Introduction
A Fabric Method has been introduced in British American Tobacco, Southampton for the investigation of the perceived odour of cigarette sidestream smoke deposited onto fabric relative to a reference sample.

To support the validation of the Fabric Method, a GC-MS method suitable for the measurement of a selection of semi-volatile markers present in the headspace of fabric exposed to sidestream smoke has been developed. The outcome of this GC-MS study was used to identify an optimized and practical method in terms of timing and logistics for the sensory assessment part.

Materials and Methods
Circular shaped pieces of fabric (60 mm diameter, white terrycloth) were exposed to the sidestream smoke of 3RF4 cigarettes (Kentucky reference cigarettes [http://www.ca.uky.edu/refcig]) (400 mg tobacco weight burnt) in a custom built smoke exposure chamber. After one hour, the fabric pieces were placed into the jars for the required length of time.

The headspace from the sidestream smoke deposited on fabric was collected on silcosteel insert, Tenax TA/Unicarb thermal desorption tubes using Flec air sampling pumps (MARKES International, UK) at a sampling rate of 50 ml/min for 5 min. Subsequently, six compounds (refer to studies 1 and 2) acting as semi-volatile markers were monitored by GC-MS measurements (Agilent GC 6890N and Network MSD 5973) after thermal desorption using a capillary column (J & W): DB-VRX, 60 m, 0.25 mm ID (internal diameter), 1.4 µm film thickness). The semi-volatile compounds were selected based on the most abundant peaks. Quantification of the marker compounds was achieved using calibration standards. It should be noted that the odour impact of these compounds in the headspace of fabric exposed to sidestream smoke was not known. However, Chien et al. (2011) monitored naphthalene and furfural as part of their assessment of volatile organics off-gassed among tobacco-exposed clothing fabrics, and previous internal work identified 3-methylpyridine in aged concentrated flue-cured sidestream smoke deposited on cloth whilst studying the most odorous volatile organic compounds (VOCs).

Study 1: Headspace measurements investigating jar size and incubation time in the jar (Figure 1).
- 2 jar sizes (1000 ml and 250 ml wide neck) – to investigate jar size due to potential logistical benefits (cleaning, storage) from using smaller jars (currently 1000 ml jars are used during sensory panel assessment).
- 9 incubation times (incubation times of 30 min, 60 min, 90 min, 120 min, 150 min, 180 min, 240 min (360 min), 24 hours (1440 min) and 24 hours with the lid removed for 30 min before sampling) – to investigate the preparation of samples in advance of the panel session (current timings are 30 min incubation in the jar prior to the sensory session and 30 min session time window).
- 6 semi-volatile markers (cyclohexane, pyridine, furfural, 3-methylpyridine, naphthalene and 1-tridecene).

Study 2: Headspace measurements investigating jar size, neck size and ‘sniff’ number (Figure 2).
- 2 jar sizes (1000 ml and 250 ml).
- 2 neck sizes (wide and narrow) – to investigate any effects on marker compound amounts.
- 1 incubation time (30 min).
- 2 sniff numbers (sniff 1 and sniff 2) – to investigate the potential to re-use jars.
- 6 semi-volatile markers (pyrrole, pyridine, furfural, 3-methylpyridine, naphthalene and 1-tridecene).

Results
Study 1: The results of Study 1 suggest that the main significant differences (statistics not shown) were between the shortest (30 min incubation) and the longest incubation times (24 hours (1440 min) incubation) with a steady decrease in compound amount over time (Figure 3). It also showed that there were no significant differences between 30 min and 60 min incubation times (p > 0.05) for the six marker compounds monitored in the headspace of the sealed jar (statistics not shown). This supported the use of a 30 min incubation time of the fabric in a jar prior to the sensory panel session to enable the headspace to build up in the jar and for the session time window to be 30 min.

The results of Study 2 also suggest that re-using the same jar after 15 min from the first assessment, i.e. taking a second ‘sniff’ would be acceptable, as the results have shown no significant change in the amounts of the marker compounds present in the headspace (Table 2). However, sensory tests would be required to confirm this.

Table 1: p-values obtained by ANOVA comparing jar size and incubation times for each of the six marker compounds. Highlighted in red are the statistically significant differences (p < 0.05).

Table 2: p-values obtained by ANOVA using GLM comparing jar size, neck size, and ‘sniff’ number for each of the six marker compounds. Highlighted in red is the statistically significant difference (p < 0.05).

Conclusions
The GC-MS headspace measurements provided good supporting information towards the newly developed and validated Fabric Method. The results support the use of a 30 min incubation time in the jar prior to the sensory session, and for the session time window to be 30 min. Neck size and jar size did not have a significant effect in the open jar system suggesting that either jar and neck size could be used, which would provide logistical benefits. In addition, the results indicate that re-using the same jar twice with a 15 min gap between assessments is acceptable. However, sensory testing would be required to confirm these results.