Safeguarding SIFT: Enhancing sustainability of Selected Ion Flow Tube Mass Spectrometry

Student name and student number: Emma L. J. Pittwood 21017865

Background: Selected Ion Flow Tube Mass Spectrometry (SIFT-MS) is a key analysis technique used for trace gas analysis, analysis of volatile organic compounds (VOCs), with the potential for use in breath analysis to inform clinical decisions. The technique relies on helium as carrier gas due to its inertness, however helium shortages in recent years have highlighted the lack of sustainability of continued reliance on a non-renewable, and increasingly expensive, resource. Alternative carrier gases, in the form of nitrogen and argon, have been explored with promising results.

Aims: In order to ensure the continued use of SIFT-MS, while reducing costs and increasing sustainability, alternative carrier gases (argon and nitrogen) are explored as potential replacements for helium. Current literature indicates that nitrogen is a good alternative, though revision of current SIFT-MS procedures are required to achieve analyses of the same standard as helium. There was an additional adapted aim to identify and repair a serious hardware fault in the Profile 3 system.

Methodologies: In addition to a comprehensive review of the literature surrounding the topic, a cost and sustainability analysis for each of the gases was conducted. Additional system diagnostics, following preliminary applied sustainable adjustments to the needle sheath, highlighted some serious hardware faults which reduced functionality of the device which needed to be rectified before further evaluation could continue. Therefore continuity testing and repairs were performed on the SIFT (model Profile 3, Instrument Science Limited, UK) in order to rectify the issue with the heating circuit in the sampling head before the gas change could be investigated.

Results: PRISMA-style literature search yielded 136 entries for the search terms “(SIFT-MS) AND helium”, “(SIFT-MS) AND nitrogen”, and “(SIFT-MS) AND argon”. The literature suggests that nitrogen is a viable option with modifications to injection energy of the gas to prevent sample molecule fragmentation and the formation of erroneous adduct ions which interfere with the mass spectra. The continuity testing confirmed the relay switch for the heating system was faulty due to additional sustainability alterations; functionality was restored upon replacement of the switch.

Conclusions: Further investigation is needed to confirm the suitability of alternative carrier gases on the Profile 3 SIFT currently operated by Keele University, and the effect of the carrier gas on the resulting mass spectra. The systematic review indicated that while both nitrogen and argon are candidates for alternative carrier gases there are several experimental and analytical

considerations which need to be accounted for, and there is a clear need for further characterisation of the carrier gas alternatives, achievable through physical investigation and the alteration of the carrier gas.

Key words: SIFT-MS, carrier gas, sustainability, mass spectrometry, medical device design.