A LabVIEW-Based Virtual Instrument System for Automated Single Column Sequential Extraction Chromatography

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1. Introduction

Extraction chromatography is a powerful tool to separate a target radionuclide from all interfering radionuclides and the matrix components in samples. It has been widely used in various fields such as characterization of radioactive wastes, environmental monitoring around nuclear facilities and radionuclide monitoring in food stuffs [1].

While the commercial analytical extraction chromatographic systems can be available for the quantitative analysis of the inorganic and organic trace constituents, laboratories usually design and set up the preparative extraction chromatographic systems for the pre-concentration and purification of radionuclides in samples [2, 3]. In addition to hardware installation, control software is also required for performing sequences of operations automatically and for the individual control of all instrument components. National Instrument's LabVIEW is a graphical programming language and a powerful tool for the instrumentation control, data acquisition and data analysis [4].

The aim of this study is to develop a LabVIEW-based virtual instrument system for automated single column extraction chromatography, which can be effectively used for the rapid and reproducible separation of radionuclides in various samples.

2. Methods and Results

The 4-channel automated single column extraction chromatographic system and its virtual instrument system based on LabVIEW have been developed.

2.1 Hardware Design

The hardware conceptual design and schematic diagram of the 4-channel automated single column extraction chromatographic system are shown in Fig. 1 and Fig. 2. The system consists of three parts: ASRS-CS (4), ASRS-MC (3) and ASRS-SS (1) which has a data acquisition device, peristaltic pumps, solenoid valves and columns. The data acquisition device is connected to a computer via USB port. The data acquisition device has two types of DAQ board: the one with 64 digital inputs/outputs is used to actuate solenoid valves and the other with 16 analog outputs is used to control the flow rate of the feeding pumps. In figure 2, the solid red line and the dotted blue line represent fluid transfer tubing and signal communication line, respectively.

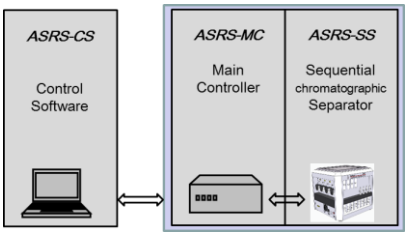

Fig. 1. Hardware conceptual design of the 4-channel automated single column extraction chromatographic system.

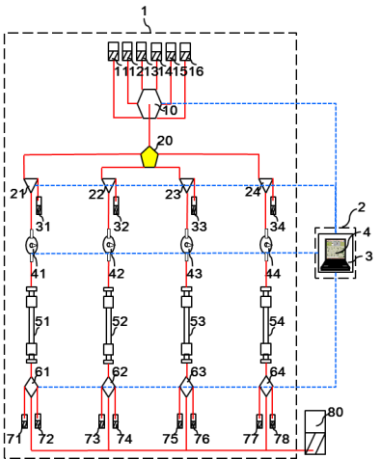

Fig. 2. Schematic diagram of the 4-channel automated single column extraction chromatographic system for the sequential separation of mixed radionuclides.

A 6-inlet port flow selection valve (10) is used to select different chemical reagents from the reagent bottles (11~16). A 4-way flow distribution connector (20) is used to evenly distribute a reagent solution into 4 columns (51~54) by four single channel step motor pumps (41~44). The 2-inlet port flow selection valves (21~24) are used to select a sample or a chemical reagent. The 3-way flow distribution valves (61~64) are used to sequentially distribute purified solutions to the first elution bottles (71, 73, 75, 77) and to the second elution bottles (72, 74, 76, 78), and also to transfer washing solution into waste bottle (80). The 3D design of the system is given in Fig. 3. This system has been commercialized as the name of 4-channel automated sequential radionuclides separator (4ch-ASRS). The 4ch-ASRS consists of five parts: reagent bottle part (R-

1~R-6), sample tube part (S1~S4), column part (C1~C4), pump part (P1~P4), and elution tube part (C1E1~C4E1 and C1E2~C4E2). The size of the 4ch-ASRS is W600 mm × D550 mm × H540 mm. This system can handle simultaneously 4 samples in a single run and sequentially separate up to two radionuclides at each column.

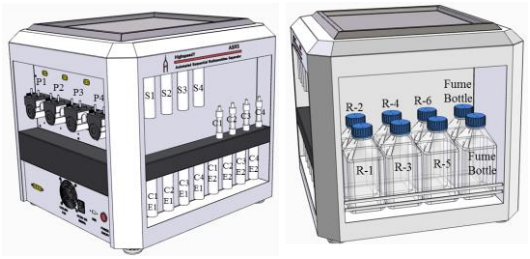

Fig. 3. The 3D design of the 4-channel automated single column extraction chromatographic system (4ch-ASRS).

2.2 Software Design

Control software developed on the LabVIEW platform is a virtual instrument to control 4ch-ASRS system by means of manipulating the most important input parameters through the graphical user interface on the computer screen. The control software consists of three windows called the front panel, which are virtual instruments for performing input and output interfacing between the software and 4ch-ASRS. The 1st window shown in Fig. 4, named as calibration parameter calculation mode, is used for calibrating the flow rate of feeding pumps. The peristaltic pump calibration is achieved by measuring the volume of de-ionized water transferred through a pump, as an analog output voltage of a data acquisition device is changed. A typical slope of a pump calibration curve is 1.7 mL/min/V.

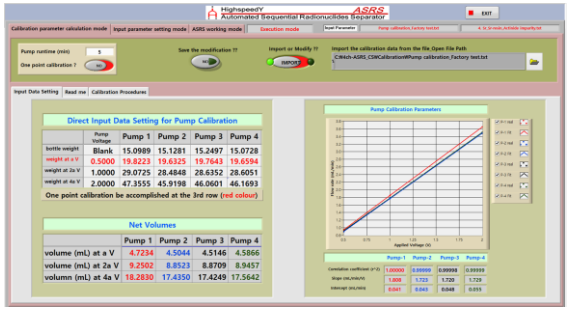

Fig. 4. A LabVIEW-based virtual instrument of the 4ch-ASRS for the feeding pump calibration.

The 2nd window shown in Fig. 5, named as input parameter setting mode, is used for setting the volumes, flow rates and selection of reagents at each step for executing an automated radiochemical process. The methods for executing the automated radiochemical process can be imported or exported in this virtual instrument. The final window shown in Fig. 6, named as ASRS working mode, is used to execute an automated radiochemical procedure for separating radionuclides from the interfering elements and matrix components.

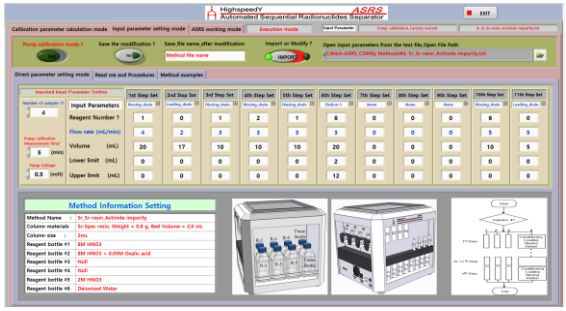

Fig. 5. A LabVIEW-based virtual instrument of the 4ch-ASRS for the input parameter setting of a method.

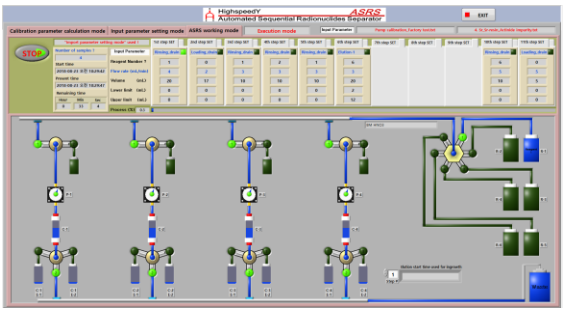

Fig. 6. A LabVIEW-based virtual instrument of the 4ch-ASRS for executing the automated radiochemical procedure of the method.

3. Conclusions

The LabVIEW-based virtual instrument system for automated single column extraction chromatography was developed and successfully applied to control the 4ch-ASRS. Compared to conventional radionuclide separation methods carried out manually, 4ch-ASRS is faster and less labor-intensive, and expected to be widely used as a convenient tool for the chemical separation of the alpha and beta radionuclides in various samples such as radioactive wastes, environmental samples and food stuffs.

REFERENCES

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