FLOW ANALYSIS METHOD FOR TRACE ELEMENTS BY ION-EXCHANGER PHASE ABSORPTIOMETRY

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ABSTRACT

The increase in attenuation of a colored species, which has been concentrated on-line onto ion exchanger packed in a flow-through cell, could be measured continuously with a spectrophotometer. The sensitivity of the present method depends both on the sample volume introduced into the flow system and the cross sectional area of the flow-through cell. It was possible to determine sample element concentration in mg/m$^3$ or lower levels with a few cm$^3$ of sample solution. The fundamental background and applicability to flow analysis of some trace elements are reviewed.

INTRODUCTION

Ion-exchanger phase absorptiometry is based on the direct measurements of the degree of light-absorption by an ion-exchanger phase which has sorbed a sample component. Since this new technique of solid-phase absorptiometry was proposed in 1976 as "ion-exchanger colorimetry" in the visible region (1) and 1983 in the ultra-violet region (2), a large number of applications have been made for the determination of trace elements in water samples without preconcentration (3-6).

The sensitivity of this method is enhanced by using thicker ion exchanger layers (7). Sensitivity is also enhanced by adopting a system in which the ratio of sample volume to the amount of ion exchanger is high (8): the use of a flow-through cell packed with a very small volume of ion exchanger is very effective. Furthermore, the implementation of on-line
detection with ion-exchange retention should further simplify our method and broaden the flexibility for the determination of trace elements in water samples.

EXPERIMENTAL

Spectrophotometer: Light measurements were made with a Nippon Bunko double-beam spectrophotometer, Model UVIDEC-320. The spectrophotometer was mounted vertically so that the top layer of the ion-exchanger beads in the flow-through cell was levelled horizontally. An inside-mirror tube (12 mm in internal diameter and 38 mm in length) was placed between the cell holder and the light-detector window to recover partly the light scattered from the cell. This reduced the background attenuation by about 1. A perforated metal plate of attenuation 2 was placed in a reference beam to balance the light intensities (Fig. 1(a)).

Flow-through cell: A flow-through cell was supplied by Nippon Quartz Glass Co.; it was black-sided, and had a 10 mm path length and 1.5 mm diameter. The cell was blocked with polypropylene (PP) filter tip and filled with the ion exchanger (about 0.01 cm³) with only 3 - 5 mm in the light-path portion of the cell (Fig. 1(b)).

Flow system: Carrier solution streams were pumped with medium pressure pumps. A sample was introduced into the stream by means of a PTFE six-way rotary valve. A sample loop was made by using a PTFE tube (1 mm i.d.). The increase in attenuation was continuously monitored at a fixed wavelength and recorded on a strip-chart recorder set at 0.5 or 1.0 absorbance full scale. A desorbing agent solution was introduced into the stream by means of another PTFE six-way rotary valve. All tubing was PTFE (1 mm i.d.).

RESULTS AND DISCUSSION

Since this technique was reported in 1987, about ten flow analysis methods using solid-phase absorptiometry have been proposed by other investigators. Here, all systems developed only by the present authors (8-16), listed in Table 1, are described in the individual sections below.

Flow diagram As shown in Fig. 2(a), the single-line flow system was employed for the determination of simple, colored ions or color-developed analytes (Table 1). For flow injection analysis, to keep the system simple, it was desirable for a coloring agent to be introduced continuously into the flow line (Fig. 2(b)). However, in some cases, this caused a gradual