Journal of Chromatography & Separation Techniques

News and Views

Miniaturized Chromatography

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Speed, Sensitivity, Ease of use, Reduction of costs and complexity are some areas where we consistently see incremental improvements in chromatography. The focus is now shifting towards miniaturization. Chromatography systems, accessories, and workflows are all now advancing rapidly. One of the major advantages of miniaturized chromatography is it has the potential to reduce the instrumentation costs drastically. Another game-changing advantage of miniaturization is that sample pathways and smaller channels decrease the need for gasses, solvents, and power requirements. This feature further allows a more portable or mobile paradigm to evolve, while lowering costs and waste. For example Axcend's most portable gradient liquid chromatography system which has tool-less design, rechargeable battery, and light weight make it compatible with almost any field application, Lucidity's miniaturized gas chromatography instrument is an elegant solution to an overcrowded bench top which sits on roughly a third of the space used by a traditional kit while not sacrificing any meaningful performance.

Miniaturized chromatography has attracted increasing attention for its potential in high-throughput analyses and point-of-care applications. Miniaturization in chromatography is receiving considerable attention because of its advantageous applicability in diverse fields including the OMICS arena (proteomics, metabolomics, lipidomics etc.) as well as several other niches such as environmental, biological, foodstuff, and pharmaceutical analysis. Miniaturization is an exciting area for research involving new instrumentation, columns improvement, novel sorbent materials, smaller volume detectors, lower dead volume connections, multidimensional systems, and so on. A major hindrance to the wide implementation of miniaturized chromatography is the absence of robust and appropriate commercial instrumentation designed and dedicated to miniaturized chromatography. Removing this obstacle will facilitate the expansion of this exciting research area involving new instrumentation, novel sorbent materials, columns improvement, smaller volume detectors, lower dead volume connections, multidimensional systems, and robust miniaturized columns available with a large range of stationary phases prepared with distinct physical (length, internal diameter, and film thickness) and chemical (sorbents) characteristics. The key drivers behind the miniaturization of columns are (1) improved column efficiency and (2) easier coupling to mass spectrometry. Small columns in both gas chromatography and liquid chromatography reduce the load on the mass spectrometer vacuum system. The development of simpler coupling of chromatography to mass spectrometry had tremendous impact and improved the research in separation science. Mass spectrometry is the most desirable detector for chromatography. Miniaturized columns reduce vacuum pump requirements, improve separation efficiency, accommodate very small samples (especially important in biomedical applications) and improve detection limits.

A variety of improvements have contributed to the success of liquid chromatography compared to gas chromatography. Gas chromatography needs considerable renovation. Gas chromatography can be considerably reduced in size without sacrifice in performance and, perhaps, with improved performance. Supercritical fluid chromatography forced the development of more robust column technology. Miniaturization of liquid chromatography is generally done to increase sensitivity, a necessity in proteomics to detect low abundant peptides and proteins. Other benefits include improving the efficiency of interfacing with mass spectrometry and reduction of solvent consumption. Nowadays, miniaturized liquid chromatography is much easier to use and both the instrumentation and the connections are operated in the same way as conventional scale liquid chromatography systems. This opens up opportunities to apply miniaturized liquid chromatography to novel workflows and applications, especially for capillary and micro liquid chromatography. Miniaturization of liquid chromatography is often associated exclusively with the increased sensitivity offered by nano liquid chromatography as required in proteomics studies. However, substantial gain in sensitivity can already be achieved in capillary and micro liquid chromatography. Additionally, UHPLC capabilities are available over the entire flow range-from nano to conventional scale-greatly simplifying the scaling down of analyses, without compromising on capabilities. While proteomics is still the main focus for nano liquid chromatography, there is much

potential in the biopharmaceutical and the forensic/toxicology applications. As mentioned, not only do users gain in sensitivity from using miniaturized liquid chromatography, but Mass Spectrometry interfacing as well as sample and solvent consumption will also reduce drastically. This pays off in extended operation time or reduction of operational costs. Switching to capillary or micro liquid chromatography could mean reaching the perfect balance of sensitivity and robustness, throughput, and ease-of-use.

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