Automatic sample preparation in commercial capillary-electrophoresis equipment

B. Santos, B.M. Simonet, A. Ríos, M. Valcárcel

To support the transfer of advances from R + D to routine analytical laboratories, we discuss recent developments in sample preparation for commercial capillary-electrophoresis (CE) equipment. We focus on practical considerations that permit the coupling or the integration of sample-treatment devices into commercial CE equipment. We describe and critically compare at-line and on-line coupling strategies. We also describe integrated in-capillary, in-vial or in-replenishment-system methodologies to perform solid-phase extraction or liquid-phase extraction.

Keywords: Capillary electrophoresis; CE; Commercial; Coupling; Equipment; Integration; Sample treatment

B. Santos, M. Valcárcel*
Department of Analytical Chemistry, University of Córdoba, Campus de Rabanales, Annex Building C-3, E-14071 Córdoba, Spain

B.M. Simonet
Department of Chemistry, University of Balearic Islands, E-07122 Palma de Mallorca, Spain

A. Ríos
Department of Analytical Chemistry and Food Technology, University of Castilla-La Mancha, E-13004 Ciudad Real, Spain

*Corresponding author.
Tel./Fax: +34 957 218616;
E-mail: qa1meobj@uco.es

1. Introduction

Today, there is a trend towards simplification and miniaturization of the analytical process [1,2], of which the main aim is to facilitate further application of methods in routine laboratories as they need reliable, robust, simple methods. All the steps in the analytical procedure need to be simplified. In the case of capillary electrophoresis (CE), simplification must focus on sample treatment and electrophoretic separation. The simplification of the electrophoretic separation process involves the rational use of both the best electrophoretic modality and a buffer with a simple composition.

CE is considered a highly efficient, flexible separation technique [3], which has become a serious competitor to chromatographic separation methodologies. In spite of the advantages of CE, its use in routine laboratories is less than chromatographic techniques, perhaps related to the requirements for sample treatment. For this reason, in CE, sample treatment is a critical factor in obtaining reliable, reproducible results, so, among other things, it is essential to avoid capillary clogging and adsorption of macromolecules on the capillary wall that can affect electroosmotic flow (EOF) [3,4]. Another important factor that limits implementation of CE in routine laboratories relates to the small volumes of sample introduced into the capillary that, on some occasions, adversely affect the precision and also result in problems with sensitivity [3–5]. To solve these problems, there have been many proposals in the literature to achieve simple sample preparation that would not only eliminate interferences from complex sample matrices but also lower the detection limits. The importance of sample treatment in CE has been pointed out and reviewed in several papers [4–6]. However, none of them is exclusively devoted to commercial equipment. This overview will describe simple, effective and robust approaches to sample preparation to be implemented in commercial CE equipment and used in routine laboratories. Fig. 1 indicates the main limitations of electrophoretic methods as a function of the analytical properties required for methods that must be applied in routine laboratories. As can be seen, sample treatment has an important effect on analytical properties; in many instances, this influence is the most critical.

As depicted Fig. 2, there are different approaches to sample treatment. Depending on the degree of human participation and the hardware required, three groups can be distinguished:

(i) batch procedures for sample treatment;
(ii) coupled devices that imply minimal human participation but require additional hardware and software; and,

0165-9936/$ - see front matter © 2006 Elsevier Ltd. All rights reserved. doi:10.1016/j.trac.2006.07.008

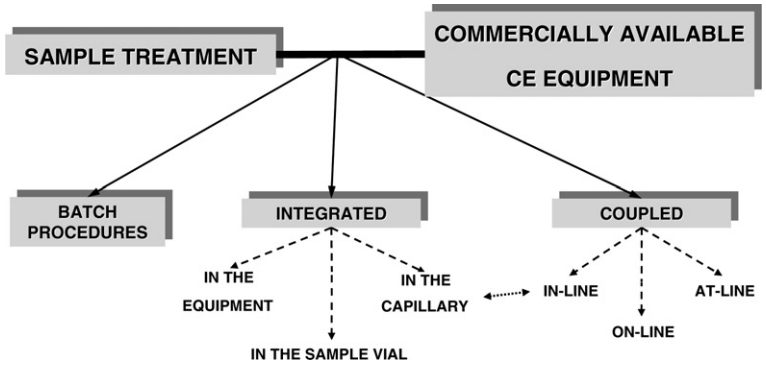

Figure 1. Different approaches to sample treatment for commercial CE equipment.

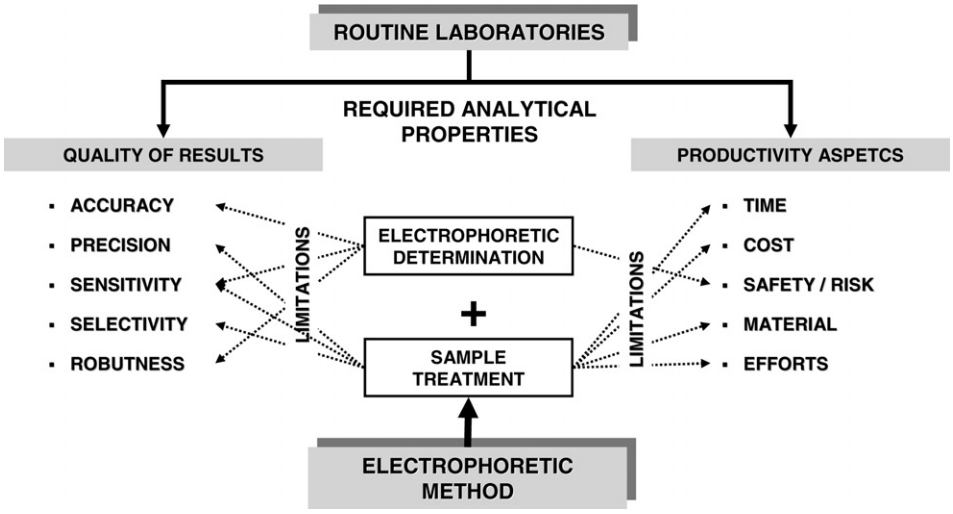

Figure 2. Effect of sample treatment and electrophoretic analysis on quality and productivity properties of analytical methods.

(iii) devices integrated into commercial CE equipment that can perform directly without human manipulation and additional hardware.

This overview will focuses on the coupled and integrated approaches. As described in Fig. 2, the integrated sample-treatment device can be located in the CE capillary, the sample vial or an auxiliary part of the equipment, such as the replenishment system. With regards to coupling methodology, this can be coupled at-line, in-line or on-line. As indicated in Fig. 2, in-line coupled methodologies are compatible with on-capillary integrated methodologies.

2. First considerations

To integrate or to couple sample-treatment devices into commercial CE equipment, it is important to take into account the following instrumental aspects:

(i) how the equipment applies the high voltage;
(ii) how the capillary is assembled in the equipment;
(iii) which vials are used;
(iv) where the autosampler is located; and,
(v) which additional devices are present in the equipment.

As indicated above, three coupling methodologies can be identified, as follows:

(i) *In-line coupling:* complete integration between sample preparation and CE equipment. Such integration normally is located in the electrophoretic capillary and involves the insertion of the interface or unit in the electrophoretic capillary.
(ii) *On-line coupling:* involves a physical connection and contact between the capillary and the flow stream coming from the sample-treatment device. Such coupling is performed via a transfer line (split-flow interface) and it connects the analytical device with the electrophoretic capillary throughout the analytical process.