Automated Microfluidic Analysis of CUP-2 UOC for Forensic Applications

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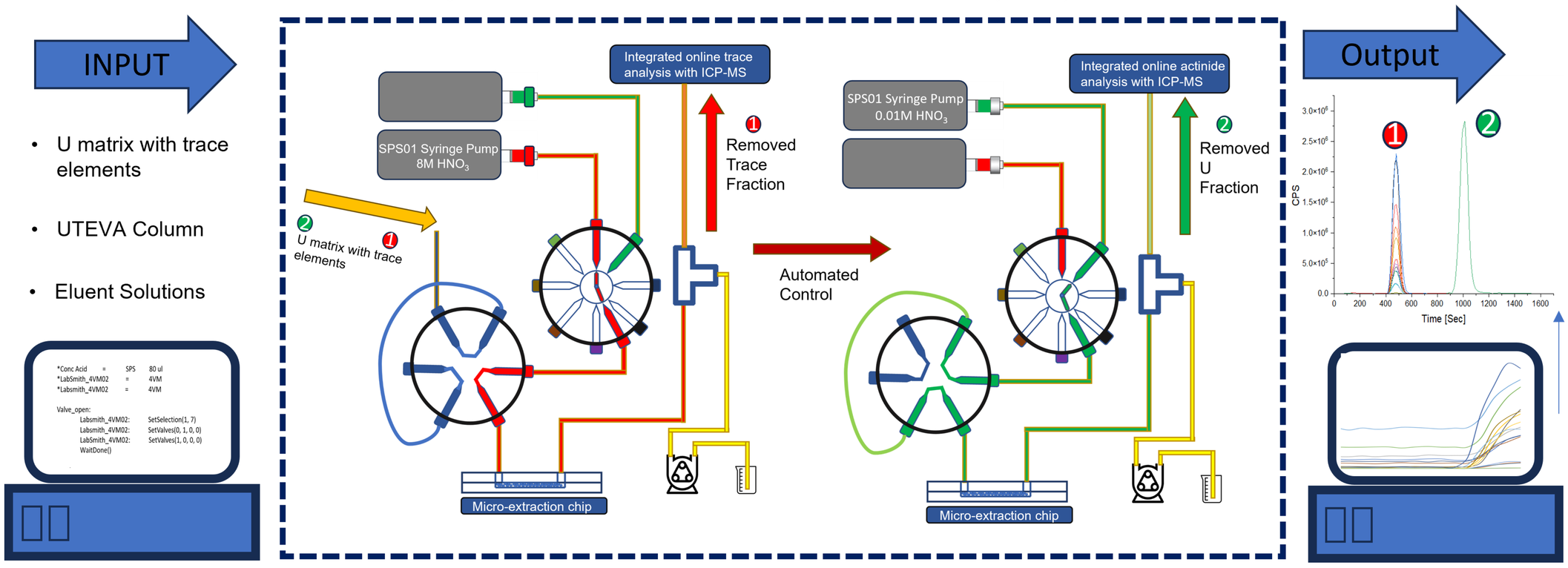


Figure 1. Graphical overview of the automated microfluidic separation – analytical system, supported by an integrated ICP-MS

Introduction

- Trace elemental composition of early fuel cycle material such as uranium ore concentrate (UOC) represents significant interest for nuclear forensics.
- Development of automated microfluidic systems presents interesting alterative for rapid nuclear forensic analysis that could reduce sample consumption, waste generation and improved safety though automation.

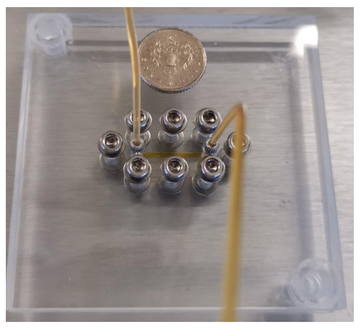


Figure 2: An assembled microfluidic device (20 µL), unpacked, compared to a five pence coin (18mm)

However, lack of integration between on-chip detection and separation hinders broad range application. → Objective – Development of coupled microfluidic systems capable of automated separation and online detection.

Aims and Methods

Figure 3: Microfluidic separation platform integration with an inline ICP-MS, mounted on 25 x 23 cm PCB board. V indicates valves, S indicates storage vessel, P indicates pumps, M indicates microfluidic devices

- Development of a microfluidic system capable of automated radiochemical separation and analysis with available exchange chromatography/ion exchange resins and integrated triple quadrupole ICP-MS. Validation of the microsystem was carried out with a simulated Uranium matrix s and CUP-2 uranium ore concentrate certified reference material (UOC-CRM).

Results

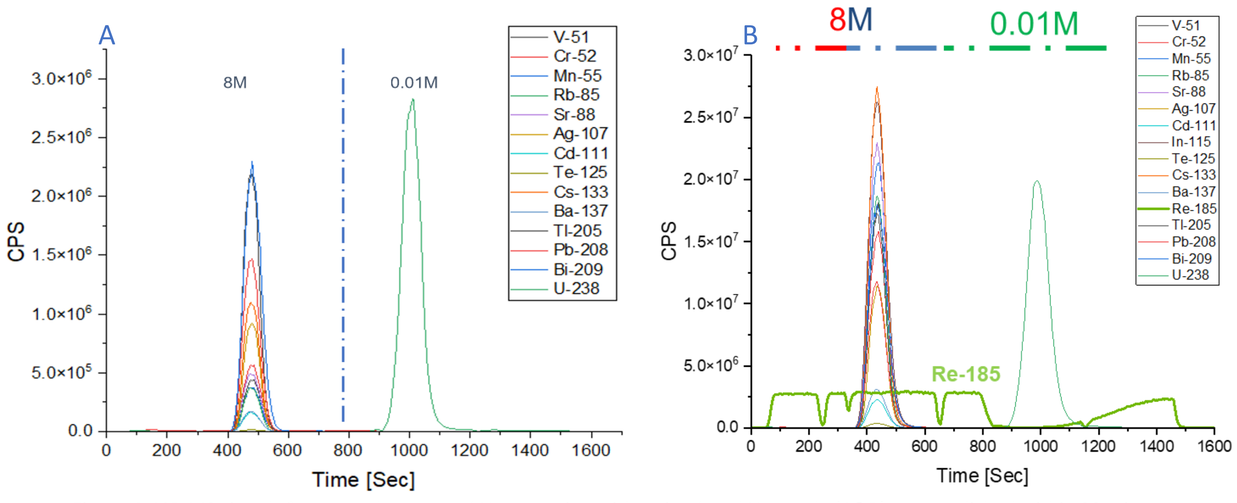


Figure 4: ICP-MS signals for trace element and U separation with a simulated U sample (A&B), accomplished within 20 mins.

- Figure 4 demonstrates successful U separation from equal concentration of 20+ trace elements. Re was used to track elution solution injection an internal standard demonstrating unreported interaction with UTEVA®.
- Trace element separation chromatogram of concentrated CUP-2 UOC, with 8 M nitric acid are shown to the right, displaying some of the trace elements analysed.
- Combination of separation – analysis online reduced analysis time per sample to less than 30 mins. While permit the usage of higher-than-normal UOC concentration for analysis at 4,800 µg UOC per g sample.

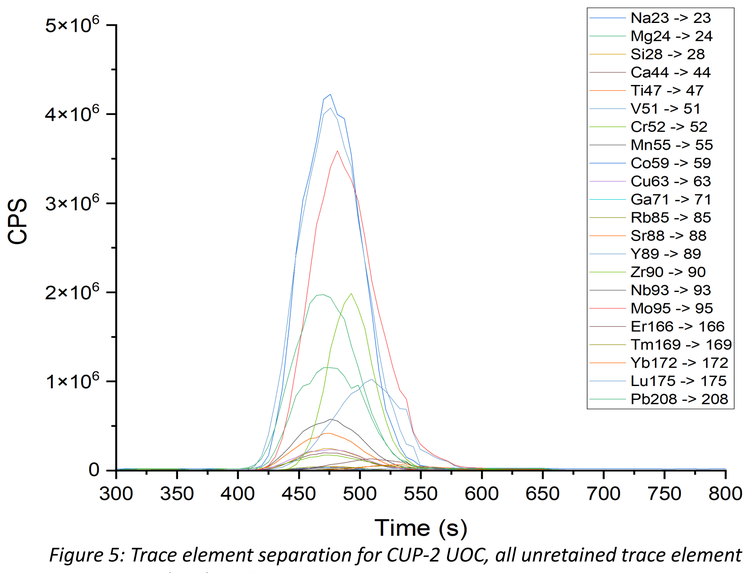
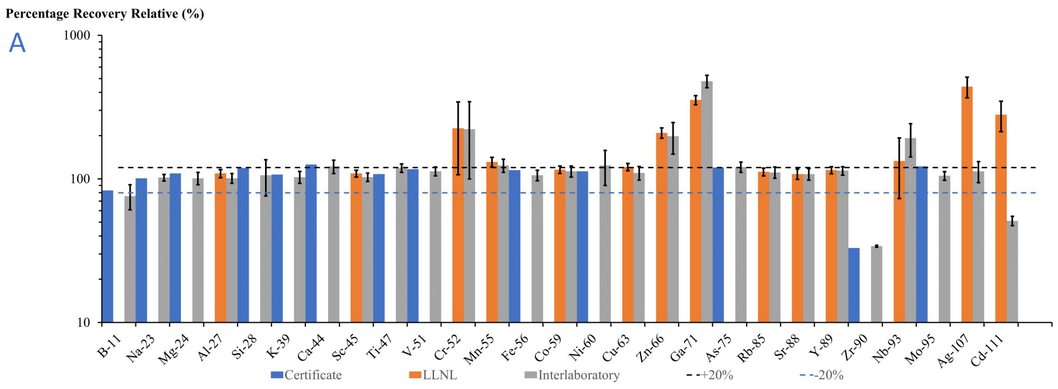


Figure 5: Trace element separation for CUP-2 UOC, all unretained trace element are separated within 10 minutes



- Elemental recovery data for microfluidic CUP-2 analysis, reported as percentage recovery compared to values from previous conventional analysis (A&B). Demonstrating satisfactory recovery with automated system for over 70% of the total element targeted, while consuming 20 µl of sample per run.

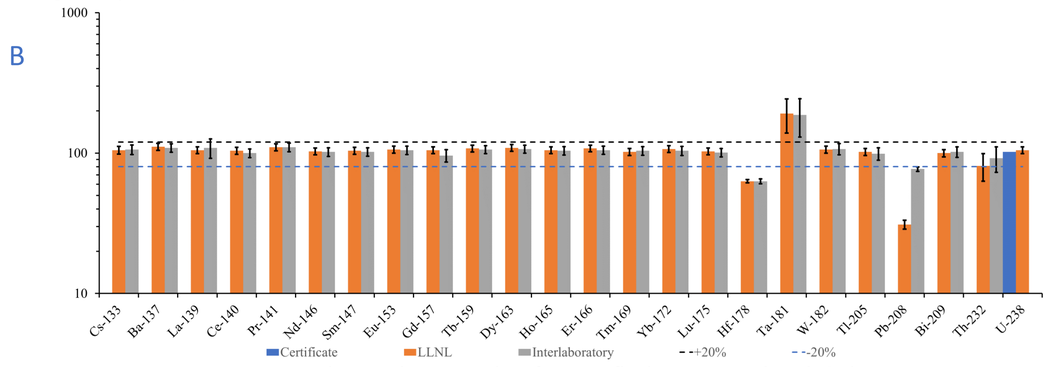


Figure 6: Elemental recovery data for microfluidic CUP-2 analysis (A&B).

Conclusion

- Successful demonstration of automated microfluidic actinide separation and analytical system has been achieved. Consuming 100 µl of the sample per analysis under 30 minutes of ICP-MS run time, producing satisfactory analytical results for over 30 elements analysed in bulk Reduction in sample size requirement are advantageous as minimal amount of police exhibits are consumed for forensic analysis.
- Further work are underway for addition of non-destructive analytical methods and other sample compositions that are within the nuclear fuel cycle.

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