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# Development of Automated Flow System for Rapid Solid-Phase Extraction of Trace Elements

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Summary

Solid-phase extraction techniques using chelating resins are useful for the separation of trace elements. The chelating resin immobilizing carboxymethylated polyethyleneimine (CM-PEI resin) can rapidly extract some trace elements over a wide pH range; however, alkali metal elements, which are present in large amounts in seawater and commercially available table salt, are not recovered and alkaline earth metal elements, which often interfere with determination of trace element, are also not collected under acidic and neutral conditions. In this study, we developed an automated flow system for high-speed solid-phase extraction separation by utilizing the CM-PEI resin.

Before the development of the system, we investigated whether the application of the internal standardization to the solid-phase extraction would eliminate the strict control of the flow volume using a pump. A fixed amount of internal standard element Y ($y_0$ mg) was added to a sample solution ($V_0$ L) containing trace elements ($x_0$ mg), and the pH was adjusted to 5.5 by adding sodium acetate solution, acid or base ($V_0 + \alpha$ L). The majority of this solution ($V_1$ L) was passed through a cartridge packed with CM-PEI resin. After eluting the extracted elements and Y with nitric acid ($V_2$ L), each element ($x_1$ mg) containing in this solution was quantified by inductively coupled plasma atomic emission spectrometry (ICP-AES) using the internal standardization. The solution for calibration curve was diluted with each element, $y_0$ mg of Y and nitric acid, and only the blank solution was fixed volume ($V_{\mathrm{Blank}}$ L). The concentration of trace elements quantitatively trapped in the resin in the first sample solution ($x_0/V_0$ mg/L) can be determined from the concentration of trace element, $C$ mg/L, obtained by ICP-AES using the internal standardization and the value, $V_{\mathrm{Blank}}/V_0$; that is, $\alpha$ L, $V_1$ L, and $V_2$ L do not need to be strictly controlled.

For the development of the system, a system consisting of three switching valves (1-6 way, 4 way, and 6 way) and a peristaltic pump was constructed. A commercially available microcontroller board and relay modules were used to control the valves and pump. By applying the internal standardization to the solid-phase extraction, a peristaltic pump, which is capable of high-speed pumping but has some problems in the accuracy of the flow volume, can be used in the system. By optimizing the valve switching and pumping conditions, we succeeded in constructing a high-throughput system.