Characterization of Inhalation Exposure Atmosphere Generated From E-Cigarettes

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INTRODUCTION

The number of e-Cigarette (e-cig) products available in the market is growing and potential exists for significant variation in physical design of the products as well as physical and chemical characteristics of the aerosol produced by these products. This study characterized the output from three major e-cig brands (hereafter referred to as Brand A, B and C), as part of preparation for the conduct of in vivo inhalation studies to determine the possible health effects of differing e-cig products.

Testing was performed under the Canadian Intense Regimen (CIR) with puff volume of 55 mL, puff duration of 2 seconds and a puff every 30 seconds. The e-cig output from the smoking machine was transported to a rodent nose-only inhalation exposure carousel. Initial tests were conducted using one e-cig per test for each of the three brands. The inhalation atmosphere at the nose port was characterized for concentration stability, puff output variability, particle size and major chemical constituents. Samples for determination of constituents were collected during the beginning, middle and end of each test. A follow up test was conducted on Brand B e-cigs by loading all 30 ports of cigarette smoking machine (CSM) head to demonstrate generation of a stable atmosphere at the nose port appropriate for the conduct of an inhalation study.

RESULTS AND DISCUSSION

TECHNICAL APPROACH

Test Protocol – One E-Cig per Test

- Conducted three separate tests with each brand of e-cig
- One port of JB 2080 rotary CSM was loaded with an e-cig while remaining 29 ports were empty
- A Real-time Aerosol Monitor (RAM) was used to measure the shape and magnitude of individual puff at the nose port
- Three sets of samples were collected from the nose port for each test run – during start, middle and end of each e-cig
- Each sample set comprised of duplicate 47 mm filters with backup sorbent tubes
- Characterized the nose port atmosphere for Wet Total Particulate Matter (WTPM), particle size using cascade impactor and chemical constituents (nicotine, glycerol and propylene glycol)

Test Protocol – Fully Loaded Machine Head

- All 30 ports of CSM were loaded with Brand B e-cigs
- Characterized the nose-port atmosphere for WTPM, concentration stability over time using the RAM, particle size using cascade impactors, and ratios of major constituents to WTPM
- Verification of particle size using a combination of Scanning Mobility Particle Sizer (SMPS) and Aerodynamic Particle Sizer (APS)

RESULTS

Test Results – One E-Cig per Test

- Product did not last for expected 240 puffs. Adjusted sample collection times for subsequent tests.
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Test Results – Fully Loaded Machine Head

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CONCLUSIONS

- Brand A e-cig produced consistent output for 240 puffs, Brand B e-cig produced output for ~110 puffs, Brand C e-cig produced much higher output which decreased steadily over 240 puffs
- The nicotine to WTPM ratio ranged from ~0.5% to ~3.5% between brands
- Glycerol was the major constituent; ranging from ~70% to ~90% of WTPM between brands
- Aerosol particle size was in sub-micron range in all three brands
- A stable exposure atmosphere can be produced with a fully loaded head
- The results demonstrate the ability to conduct controlled in vivo inhalation toxicology studies with e-cigs