Electronic cigarettes (e-cigarettes) and heated tobacco (Heat-Not-Burn) products are gaining acceptance as alternatives to traditional tobacco products. Consequently, there is a growing interest from regulators and public health authorities in exploring the implications for the air quality by breathers.

In the first part of our work we aimed to perform an assessment of indoor air quality by analyzing the airborne concentrations of nicotine, propylene glycol and glycerol (the major components of e-cigarette liquids) before, during and after use of e-cigarettes in real-life conditions. As there are no general indoor air quality guidelines or standards for nicotine, propylene glycol or glycerol, a comparison of the findings to UK workplace exposure limits (WELs) would be made to provide an indication of potential bystander air quality [2].

As the quality of indoor air is influenced by the chemical composition of exhaled breath, in the second part of our work we aimed to determine whether Proton Transfer Reaction Mass Spectrometry (PTR-MS) may be a suitable technique for the real-time analysis of chemicals released in exhaled breath following use of a range of nicotine delivery products. Please refer to our second SINTI-USA 2015 poster presented today for more information from our PTR-MS pilot studies (session 2 poster #54).

The analytical technique PTR-MS (Proton Transfer Reaction Mass Spectrometry) is a sensitive tool for the simultaneous real-time monitoring of volatile organic compounds (VOCs) with high sensitivity. PTR-MS is a technique that does not require sample pretreatment and can be used for rapid determination of exhaled breath profiles in medical diagnostics.

We recently published an indoor air quality mathematical model to predict potential bystander exposures to exhaled e-cigarette aerosol constituents [3]. Here we identified ‘quantity of chemical constituent exhaled’ as the most important factor influencing indoor air quality and bystander exposure. Therefore, it is essential that precise measurements are made regarding the quantity of compounds exhaled for the e-cigarette user (i.e. nicotine) when determining potential bystander exposure. As the composition of the exhaled breath will influence the quality of indoor ambient air, PTR-MS may be used as part of an assessment scheme for indoor air quality.

In this proof-of-concept study we aimed to identify and determine the breath concentrations of nicotine following use of a range of nicotine delivery products. Representative data presented in Figure 3 shows mass spectrometric profiles of exhaled breath following a single exhalation event after product use (n = 20) at different background breath control (black). The peaks at m/z 119 and 37 [m/z (and their isoprostane) represent the reactive ions (r-H2O) and their clusters. The PTR-MS has been calibrated for nicotine (m/z 163). It can be observed that [a] after regular conventional, the compounds released following use of the specific nicotine delivery product, their identities remain to be determined in future.

Following-use of a conventional cigarette and heated tobacco product, a large number of different chemicals are released in the exhaled breath, as shown by the red spectra across a range of masses. With regards to exhaled nicotine, 1150 pg (parts per billion) nicotine were detected in the exhaled breath following use of the conventional cigarette (a) and 1940 pg nicotine following use of the heated tobacco device (b). In contrast, with the non-tobacco products, nicotine was detected in the exhaled breath at 7 pg following use of the e-cigarette (c) and 1 pg nicotine following use of the nicotine inhalator (d).

An electronic cigarette (e-cigarette) air quality study was conducted by a leading independent UK accredited laboratory with recognised expertise in e-cigarette measurements and analyses for Imperial Tobacco to assess the concentration of nicotine, propylene glycol and glycerol (the main components of e-cigarette liquid) in the ambient air before, during and after use of the PuriTane™ 16 mg disposable e-cigarette (manufacturer Forment Ventures B.V.) in an office environment.

The heated breath composition after use of the tested product is shown in Figure 4. Despite differences in the mass range between the products, the concentration of nicotine, propylene glycol and glycerol was estimated in the ambient air before, during and after use of e-cigarettes, with a reduction in concentrations for nicotine and glycerol during the non-smoking period. The results of this study are in line with previous findings, which have shown a decrease in the levels of nicotine and glycerol following e-cigarette use in both indoor and outdoor environments. Therefore, these findings support the growing body of evidence suggesting that e-cigarettes may be a safer alternative to traditional cigarettes, with lower expected levels of harmful substances in exhaled breath.

During the use of the PuriTane™ 16 mg disposable e-cigarette in the small office space indoor air quality study, the concentration of propylene glycol measured in the office air, and therefore breathed by bystanders, was significantly lower than that predicted by the UK WEL. Exposure of bystanders to indoor ambient air following exhalation of the heated breath or the levels seen in this study within the e-cigarette aerosol would not be anticipated to cause health problems, a conclusion in agreement with [5]. There was no measurable increase in the concentration of nicotine in the indoor ambient air during vaping. To explore this further, we aim to determine (i) the quantity of nicotine retained by the e-cigarette user (i.e. the fraction not exhaled into the ambient air) and (ii) whether any potential nicotine in the exhaled aerosol is deposited to various surfaces.

As might be expected from the tobacco basis of conventional cigarettes and heated tobacco (Heat-Not-Burn), many more chemical compounds are detected in exhaled breath compared to simple electronic vapour products. Of note, substantially more nicotine is present in the exhaled breath following use of the tobacco based products. Due to the wide range of chemical species detected in the exhaled breath following use of the heated tobacco product, it is likely use of this product could impact indoor air quality in other ways that have not been reported for conventional cigarettes. As such, this is an important area for further research.

The indoor air quality experimental design and methodology used in our work may be employed to evaluate the indoor ambient air quality assessment of other chemicals or products. Moreover, our proof-of-concept PTR-MS work showed the potential of this technology to be used as a technique to monitor the emissions from a range of nicotine delivery products and quantify released VOCs in real-time under a range of conditions and determine the impact on indoor air quality.