Trends in Analytical Chemistry 98 (2018) 1–18

Contents lists available at ScienceDirect

Trends in Analytical Chemistry

journal homepage: www.elsevier.com/locate/trac

Multisyringe flow injection analysis in spectroanalytical techniques – A review

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ARTICLE INFO

Article history:

Keywords:
Multisyringe flow injection analysis
MSFIA
Hyphenation
Multisyringe chromatography
Spectroanalytical techniques

ABSTRACT

This work presents the advantages, drawbacks and performances of Multisyringe Flow Injection Analysis (MSFIA) systems in the determination of metals, metalloids, organic and inorganic compounds in several kind of samples employing spectroanalytical techniques. General topics, as multisyringe description, software and comparison between MSFIA and other continuous flow techniques are also discussed. Employ of MSFIA systems coupled to molecular spectrophotometry, atomic spectrometry and hyphenation with other techniques are presented.

1. Introduction

Nowadays, the flow analysis techniques are tools of great importance in the laboratories considering the possible applications and advantages that can be obtained: increase sample throughputs; reduction of reagent and sample consumption; decrease of sample handling; allow online sample pretreatment steps including digestion, separation, preconcentration, dilution, gas diffusion, dialysis, etc.; allow automation; allow coupling with several detection analytical systems, improving selectivity and sensitivity [1]. Between these, the Multisyringe Flow Injection Analysis (MSFIA) was established combining the advantages of several techniques: working in parallel like Flow Injection Analysis (FIA), robust like Sequential Injection Analysis (SIA), and using solenoid valves like Multicommutation Flow Injection Analysis (MCFIA) [2,3].

2. Multisyringe description

The MSFIA was first described on 1999 by Cerdà and co. [4] using a conventional automatic burette, modified in order to handle simultaneously four syringes, whose pistons were connected to the same transmission bar. The MSFIA system had four syringes working in parallel, which increased sampling frequency. Also three-way solenoid valves were placed on the head of each syringe, allowing the return of the liquids to the reservoirs when they were not required, minimizing sample and reagent consumption and waste generation [2]. Currently, on the rear panel of the multisyringe several connectors with different purposes may be find: a power supply for the instrument, two serial ports to make a chain of elements (for the first of the chain one port connected to a PC, the second port to connect with the next element of the chain), and four additional analogic outputs, the voltages of each of which may be programmed independently between 2.5 and to 13 V. These four outputs greatly expands the possibilities of the burette, since may be used for several different purposes, like trigger additional solenoid valves, light LEDs, trigger fans, trigger big instruments, like ICP OES, AAS, ICP-MS, CG-MS, etc, taking profit of their event inputs.

3. Software

One of the major difficulties of flow systems was to control all devices, program their operation, and perform data acquisition and processing. This difficulty explains the slow initial development of computer controlled flow techniques. For this reason, the software called AutoAnalysis was developed [5] which is a hardware-

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https://doi.org/10.1016/j.trac.2017.10.016
0165-9936/

independent system for automating various analytical methods. System design was based on the division of the software into four layers, defining a communications interface among them. The definition of these layers allowed the isolation of the highest, corresponding to the analytical application, from the lowest, the hardware, composed of the various parts of the block diagram.

The four logical layers were:

- definition of the main application (layer 4),
- selection of the necessary instruments forming parts of the block diagram (layer 3),
- definition of the schemes of connection with the instruments (layer 2), and
- hardware level of the instruments and apparatus (layer 1).

Although this system was initially designed for automating flow techniques (flow injection analysis, FIA, and sequential-injection analysis, SIA), its conception allowed the development of much more general applications, depending on the user's imagination. The system is very open, in the sense that it is not necessary to adapt the program as system possibilities are expanded. Thus, if a new instrumentation (modules in the block diagram) is incorporated, one need only develop independently a minimum of software to comply with the previously defined interface. This system was developed under the 32-bit Windows 95 environment, making the exchange of information with other applications very simple and allowing the various possibilities offered by the program to be executed simultaneously (for example, data acquisition and processing). After a great number of years of development, currently there are a great number of dynamic link libraries (DLLs) which may be used to configure automatic spectro analaytical systems (Table 1).

4. MSFIA in spectroanalytical techniques

Most of the methods established employing MSFIA systems have used spectroanalytical techniques for detection. Between these, the molecular absorption spectrophotometry (MAS), atomic fluorescence spectrometry (AFS), atomic absorption spectrometry (AAS) and inductively coupled plasma mass spectrometry (ICP-MS) have been often employed [3,6,7]. All of these have their specific advantages and they are employed according to the objectives required in each method.

4.1. MSFIA in molecular absorption spectrophotometry

The molecular absorption spectrophotometry is one of the analytical technique most utilized in automated methods using MSFIA systems. The MSFIA can allow for liquid-liquid [8] and solid phase extraction, either using filled micro-columns [9] or extraction discs. Since the program AutoAnalysis allows the use of known informatics commands, like to make loops, marks, waiting periods, conditionals, etc. the use of these preconcentration and clean-up techniques allows to develop smart system in order to make

Table 1
Modules with DLLs used in spectroanalytical automatic systems.

Common for all techniques		
Device	Model	Firm
Automatic burette	MicroBur 4S	CRISON
Compact titrator		CRISON
Valve module, (two 8-channel switching valves)	Pump 2060	CRISON
Valve module, (one 8-channel selection valve, and one 6-channel injection valve)	Pump 2060	CRISON
Valve module (6, 8,10 or 27-channels switching valve)		SCIWARE
Injection valve		SCIWARE
Automatic sampler,	MicroSampler 2040	CRISON
Lab-on-valve		SCIWARE
Chip-on-Valve		SCIWARE
Multisyringe chromatographic system		SCIWARE
Molecular spectroscopy		
Diode array spectrophotometer	HP8452A	Hewlett-Packard
Diode array spectrophotometer	HP8453	Hewlett-Packard
CCD spectrophotometer,	USB2000, 2000+, 4000, QE65000	Ocean Optics
Fluorimeter	LS5	Perkin-Elmer
Fluorimeter	LS50	Perkin-Elmer
Fiber-optic spectrophotometer,	662	Metrohm
Chemiluminiscence detector		SCIWARE
Atomic spectroscopy		
AFS hydrides	Excalibur	PSA Analytical
AFS cold vapor	Merlin	PSA Analytical
Hyphenated techniques using two computers, one for autoanalysis, the other for the instrument		
ICP OES		Perkin Elmer
ICP-MS		Perkin Elmer
Auxiliary instruments		
Conductimeter,	GLP 31	CRISON
pH meter,	DigiLab 517	CRISON
pH meter	MicropH 2002	CRISON
Microwave oven,	Maxi digest MX 350	PROLABO
A/D Card	DASH8	Metrabyte
A/D converter		Ibercomp
A/D converter		EasyDAQ
Digital outputs	8, 16, 24 relays	EasyDAQ
Peristaltic pumps	Reglo Digital	Ismatec
Multimeter	VC820	Volcraft
Interface for hyphenation		SCIWARE