown in Figure 7. A significant difference is observed between products (not shown) and between the 55 and 80mL sampling regimes. No effect is observed for device, replicate or menthol inclusion.

SUMMARY

• Techniques for size measurement of e-cigarette aerosol have been described and show good precision for latest generation products
• Published Pharmacopoiea standards are available for the validity of Laser Diffraction procedures as a relevant regulatory test methodology
• Acceptance criteria for $d_{50}$ are $S_{rel} \leq 10\%$ over at least 6 replicates ($S_{rel} \leq 20\%$ for $d_{50} < 1 \mu m$)

Figure 1. Schematic of an e-cigarette

Figure 2. Malvern Spraytec + Smoking Cycle Simulator

The puff profiles were generated by a Smoking Cycle Simulator (SCS : Cambustion, UK) which integrates the sample and measurement volume via constant volume sampling.

Figure 3 & 4. Aerosol diameter & number

Figure 5. Mobility (268 ± 14 nm) versus optical diameter (424 ± 13 nm)

Figure 6. Mobility diameter : ‘Good’ (388 ± 7 nm) versus ‘poor’ (361 ± 99 nm)

Figure 7. e-cigarette effects plot