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EDITORIAL

# Monolithic columns in liquid phase separations

**Luis A. Colon**

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The separation of chemical entities in a complex sample mixture is a common problem in chemical/biochemical analysis. Since the vast majority of sample mixtures exist in solution or are brought into solution, liquid phase separations have become a preferred choice for resolving sample mixtures. Within this context and in its broader sense, liquid chromatography (LC) continues to be an indispensable technique in most analytical/bioanalytical laboratories. This is the result of numerous theoretical and technological advances, which have had a remarkable impact on chemical analysis—one recent example is the field of proteomics, which relies heavily on LC to separate complex mixtures of peptides from proteolytic digests. Indeed, it is difficult to imagine an analytical laboratory without state-of-the-art LC equipment.

Column technology is one of the most investigated research topics in chromatographic techniques, and LC is not an exception. This is not surprising since it is within the column that the chromatographic processes occur, making the column the "heart" of the separation system. The development of new separation media is essential in achieving a high degree of selectivity, high efficiency, and faster separations to deal with the increasing demands imposed by the complexity of samples in chemical analysis.

In recent years, we have seen a remarkable evolution in column technology for LC. Although columns packed with silica microparticulates have predominated in LC and ancillary techniques, monolithic columns have emerged as a viable alternative for liquid phase separations. A monolithic column can be defined as a continuous solid matrix that is porous in nature, containing interconnected flow paths, and can take various formats (e.g., rod-like, flat bed, tubular); the retentive phase is at the surface of this material. The porous, rod-like structures have been the most popular. These porous structures are generally classified into polymeric or silica-based monoliths and can be fabricated by in situ polymerization of organic monomeric precursors in porogenic solvents, for polymeric monoliths, or by sol–gel chemistry in the case of silica monoliths. The main attraction of monolithic columns compared with particle-packed columns is their high axial permeability. This provides low back pressures with excellent flow characteristics, fast mass transfer, and fast separations, without sacrificing separation efficiency.

After about two decades of developmental progress since the initial seminal work of Hjerten (1989), Svec (early 1990s), and Tanaka (mid 1990s), monolithic columns have found applicability in different separation modes: reversed-phase chromatography, ion-exchange chromatography, hydrophilic interaction chromatography, size-exclusion chromatography, molecular imprints, and affinity chromatography, to mention a few, and a variety of such modes are commercially available. Monoliths have been used in various formats beyond LC, including solid-phase extraction, sample preconcentration, and 96-well disc arrays for the separation of many compounds in, for example, the pharmaceutical, environmental, microfluidics, and molecular bioprocessing fields.

Today, developmental work and applications of monolithic columns in liquid phase separations continue. A quick search in the Web of Knowledge (Thomson

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L. A. Colon (✉)
Department of Chemistry, The State University of New York at Buffalo,
578 Natural Science Complex,
Buffalo, NY 14260-3000, USA
e-mail: lacolon@buffalo.edu

Reuters) using the topical areas of "(monoliths or monolithic columns) and liquid chromatography" for the past 5 years (2008–2012) retrieved 1,518 entries (about 304 per year on average). This still reflects a field that is full of dynamic activity. This topical collection of *Analytical and Bioanalytical Chemistry* is focused on monolithic columns and provides a glimpse of the current research activity in the field. It provides a collection of original articles on recent advances and reviews of specific areas of monolithic columns in liquid phase separations. Current trends indicate that the technology has matured to the point where very specific applications are now being explored in solving particular separation problems. Application to the separation of biomolecules is expected to continue steadily, particularly using biocompatible monoliths. Fast and efficient separations at low back pressures, particularly in miniaturized formats, where solvent consumption is minimized, will continue to attract separation scientists. New research opportunities are also emerging. One exciting prospect is the use of nanomaterials as stationary phases coupled with monolithic columns, as two of the articles in this issue discuss, which may provide unique selectivity. In all, this topical collection proves that monolithic columns are here to stay as an alternative to packed columns in liquid phase separations. I hope you enjoy reading the work presented here, as I did, and look forward to future progress in the area of monolithic columns.

**Luis A. Colón** is Professor of Chemistry and Associate Dean of the Graduate School at The State University of New York at Buffalo. His current research interests are in the fields of microchemistry/nanochemistry and separation science in general, including the development of chromatographic media for liquid-phase separations and detection schemes for monitoring mass-limited samples, the use of nanotechnology in separations, and the development of new strategies to separate and analyze complex chemical and biochemical sample mixtures.