Overview and new Developments Radioanalytics

TKI Workshop

Steffen Happel

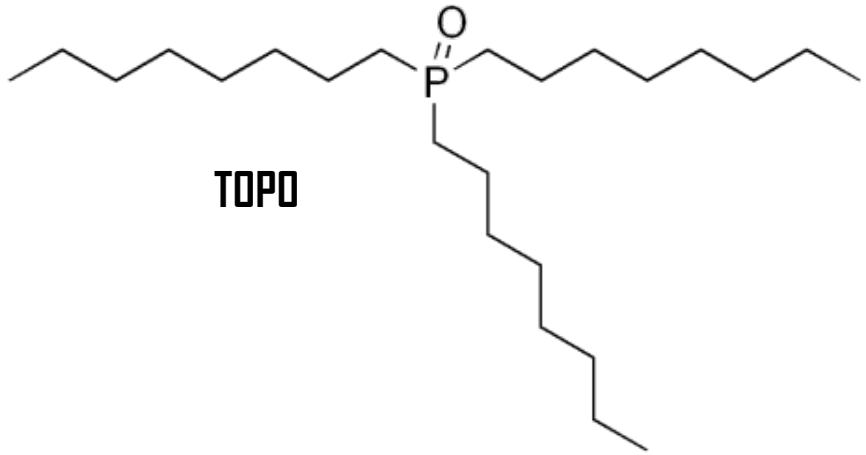
01/09/2026

TRISKEM
Expertise in Separation Chemistry

Overview

- TK200 Resin
- TK221 Resin
- Sr-90 in seawater (TK227)
- Radium
  - TK100/1 Resin
  - TK102 Resin
  - Ongoing: TK103 Resin
- Tc separation
  - TK201 Resin
  - TK202 Resin
  - TK200 Resin
- TKElScint
  - TK-TcScint
  - TK-SrScint
- TK400 Resin
- Impregnated membrane filters
- CL Resin
- CS Resins
- Upcoming: TK300 Resin
- Upcoming: SE Resin
- On-going projects

TK200 Resin



TOPO

Based on TOPO extractant

High retention of actinides

Applications:

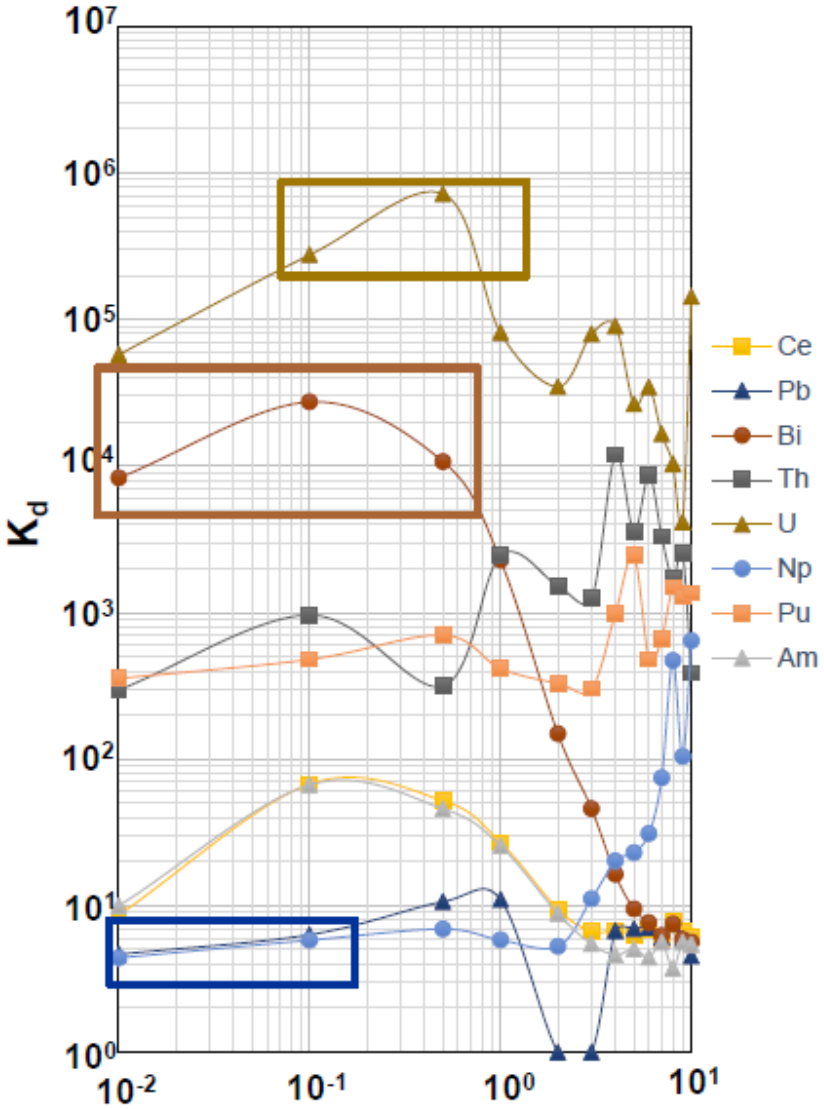
- Use for very efficient U removal from Pu
- Determination of Tc-99 in water samples
- Ga-68 production (in combination with ZR Resin or TK400 Resin)
- Actinide separation from water samples

Extracts actinides even at pH 1 - 2 (nitric acid)

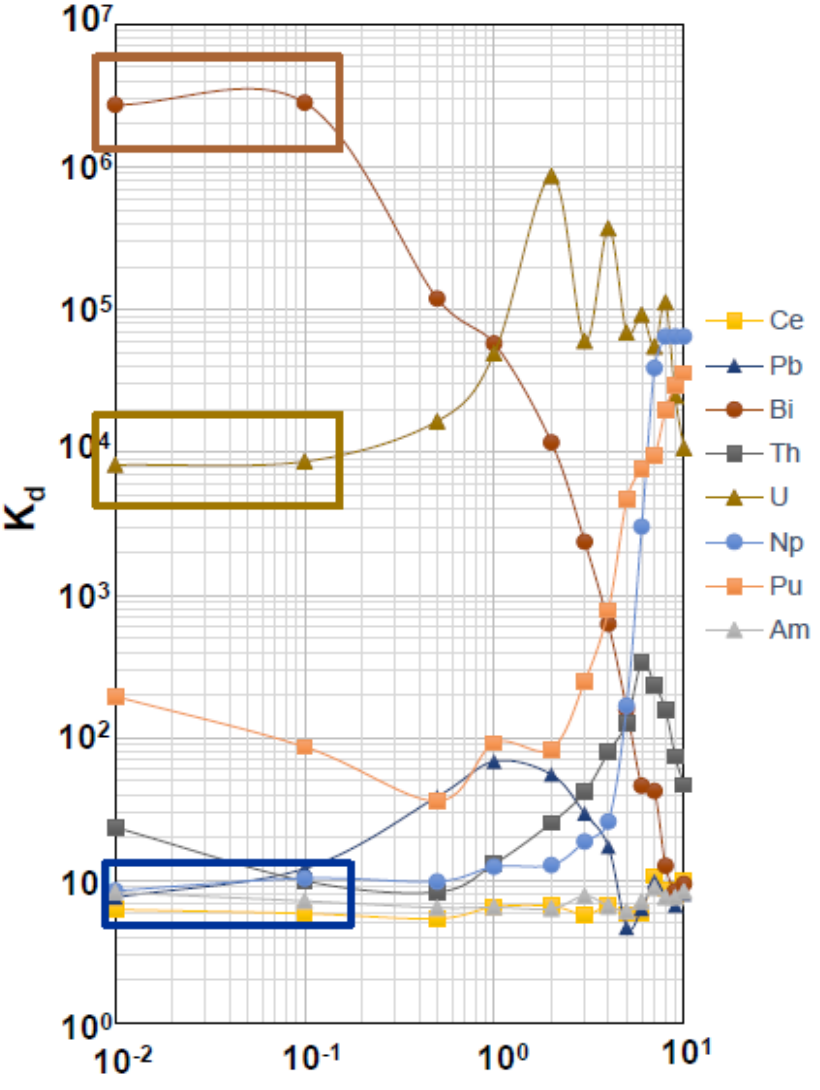
- Preconcentration and purification of selected actinides on same column
- ‘In the field’?

Actinides on TK200

(all data Van Es et al.)

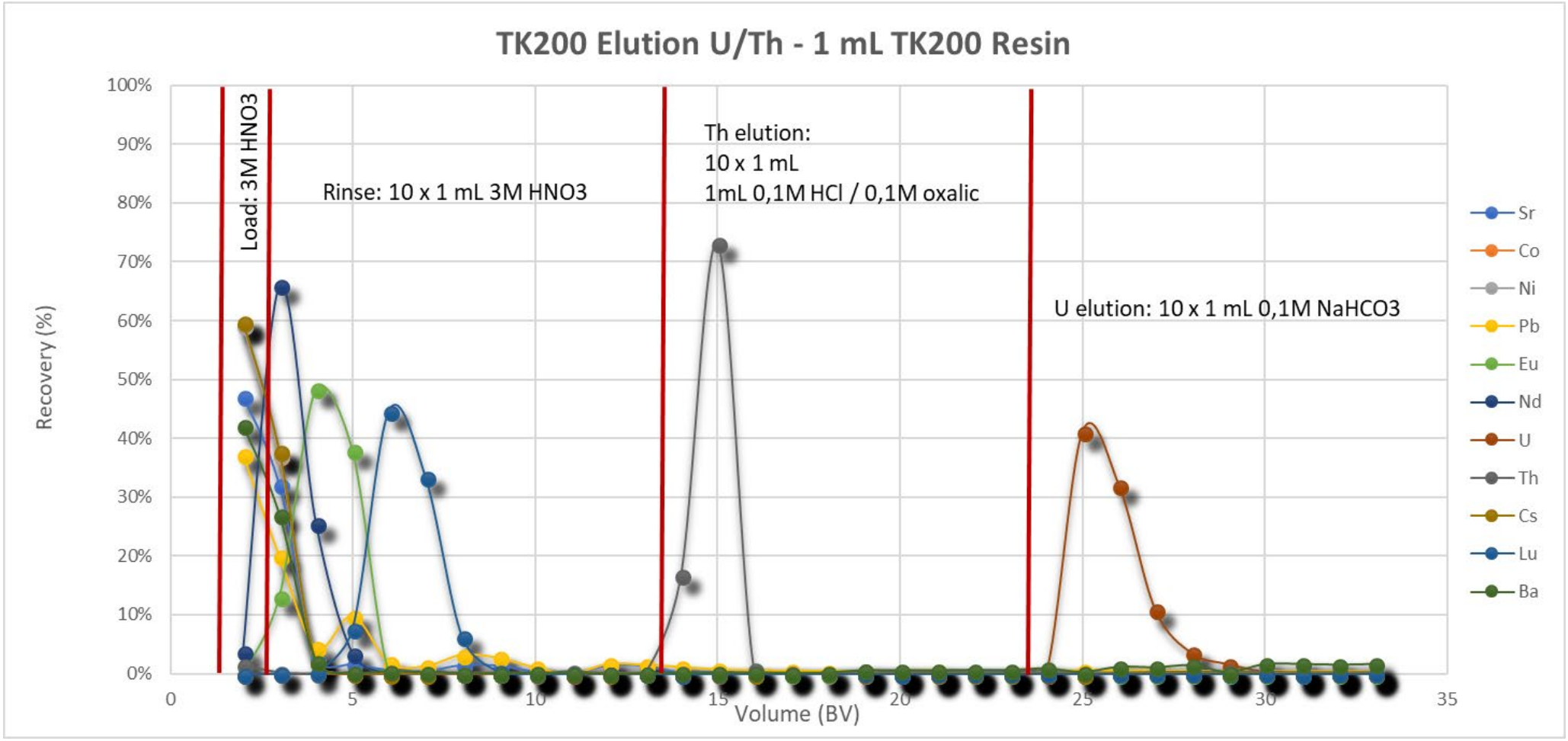


vanEs et al. $[HNO_3]$ M



VanEs et al. [HCl] M

U/Th separation on TK200



Load: 3M HNO_3 or ≥ 1L pH2 (HNO_3)

Very clean U/Th separation

Oxalate instead of carbonate

TK200 Resin - U/Pu separation

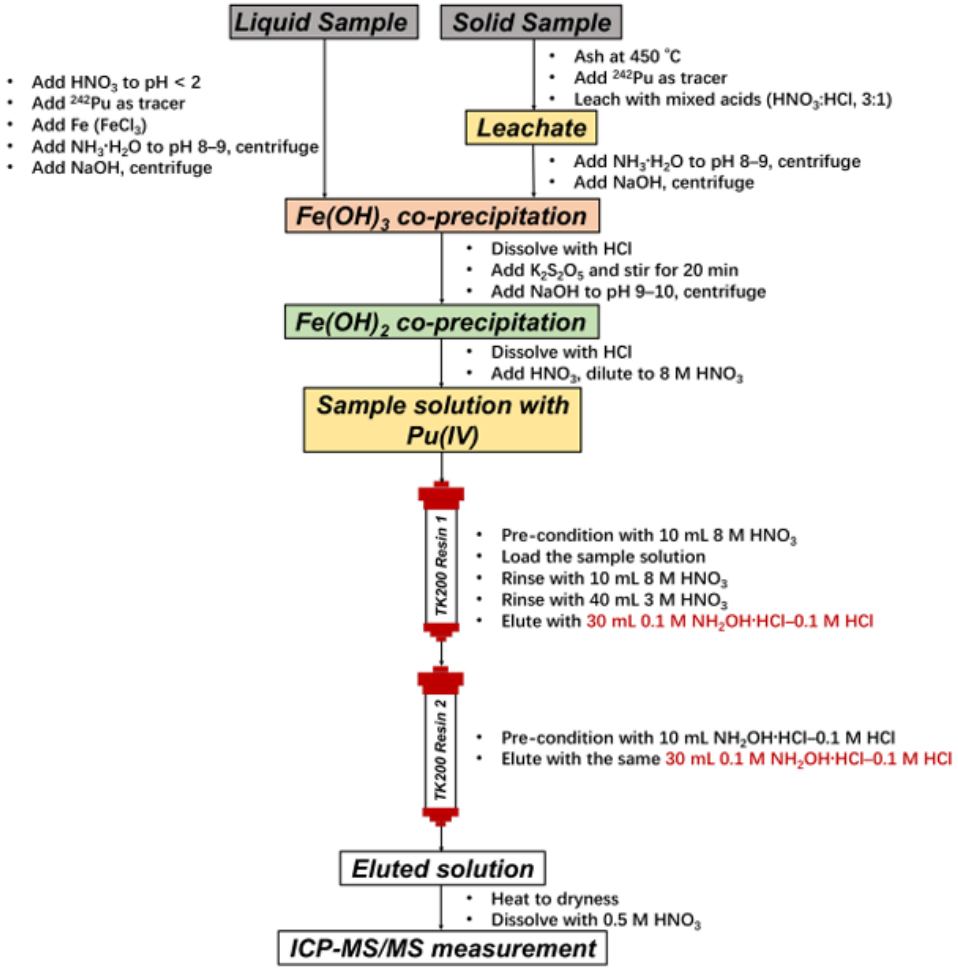


Figure S1. Analytical procedure for determination of plutonium isotopes (^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu)

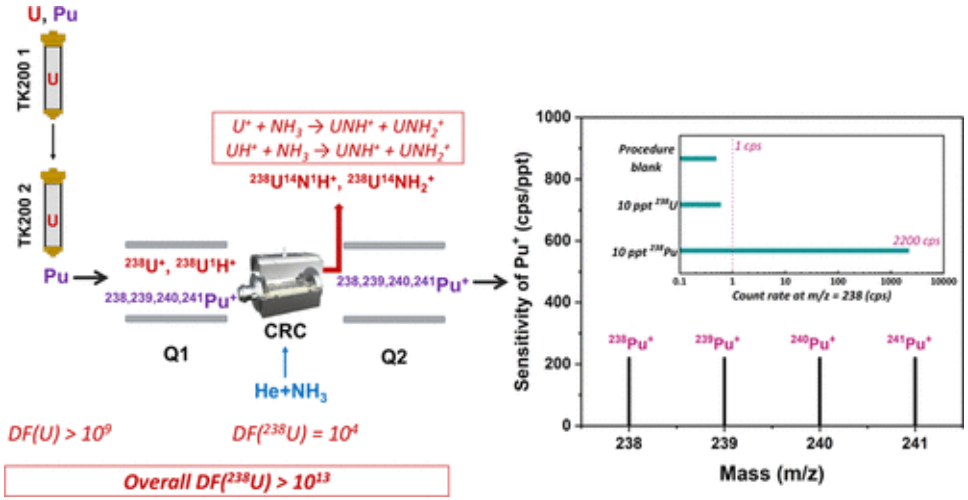
Recent publication by Huang et al.

Better U removal: **$D_f(U) > 10^9$**

Additional U removal via $He+NH_3$

Overall $D_f(U) > 10^{13}$

Pu isotopes incl. Pu-238 via ICP-MS/MS



Zhao Huang, Xiaolin Hou, Xue Zhao, Rapid and Simultaneous Determination of 238Pu, 239Pu, 240Pu, and 241Pu in Samples with High-Level Uranium Using ICP-MS/MS and Extraction Chromatography, Anal. Chem. 2023, 95, 34, 12931–12939, https://doi.org/10.1021/acs.analchem.3c02526

TK200 Resin: new applications

ELSEVIER

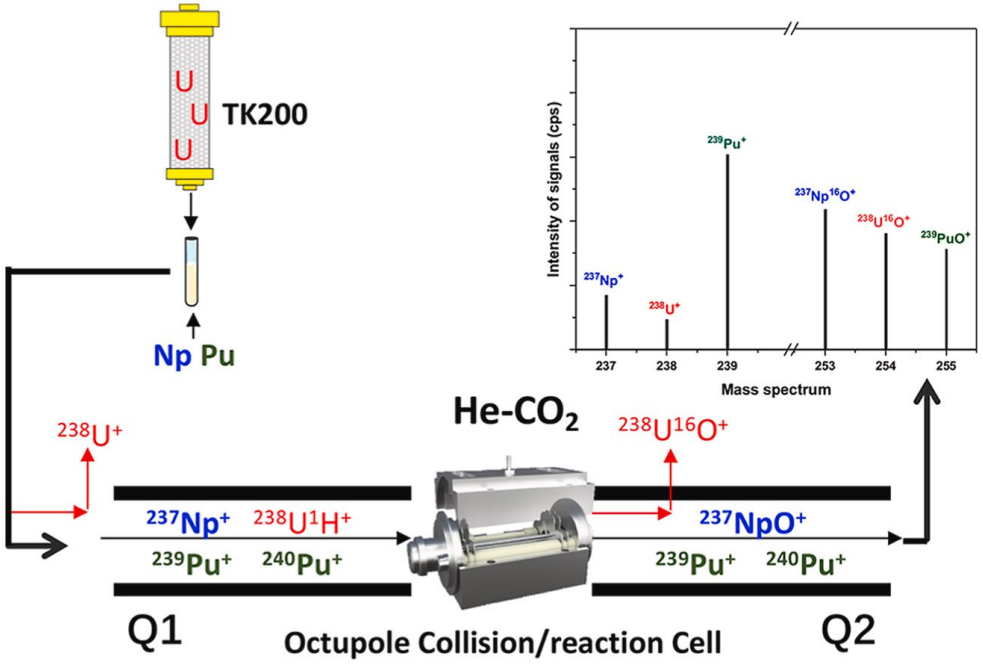
Talanta

Volume 265, 1 December 2023, 124798



Simultaneous determination of femtogram levels of ^{237}Np, ^{239}Pu, and ^{240}Pu in environmental solid samples using extraction chromatography and ICP-MS/MS

Zhao Huang [a b d], Xiaolin Hou [a b c] ✉, Jixin Qiao [a], Xue Zhao [b c e]



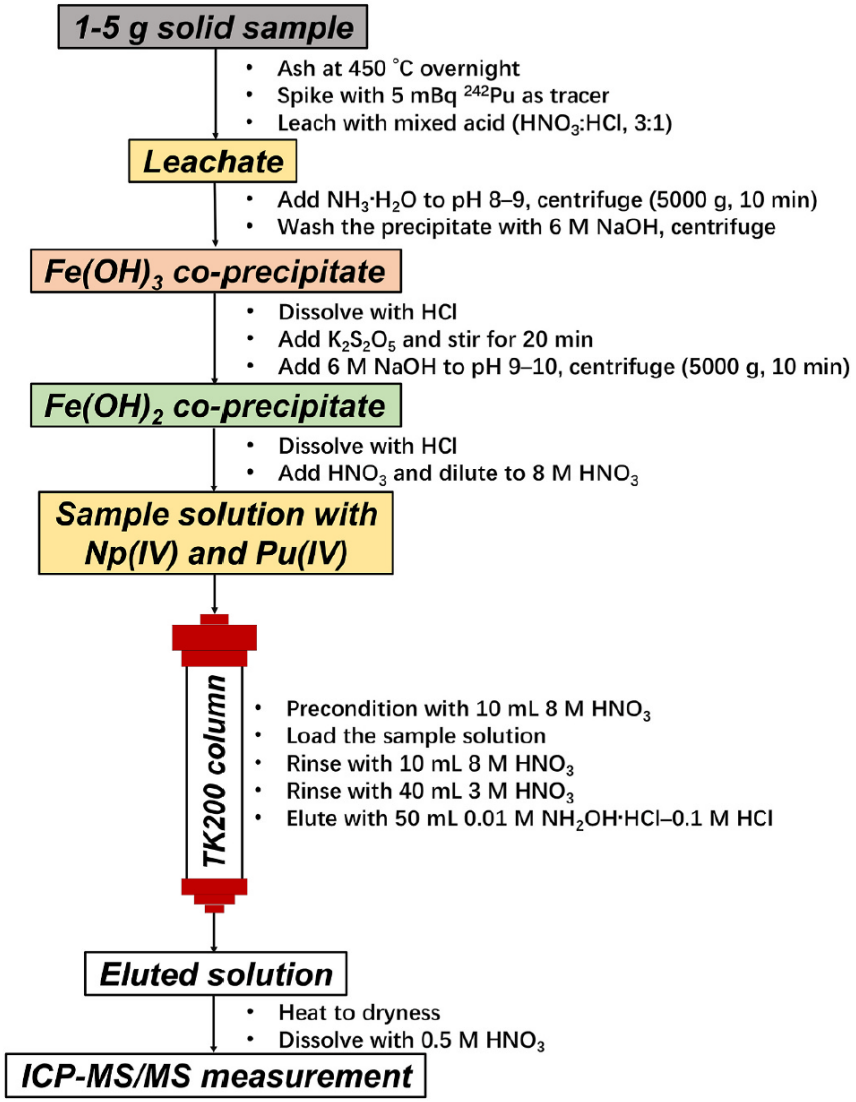


Fig. 1. Sample pretreatment procedure and optimized conditions for the simultaneous separation of Np and Pu.

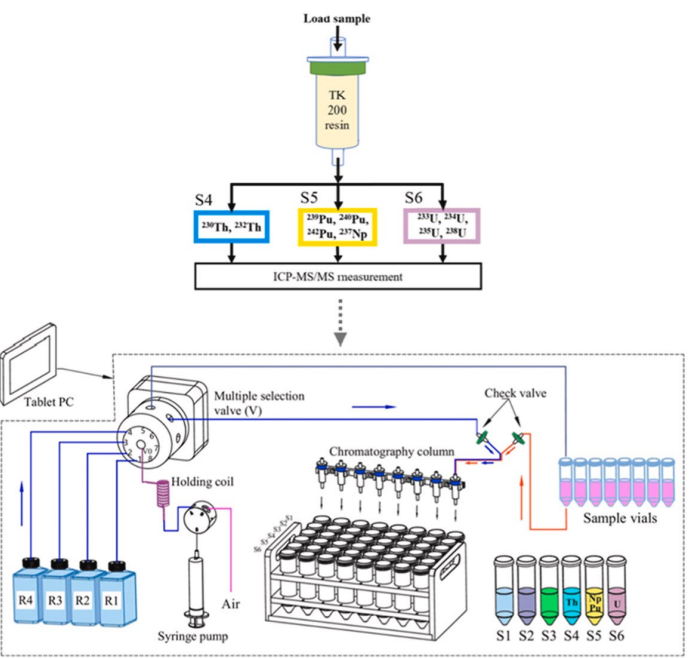
TK200 Resin: new applications

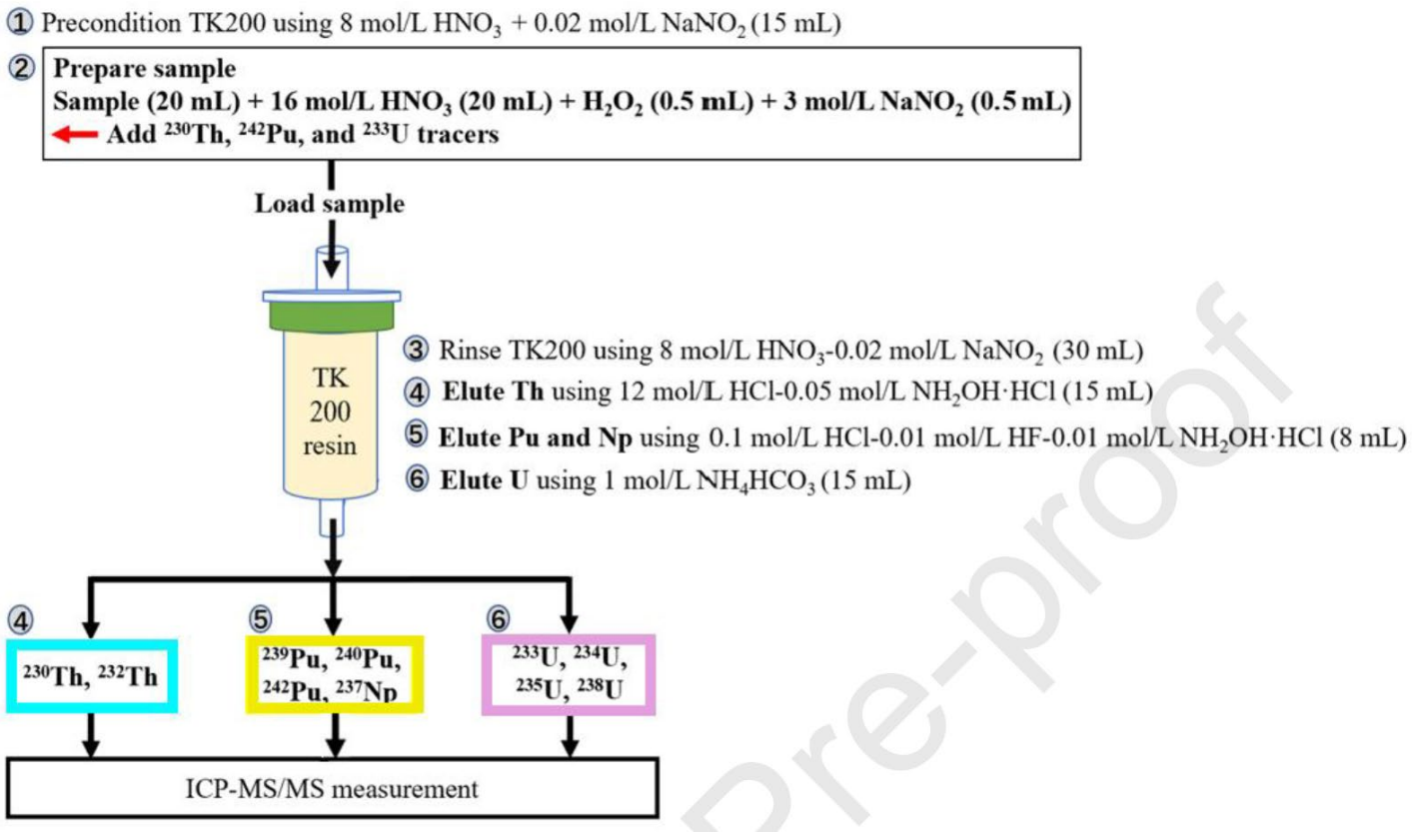
Talanta
Volume 306, 15 August 2026, 129700

Development of emergency radio-bioassay method for Th, Pu, Np and U in urine samples using single-column chromatography, automated operation system and ICP-MS/MS

Maoyi Luo [a b c], Rong Guo [a], Yang Wu [a b], Yunshi Xiao [a], Ni Yuan [a b], Jing Zhang, Quan An [a b], Liye Liu [a b], Taeko Shinonaga [a b d]

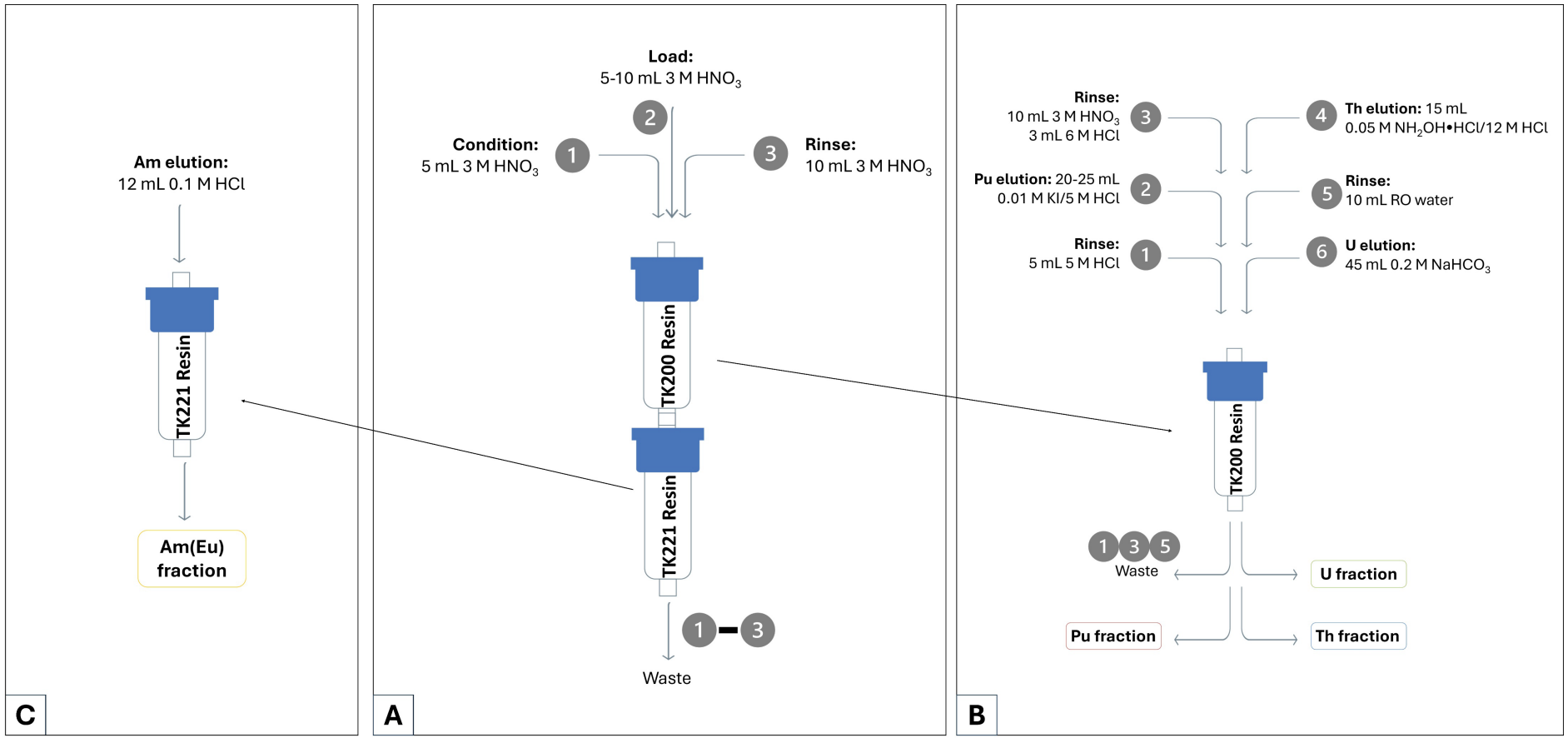
Sequential AC separation





Pre-proof

On-going: integration of TK221

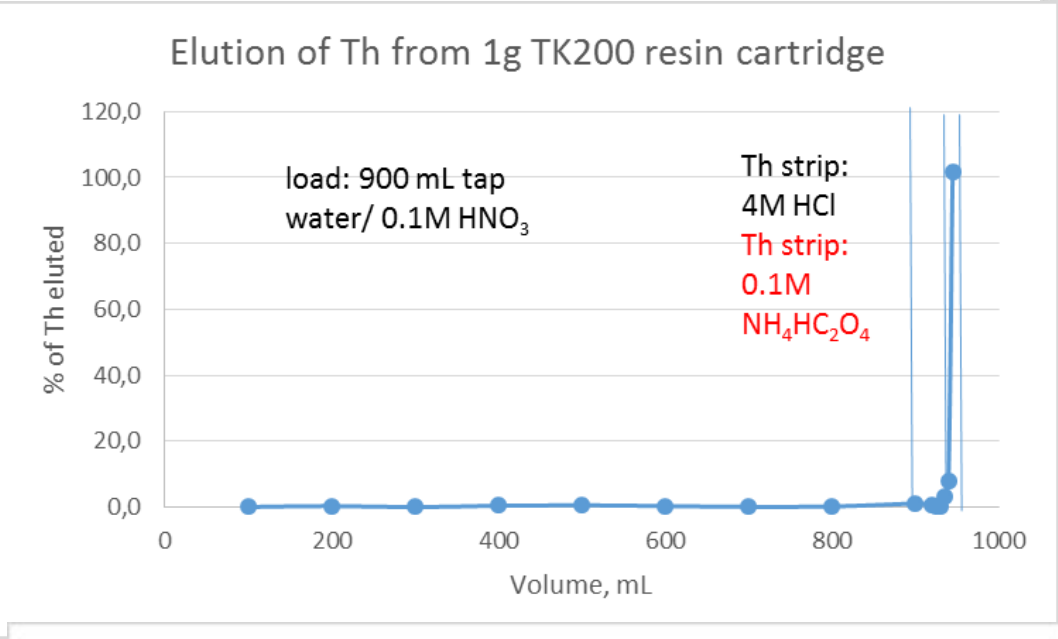


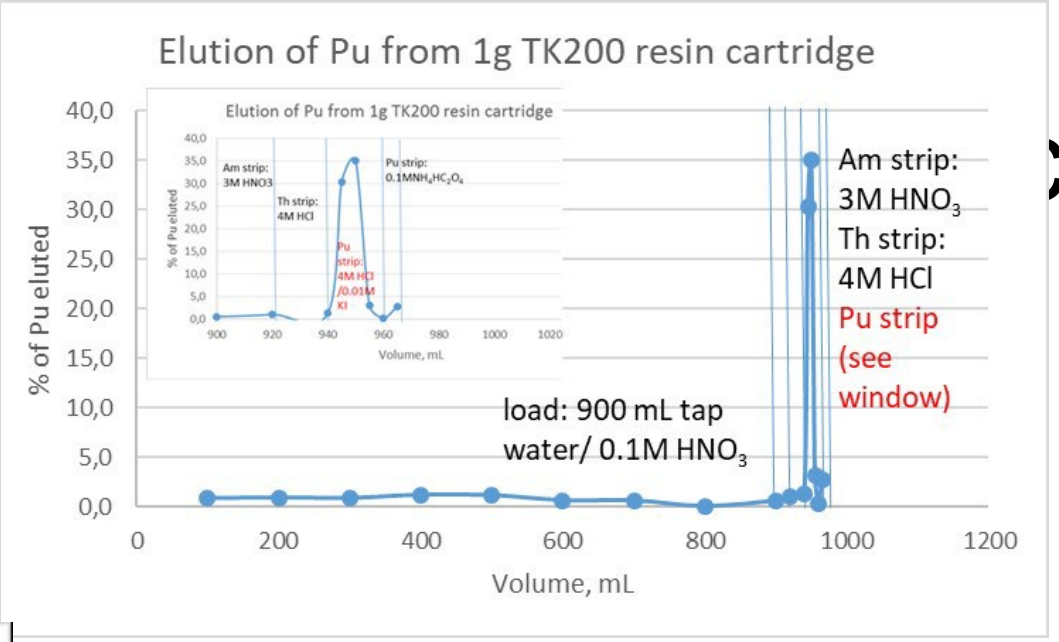
Load from 3M HNO3 after redox adjustment

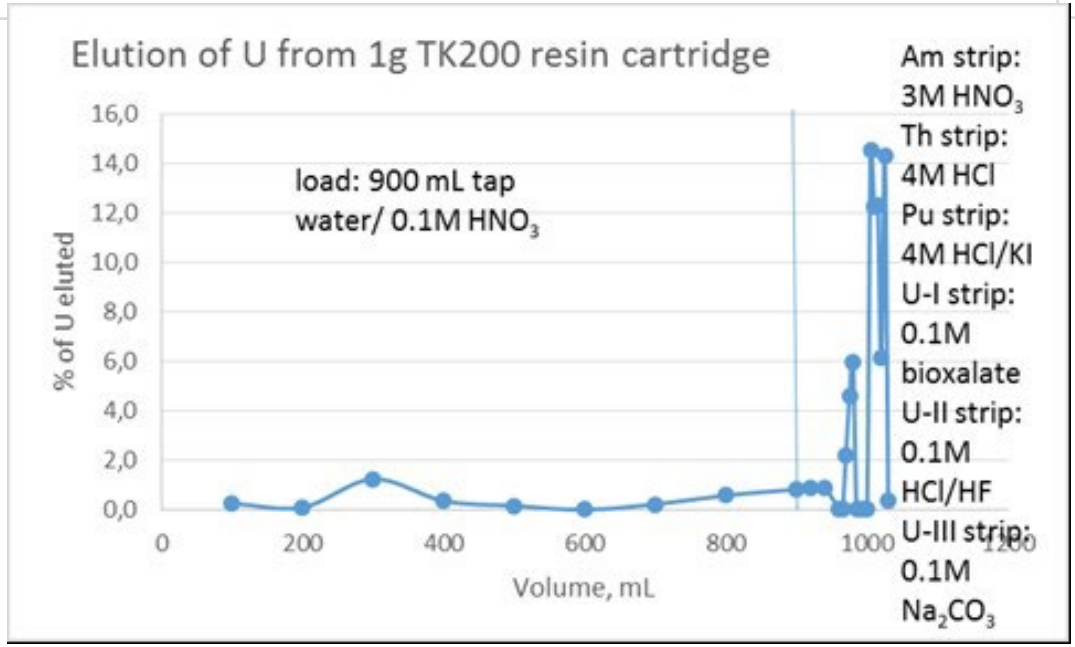
Separation of U, Pu and Th on TK200

Am passes through onto TK221

Actinides on TK200 – Application



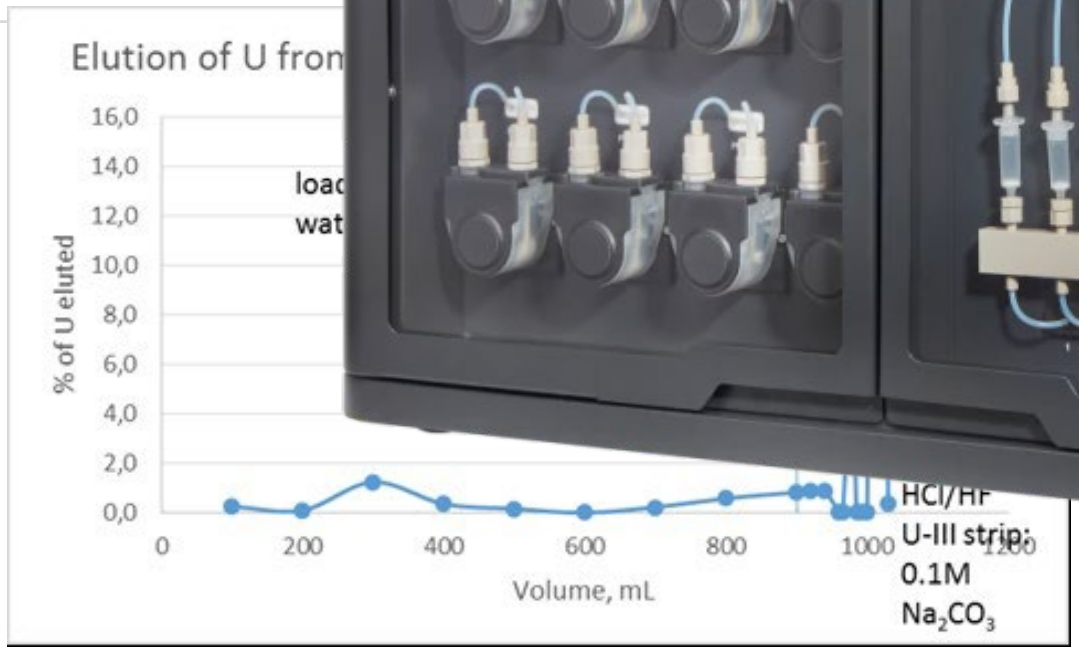




- Data by N. Vajda (RadAnal)
- Method development on-going
- Direct load of U, Th and Pu from acidified water samples (here 900 mL on 2 mL TK200)
- Sequential separation on TK200
- Automatisation & 'in the field' preconcentration'?

Actinides on TK200 – Application





oing

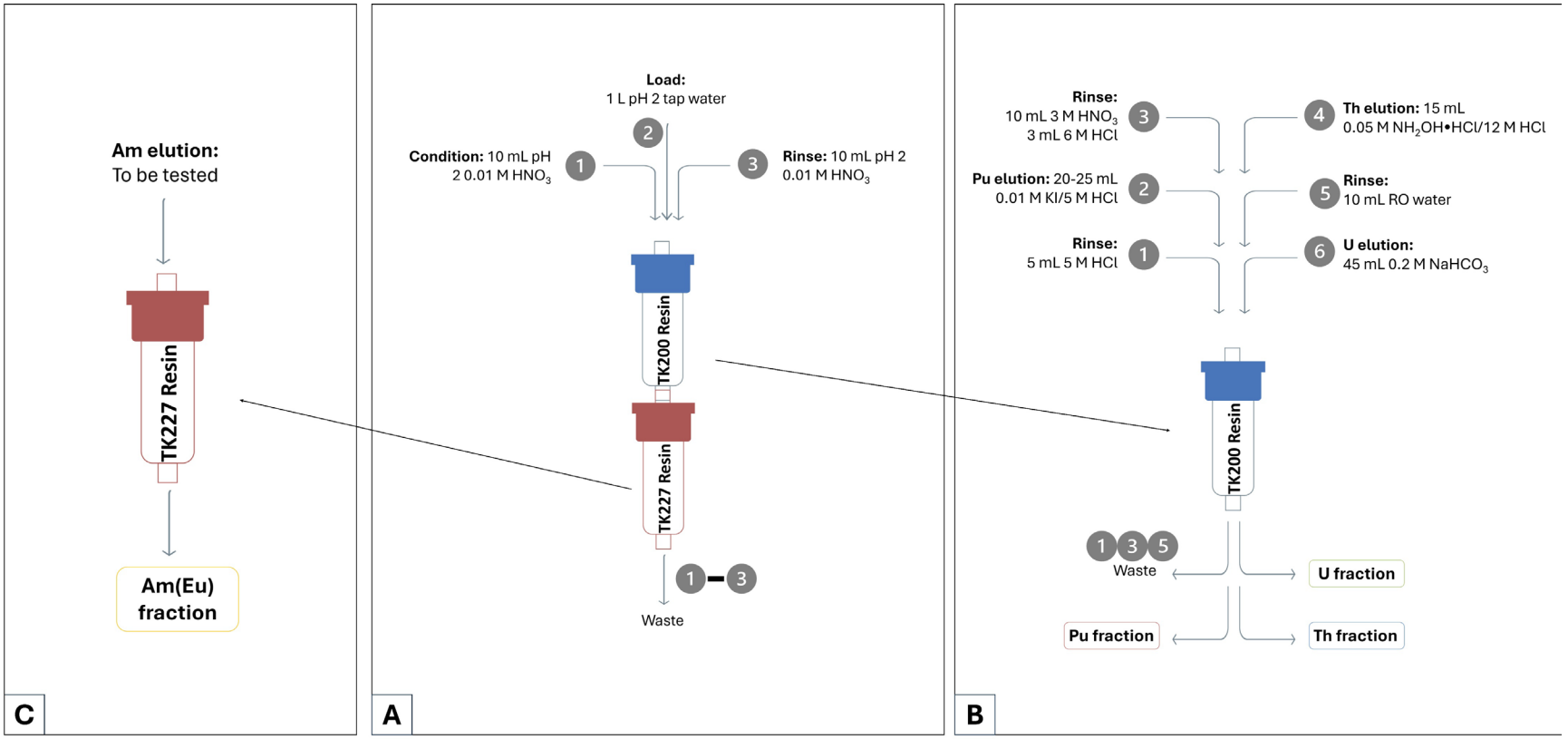
from

ere 900 mL

n on TK200

- Automatisation & 'in the field' preconcentration'?

On-going: integration of TK227



TK200 retains U, Pu, Th from HNO_3 pH 1-2, not Am

TK227 retains Am under these conditions

TK200 – direct Pu load/separation

One TK200 cartridge

- Preconcentration and purification

Automized separation

Acidified water samples (1 L)

Flow rate 15 mL/min

D_F(U): 10^4 - 10^5

LoD:

- 0.32 µBq/L Pu-239
- 2.00 µBq/L Pu-240

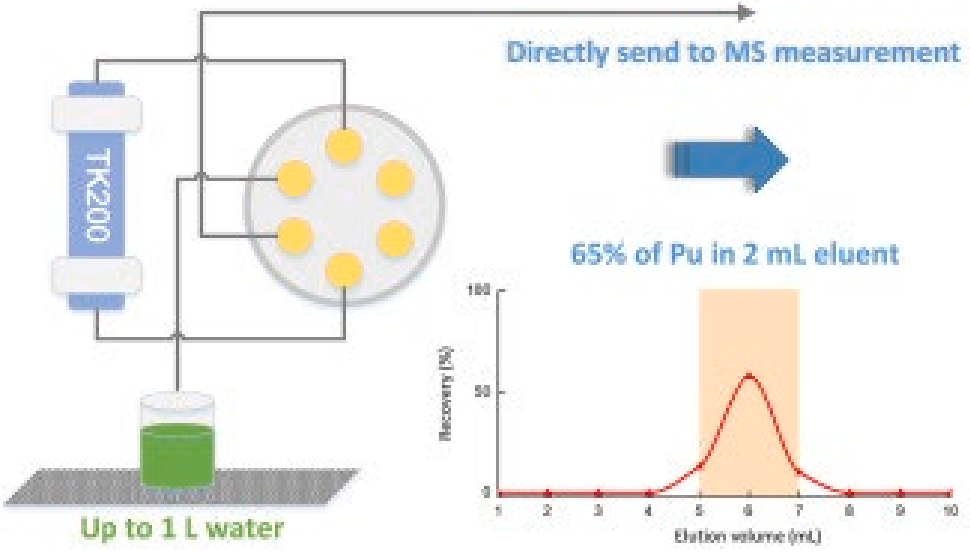
ELSEVIER

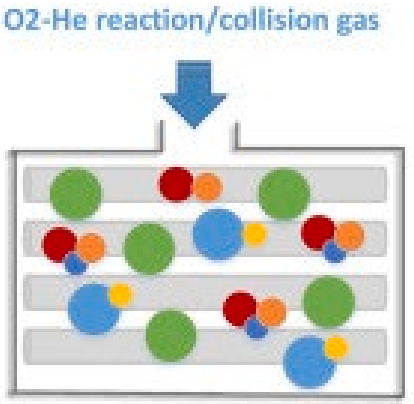
Talanta

Volume 262, 1 September 2023, 124710

A novel strategy for Pu determination in water samples by automated separation in combination with direct ICP-MS/MS measurement

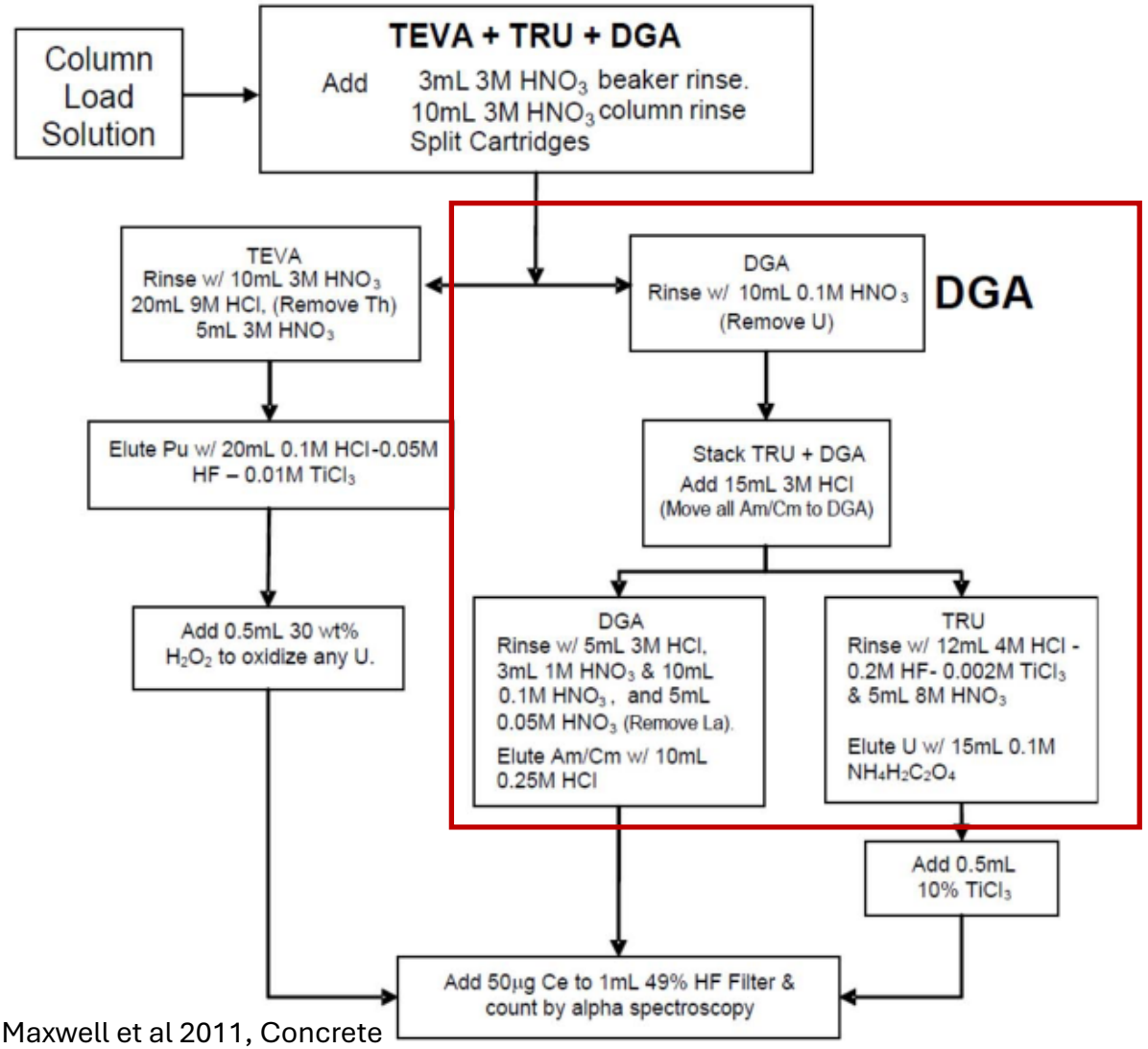
Youyi Ni [a], Wenting Bu [a], Ke Xiong [a], Sheng Hu [a], Chuting Yang [a], Liguo Cao [b]





- Reduced reagent usage
- Minimized labor intensity
- LODs for Pu down to µBq/L

TK221 Resin



Maxwell et al 2011, Concrete and brick samples

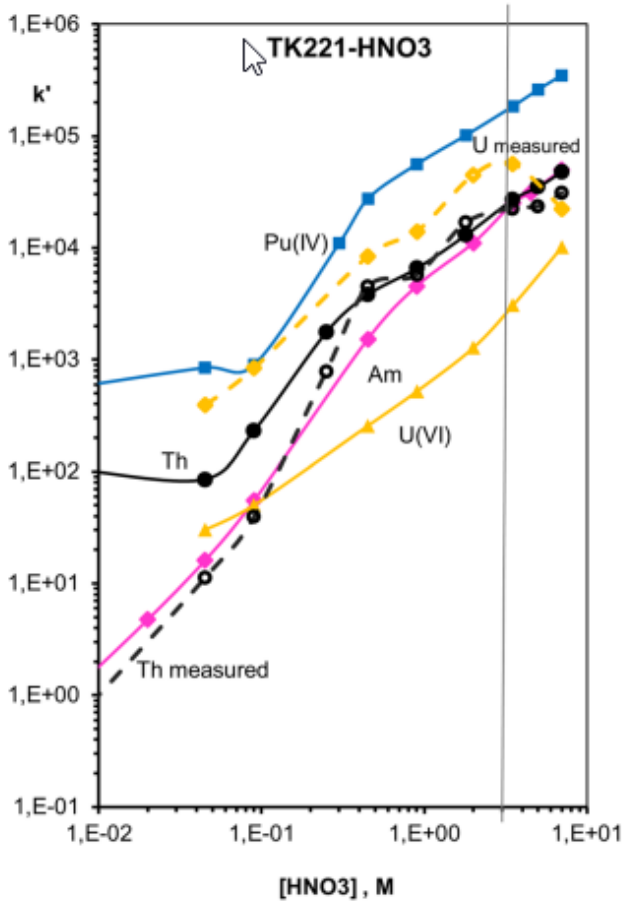
Maxwell et al.

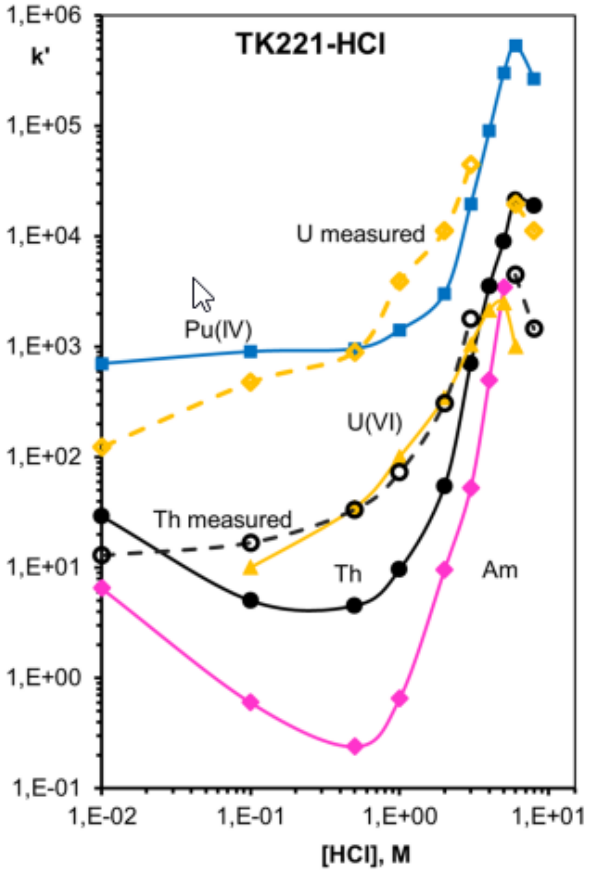
- Originally made for use in Lu-177 method
- Use in AC separation,
- DGA Resin:
  - High Am retention, rather low U retention
- TRU Resin:
  - Low Am retention, very high U retention
- For high matrix samples often both needed

TK221 Resin

Resin based on a mixture of diglycolamide and phosphine oxide + traces long chained alcohol on inert support with aromatic groups.

- Main applications in RadPharm:
  - Lu, Tb concentration from high acid and elution in small volume of dilute HCl
  - Ac-225 purification
  - Improved radiolysis stability
- Potential use in actinide separations?





(Papp, I., Vajda, N. & Happel, S. An improved rapid method for the determination of actinides in water. *J Radioanal Nucl Chem* **331**, 3835–3846 (2022). https://doi.org/10.1007/s10967-022-08389-9)

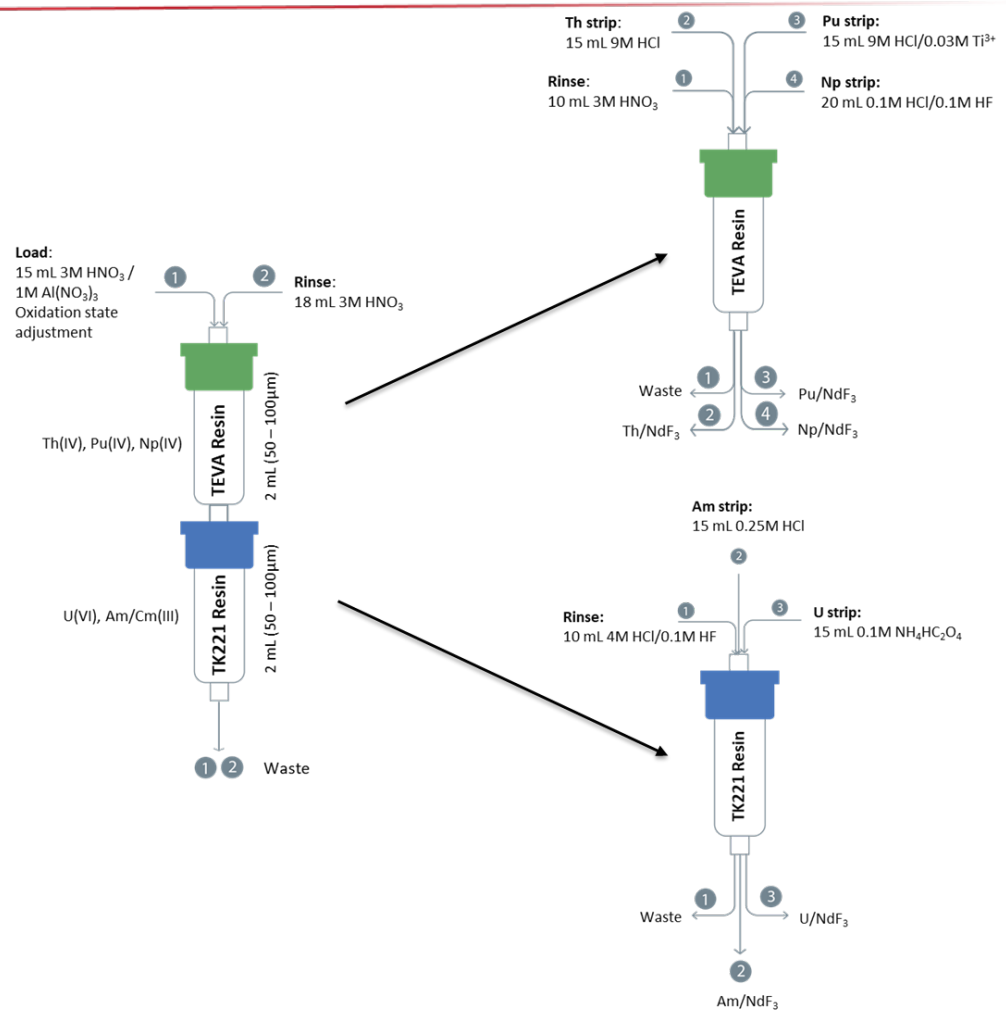
TK221 Resin – actinide separation

- Synergies between extractants
- Higher U retention than DGA
- Higher Am retention than TRU

Cooperation with Nora Vajda

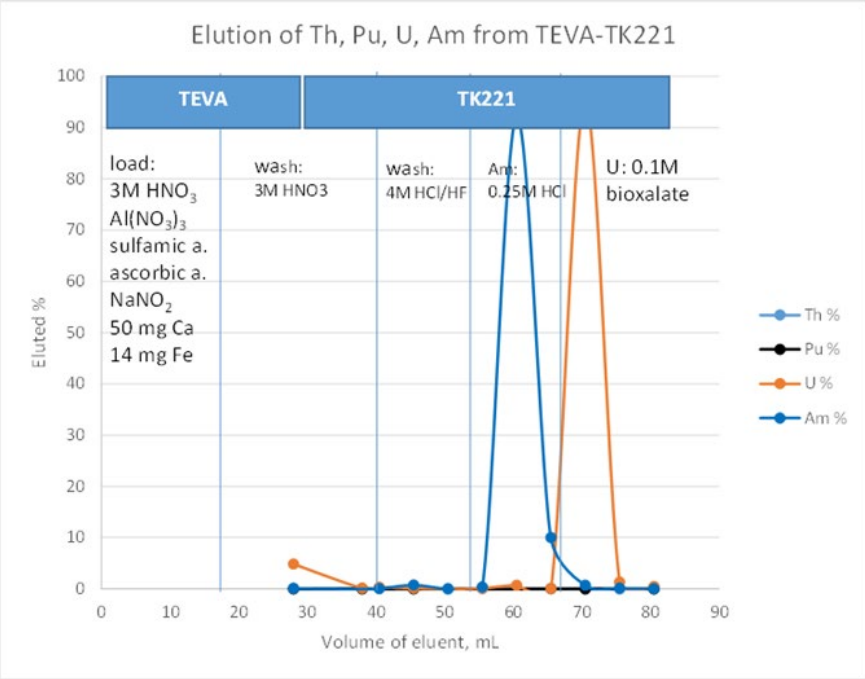
Method development for water samples

- TEVA/TK221 method
- Ideally later also soil and decommissioning samples
- Influence of Fe and Ca?
  - Ca leads to stronger Am retention



Papp, I., Vajda, N. & Happel, S. *J Radioanal Nucl Chem* (2022). https://doi.org/10.1007/s10967-022-08389-9

TK221 Resin



Th and Pu removed with TEVA.
Am and U separation on TK221 Am elution before U

Table 3 Recovery of actinide tracers from spiked water samples

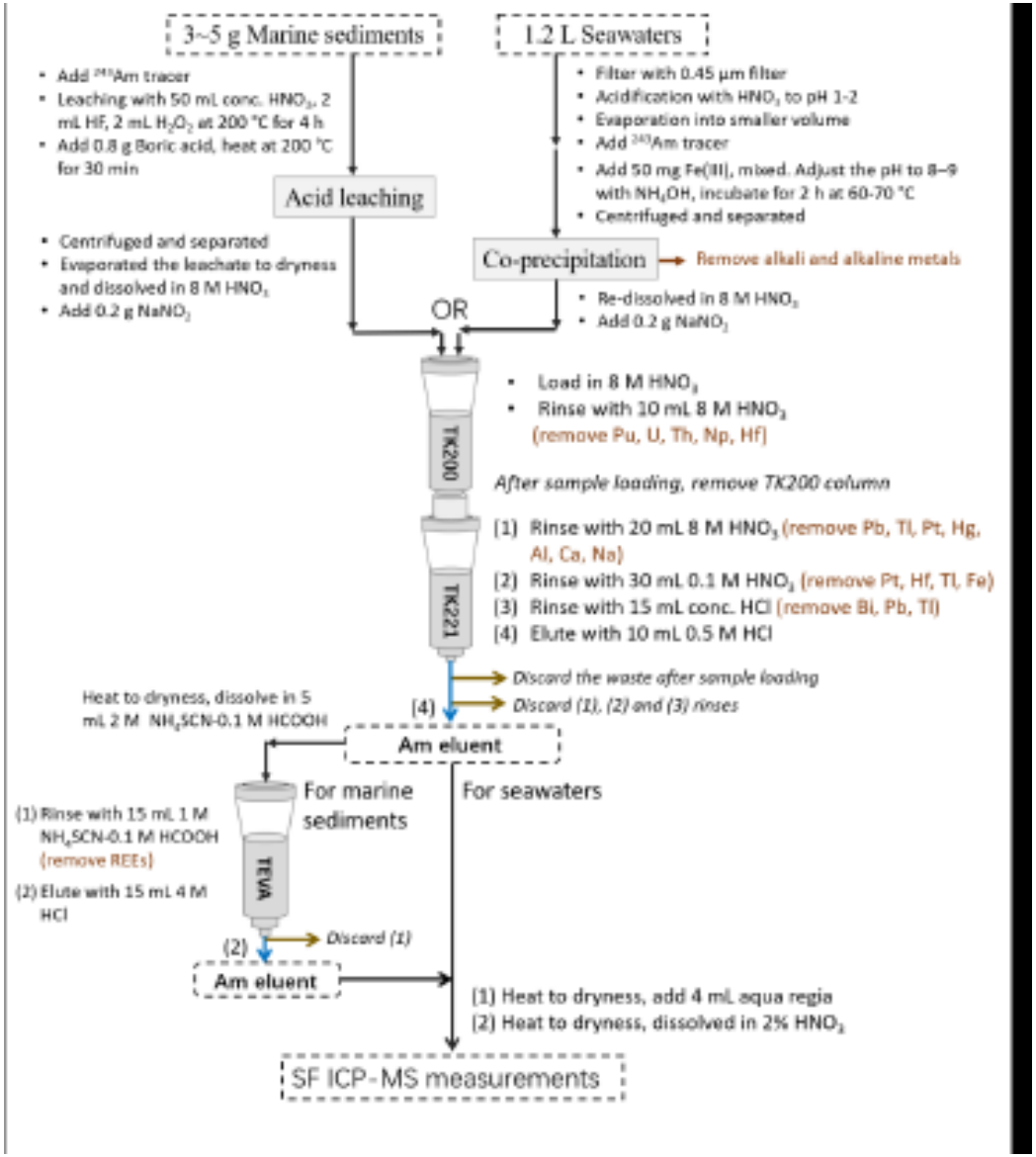
	Actinides determiantion	
	Without Np separation	With Np separation
	Yield	Yield
	%	%
TAP water		
^{230}Th	90 ± 8	86 ± 7
^{239}Pu	108 ± 7	95 ± 7
^{237}Np	–	91 ± 9
^{241}Am	103 ± 7	97 ± 6
^{233}U	103 ± 7	70 ± 7
SEA water		
^{230}Th	71 ± 7	61 ± 6
^{239}Pu	91 ± 7	87 ± 6
^{237}Np	–	93 ± 8
^{241}Am	89 ± 7	92 ± 6
^{233}U	88 ± 7	59 ± 6

Analyte	Target values		Measured values			Relative bias	MARB[a]	Z-score[b]	Test evaluation
	Mean activity concentration	Standard deviation (sd)	Activity concentration	Standard uncertainty	Relative standard uncertainty				
	Bq/kg	Bq/kg	Bq/kg	Bq/kg	%	%	%		
^{239}Pu	5.93	2.27	5.09	0.24	4.7	14	25	0.37	Accepted
^{241}Am	4.85	0.57	4.73	0.15	3.2	2.5	30	0.21	Accepted
^{244}Cm	7.02	2	7.19	0.34	4.7	2.4	25	0.09	Accepted

[a]Maximum Acceptable Relative Bias
[b]Z = |Xreported—Xtarget|/sdtarget

- Method tested on spiked tap and sea water samples
- High yields (88+ for U and Am)
- Analysis of IAEA-TEL-2021–03 WWOPT successful
- On-going: use for solid samples
- TK201/TK221, TK200/TK221 methods?

Tandem TK200/TK221



- Ling Zhang, Emilia Vassileva, Determination of ultra-trace level ^{241}Am in marine sediment and seawater by combining TK200-TK221 tandem-column extraction chromatography and SF ICP-MS, Talanta, 271, 2024, 125724, https://doi.org/10.1016/j.talanta.2024.125724

Conclusion:

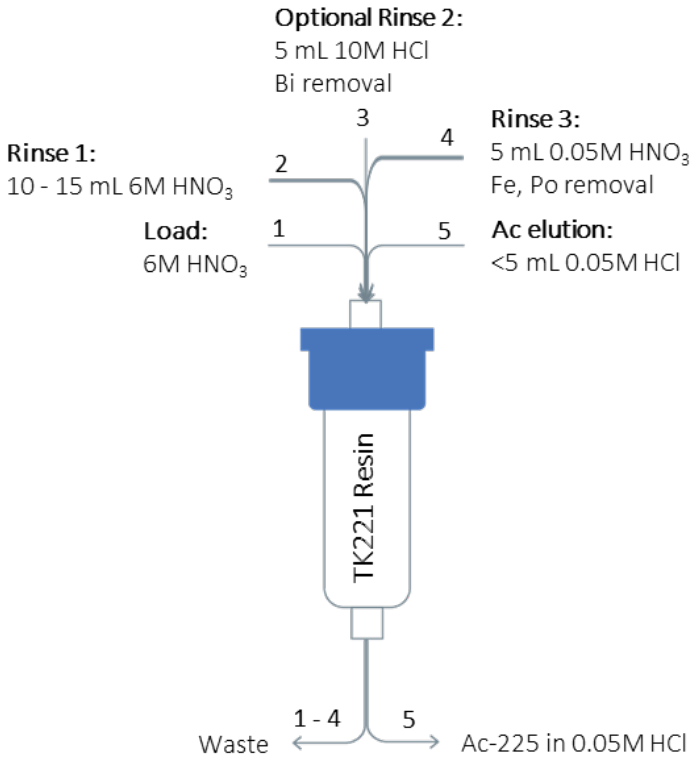
For DGA separation, the decontamination factors (DFs) for Pu, U, and Th were calculated to be $(1.8 \pm 0.4) \times 10^3$, $(3.0 \pm 1.0) \times 10^4$, and 24±6, respectively.

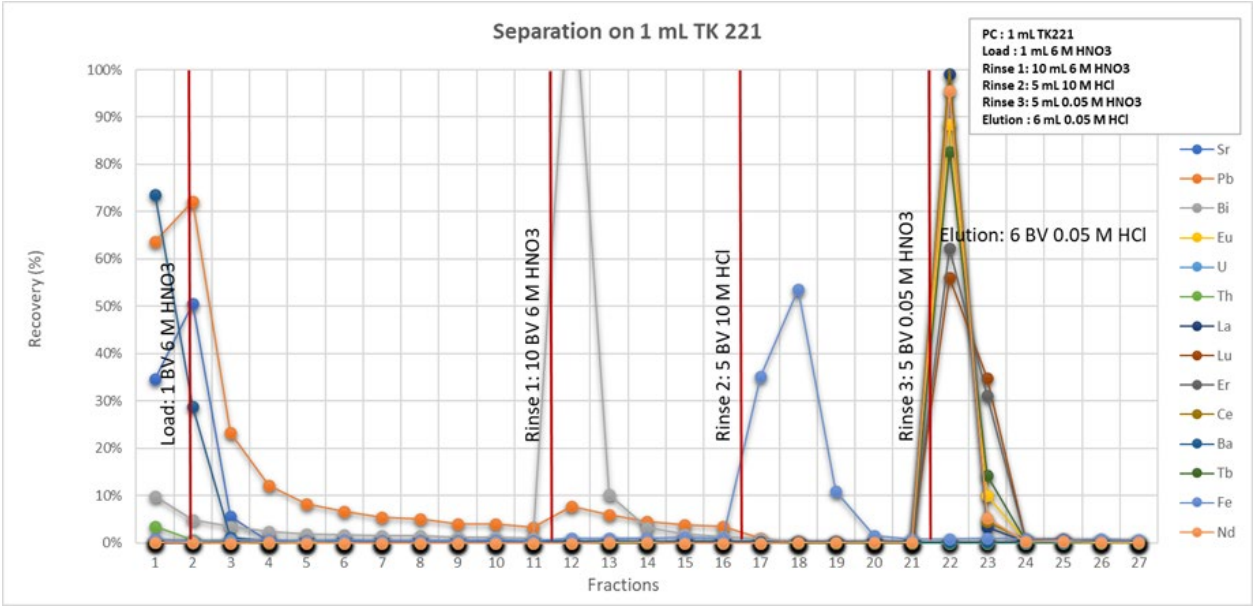
For TK221 separation, the DFs for Pu, U, and Th were $(1.5 \pm 0.2) \times 10^4$, $(2.1 \pm 0.3) \times 10^4$, and $(1.2 \pm 0.1) \times 10^3$, respectively.

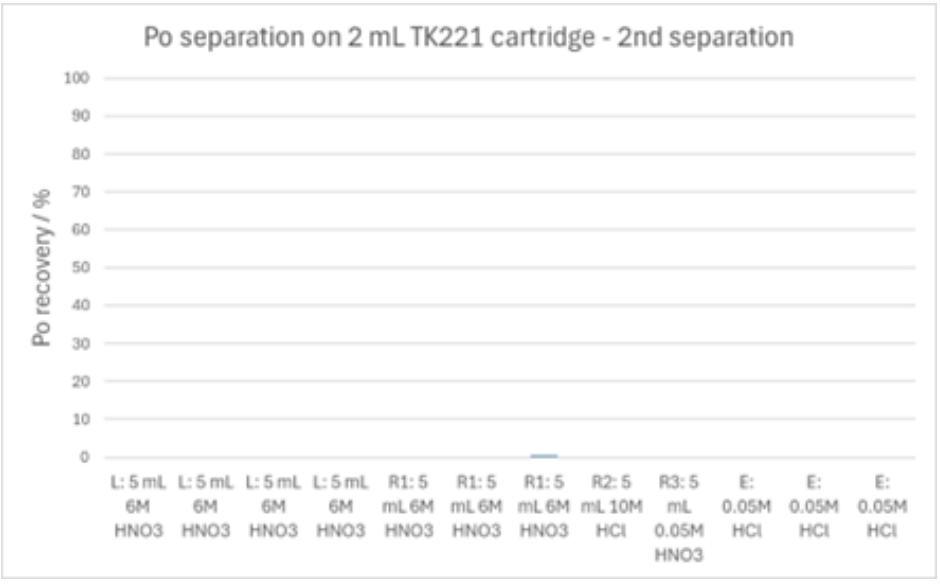
It can be seen that the TK221 resin displayed remarkably better performance for the removal of Pu and Th than DGA resin, while with an excellent decontamination ability of U, close to DGA.

=> Use for Ra-226/8 instead of DGA?

Ac separation => RP presentation
Analytical questions:
bioassay (e.g. BfS) and environment







Load from 2 – 6M HNO_3
Rinse with 6M HNO_3
10M HCl => Bi removal and
0.05M HNO_3 (Fe removal)
Ac elution in 0.05M HCl
Po remains on TK221

Sr-90 in seawater – KAERI method

A simple and straightforward technique for analyzing radionuclides in seawater

18 Apr, 2024

Hyuncheol Kim (hckim3@kaeri.re.kr), **Gahyun Kim** (ghkim97@kaeri.re.kr)

Sr-90 in seawater – KAERI method

Materials and Apparatus

TRISKEM INTERNATIONAL

AMP-PAN (or KNiFC-PAN)

DGA resin

2 mL column



SALT-100 (*WITHTECH Ltd. ; South Korea*)

Eight peristaltic pump
Flow rate: 10 – 100 mL min^{-1}
Applicable with 2 mL/ 5 mL column
https://www.withtech.co.kr/en/busi/new_busiList_5.php



Hidex Q-ARE

Automated Radionuclide Extraction System

Q uick
A utomated
R adionuclide
E xtraction

The most advanced automated radionuclide extraction chromatography system dedicated to radionuclide separation from environmental, food and decommissioning samples.

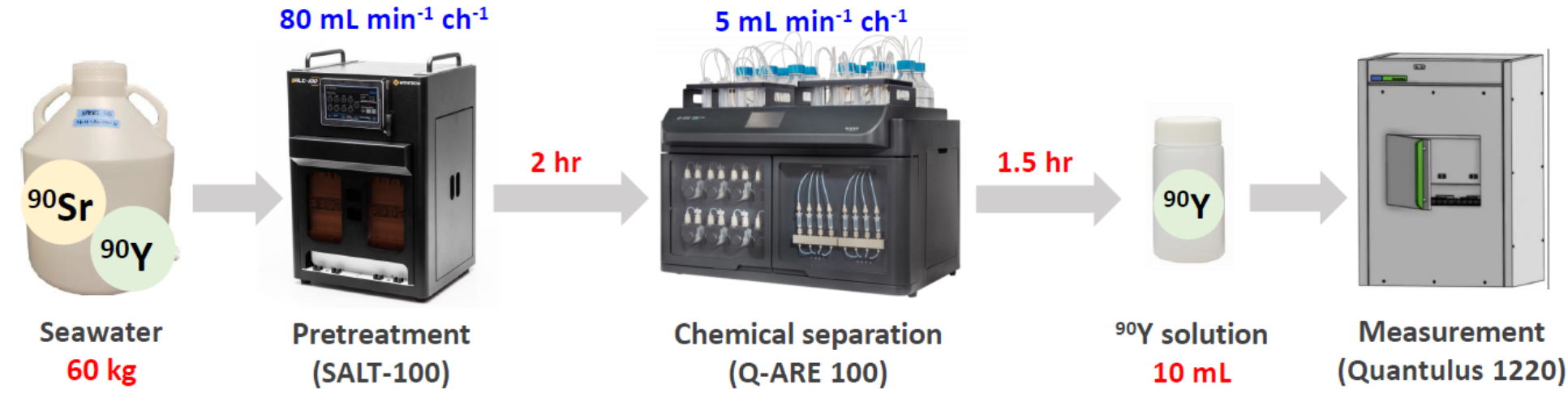
Quick and easy-to-use unattended radionuclide extraction

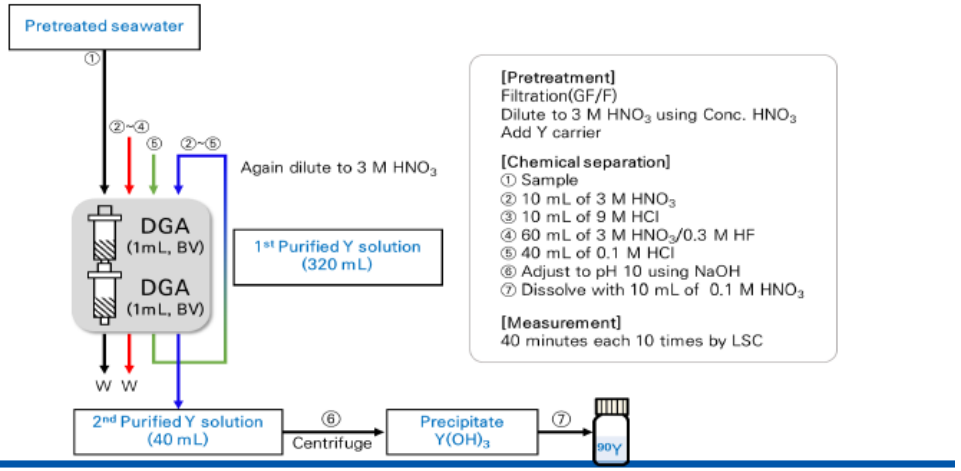
User friendly, intuitive and hassle free.

https://www.hidex.com/

Sr-90 in seawater – KAERI method

^{90}Sr in seawater; procedure





- Separation & sample prep ~4h (w/o measurement)
- Typically >85% yield
- Presentation by Hyuncheol Kim at the TrisKem / Raddec Workshop, 18.04.2024
- Presentation and video available on our website

Sr-90 in seawater – KAERI method

- Rapid automized separation of Y-90 from sea water (60 kg)
  - Aim: determination of Sr-90
  - Faster than standard methods
- Potential drawback: Sample needs to be adjusted to 3M HNO_3
  => large amounts of conc. HNO_3
- Ongoing: TO-DGA based resin to allow loading from lower HNO_3

=> ‘TK227 Resin’

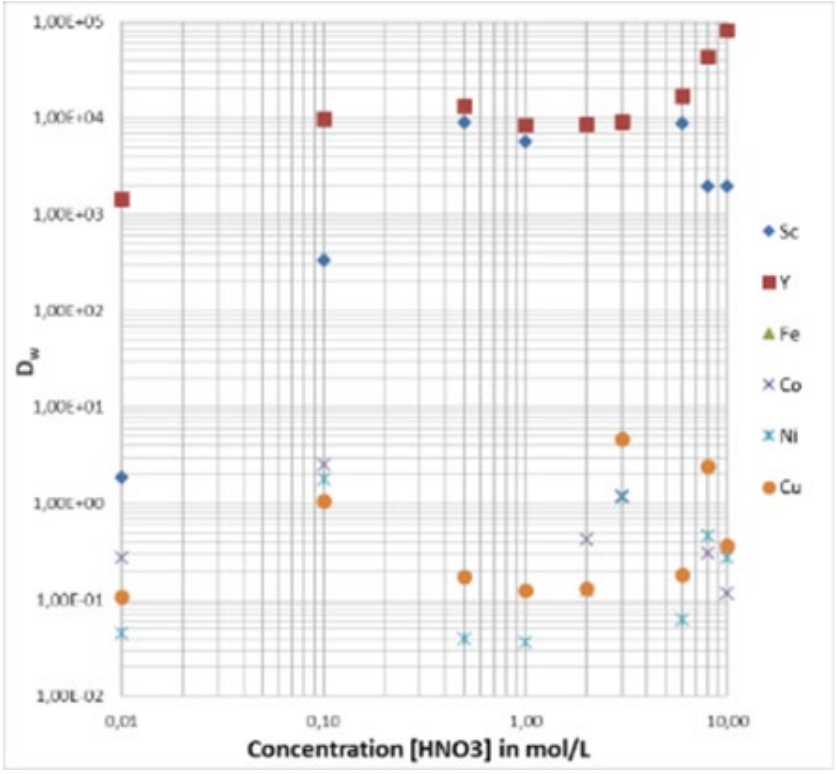
- Similar approach for Am possible?
- SALT / Q-ARE approach also for used Cs-134/7 via AMP-PAN

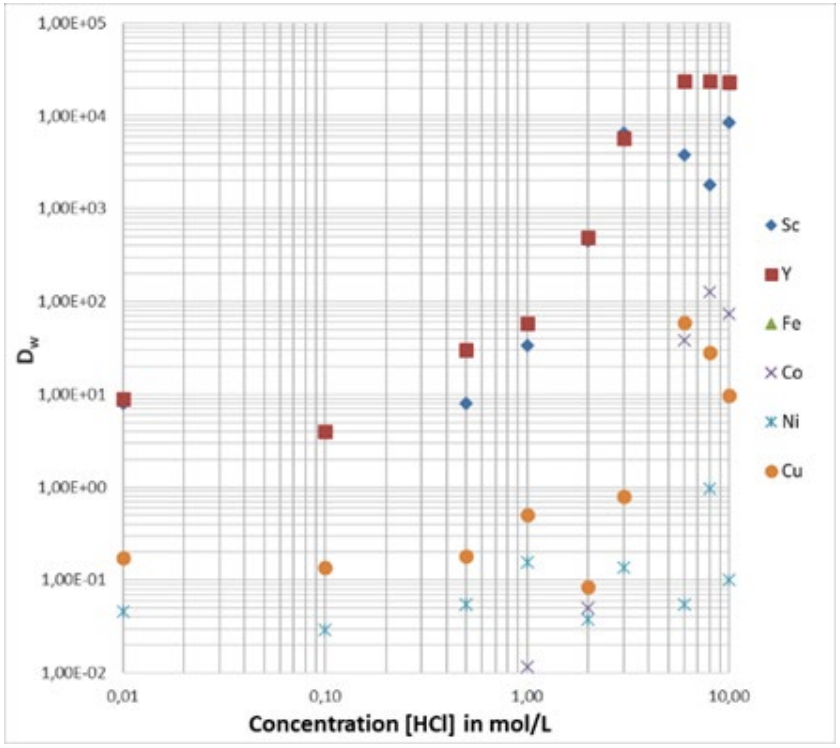
TK227 Resin

Addition of ionic liquid increased Y retention (idem e.g. lanthanides, especially heavy lanthanides) at lower acid concentrations, especially in HNO_3. Also Includes phase stabilizer.

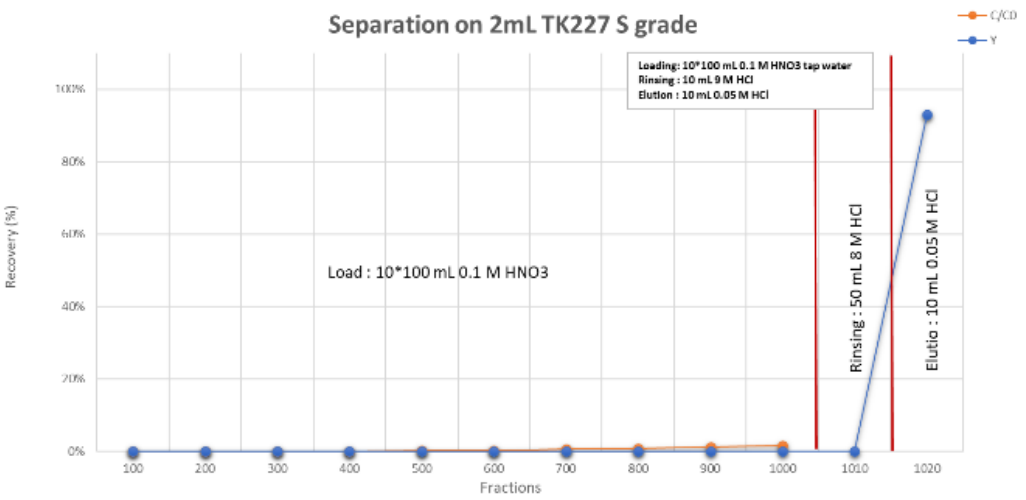
Remark: too high amounts of IL will lead to low elution yields (=> TK225 – large amount of IL – use in decontamination of effluents from radiolanthanides).

Remark: Separation on TK227 optimized for mg amounts of carrier.

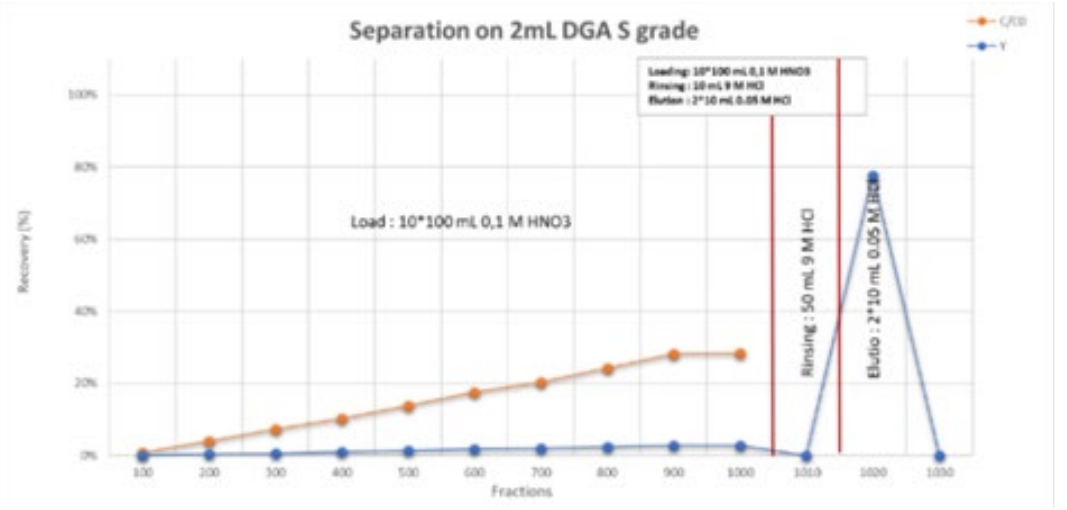




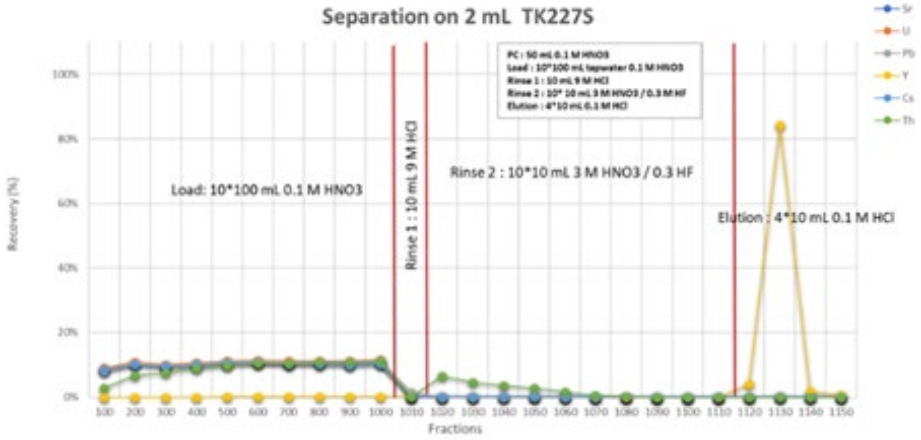
TK227 Resin – drinking water



Elution study, 1L tap water, loading from 0.1M HNO_3, Y separation, 2mL TK227 Resin cartridge



Elution study, 1L tap water, loading from 0.1M HNO_3, Y separation, 2mL DGA,N Resin cartridge



Elution study, 1L tap water, Loading from 0.1M HNO_3, Y separation, 2mL TK227 Resin cartridge, selected elements

Y retention on TK227 from 1L 0.1M HNO_3

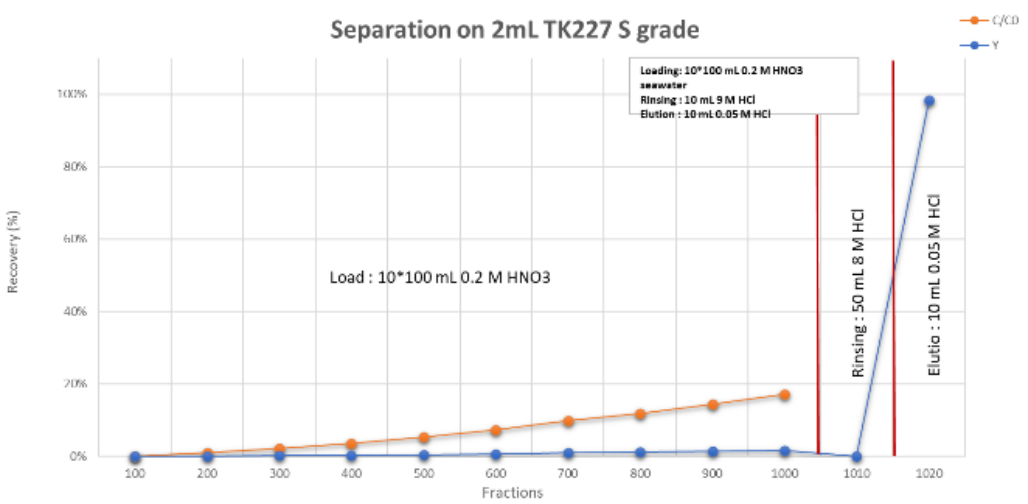
Loading at 10mL/min

Separation from interferences following Kim et al.

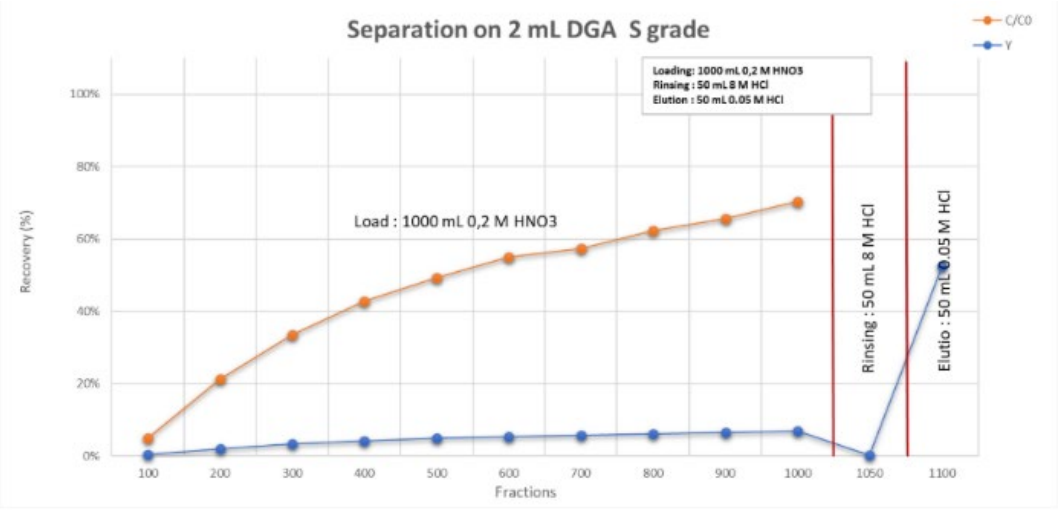
Rapid method for Sr-90 in water?

Use of scintillating beads (PSm)?

TK227 Resin – sea water



Elution study, 1L sea water, loading from 0.2M HNO_3, Y separation, 2mL TK227 Resin cartridge



Elution study, 1L sea water, loading from 0.2M HNO_3, Y separation, 2mL DGA,N Resin cartridge

- Sea water requires high HNO_3 concentration for Y retention (at least 0.2M, better higher)
- Loading at 10mL/min
- On TK227 Resin Y breakthrough when loading 1L (<20%) but less than DGA,N (~70%) => higher HNO_3 required to improve yields
- TK227 Resin use in KAERI method showing better yields but acidification to 2M HNO_3 still needed.

On-going: TK227 Disc



20 % EtOH
0,5 M HNO_3

1 L tap water
0,5 M HNO_3

0,5 M HNO_3
9 M HCl

Y elution
20 mL 0,1 M HCl

Use of 47mm TK227 Disc instead of cartridges

Surface waters

Filtration set-up

Load from 0.5M HNO3, 1mh Y carrier

Higher flow rate: 10 – 15mL/min

Y-90 retained

Quantification via:

Cerenkov (Disc in vial + 20mL water)

LSC (Disc in vial + 10mL each water and cocktail or cocktail only)

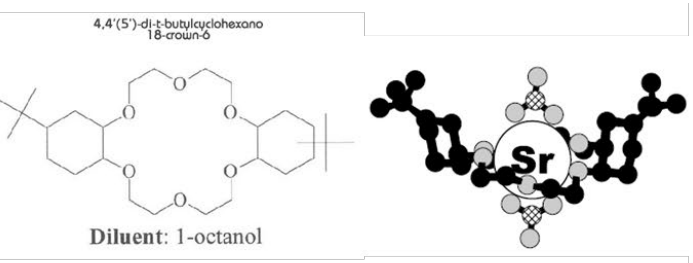
Disc elution with 0.1M HCl (currently 40mL) measurement via Cerenkov or LSC

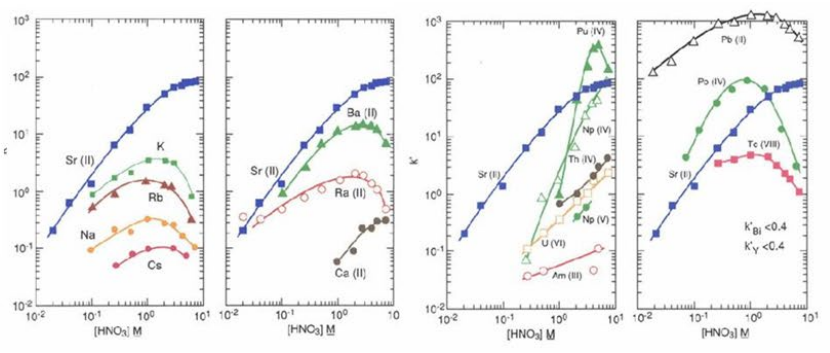
To be tested: direct measurement of the Disc via GPC

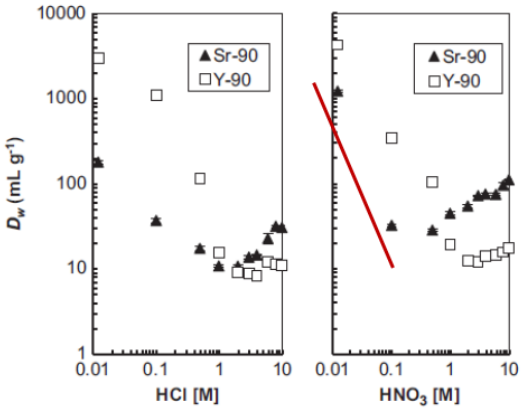
TK100/1 Resins

Based on same crownether as SR Resin

- Different solvents, Sr and Pb uptake also between pH 2 and 7
- Concentration and purification on same column







Typical applications:

- Pb-210 in water samples (up to > 5L per 2 mL column/cartridge)
- Sr-90 by ICP-MS (very high Zr-90 decontamination) => NPL
- Ra-226 by ICP-MS => NPL (Load and purification in one step)
  - Agilent application note

TK100 Resin

Development for measurement of ^{90}Sr and ^{226}Ra by Russel and Van Es from NPL

Rapid Analysis of Radium-226 in Water Samples by ICP-QQQ

Application Note

Nuclear, environmental

https://www.agilent.com/cs/library/applications/8800_ICP-MS_5991-8324EN_radium_analysis.pdf

Authors

Ben Russell[1], Elsje May van Es[1,2], Glenn Woods[3], David Read[1,2]

1. National Physical Laboratory, Teddington, UK

2. Chemistry Department, University of Surrey, Guildford, Surrey, UK



Applied Radiation and Isotopes 126 (2017) 35–39

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

Development of an optimised method for analysis of ^{90}Sr in decommissioning wastes by triple quadrupole inductively coupled plasma mass spectrometry

B. Russell*, M. García-Miranda, P. Ivanov

National Physical Laboratory, Hampton Road, Teddington, TW11 0LW, UK

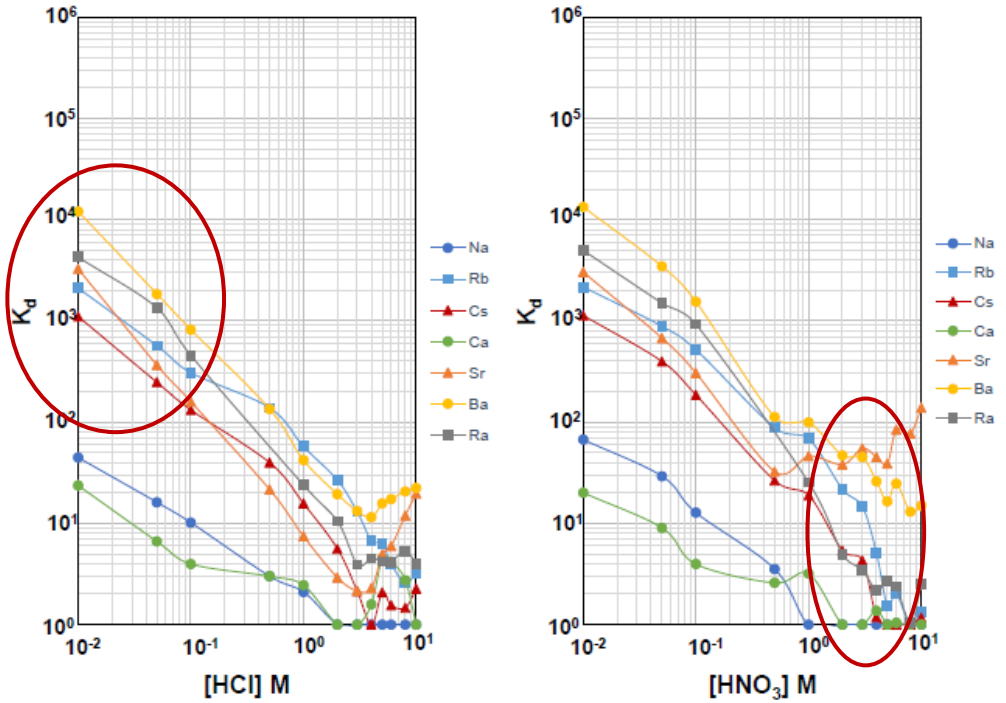
TK100 contains HDEHP

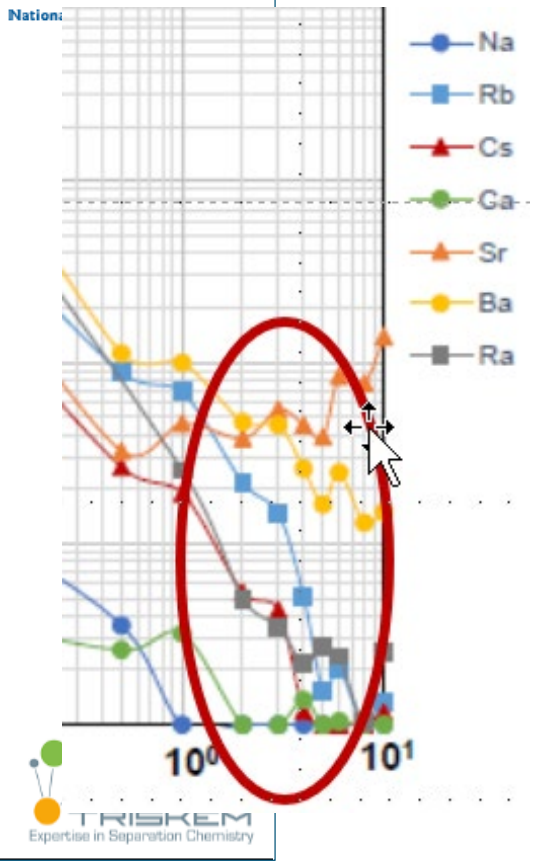
⇒very high Zr retention => high Zr decontamination

⇒ Sr elution in ≥0.5M HCl

TK101 - Radium

TK101 Group 1 and 2

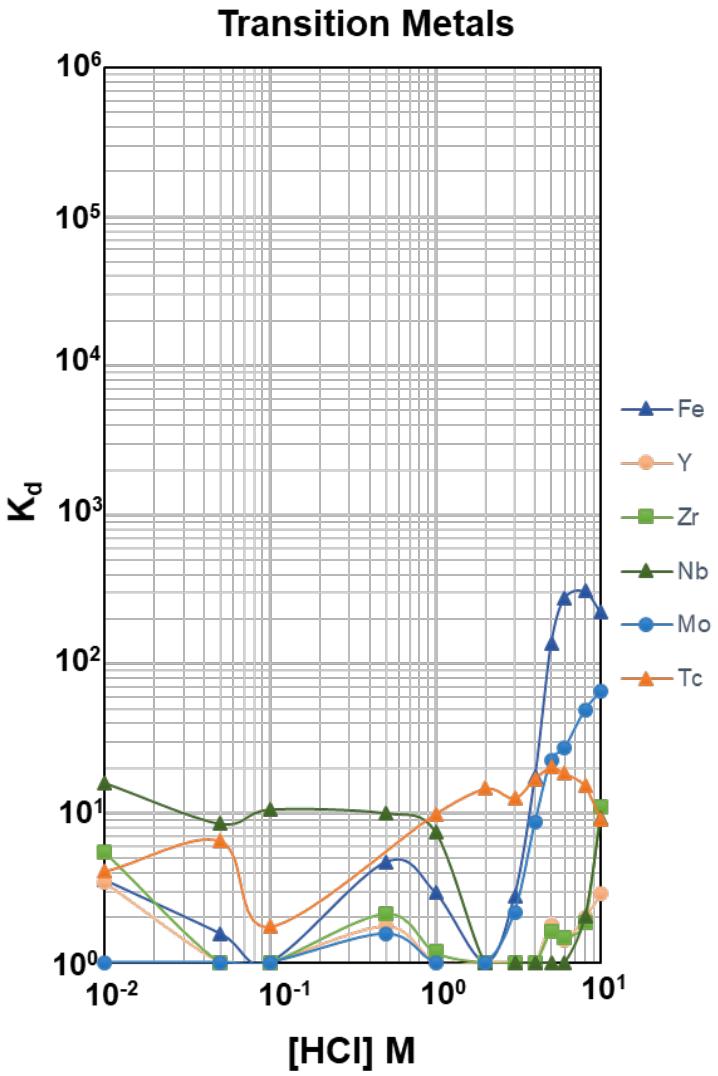


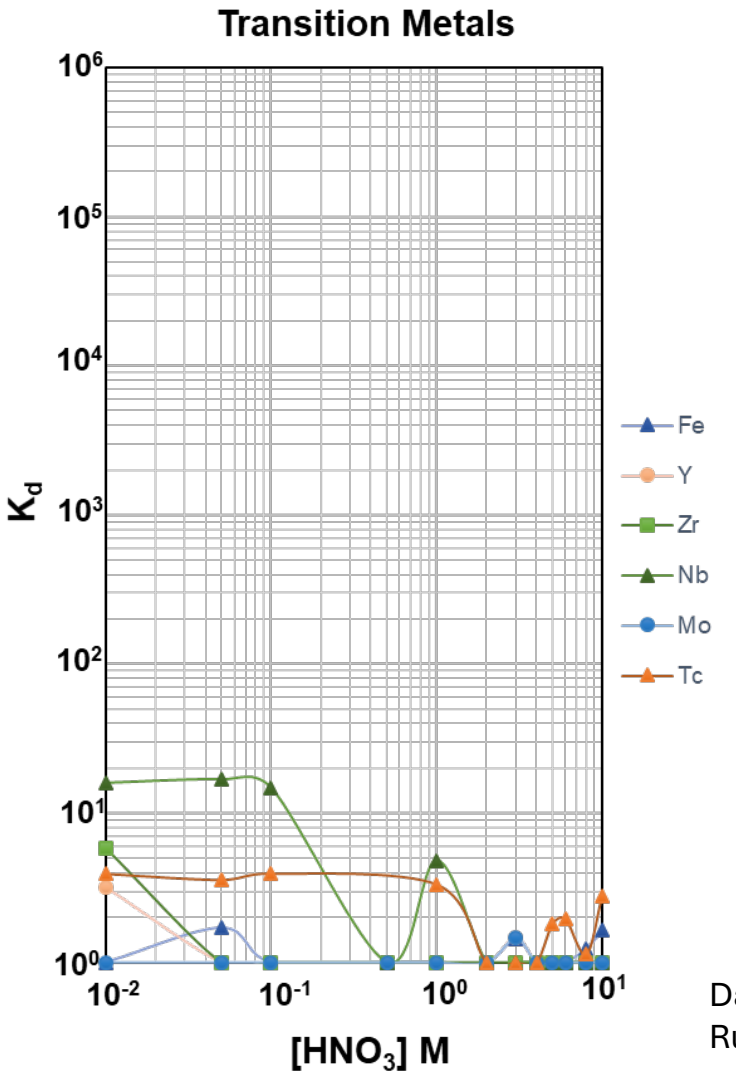


Data provided by Russel et al. (NPL)

- Ra retention from water/dilute acid up to ~0.5M HNO_3/HCl
- At higher conc. selectivity closer to SR Resin/TK102 Resin

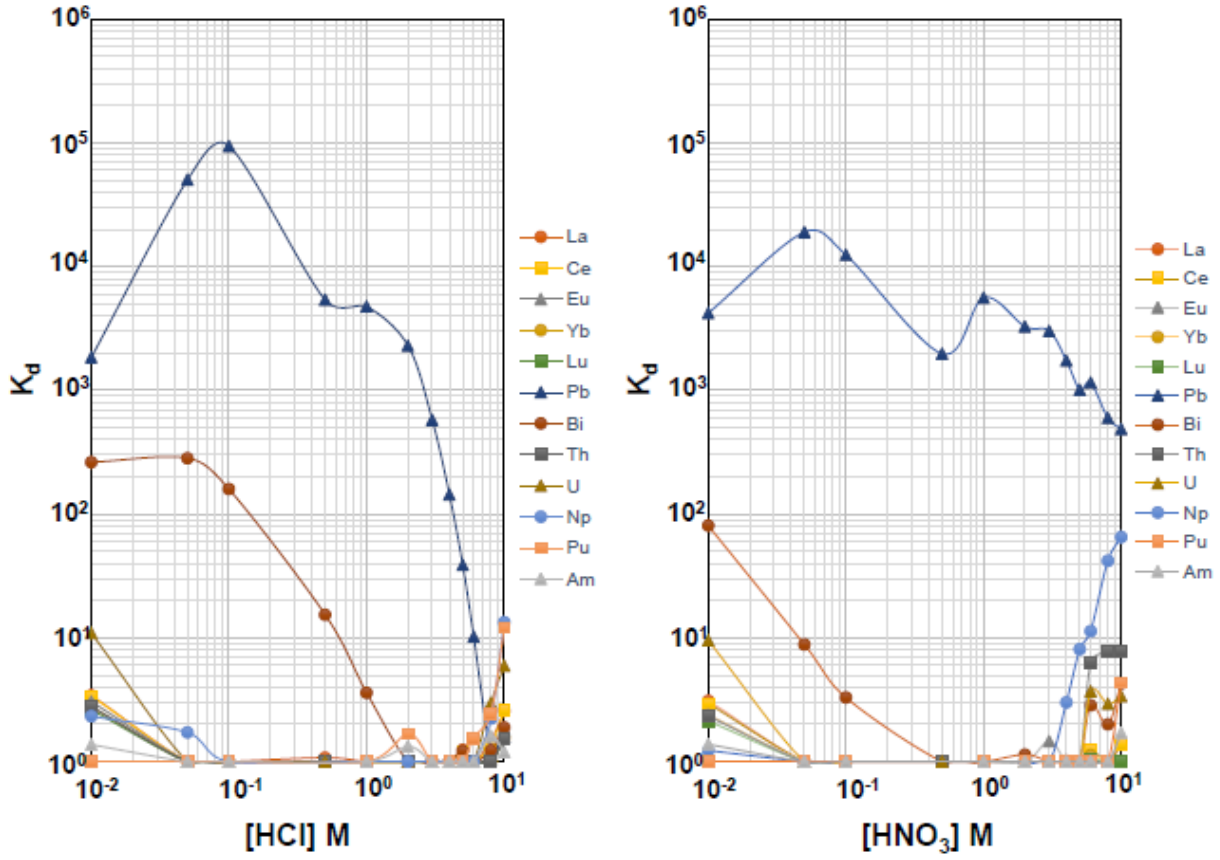
TK101 Transition Metals





Data provided by Russel et al. (NPL)

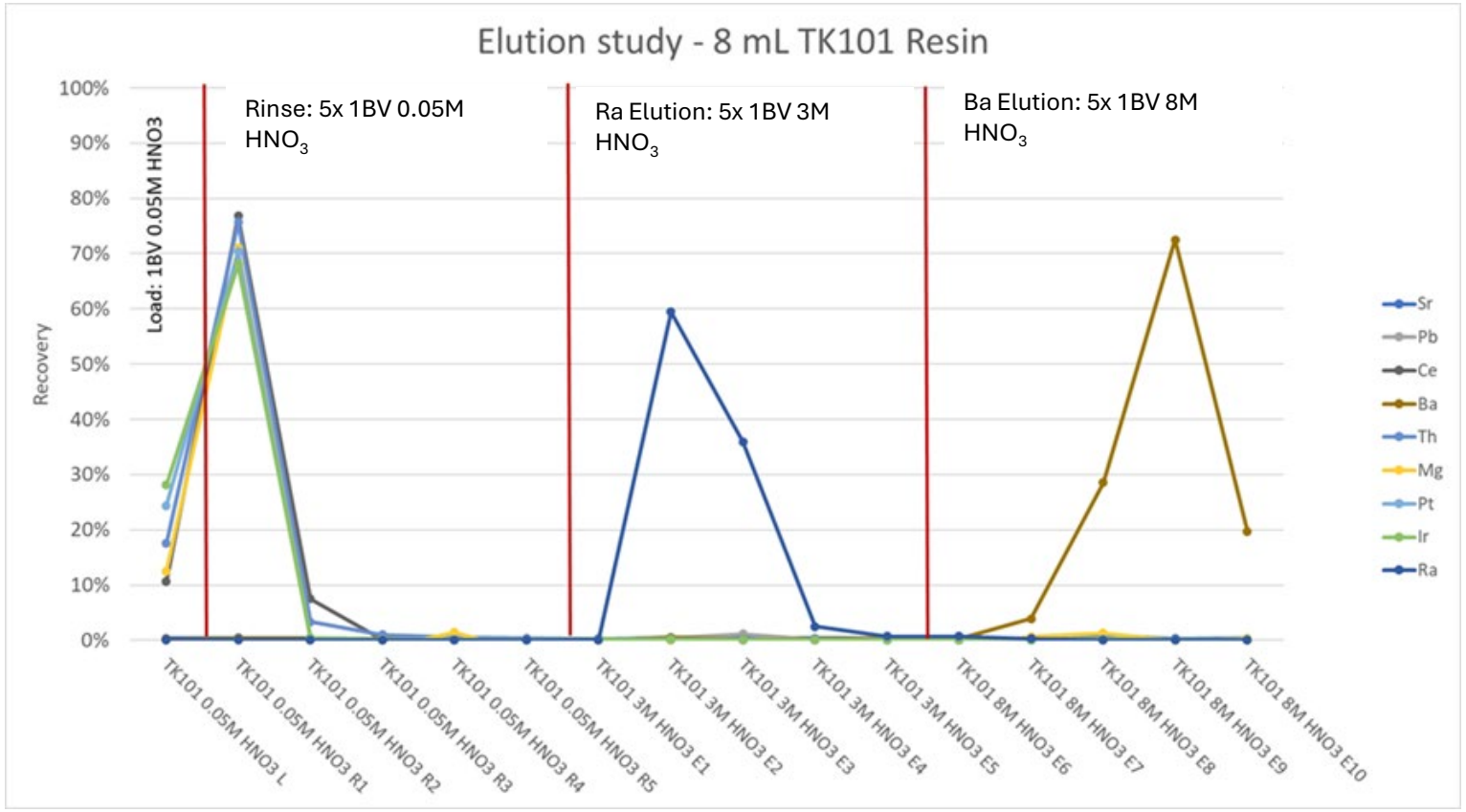
TK101 - Ra



Data provided by Russel et al. (NPL)

- No / extremely low selectivity for Th/U
- Very strong Pb retention => elution in high HCl or citrate

Ra separation on TK101



Good Ra separation when loading from dilute HNO_3/HCl – up to 300mL per 2mL cartridge

When eluting Ra in 3M HNO_3, Ba, Pb, Sr remain retained

Further Ba removal via TK102 possible

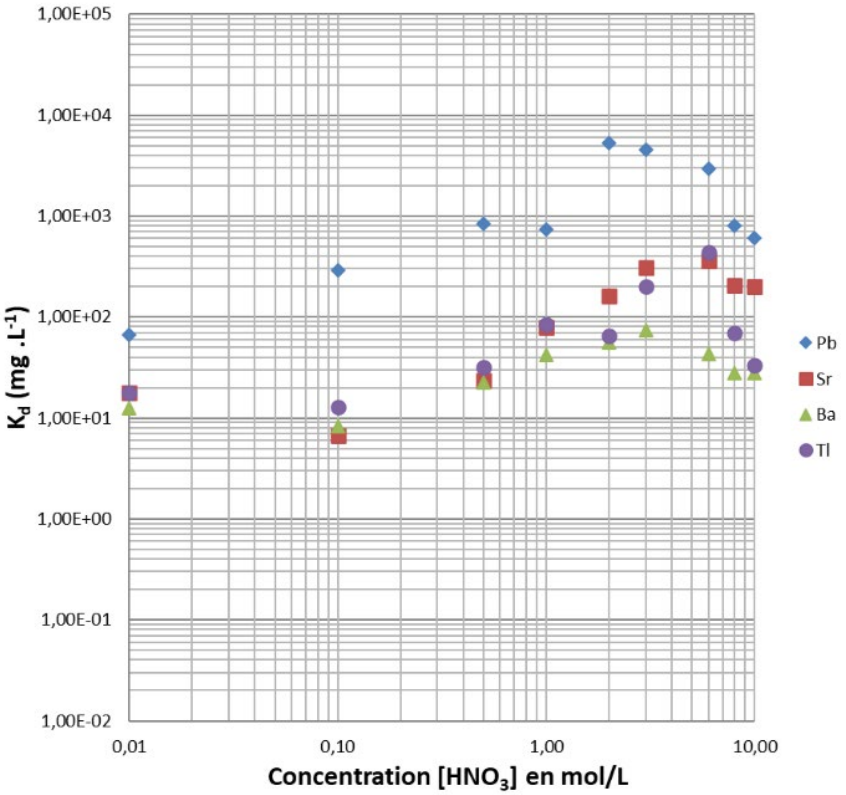
Ra/Ba co-eluted in 8M HNO_3

No retention of U, Th, Pt, Ir,…

TK102 Resin

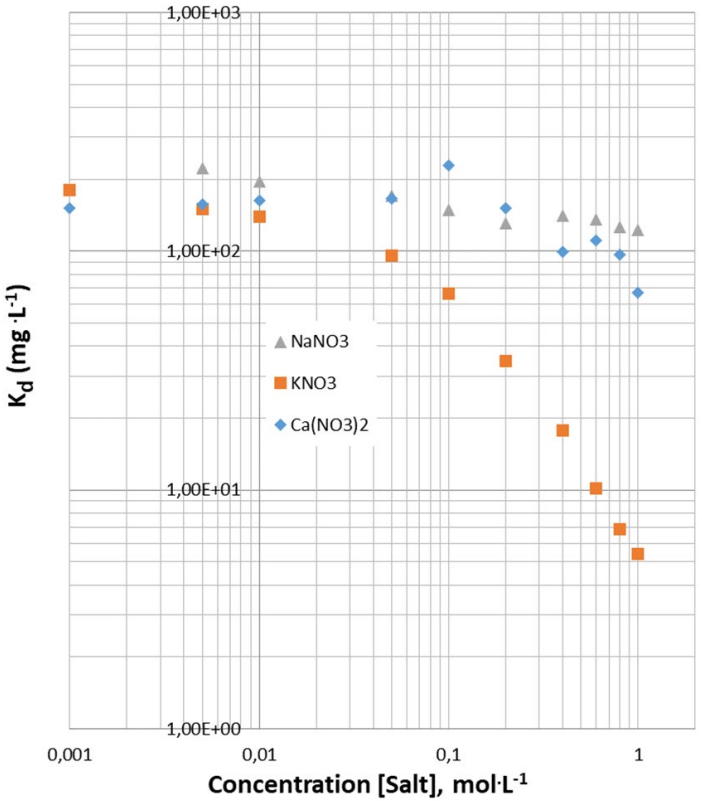
- Modified version of SR Resin
  - Same crown-ether
  - Dliuent, inert support and CE/D ratios => different
  - Higher Sr, Pb and Ba retention than SR Resin
  - Less bleeding of organic materials
  - Generally higher D_W and capacity for Sr, Pb and Ba
- Work by Illarion Dohvyi (Poster during ERA14), Marine Bas, Soumaya Khalfallah, Nora Vajda, Steffen Happel
- Optimized for Ra/Ba separation => main use
- Under testing: use in Sr isotope ratios via TIMS (less bleeding) and decommissioning samples

TK102 Resin - Determination of Kd values



Distribution coefficients of selected elements on TK102 Resin in HNO_3

► Sr, Ba, Pb and Tl show high D_W in HNO_3

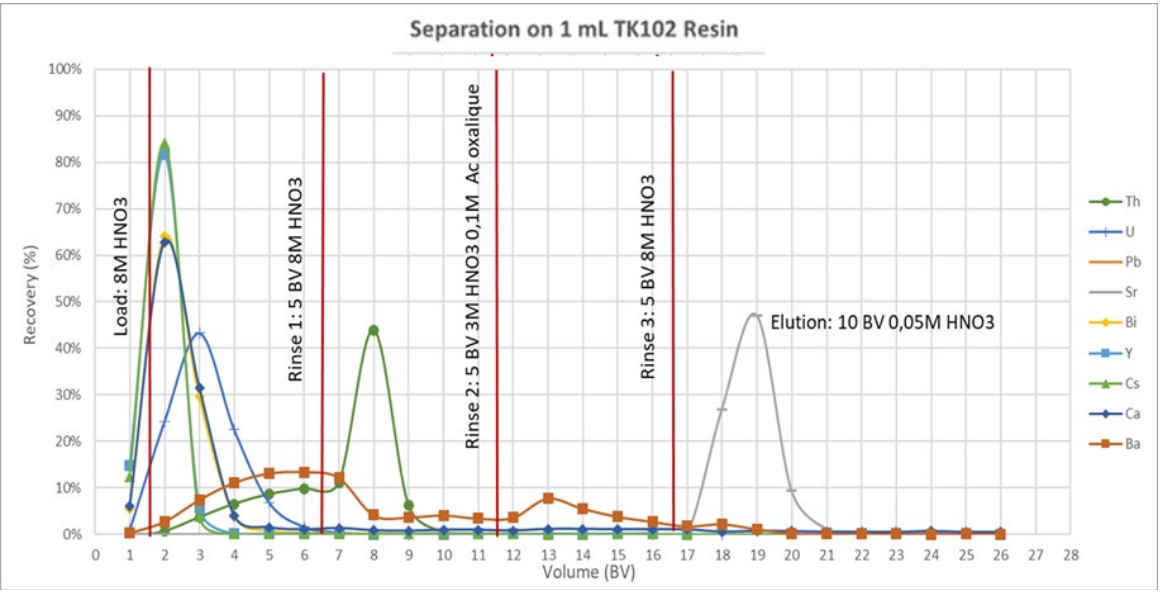


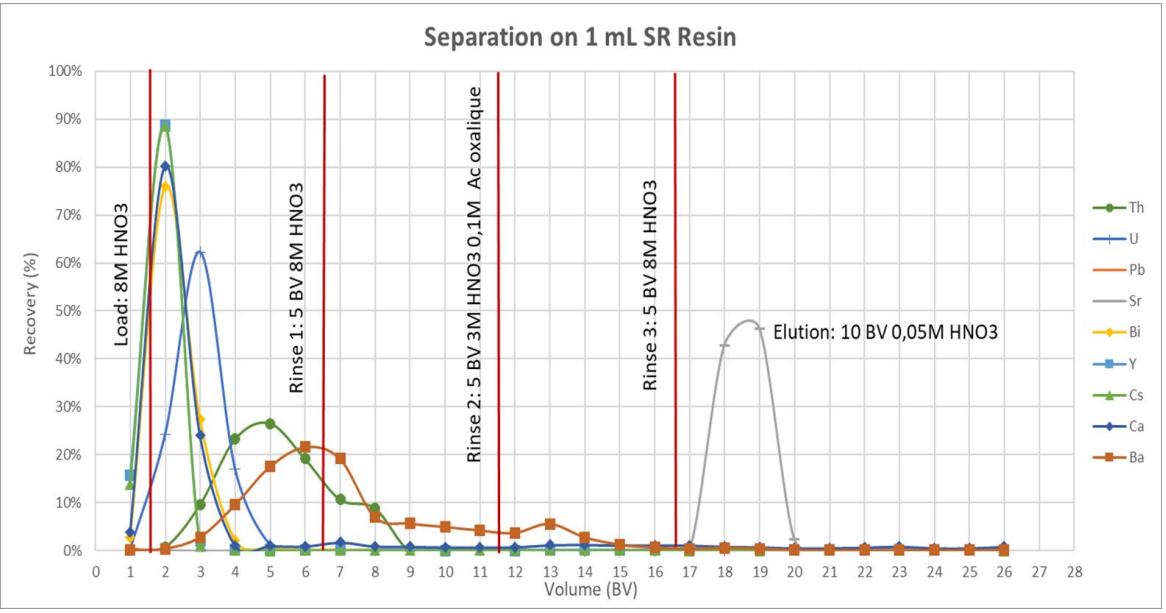
Distribution coefficients of Sr on TK102 Resin in 3 M HNO_3 in the presence of different salts

► D_w Sr decreases by 30% with $NaNO_3$ up to 1 M,

► no effect of KNO_3 and $Ca(NO_3)_2$ up to 0.05 M.

TK102 Resin – Elution curves comparison vs SR Resin - Sr separation

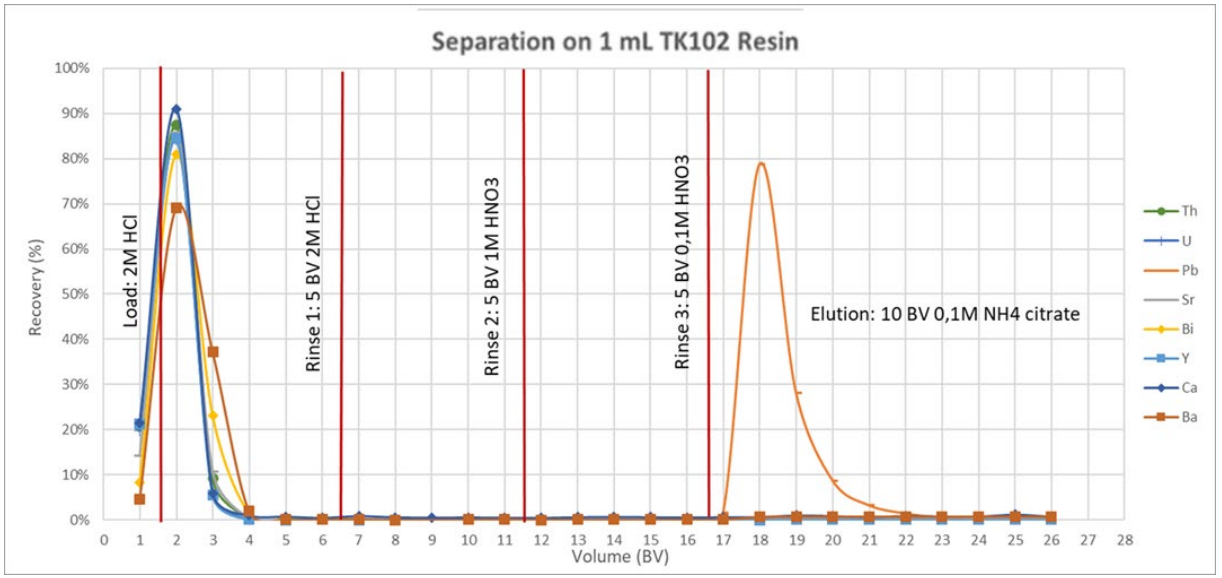


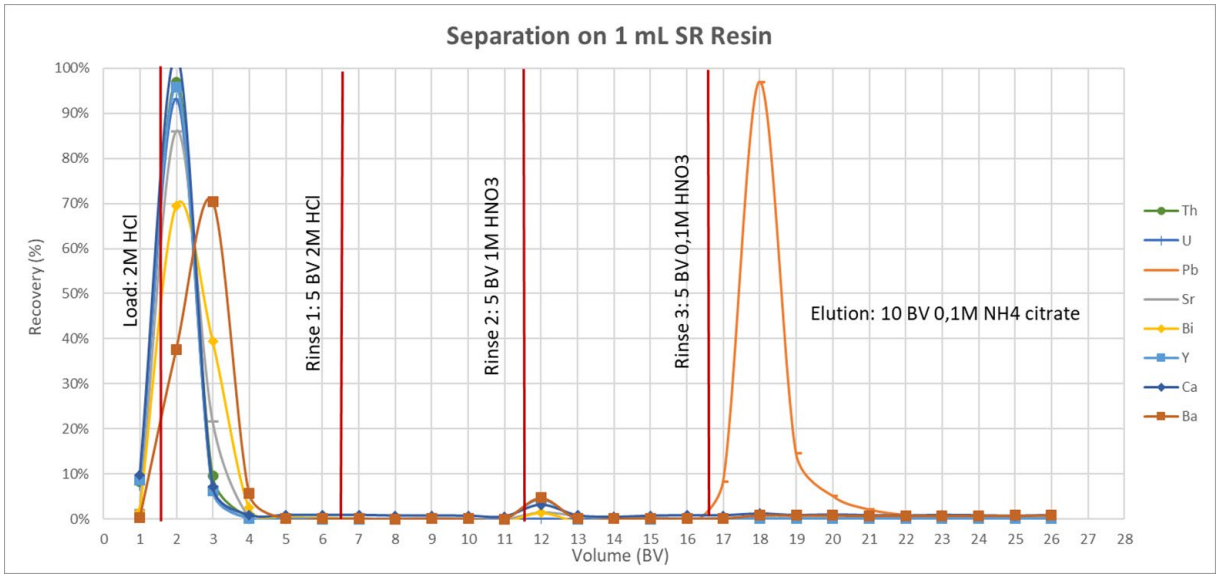


TK102 Resin vs SR resin:
Sr elution study in 8M HNO_3 load medium

Resins TK102 and SR similar for the separation of elements Th/U/Pb/SR/Ca/Bi/Y/Ca and Ba

TK102 Resin – Elution curves comparison vs SR Resin - Pb separation

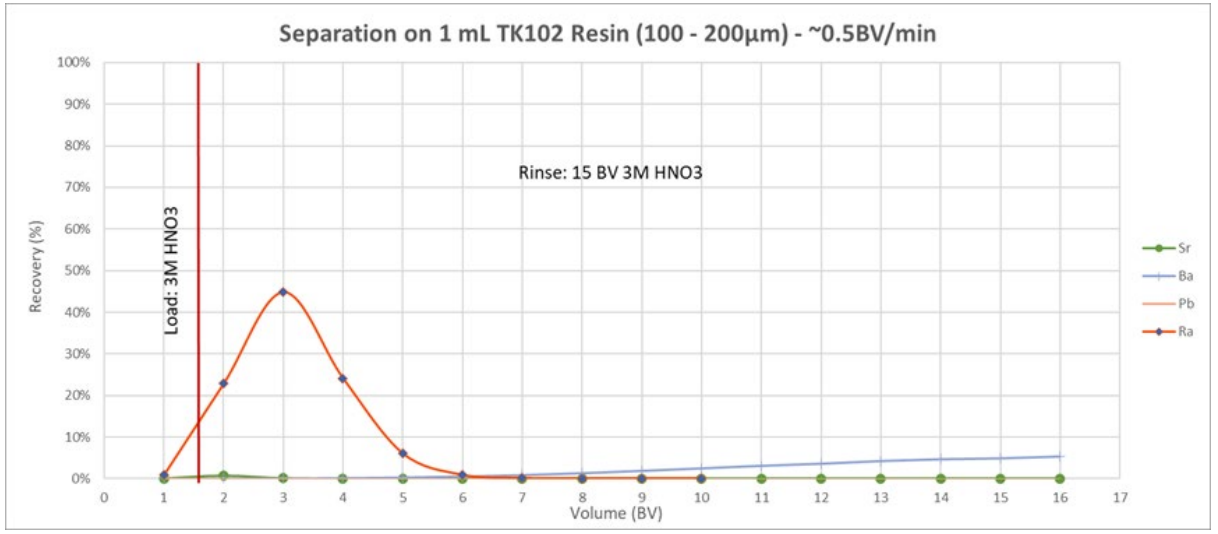


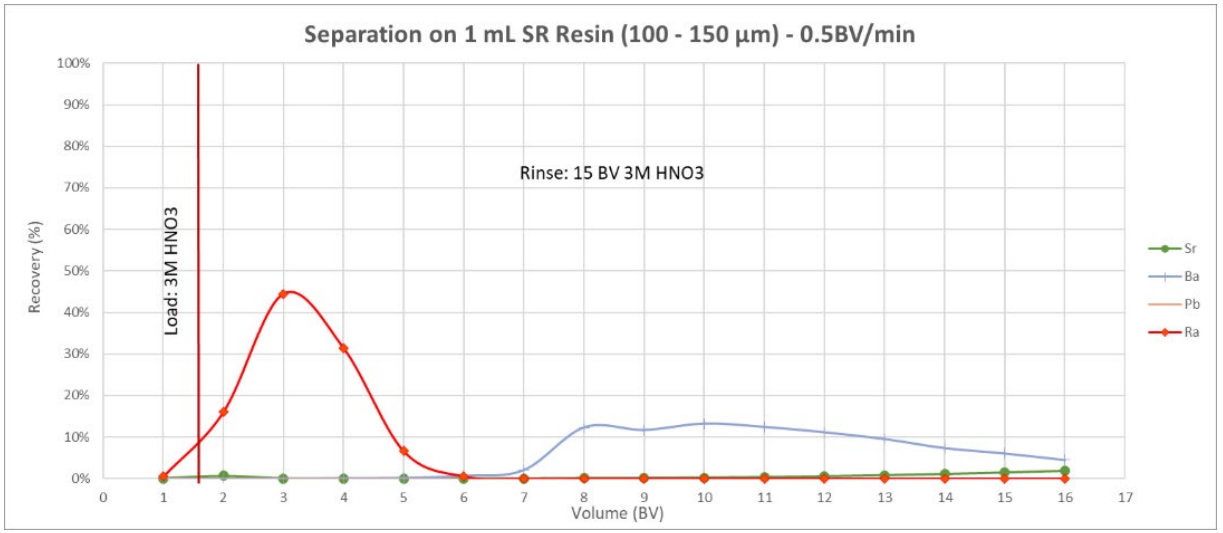


TK102 Resin vs SR resin:
Pb elution study with 2M HCl loading medium

Resins TK102 and SR similar for the separation of elements Th/U/Pb/SR/Ca/Bi/Y/Ca and Ba

Ra/Ba separation

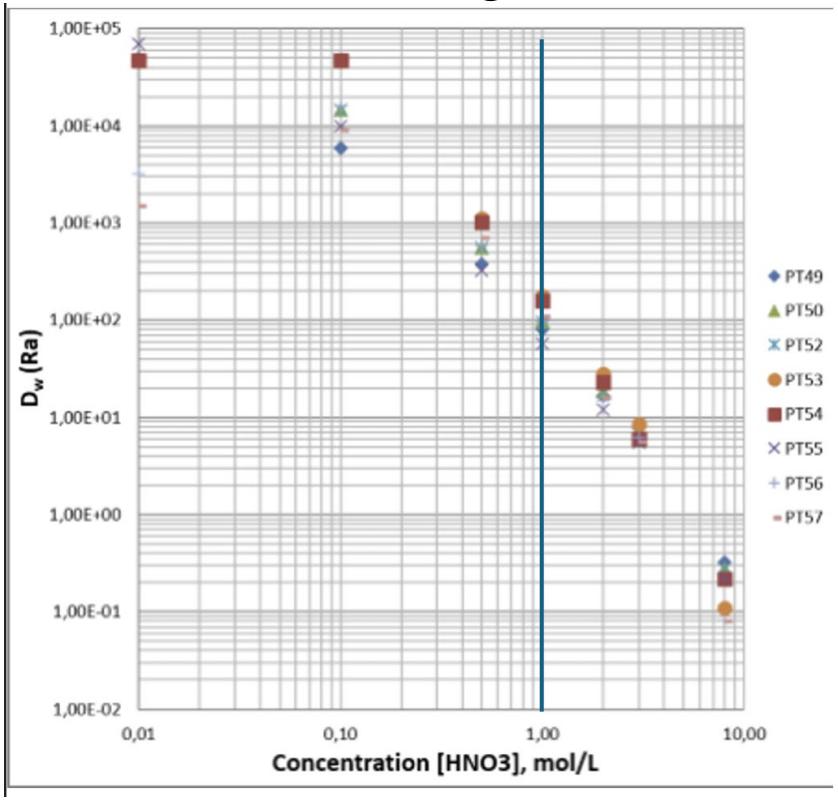




- SR Resin: high Ba breakthrough starts after 7 – 8 bed volumes
- TK102 Resin: significantly lower Ba breakthrough
- Suitable for Ba removal from Ra at 3M HNO_3

Under development: TK103 Resin

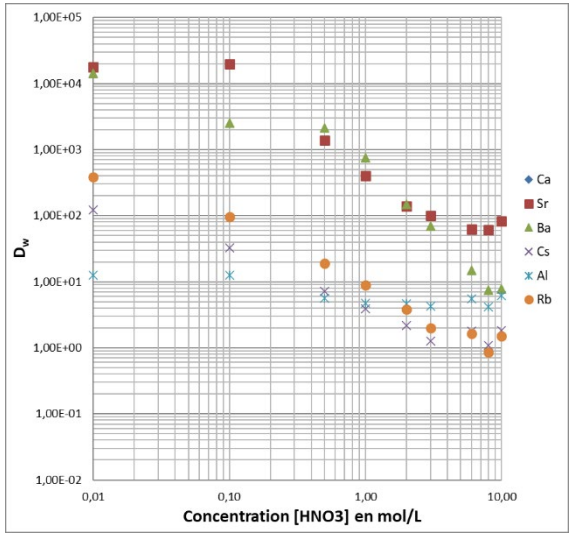
Several PT being tested



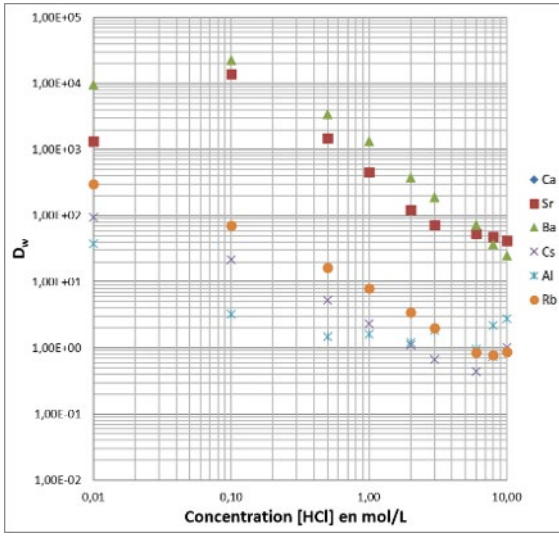
Ra Dw values PT under testing, HNO_3

Improved Ra retention at 1M HNO_3 compared to TK101 Resin

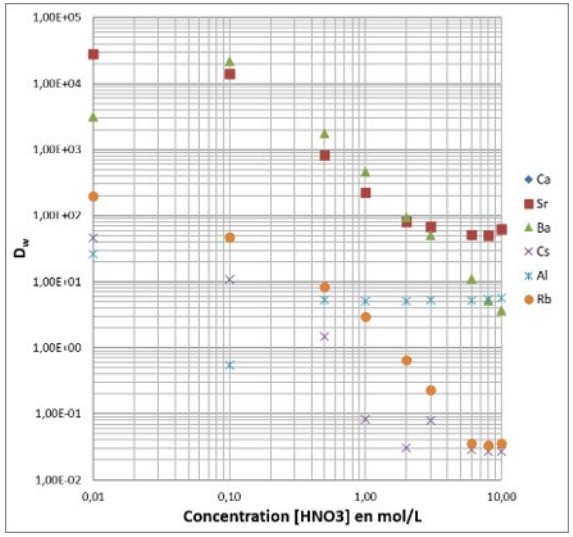
2 PT under further testing (PT 52 and 56), one containing a fluorinated compound, the other does not



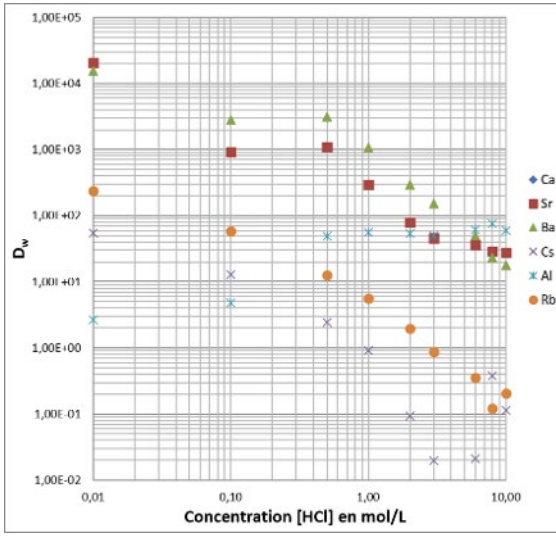
Dw values PT52, HNO_3



Dw values PT52, HCl

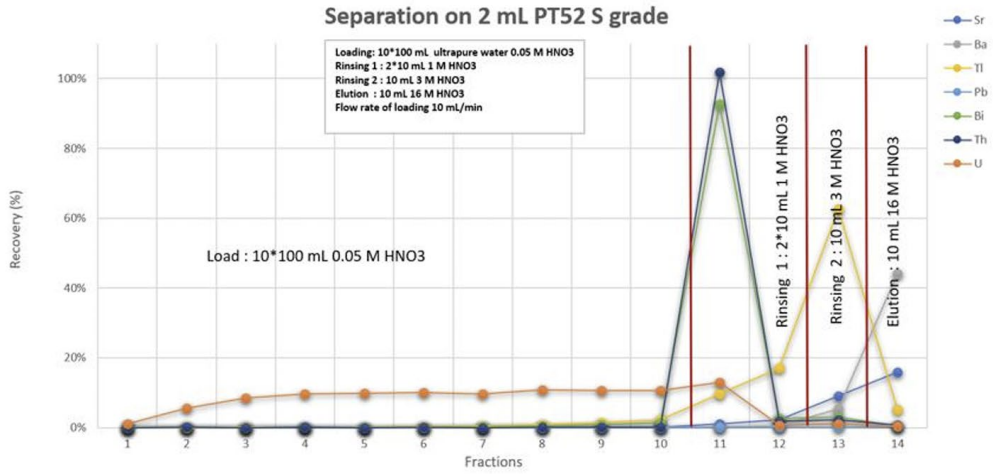


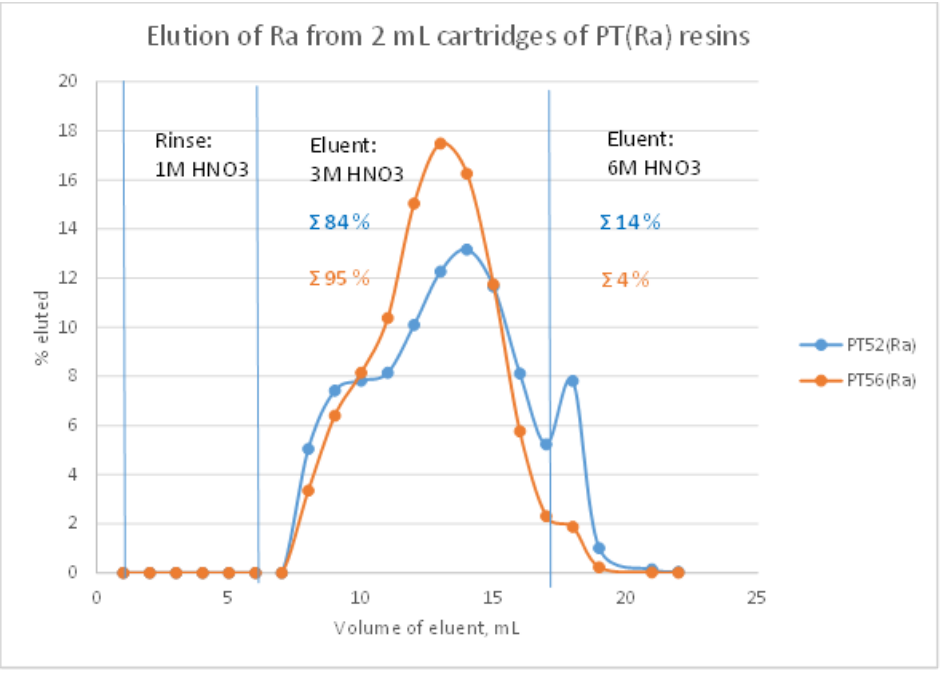
Dw values PT56, HNO_3

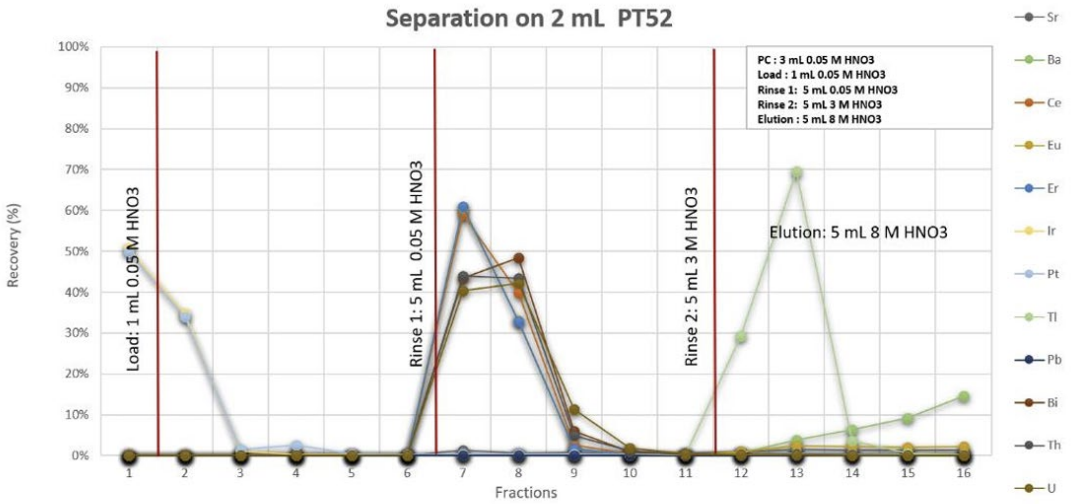


Dw values PT56, HCl

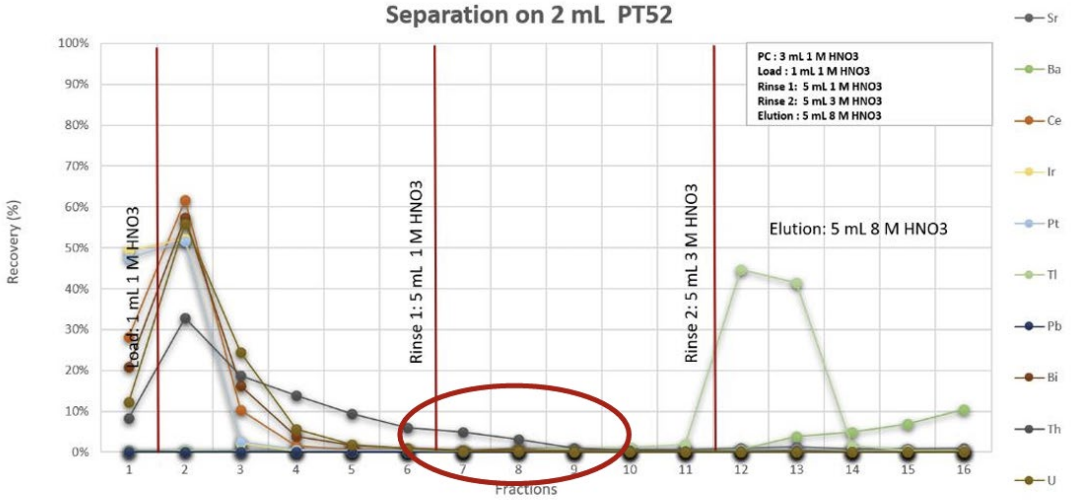
TK103 Resin – elutions studies







PT52



PT52

TK103 Resin

- Choice between 2 PT, probably PT w/o fluorinated compound
  - With fluorinated compound better Ra retention in 1M HNO_3
  - But elution in 3M HNO_3 less sharp
  - PFAS…
  - No difference in selectivity
- Ra uptake from dilute acid to 1M HNO_3
- 1M HNO_3 better than TK101
- High Sr uptake even in low to medium HCl
- In dilute acid it is possible to load 1L of water through a 2mL cartridge
- In dilute acid several RN retained, rince with 1M HNO_3 for RN removal (special attention to Th)
- Ra elution in 10 - 15mL 3M HNO_3 (sharper in higher HNO_3)
- Ba elution requires conc HNO_3 or complexant (e.g. EDTA)
- Next step: TK103 Disc and real samples

Tc-99 separation

Tc-99 (difficult to measure – DTM Radionuclide) – 100% beta emitter

TEVA resin allows for Tc separation but quantitative elution needs highly acidic medium

➢ Other options

TK201 Resin

TK202 Resin

TK200 Resin

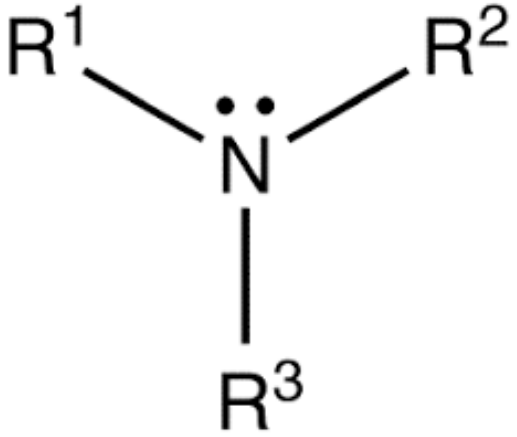
TK-TcScint

TK201 Resin

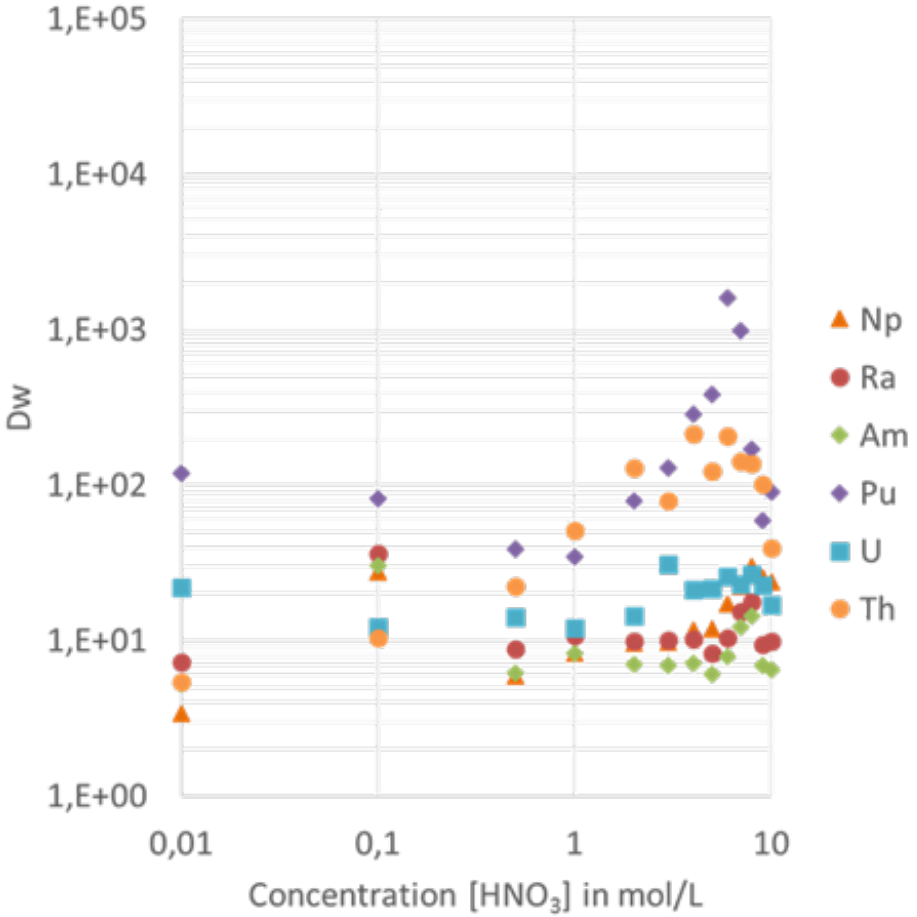
Based on tertiary amine (weak Anion Exchanger) impregnated on inert support

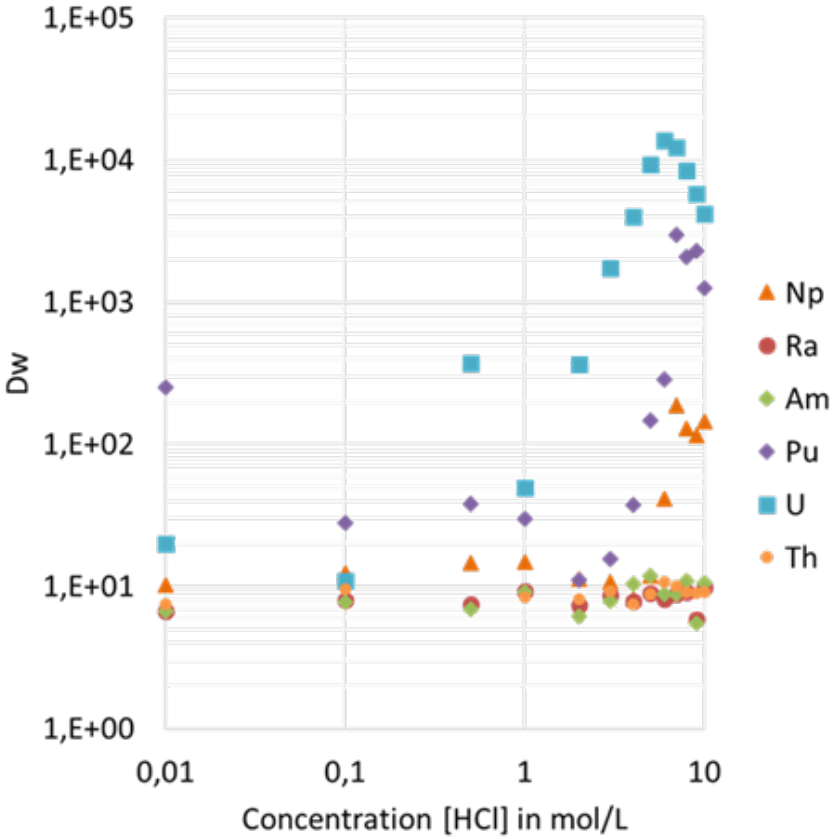
Main applications:

- Tc separation
  - Environmental monitoring
  - Decommissioning
  - Easier to elute
    - Use of NH_4OH or 3M HNO_3
- Cu separation
  - Cu-61/4 from Ni targets
- Zn, Fe separation
  - Geochemistry



TK201 – Actinides



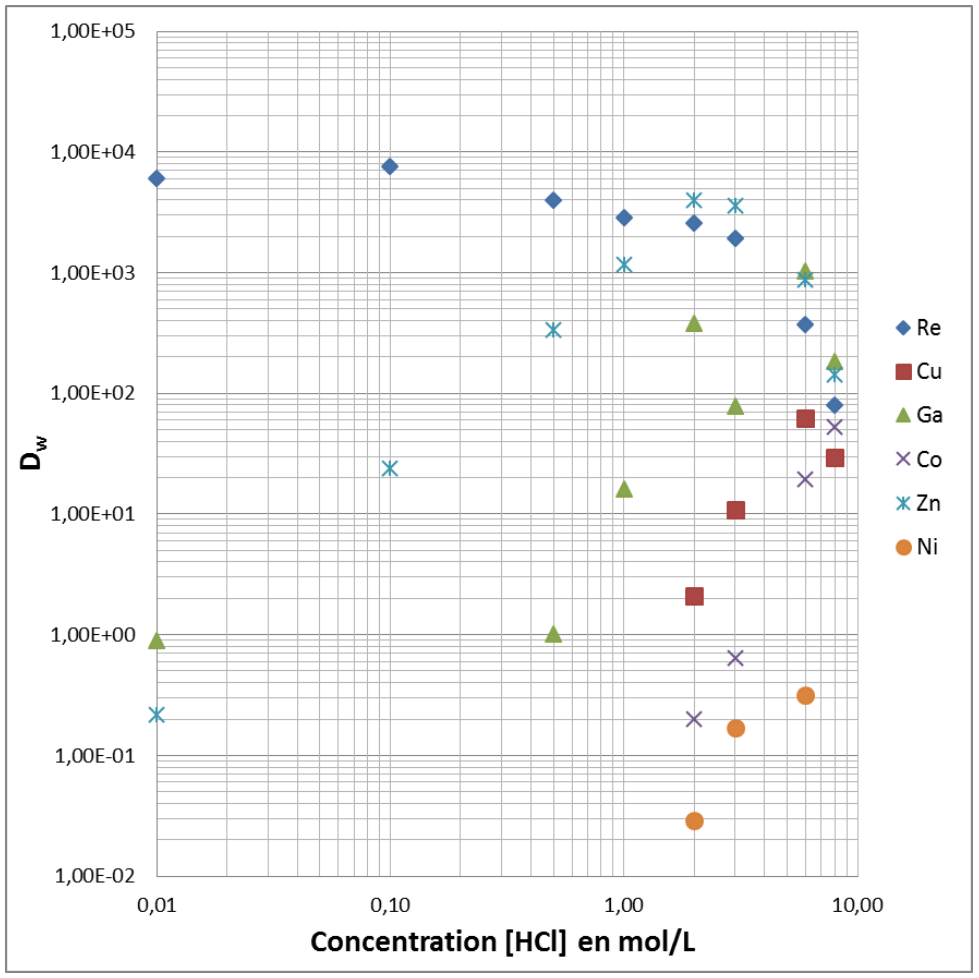


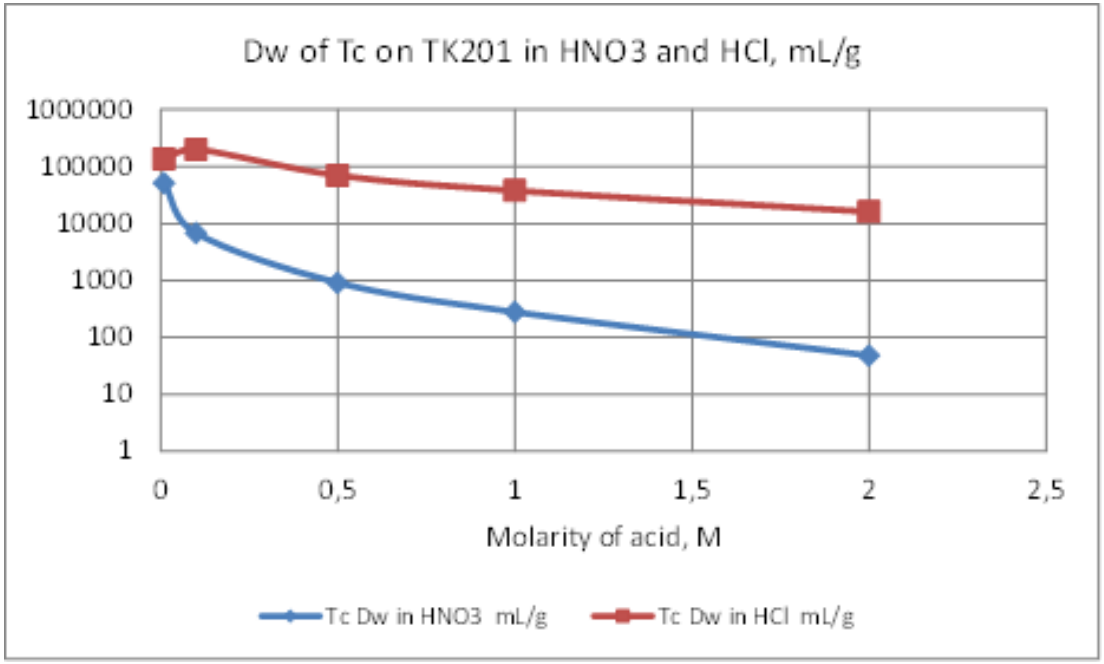
- Re uptake between pH 2 – 5M HCl
- In HNO_3 medium, Re fixed at pH 1-2

- High U and Pu uptake at high HCl
- Elution at low HCl

Data Russel et al. NPL

TK201 – Dw values





Tc well retained at c(HNO_3) <1M

Tc retention significantly higher in HCl

No Mo retention at > 0.7M HNO_3

TK201 Resin – Elution curve

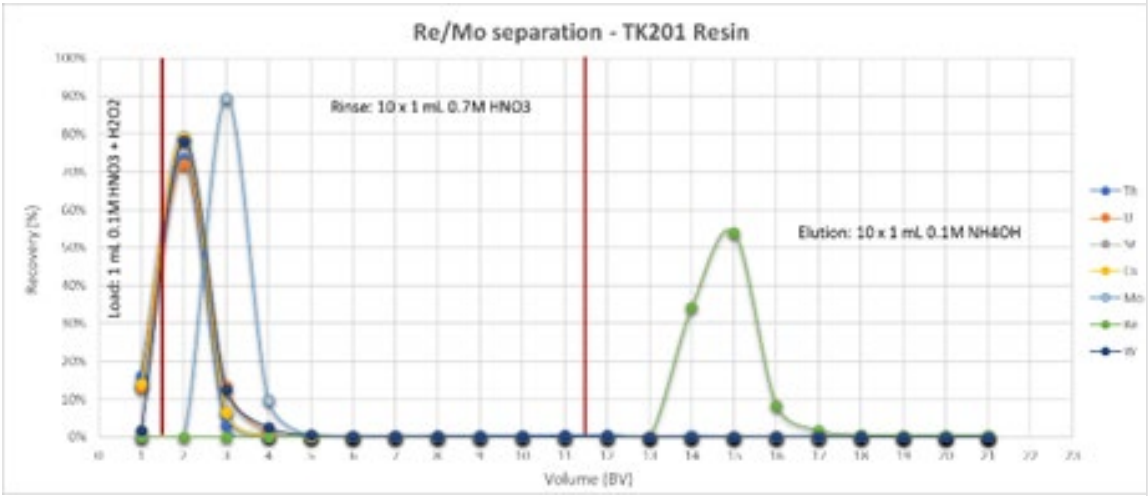
Load of sample at pH 1-2 to retain Re & Tc

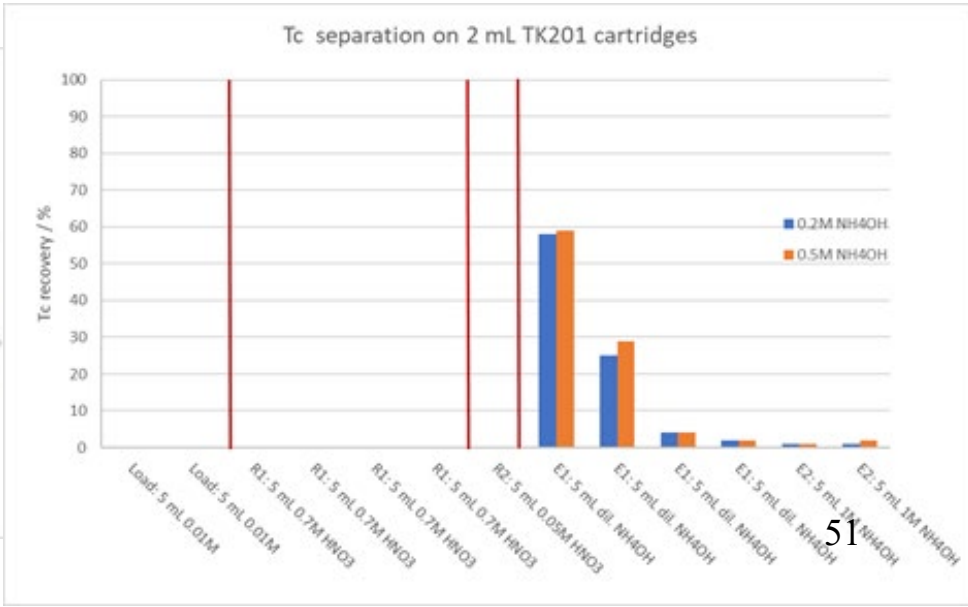
Interferences removed during load/rinse

Mo elution at 0.7M HNO_3

Tc/Re elution in 3M HNO_3

Preferable eluton option: ≥ 0.5M NH_4OH





ACS OMEGA

http://pubs.acs.org/journal/acsodf

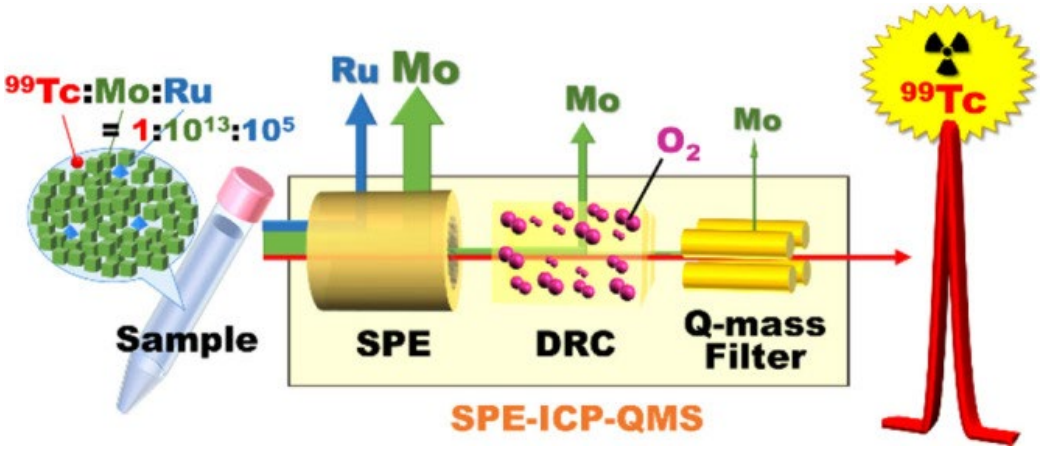
Article

Online Solid-Phase Extraction–Inductively Coupled Plasma–Quadrupole Mass Spectrometry with Oxygen Dynamic Reaction for Quantification of Technetium-99

Makoto Matsueda,* Kayo Yanagisawa, Kazuma Koarai, Motoki Terashima, Kenso Fujiwara, Hironobu Abe, Akihiro Kitamura, and Yoshitaka Takagai*

Cite This: *ACS Omega* 2021, 6, 19281–19290

Read Online



JAAS

ROYAL SOCIETY OF CHEMISTRY

PAPER

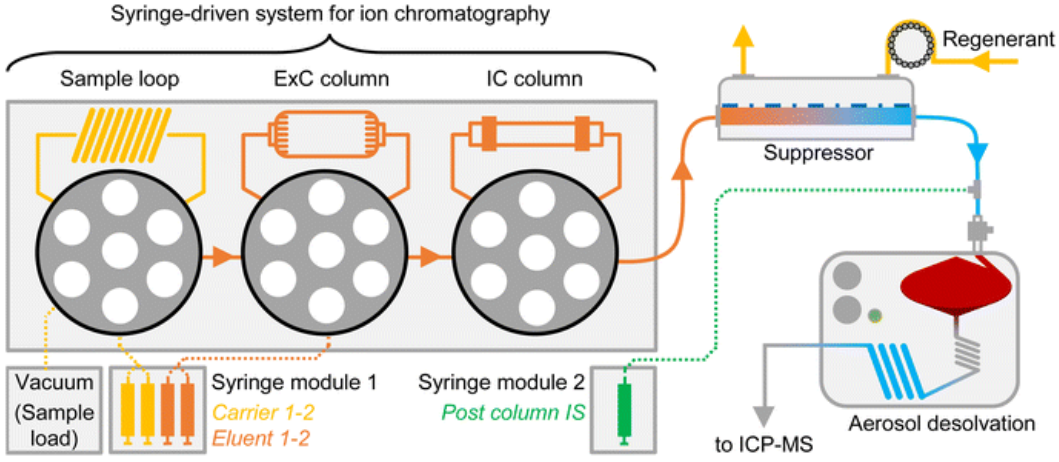
View Article Online
View Journal | View Issue

Check for updates

Cite this: *J. Anal. At. Spectrom.*, 2024, 39, 2774

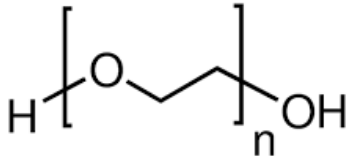
Quantification of technetium-99 in wastewater by means of automated on-line extraction chromatography – anion-exchange chromatography – inductively coupled plasma-mass spectrometry†

Maximilian Horstmann, [a] C. Derrick Quarles, Jr, [b] Steffen Happel,[c] Michael Sperling, [d] Andreas Faust, [e] David Clases [*f] and Uwe Karst [*a]



Second publication including TK201 Discs for higher sample load => better LoD

TK202 Resin

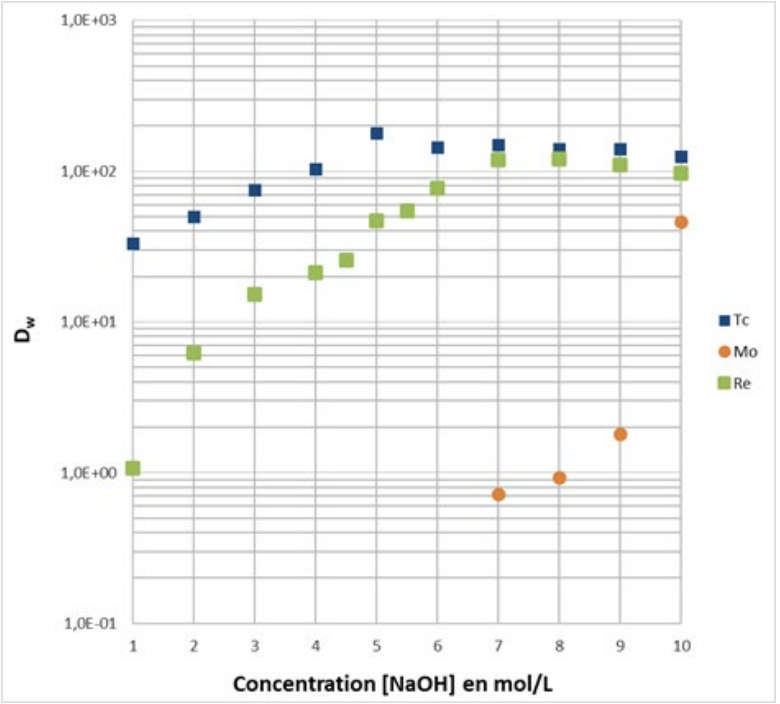


Polyethylene Glycol (PEG) grafted on inert support

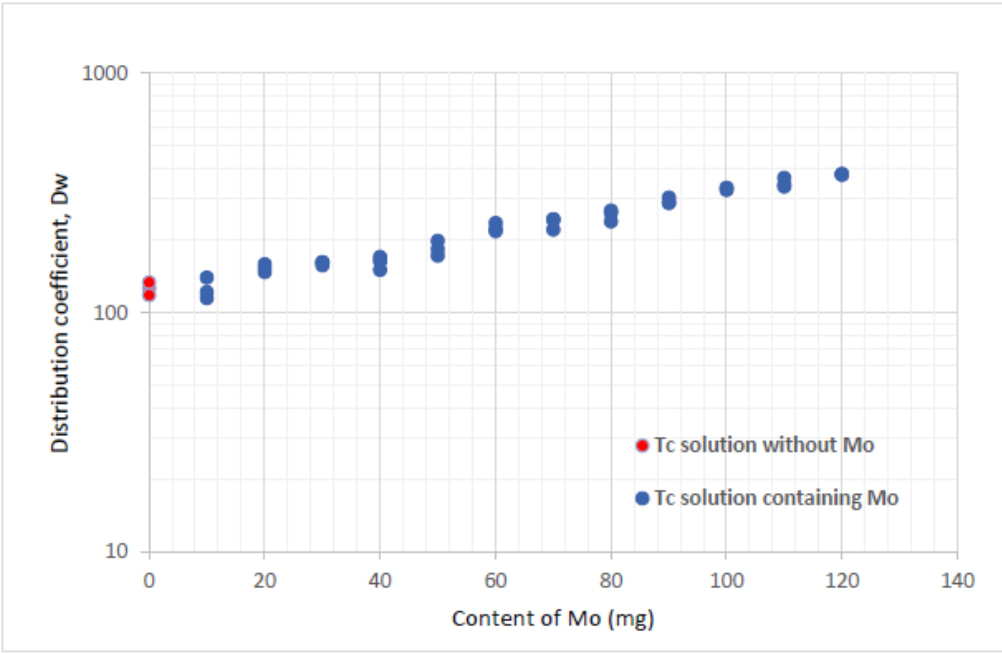
Retention of chaotropic anions e.g; TcO_4^- in the presence of kosmotropic anions (SO_4^{2-}, CO_3^{2-}, OH^-, MoO_4^{2-},…)

For samples rich in Mo: Tc yield > 90% for 6 – 8g Mo per g TK202

Analytical application: e.g. Tc-99 in concrete samples



Dw values for Tc, Re and Mo on TK202 Resin, at varying NaOH concentrations. Tc data taken from Cieszykowska et al.



Dw values for Tc in 5M NaOH using 40 mg TK202 Resin, increasing amounts of Mo. Data taken from Cieszykowska et al.

TK202 Resin

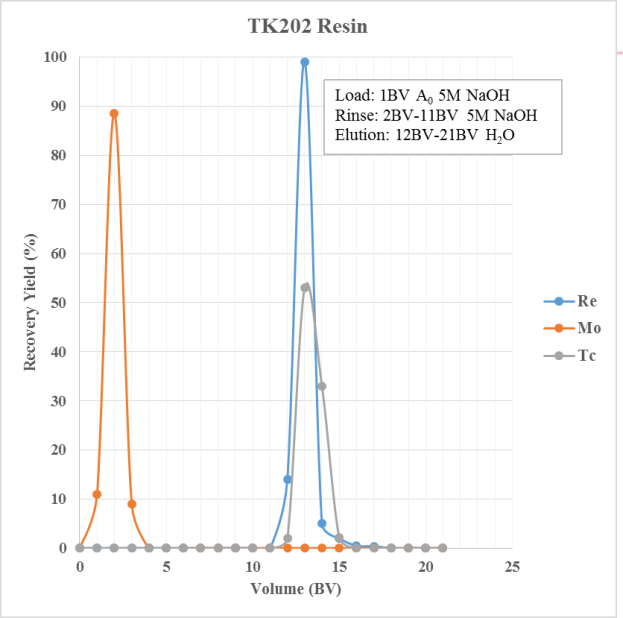
Retention of Tc from concentrated NaOH medium (5 - 7M)

- Alkaline Fusion e.g. decommissioning samples
- Dissolution of Mo target
- Clean separation from other tested elements

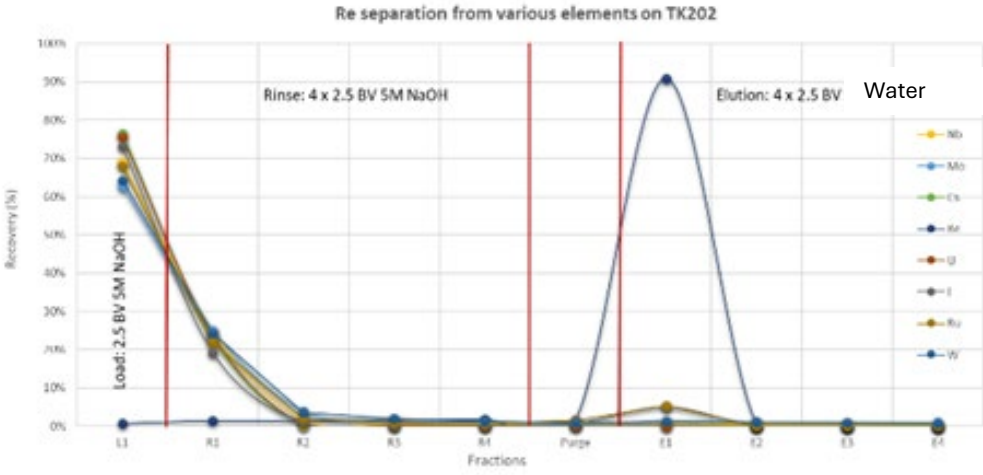
Re can be used as internal standard

Elution in a small volume of water

- Eluat remains slightly alkaline
- Load on CEX to neutralise medium + remove Na^+
- Potentially load on aluminum oxide to remove last Mo traces + elution in 0.9% NaCl



Re/Tc separation from Mo on TK202 Resin



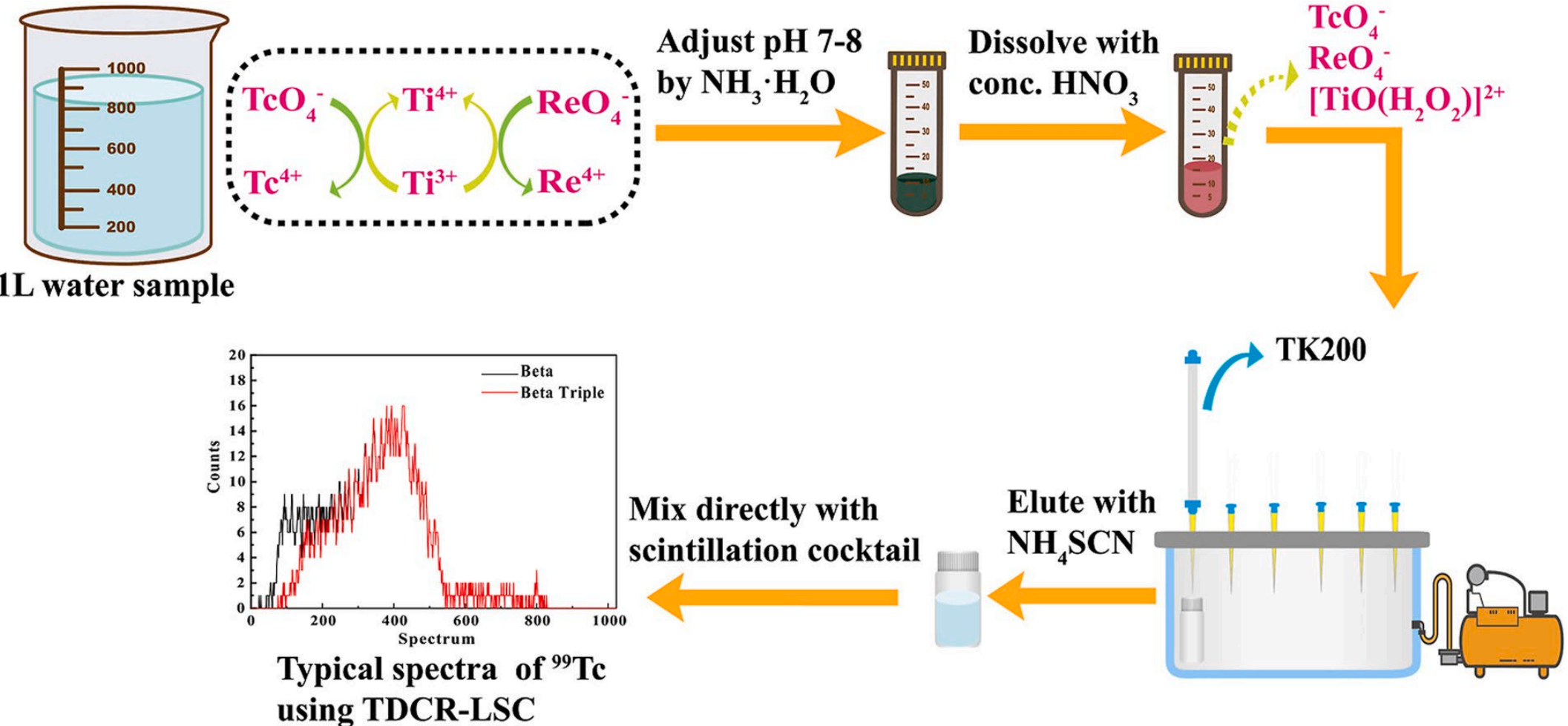
Re separation from selected elements on 2 mL TK202 Resin cartridge, load and rinse at 1 BV/min, elution at 0.25 BV/min.

TK200 Resin

Journal of Environmental Radioactivity
Volumes 251–252, October 2022, 106954

Rapid determination of ^{99}Tc in water samples using $Ti(OH)_3$-TcO_2 co-precipitation and TK200 resin by liquid scintillation counting

Ni Yuan [a], Quan An [a], Shan Xing [a b], Xiongxin Dai [a], Xiaolin Hou [c d], Yonggang Yang [a], Yan Ma [a]



TK200 Resin

Journal of Environmental Radioactivity
Volumes 251–252, October 2022, 106954

Rapid determination of ^{99}Tc in water samples using $Ti(OH)_3$-TcO_2 co-precipitation and TK200 resin by liquid scintillation counting

Ni Yuan [a], Quan An [a], Shan Xing [a b], Xiongxin Dai [a], Xiaolin Hou [c d], Yonggang Yang [a], Yan Ma [a]

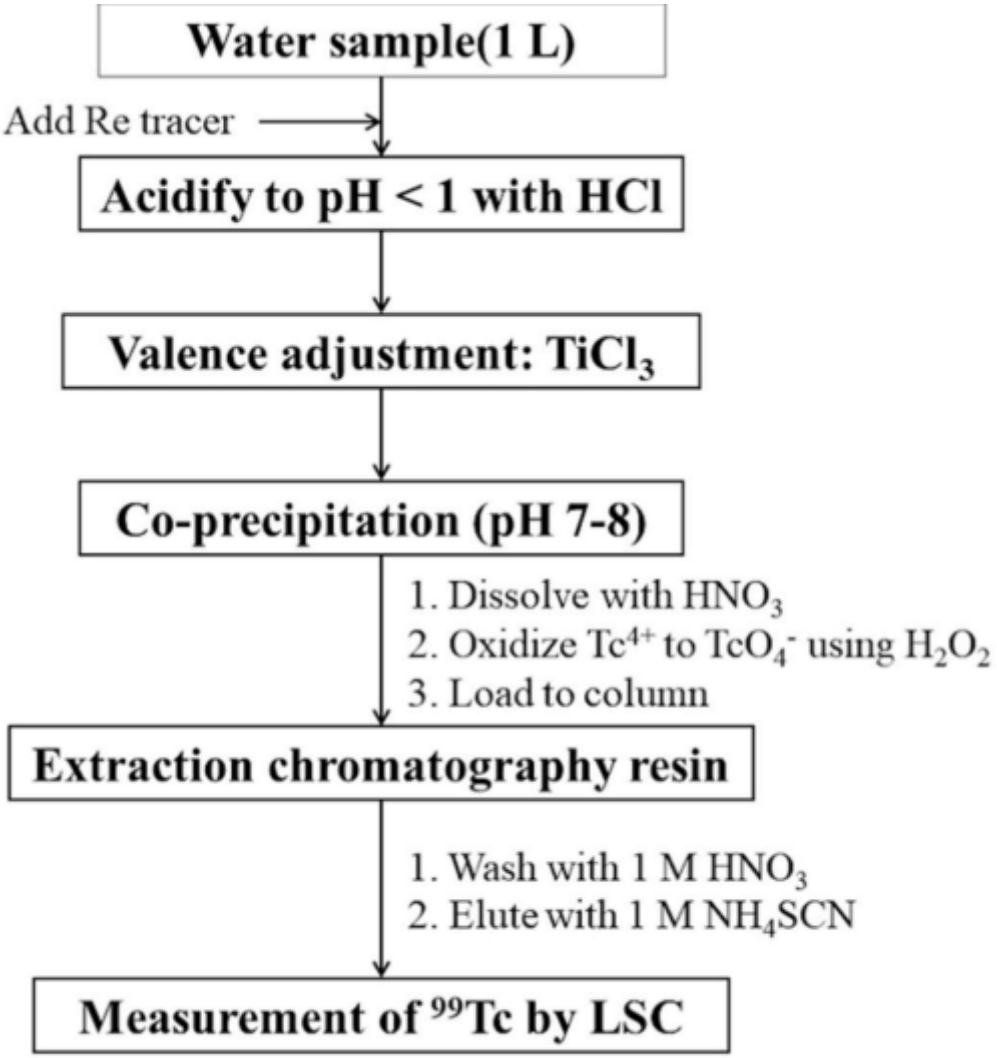
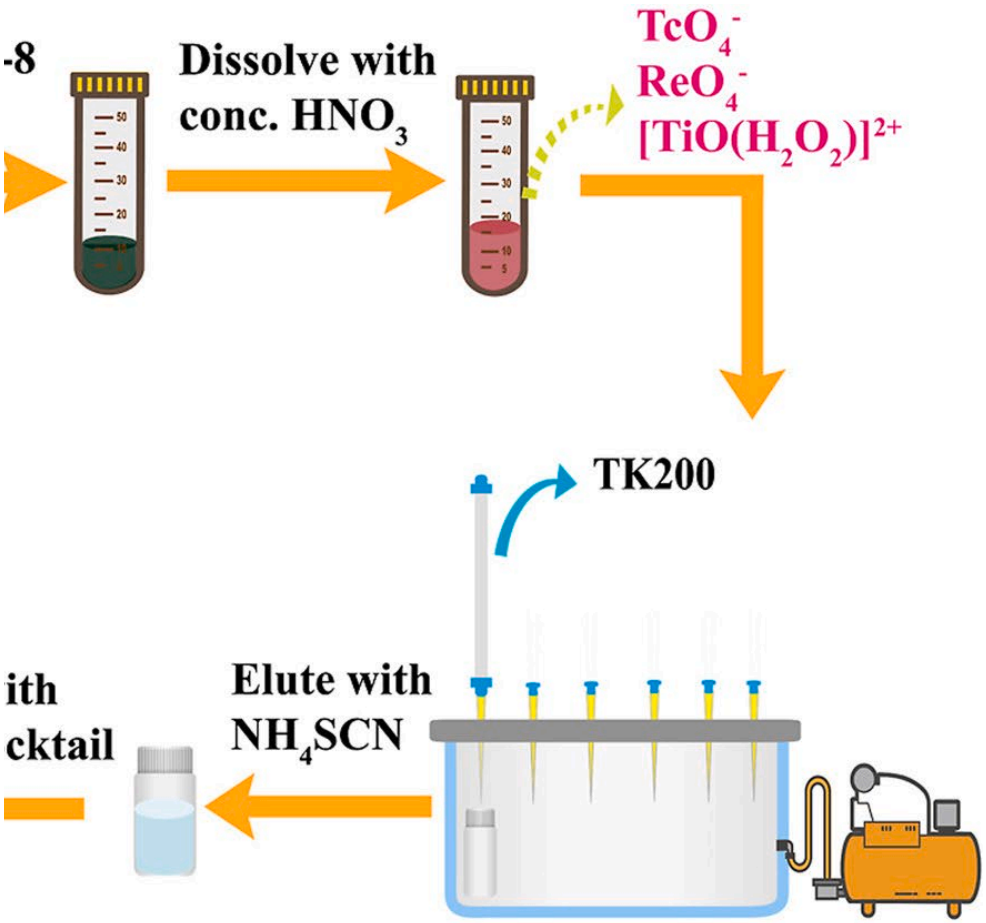


Fig. 1. Schematic diagram of the chemical procedure for separating ^{99}Tc from the water sample.



using TDCR-LSC

TK-TcScint

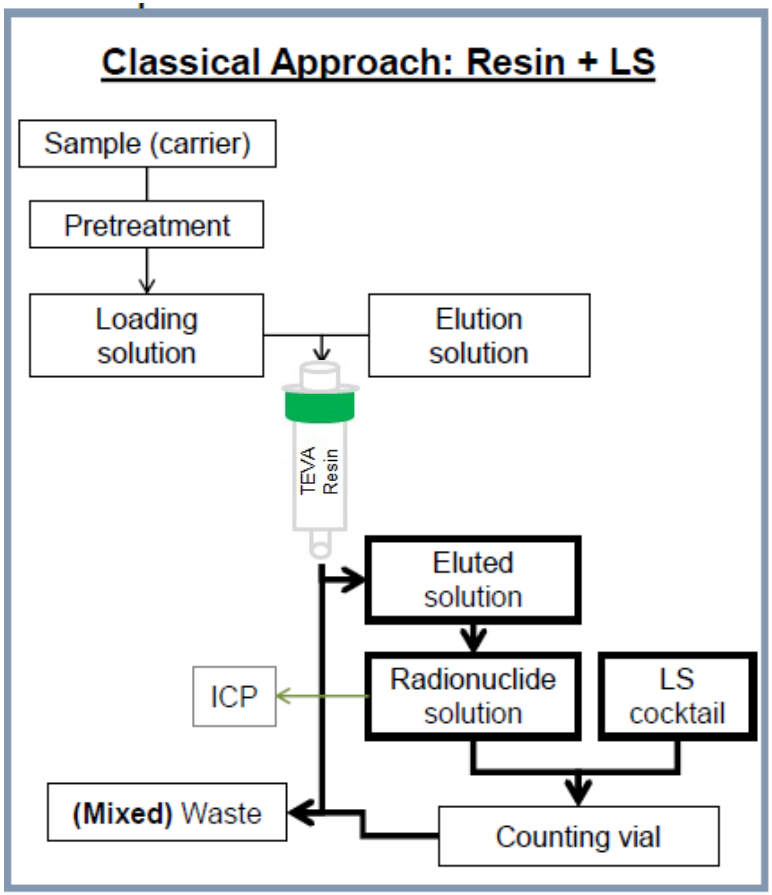
Plastic scintillating beads impregnated with selective extractant

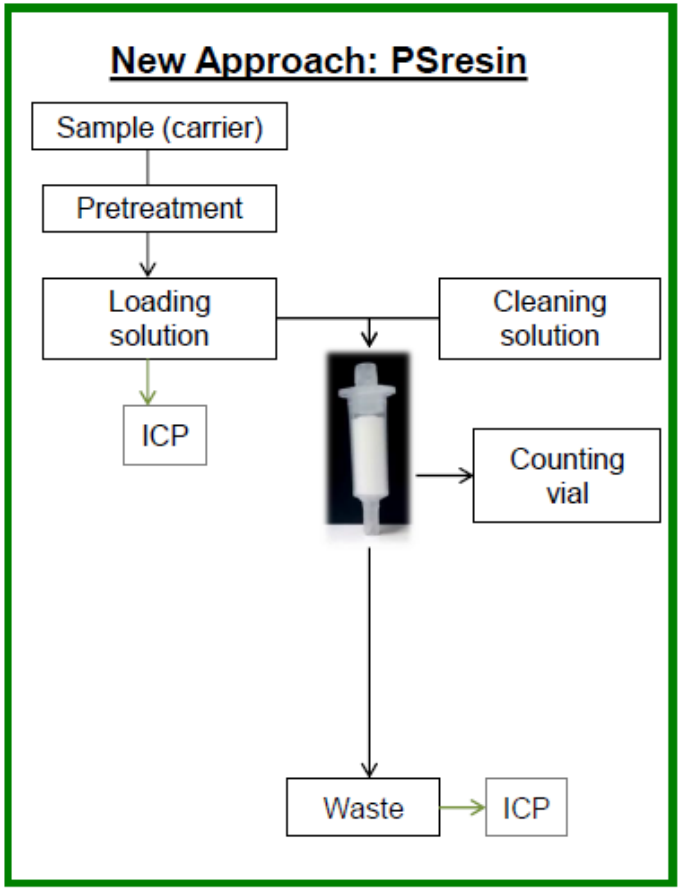
Developped by University of Barcelona

- García, Tarancón, Bagán

- « TK-ElScint » product line
  - 1st product: « TK-TcScint »
    - Quaternary ammonium + phase modifier (similar selectivity to TEVA)
    - Environment/decommissioning => Tc-99 by LSC
  - New: TK-SrScint
    - Sr and Pb
  - More products under development:
  - gross alpha(/TK-GA), DGA(/TK227), TK101 (Pb, Ra,..),...

TK-TcScint





Direct mesurement of the cartrige by LSC after loading and rinsing

- NO elution/evaporation/aliquoting => easy automatisation

Chemical yield via Re/ICP-MS in eluates.

TK-TcScint

Use of TK-TCScint in aqueous/urine samples for Tc-99 determination (Garcia et al., TKI UGM Cambridge 2018)

MOP:

2ml cartridge using Vacbox

1mg Re carrier

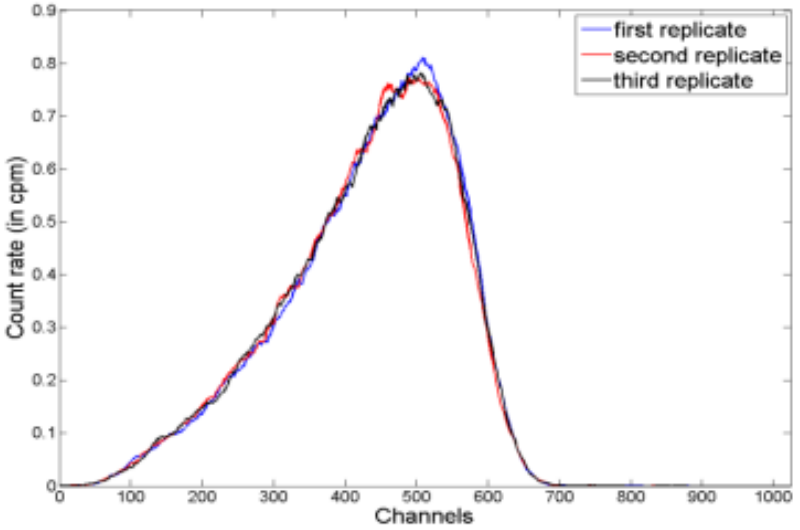
Precondition with 2ml 0.1M HCl

Load 10ml sample in 0.1M HCl

Rinse 4x2ml DI H_2O

Results

Recovery of Rhenium (by ICP-OES)	> 98.8 %
Recovery of ^{99}Tc (by LS):	> 98.8 %
^{99}Tc Detection Efficiency (%):	89.5(0.6)
Background (cpm):	1.09
Quenching Parameter (SQP(E)):	787(7)



TK-SrScint

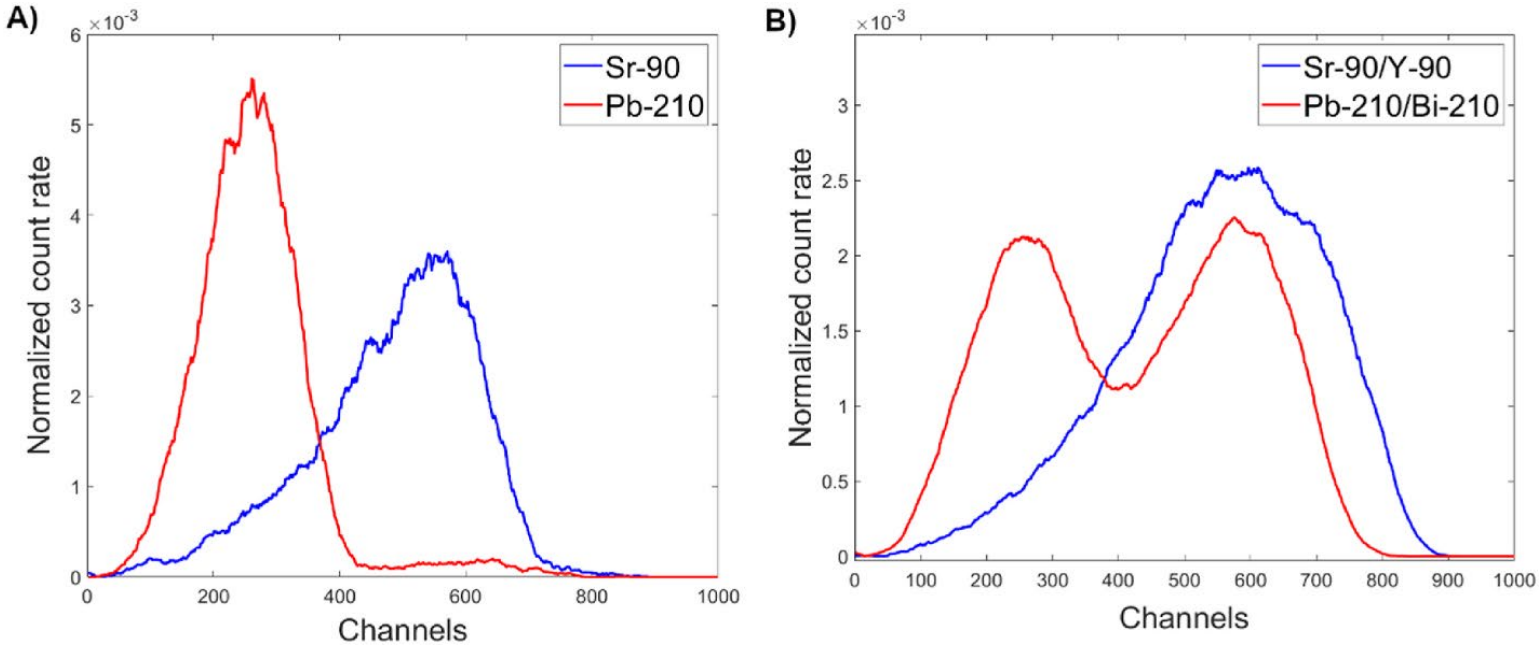
Impregnated plastic scintillation beads (PSm)

TK102 extractanten system (better loading volumen, capacity)

Crown ether + fluorinated alcohol

Sr and Pb retention => chemical yield typically Sr or Pb carrier in eluate via ICP

Detection efficiency for Sr-90: >90%, after Y-90 ingrowth >190%



Normalized LSC spectra Sr-90/Y-90 (blue) and Pb-210/Bi-210 (red)
on TK-SrScint at t= 0 (A) and after ingrowth of the daughters at t >21 Tagen (B).

TK-SrScint

Well suitable for decommissioning samples (no presence of Pb-210)

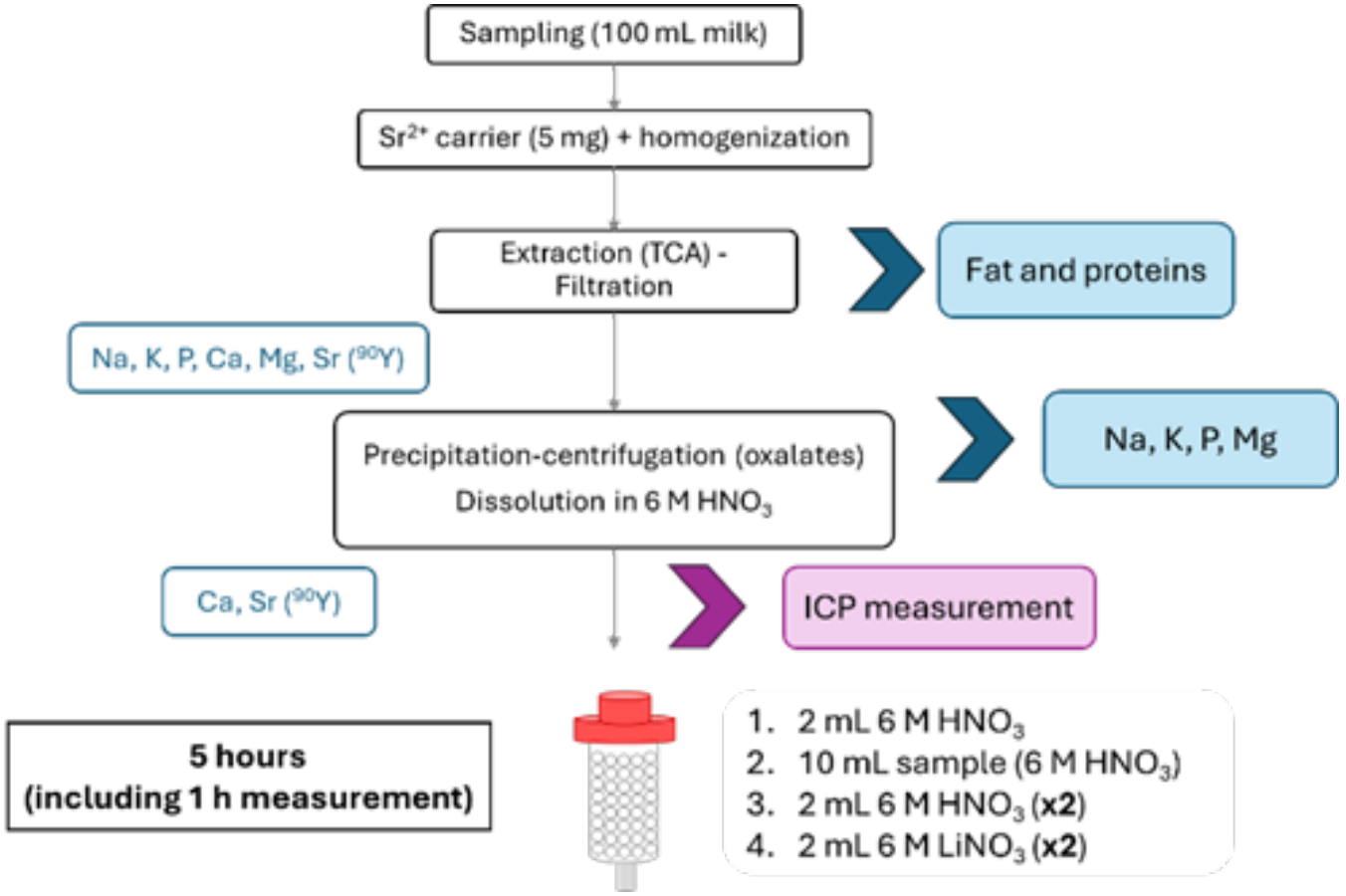
Environmental samples, potential for false positives through Pb-210 (and Bi-210)

- No Sr elution, Pb and Sr remain on the resin, Y-90 and Bi-210 ingrowth
- Tarancon et al. Pb-210 removal through co-precipitation with iodate in presence of Ca at ΔT. Sr remains in solution
- Sr co-precipitation with Ca-Phosphate
- Dissolution in 8 M HNO_3
- Load onto TK-SrScint
- Rinse with 8M HNO_3, followed by 6M HNO_3 and 6M $LiNO_3$ (acid removal)

For 1L Wasserproben: additional preconcentration via carbonate co precipitation

=> Chemical yield for full process between 63 % and 81 %

TK-SrScint – Rapid method Sr-90 in milk



Sr-90 determination using TK-SrScint

TK400 Resin

Long chained alcohol

- First work by Knight et al. on Np/Pa separation

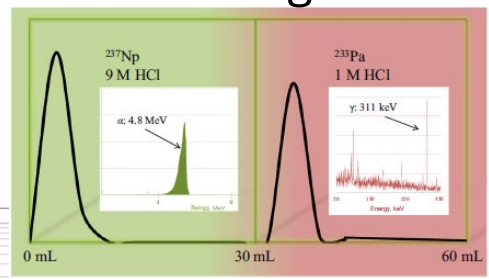
Retention only at high HCl concentration (>6M HCl), elution in low HCl, water,…

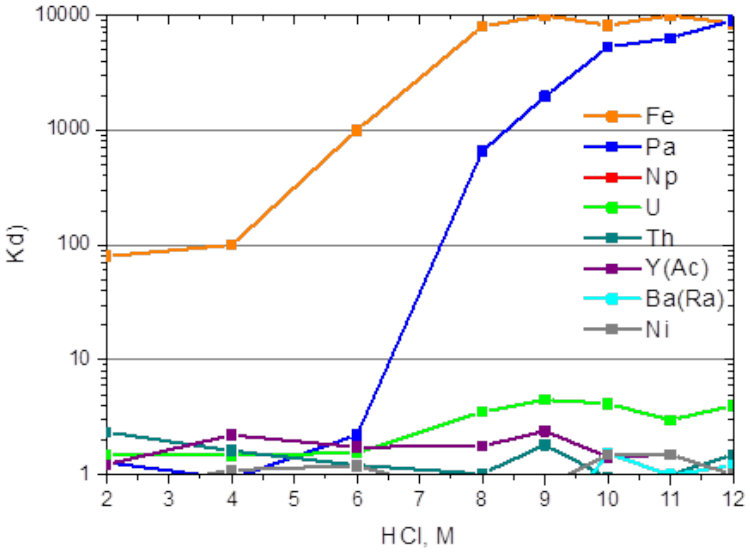
Main application: Pa separation & Ga-68 production

Also retains **Mo, Fe**, Po, **Nb**,… working on **Sb** and **At**

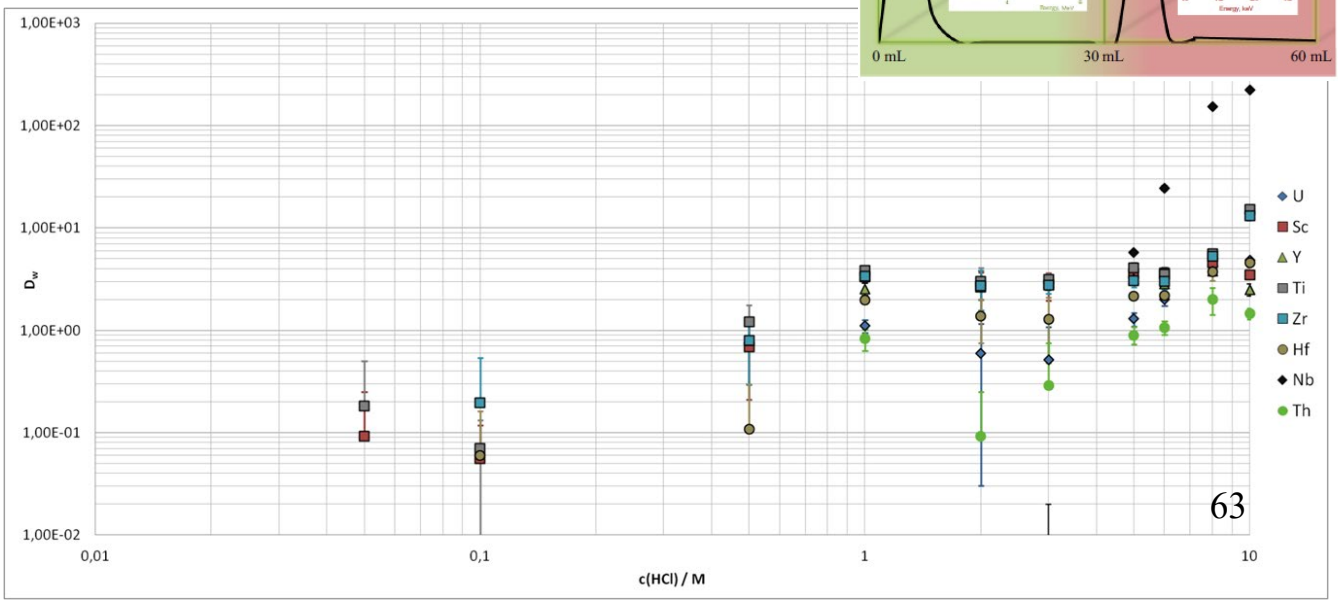
Higher Fe capacity than e.g. TRU Resin (~15mg Fe/g TK400)

Knight et al.

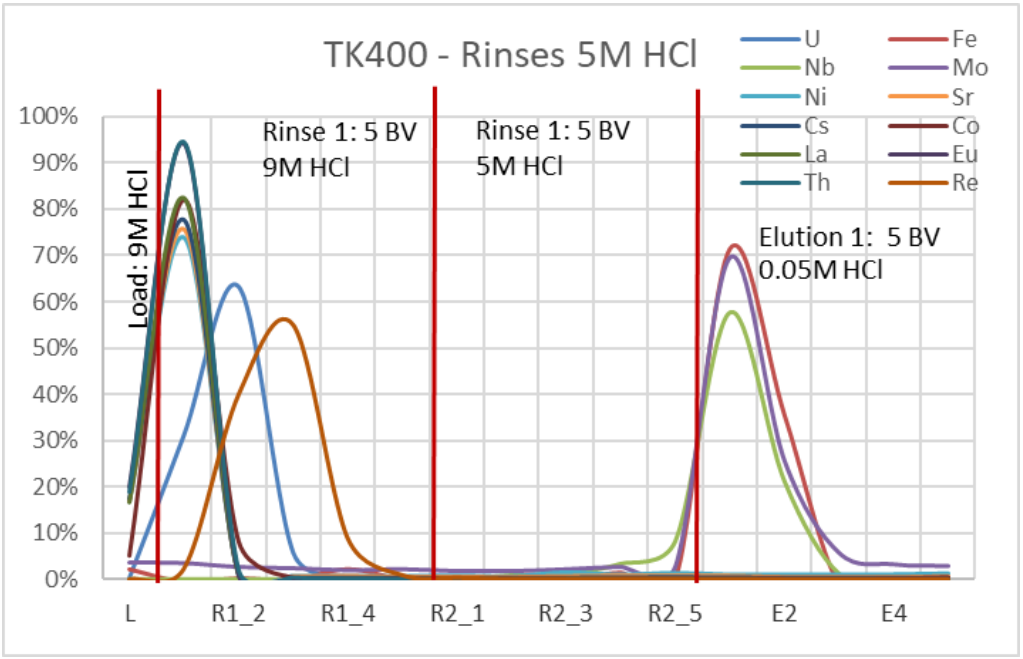


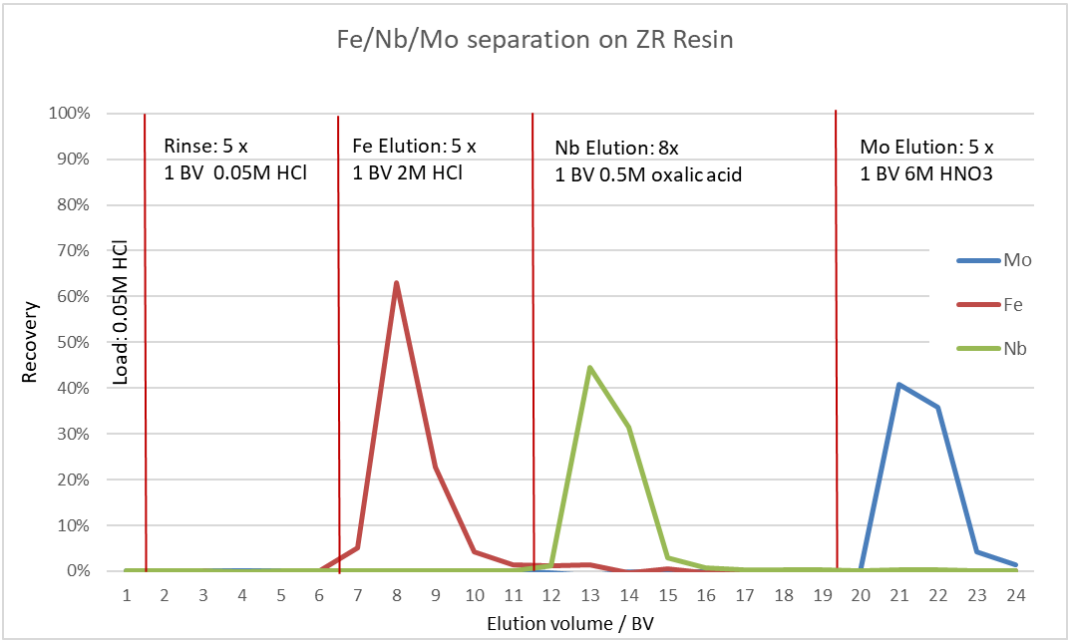


Data provided y B. Russel (NPL)



Fe/Mo/Nb separation





- Part of sequential method for determination of Fe, Ni, Zr, Mo, Nb, Tc in stainless steal (PhD student with Subatech, cooperation with IPHC)
  - Project includes modified NI Resin for improved selectivity (esp. Cu)
- Recovery of Fe/Nb/Mo from high HCl on TK400
- Majority of other elements removed during load and rinses (9M and 5M HCl)
- Fe/Nb and Mo eluted in dilute HCl => separation on ZR Resin

On-going: PhD thesis Eya Abed

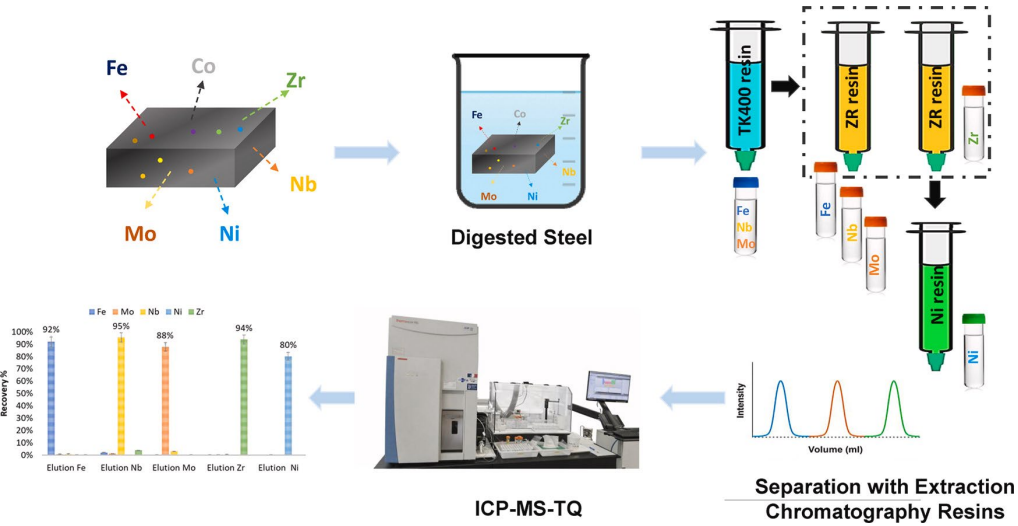
ELSEVIER

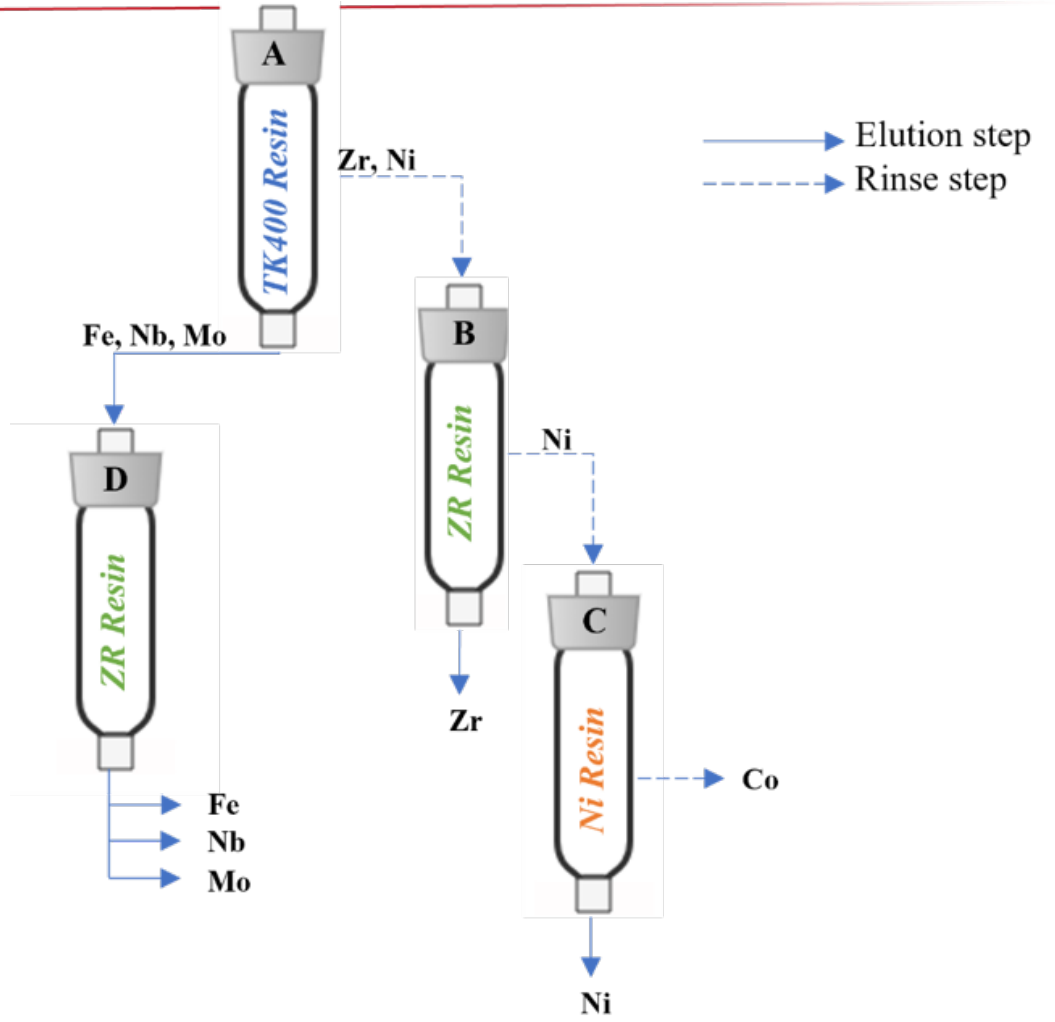
Analytica Chimica Acta

Volume 1419, 15 October 2026, 345891

Optimized single-sample sequential separation for stable elements (Fe, Ni, Mo, Nb, and Zr) at trace levels

Eya Abed [a b], Anne-Laure Nivesse [a], Tomo Suzuki-Muresan [a], Illarion Dovhyi [b], Nicolas Bessaguet [a], Steffen Happel [b], Gilles Montavon [a]



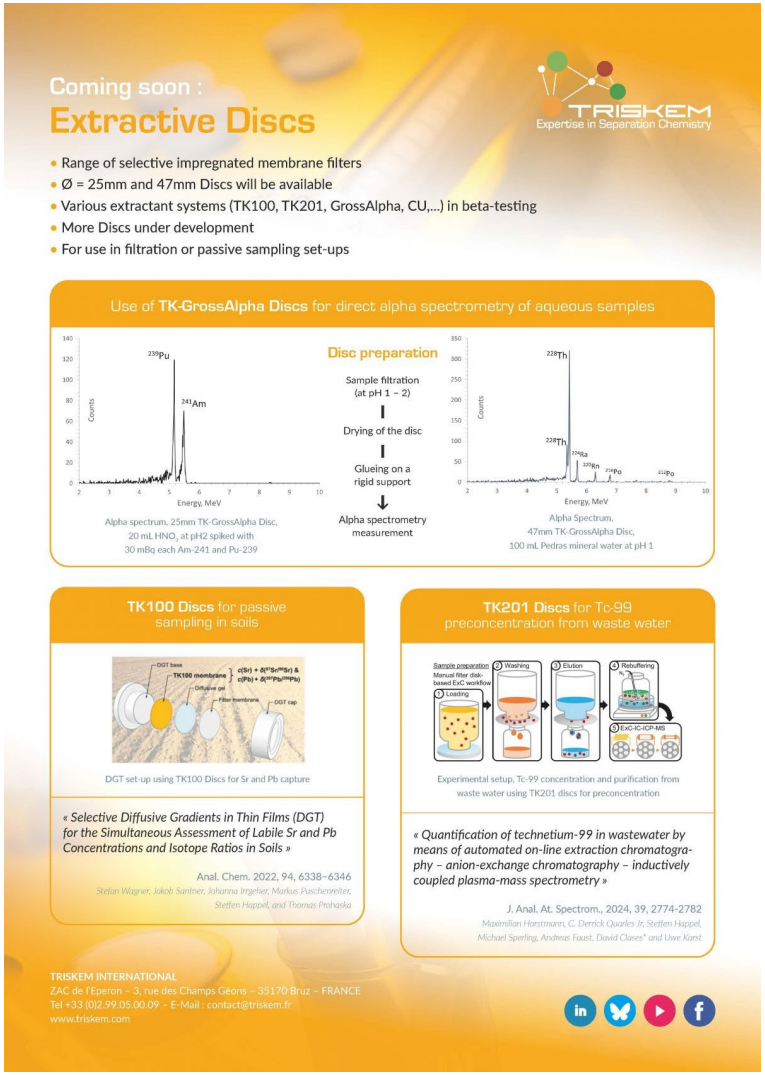


Determination of multiple analytes in decommissioning samples

Ongoing: improved NI Resin

New/under development impregnated membrane filters

Tesmarac
joint research laboratory



Special membrane filters impregnated with extractant(s)

25mm and 47mm Discs available

Commercialized:

- TK-GA Discs (Gross Actinide)

Beta Testing:

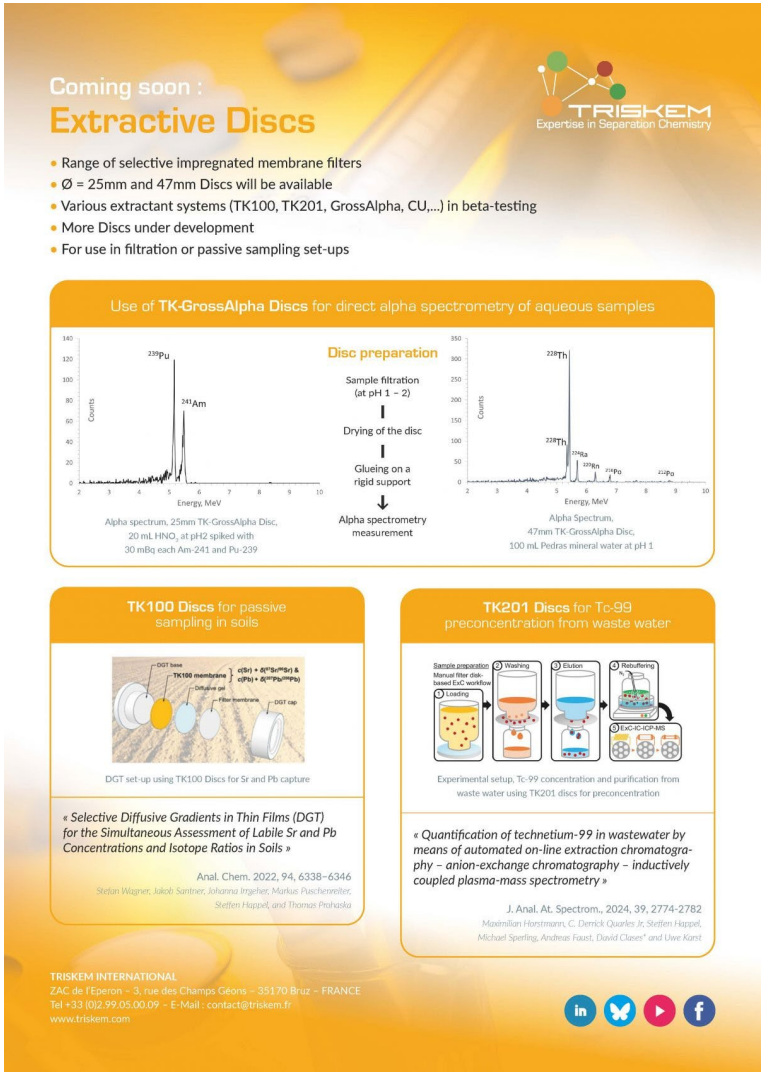
- TK100 & TK201 (both published), CU,...
- TK200 (U, Th, Pu) und TK221 (U, Th, Am, Pu) => sequentila separation (evtl. TK201 (Pu, Th)) => rapid screening?
- Alphaspec: Retention vs. Retention on the surface (70 - >90%)

Under development:

- TK102/TK227 - Rapid methods for Sr, TK101 (Pb, Ra),...

New/under development: impregnated membrane filters

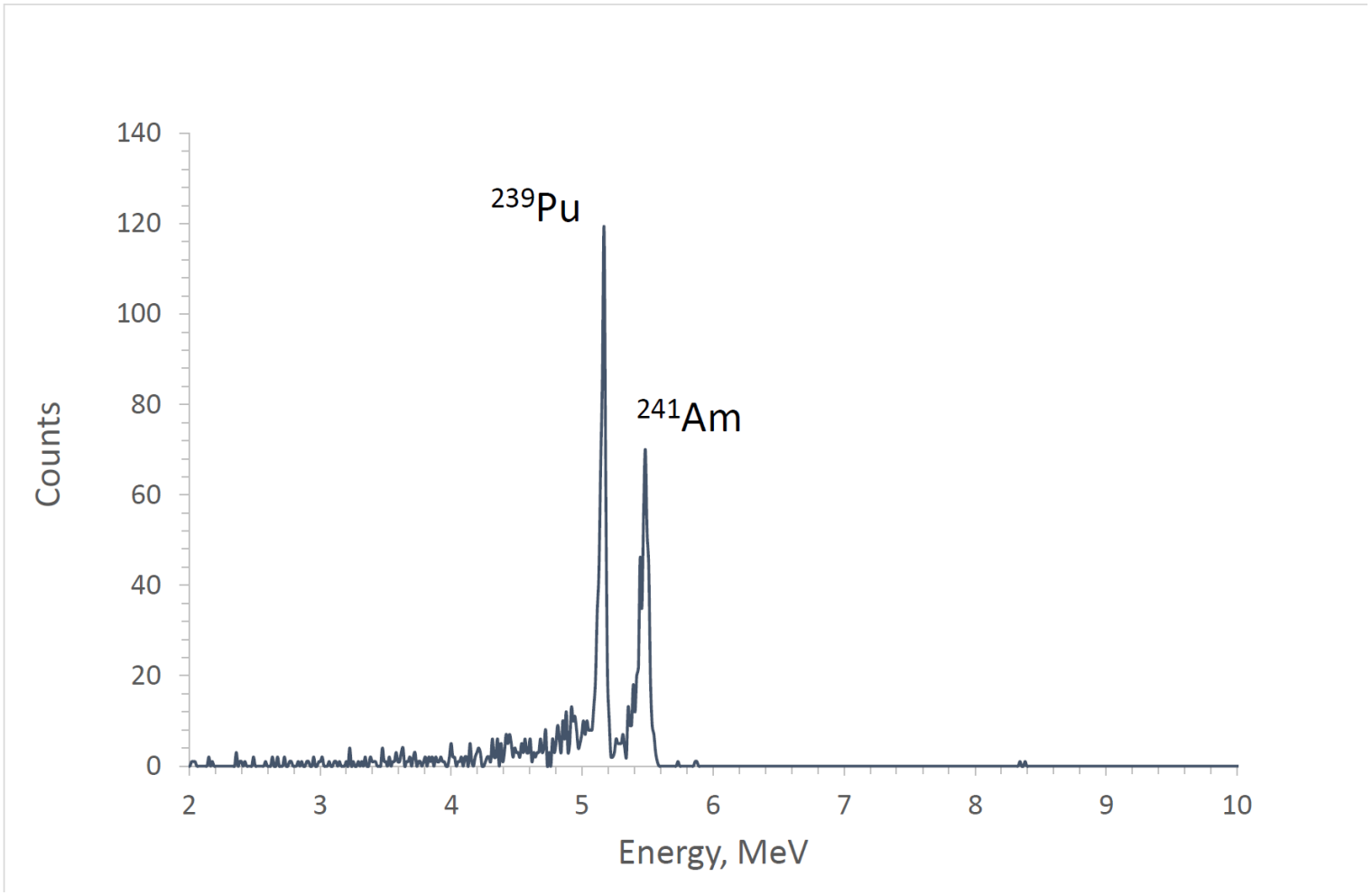
Tesmarac
joint research laboratory



Typical applications of TK-GA Disc:

- pH 1 – 2 (for some actinides up to 3M HNO_3)
- Preconditioning of the disc: 20% EtOH:water, water, then loading medium
- Loading of the sample, flow rate: 1 - 10mL/min,
- Lower flow rates seem to favor better resolution
- 25 mm Discs typically up to 100mL samples,
- 47 mm Discs typically up to 1L (higher volumes possible depending on extractant system)
- Rinse with water and 20% EtOH:water
- Drying and glueing onto steel disc => alpha spectometry.
- Optional: subsequent Alpha/Beta via LSC

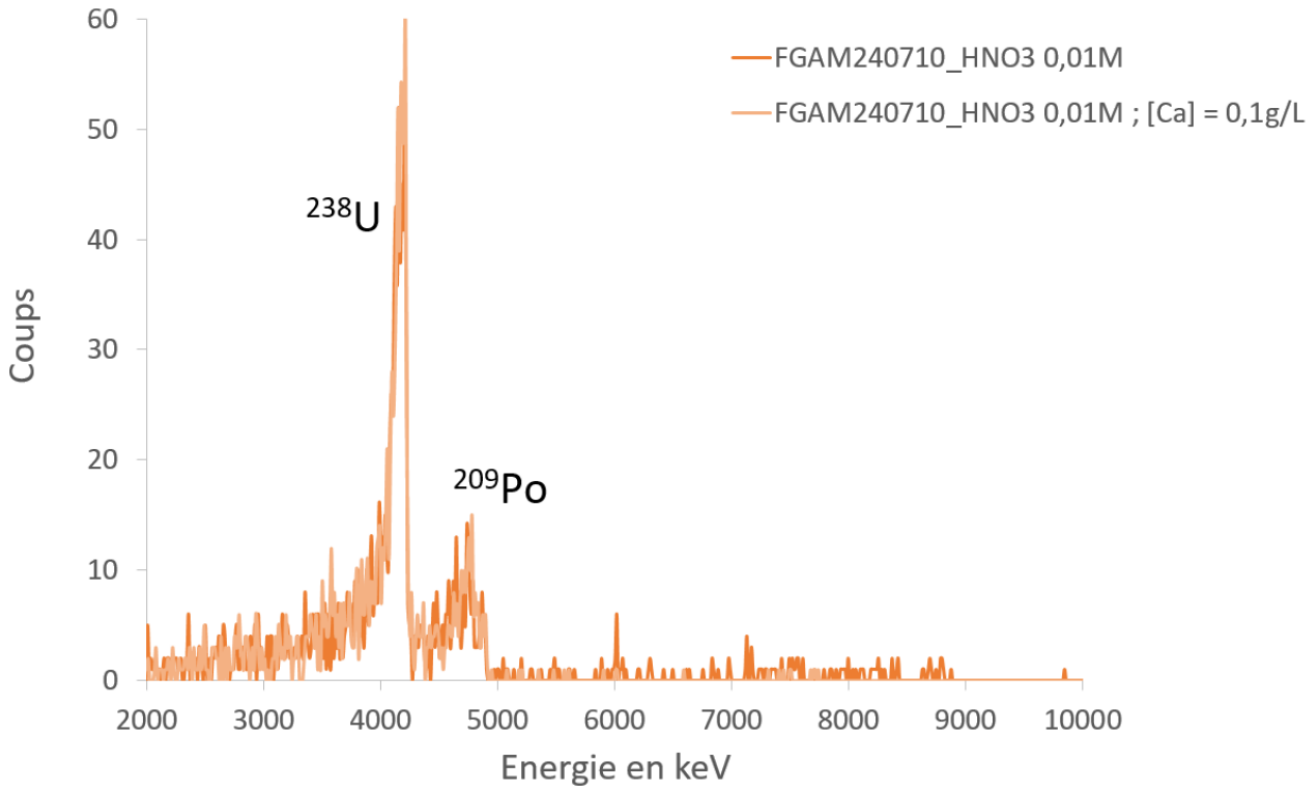
TK-GA Disc – Am/Pu in spiked acidified water



Alpha spectrum, Am-241 & Pu-239, each ~50mBq, 100mL pH2 HNO_3

TK-GA Disc – U/Po in spiked acidified water

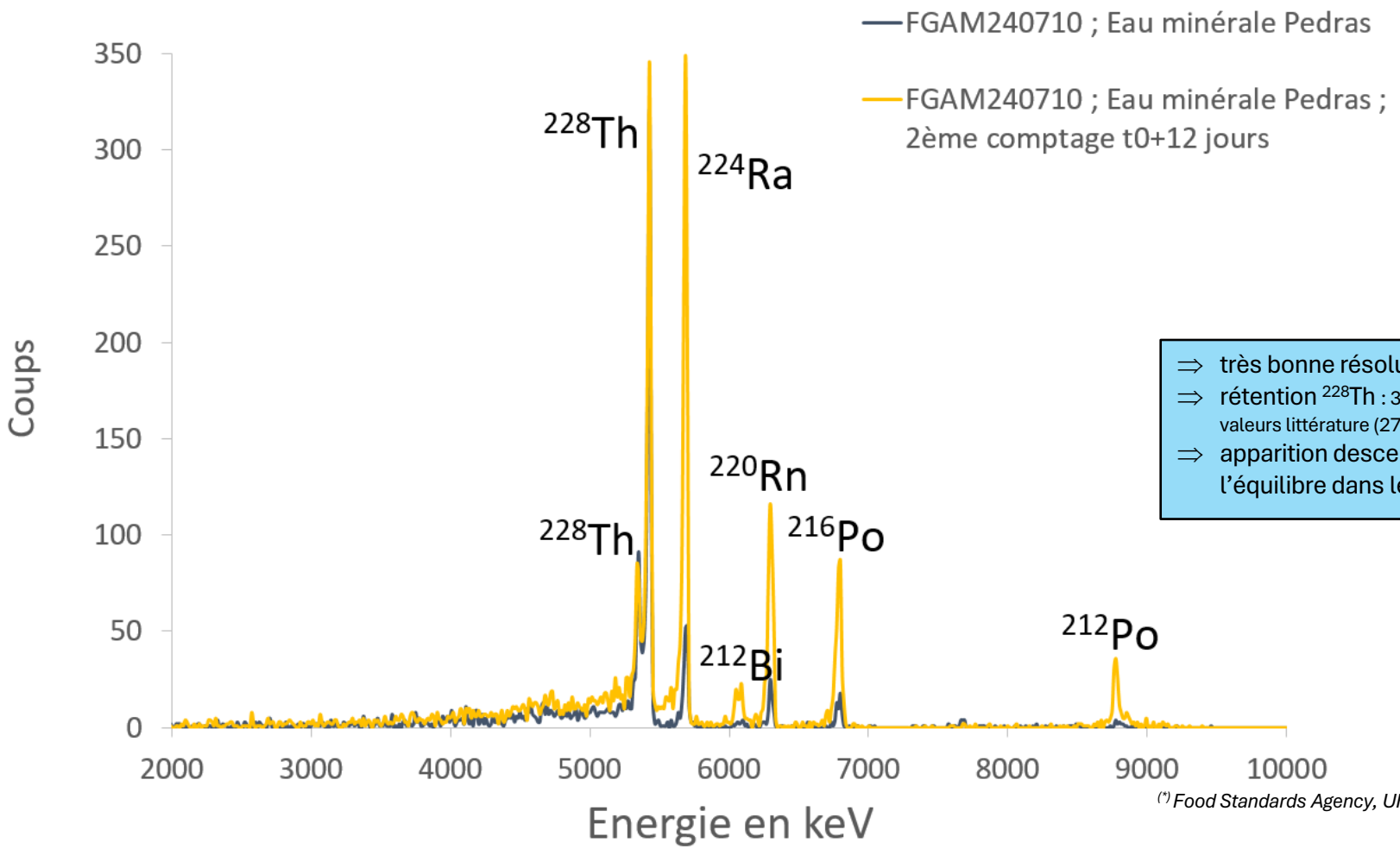
→ Solution synthétique simple dopée en ^{238}U et ^{209}Po
(100mL HNO_3 0,01M ; sans ou avec Ca à 0,1g/L ; 30mBq soit <u>0,3Bq/L</u>)



Tesmarac joint research laboratory

Résultats :

→ Eau minérale naturelle : Pedras (100mL)



⇒ très bonne résolution

⇒ rétention ^{228}Th : 320mBq/L mesuré = cohérent avec valeurs littérature (270mBq/L (*))

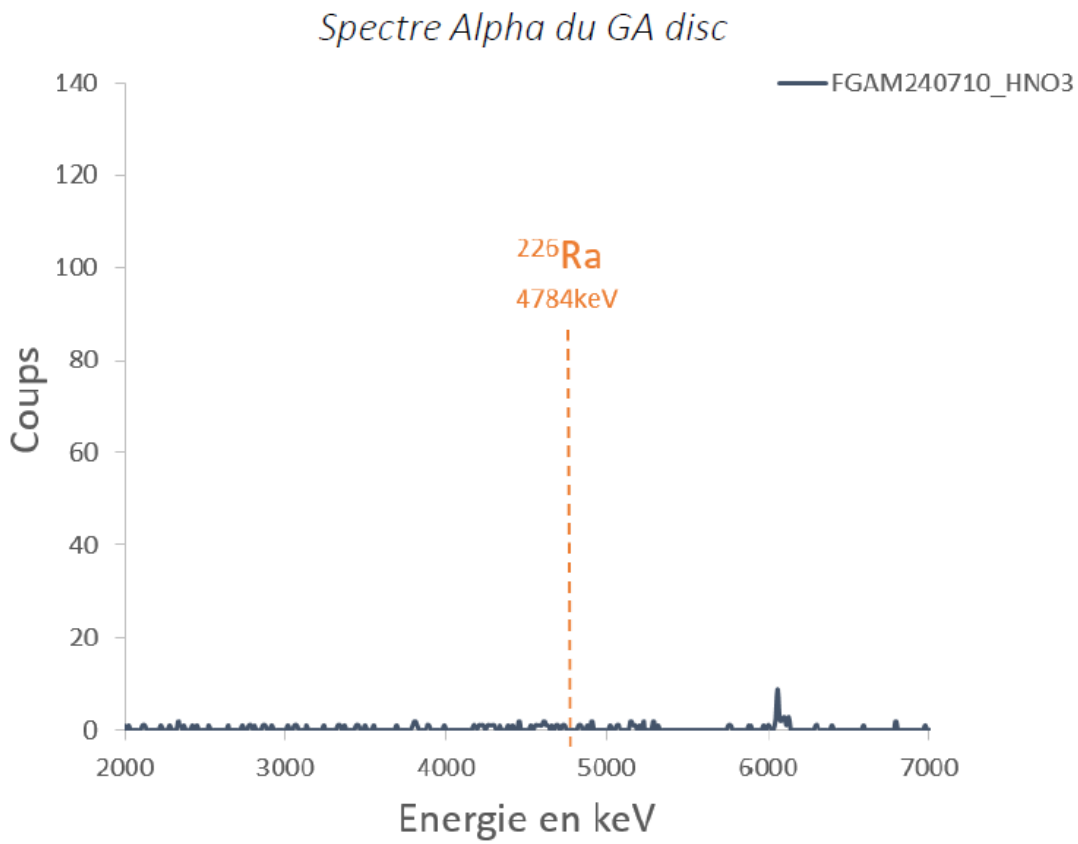
⇒ apparition descendants du ^{228}Th puis mise à l'équilibre dans le temps

(*) *Food Standards Agency, UK, Report 67/04 September 2004*

No Ra Retention in pH1 , Th very well retained. Good resolution

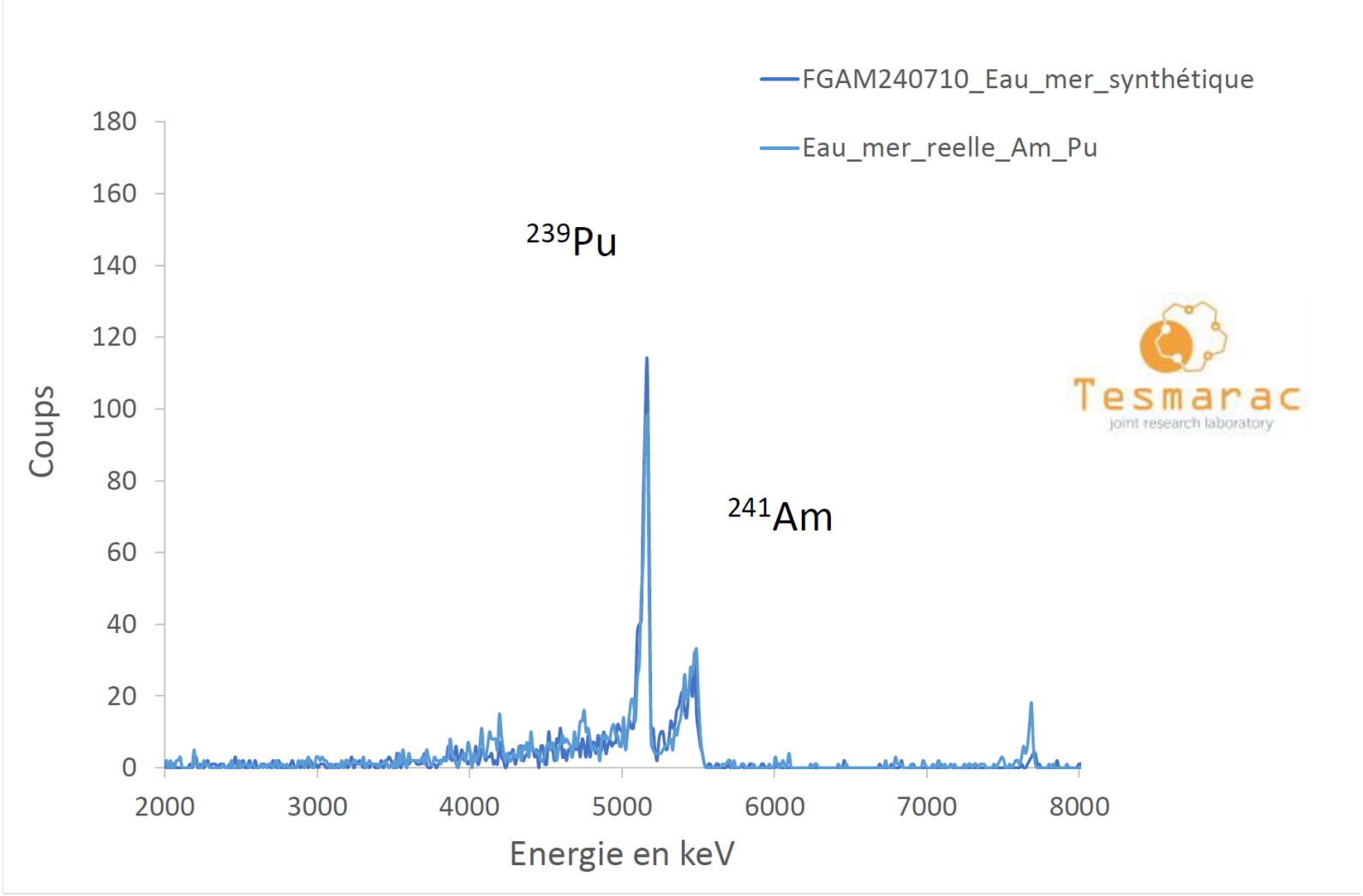
TK-GA Disc – Ra in spiked acidified water

→ Solution synthétique simple HNO_3 (100mL) 0,01M dopée en ^{226}Ra (30mBq soit 0,3Bq/L) *(résultats octobre 2024)*



No Ra retention at Ph 1 and 2. Ra retained at higher pH but no spectrum

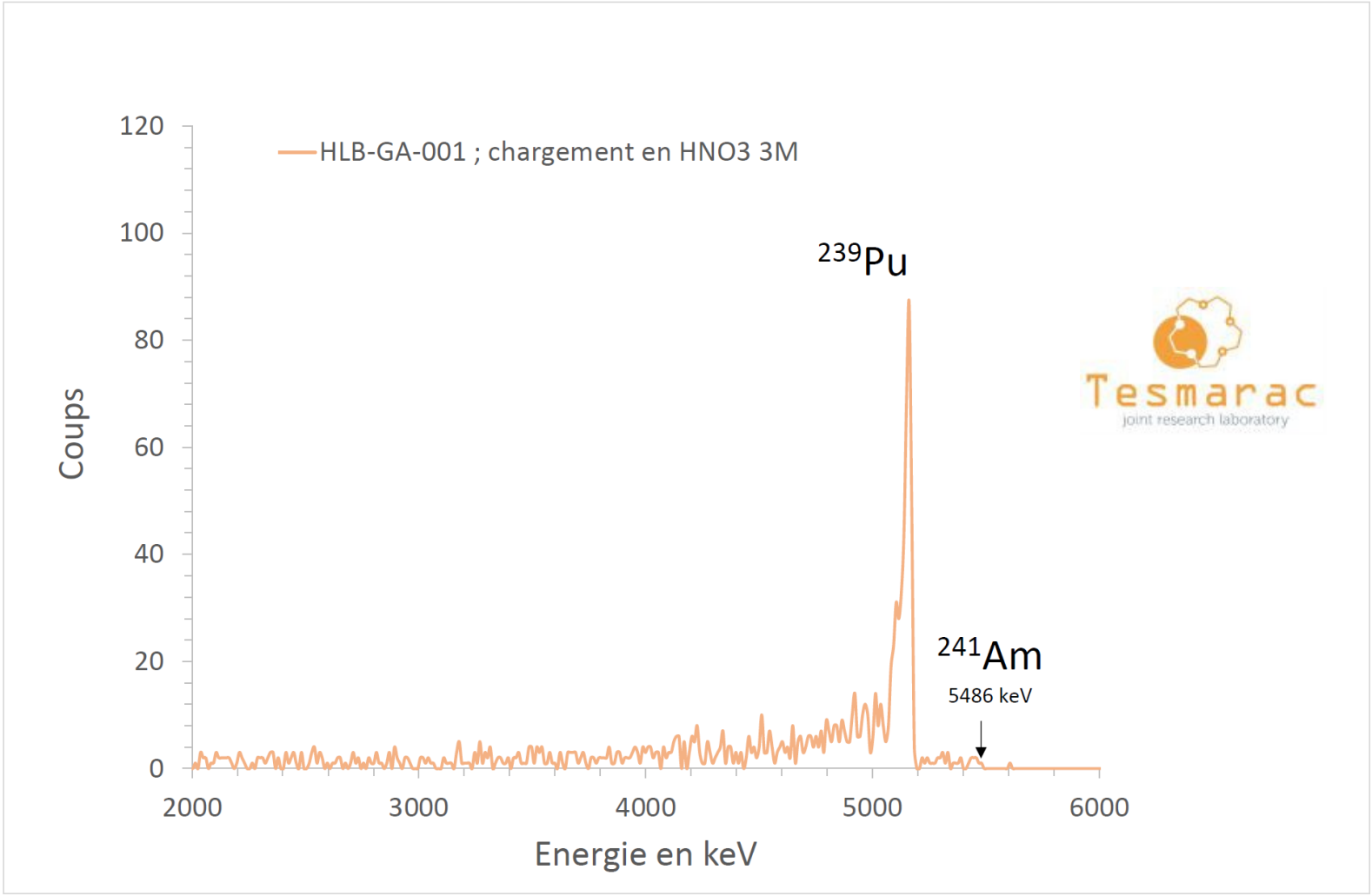
TK-GA Disc – Am/Pu in sea water



Alpha spectrum, Am-241 & Pu-239, each ~30mBq, 100mL sea water, pH2 HNO_3

Higher yields for Pu

TK-GA Disc – Am/Pu in 3M HNO_3



Alpha spectrum, Am-241 & Pu-239, each ~50mBq, 100mL 3M HNO_3

High yields for Pu, no Am retention

Next steps

TK-GA Discs:

- Publication upcoming
- Other matrices (e.g. primary cooliant) and acid concentrations
- Spectrum deconvolusion => Subatech
- More data on other alpha emitters
- Behaviour of Ra
  - Retention at pH3-4 but no alpha spectrum
  - Migration into the disc?

TK221 and TK200 Discs in 3M HNO_3

- Stacking for AC screening? => rapid screening methods
- => looks good cold, alpha spectra?

TK201 and TK103 Discs (Ra) and method optimisation

Sr via TK102 and TK227 Discs? LSC? GPC?

More discs…

Passive sampling

- Wagner et al.
- Passive sampling via DGT (Diffusive Gradiant in Thin films) => ‘bio-availability’
- TK100 Discs for Sr, Pb, Zn and Sr-90
- CU Discs for Cu

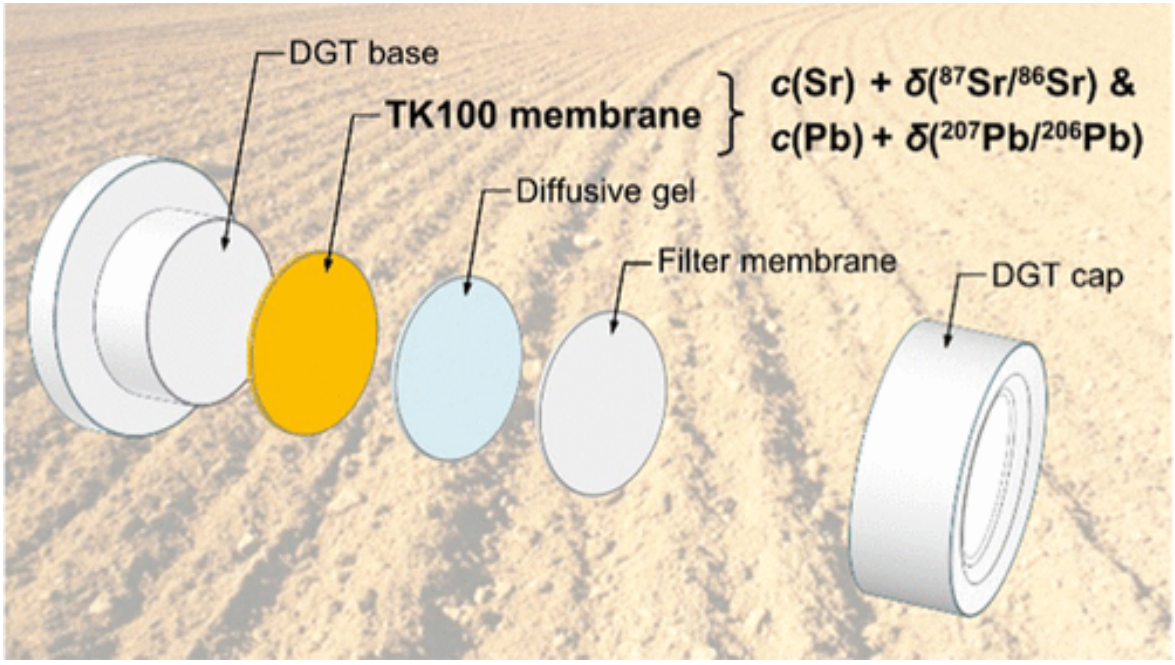
analytical chemistry

pubs.acs.org/ac Article

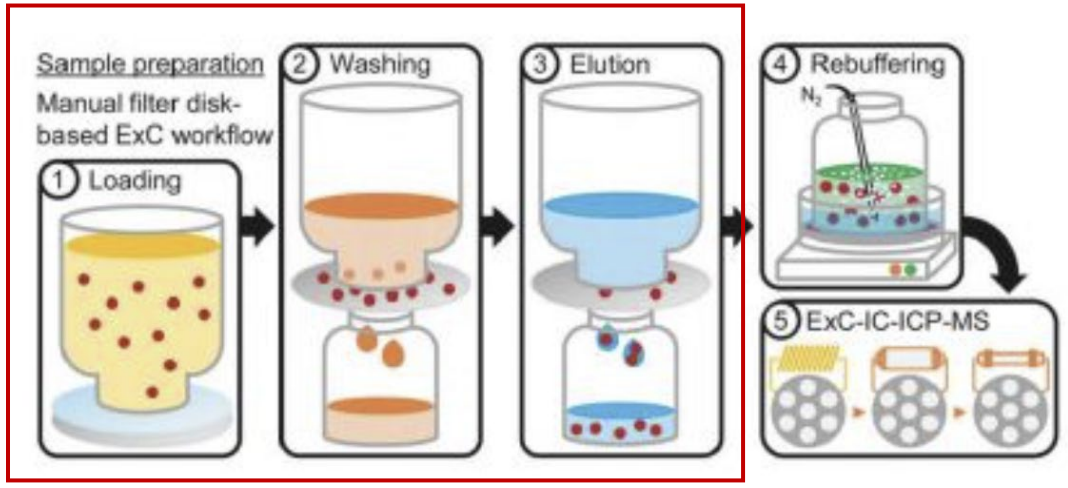
Selective Diffusive Gradients in Thin Films (DGT) for the Simultaneous Assessment of Labile Sr and Pb Concentrations and Isotope Ratios in Soils

Stefan Wagner, Jakob Santner, Johanna Irrgeher, Markus Puschenreiter, Steffen Happel, and Thomas Prohaska*

Cite This: *Anal. Chem.* 2022, 94, 6338–6346 Read Online



Tc Preconcentration



Experimental setup, Tc-99 concentration and purification from waste water using TK201 discs for preconcentration

- 1L hospital waste water
- Preconcentration on 47mm TK201 Disc
- Elution in 0.5M NH_4OH
- Readjustment of pH to allow loading onto TK201 column (PrepFast)
- Elution in 0.5M NH_4OH concentration/purification step)
- Load onto IC column
- Elution in 0.15M NH_4NO3 in very small volume
- ~100% chemical yield
- LoD < 1fg/kg

« Quantification of technetium-99 in wastewater by means of automated on-line extraction chromatography – anion-exchange chromatography – inductively coupled plasma-mass spectrometry »

J. Anal. At. Spectrom., 2024, 39, 2774-2782

Maximilian Horstmann, C. Derrick Quarles Jr, Steffen Happel, Michael Sperling, Andreas Faust, David Clases and Uwe Karst*

CL Resin

- Extractant: Phospine sulfide
  - ➢ Main application: Cl-36/radioiodine
  - ➢ Also used for Ag and Pa separation
- Selective for soft cations
- Halogene selectivity by loading with Ag^+
- Similar to Ag^+ anion solubility
- Sample loading on Ag^+ loaded CL resin
  - ➢ Ag+ loading from sulfuric, nitric and aqueous possible
  - ➢ Acidic, neutral or slightly alkaline conditions
    - ▪Original paper[+]: water/effluents and leached solid samples (concrete, soil, filter)
    - ▪ Leaching: 4h, 70°C, 1M NaOH, Alternative: Raddec

Analyte	Extraction condition	D_w, $mL.g^{-1}$
Ag	1M H_2SO_4	650000
Ag	Sulfuric acid, pH 3	600000
Ag	Sulfuric acid, pH 5	350000
Cd	1M H_2SO_4	<1
Ce	1M H_2SO_4	4
Co	1M H_2SO_4	<1
Cu	1M H_2SO_4	<1
Fe	1M H_2SO_4	<1
Mn	1M H_2SO_4	<1
Ni	1M H_2SO_4	<1
Pd	1M H_2SO_4	87000
Zn	1M H_2SO_4	25

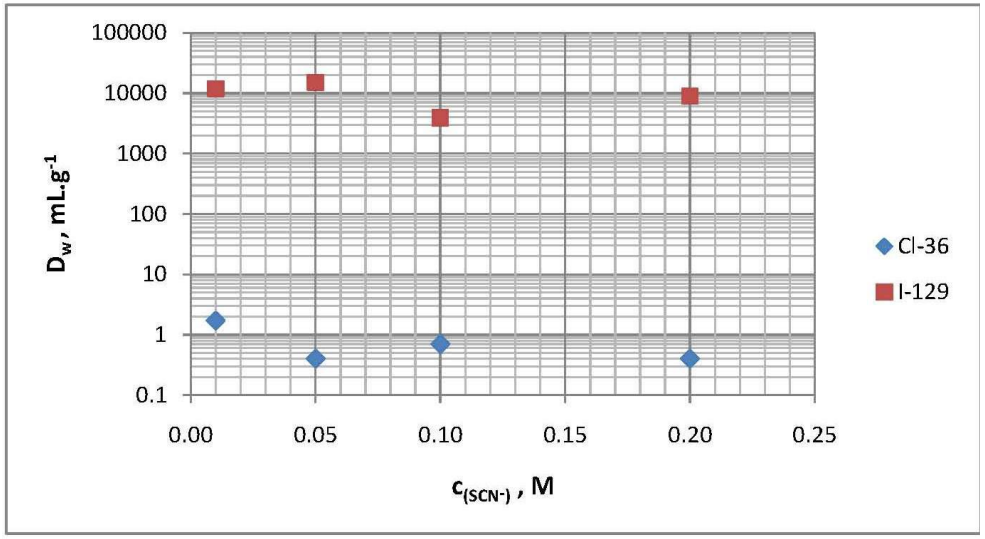
+ A. Zulauf, S. Happel, M. B. Mokili, A. Bombard, H.Jungclas: Characterization of an extraction chromatographic resin for the separation and determination of 36Cl and 129I. J. Radanal Nucl Chem, 286(2), 539-546

Resin characterization – Ag^+ loaded CL resin

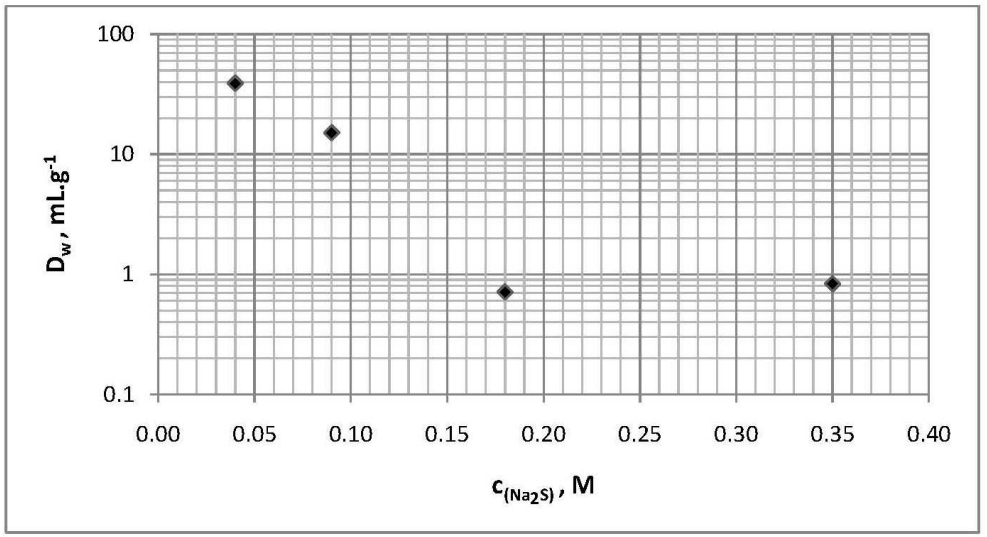
Isotope	D_w retention
Cl-36	1600
I-129	1980

Retention of chloride (^{36}Cl) and iodide (^{129}I) in 1M H_2SO_4

- High uptake of chloride and iodide onto Ag^+ loaded CL-resin in 1M H_2SO_4
- Remark: iodate also retained, chlorate not



D_w of chloride (^{36}Cl) and iodide (^{129}I) on Ag loaded CL resin at pH 7 and varying SCN^- concentrations

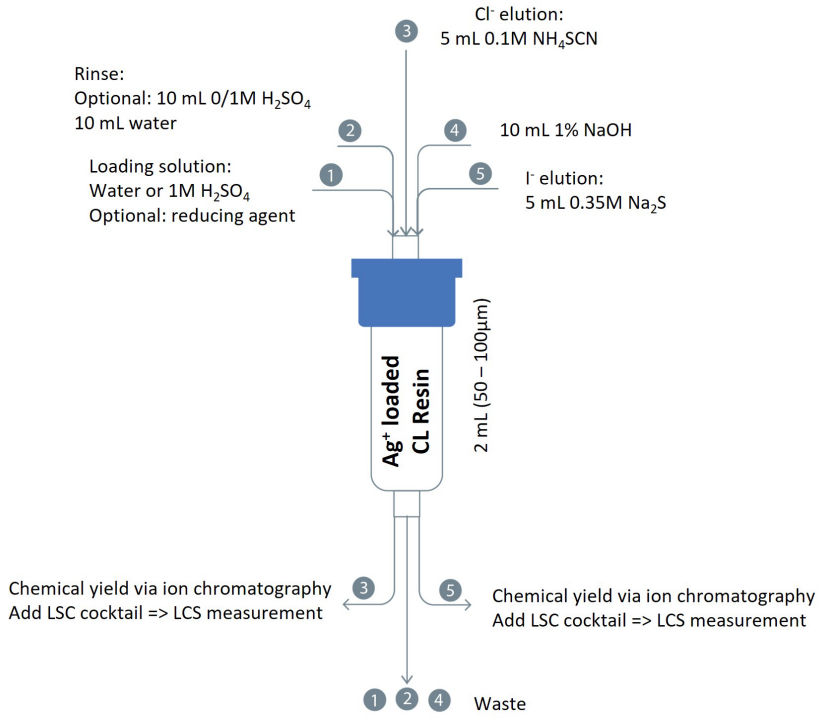


D_w of iodide (^{129}I) on Ag loaded CL resin at pH 7 and varying Na_2S concentrations

- Chloride: very low D_w at all tested SCN^- concentrations
- Iodide: high D_w at all tested SCN^- concentrations, low D_w at elevated Na_2S concentrations

Determination of Cl-36 / I-129 using CL Resin

- Loading from water, slightly alkaline or acidic conditions
- May be bubbler solution from Pyrolyser unit
- Optional: reducing agent (Cl-/I-)
- Rinse with 10ml of deion. Water
  - ➢ Eliminates matrix elements
- Elute chloride with 5ml of 0.1M SCN^-
  - ➢ Directly mixed with LSC cocktail and counted
- Rinse with 10ml of 1% NaOH
  - ➢ Increases iodide yield
- Elute iodide with 5ml of 0.35M Na_2S, mix with LSC cocktail
  - ➢ Fume hood…
  - ➢ Directly mixed with LSC cocktail and counted
- Yields in general > 90 - 100%



Pyrolyser method

- Allows for analysis of large solid samples (several g)
- Thermal decomposition of the samples and desorption of Cl Species in

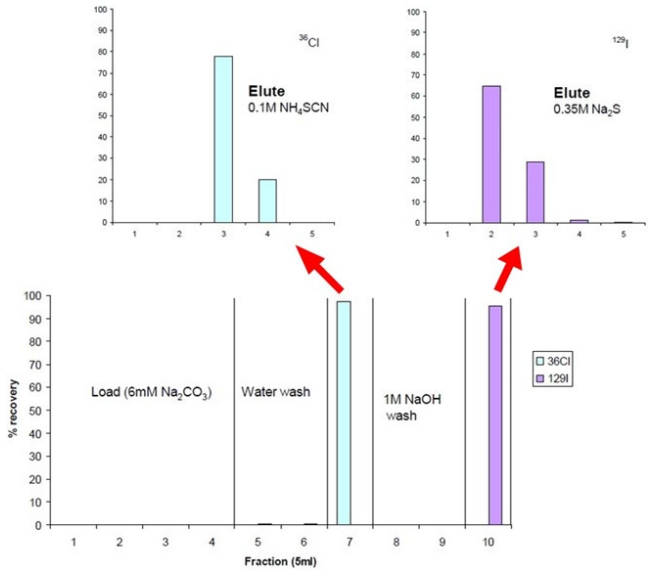
Pyrolyser furnace at 900°C (ca. 2h)

- System flushed with humidified air; samples also humidified (1ml water)
- Decomposition products trapped in bubbler containing alkaline solution
  - 6 mM Na_2CO_3 used (yield > 80%)
- Separation/purification on CL Resin



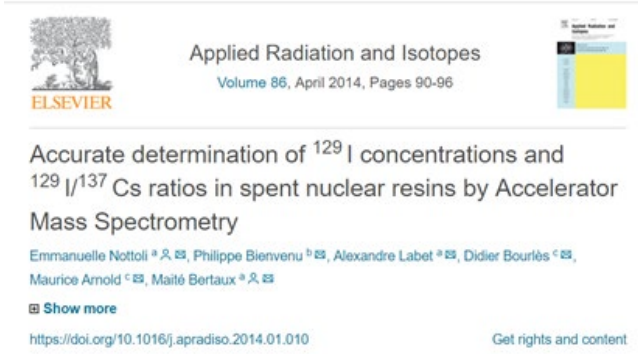
Analysis of spent resin

Sample type	Expected value	Measured value
Ion exchange resin	4.1 kBq	4.3 ± 0.1 kBq



I-129 in spent resin via AMS

Nottoli et al.: I-129 in spent resins by AMS



Resin mineralisation by

- microwave digestion (HNO_3/$HClO_4$) or
- oxygen bomb combustion (iodine trapped in NaOH)

Iodine purified on CL Resin using a modified purification method

- Load and Rinse 1M NaOH
- Cl^- elution via SCN^-, I^- elution via S^{2-}

Samples prepared for AMS measurement by:

- oxidation of the sulphide to sulphate with H_2O_2
- removal of the sulphate by precipitation with Ba / centrifugation
- AgI precipitation.

Cl-36 via ICP-MS/MS

Analytica Chimica Acta 1410 (2026) 345611

Contents lists available at ScienceDirect

Analytica Chimica Acta

journal homepage: www.elsevier.com/locate/aca

« S » free elution of Cl-36 to avoid isobaric interference

Allows for ICP-MS/MS analysis

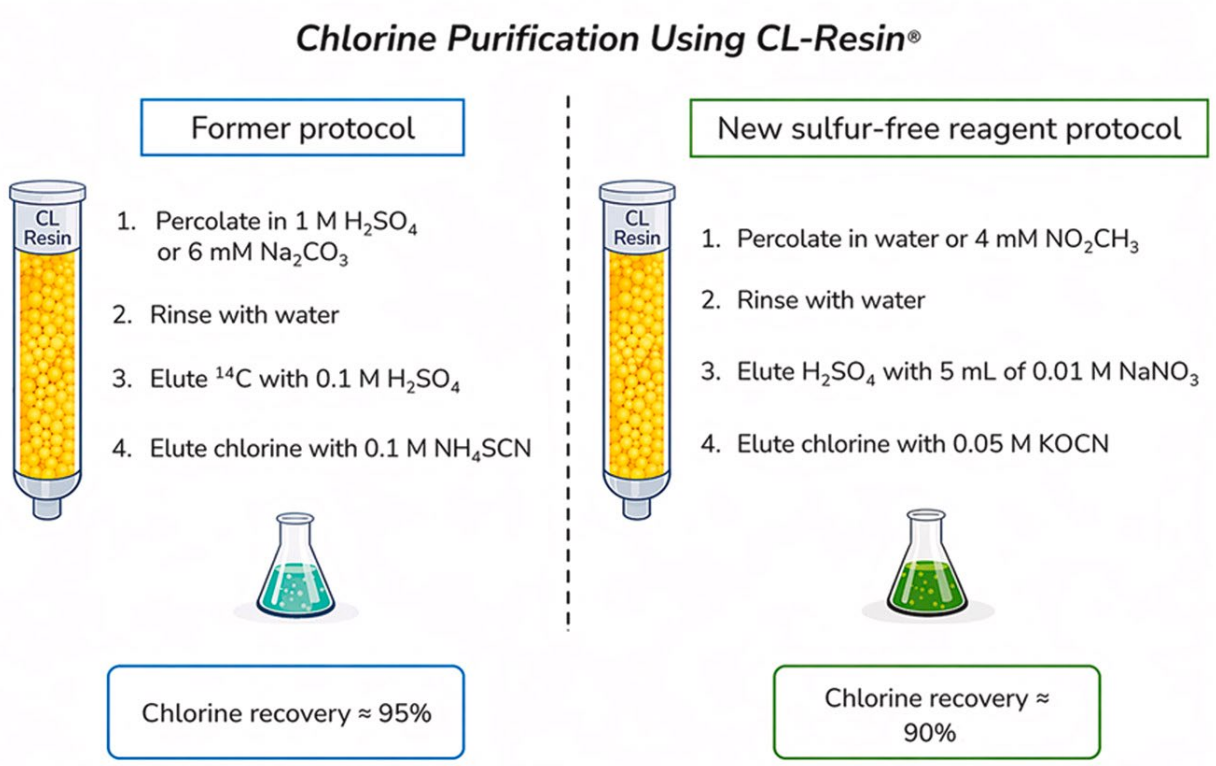
Investigation of the CL-resin® properties for a sulfur-free content molecule protocol

Amayès Gaston-Bellegarde [a,b,*], Azza Habibi [b], Pascal Fichet [c]

[a] Sorbone University, Paris, France
[b] The French Authority for Nuclear Safety and Radiation Protection, Le Vésinet, France
[c] The French Alternative Energies and Atomic Energy Commission, Saclay, France

Table 1. Solubility product constant (K_{sp}) and calculated solubility (s) of silver compounds.

Compound	K_{sp}	Solubility (s) mol.L^{-1}	References
AgCl	1.77×10^{-10}	1.33×10^{-5}	[3]
Ag_2CO_3	8.46×10^{-12}	1.28×10^{-4}	[3]
AgOCN	2.3×10^{-7}	4.8×10^{-4}	[14]
AgSCN	1.03×10^{-12}	1.01×10^{-6}	[3]
Ag_2SO_4	1.20×10^{-5}	1.44×10^{-2}	[3]
AgCN	5.97×10^{-17}	1.10×10^{-8}	[3]
Ag_2SO_3	1.50×10^{-14}	1.55×10^{-5}	[3]



CL Resin - I-131 in biological samples and hospital effluents

Talanta 206 (2020) 120224

Contents lists available at ScienceDirect

Talanta

journal homepage: www.elsevier.com/locate/talanta



Fast-response flow-based method for evaluating ^{131}I from biological and hospital waste samples exploiting liquid scintillation detection

Donagi Esparza[a,b], Manuel Valiente[c], Antoni Borràs[a], Marina Villar[c], Luz O. Leal[b], Fernando Vega[c], Víctor Cerdà[d], Laura Ferrer[a,*]

[a] Environmental Radioactivity Laboratory (LaboRA), University of the Balearic Islands, Cra. Valldemossa Km 7.5, 07122, Palma, Spain
[b] Environment and Energy Department, Advanced Materials Research Center (CIMAV) S.C., Miguel de Cervantes 120, Chihuahua, Chih., 31136, Mexico
[c] Radiopharmacy Service, Son Espases University Hospital, Cra. Valldemossa 79, 07120, Palma de Mallorca, Spain
[d] Department of Chemistry, University of the Balearic Islands, Cra. Valldemossa Km 7.5, 07122, Palma, Spain

Lab-on-valve analysis with 135mg CL Resin/extraction

>80% recovery of iodine

MDA 0,05Bq I-131

CL Resin – Iodine removal from effluents

Decamp et al.: Iodine removal from elevated sample volumes[§]

- Treatment of complex process effluents
  - > 10 L radioactive effluent (1M HNO_3)
- Issues with rad. waste storage
  - Storage as liquid waste challenging
  - Preferably stored as solid waste
- Use of mixed-bed columns
  - 3g Ag loaded CL resin (plus 4g XAD-4 resin)
- Flow rate up to 180 mL/min
- Radio-iodine retention: 89% - 98%
- Retention of up to 2000 GBq radio-iodine per 7g column

Example for decontamination of effluents

[§] C. Decamp (IRE), S. Happel: Utilization of a mixed-bed column for the removal of iodine from radioactive process waste solutions, Journal of Radioanalytical and Nuclear Chemistry, online April 2013, DOI: 10.1007/s10967-013-2503-1

CL Resin – other radionuclides

Chromatographic separation of the theranostic radionuclide ^{111}Ag from a proton irradiated thorium matrix

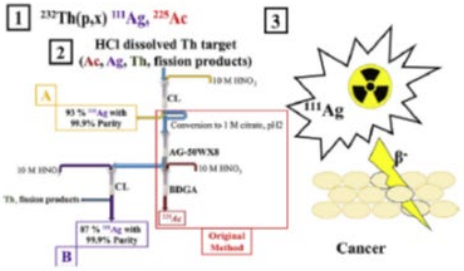
Tara Mastren [a], Valery Radchenko [a, 1], Jonathan W. Engle [a, 2], John W. Weidner [a], Allison Owens [b], Lance E. Wyant [b], Roy Copping [b], Mark Brugh [a], F. Meiring Nortier [a], Eva R. Birnbaum [a], Kevin D. John [a], Michael E. Fassbender [a, *]

[a] Chemistry Division, Los Alamos National Laboratory, P.O. Box 1663, Los Alamos, NM 87545, USA
[b] Nuclear Security and Isotope Technology Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

HIGHLIGHTS

- Chromatographic recovery of medical isotope ^{111}Ag from proton irradiated thorium targets.
- First-time measured equilibrium distribution coefficients for silver and ruthenium on CL resin.
- ^{232}Th (p, fission) cross-section data for the formation of ^{111}Ag and ^{110m}Ag.

GRAPHICAL ABSTRACT



Anal. Chem., 2018, https://pubs.acs.org/doi/10.1021/acs.analchem.8b01380

Separation of protactinium employing sulfur-based extraction chromatographic resins

Tara Mastren[†], Benjamin W. Stein[†], T. Gannon Parker[†], Valery Radchenko[†#], Roy Copping[‡], Allison Owens[‡], Lance E. Wyant[‡], Mark Brugh[†], Stosh A. Kozimor[†], F. Meiring Nortier[†], Eva R. Birnbaum[†], Kevin D. John[†], Michael E. Fassbender[†*]

[†]Chemistry Division, Los Alamos National Laboratory, P.O. Box 1663, Los Alamos, NM 87545, USA
[‡]Nuclear Security and Isotope Technology Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

[#]Current Address: Life Sciences Division, TRIUMF, 4004 Wesbrook Mall, Vancouver, BC, V6T2A3, Canada

Cs Resins



Originally developed by Sebesta et al.

Two resins:

- AMP-PAN (slightly acidic to neutral samples)
- KNiFC-PAN (generally neutral water samples)
- 70 – 85% active componant, fast kinetics

Both resins efficiently remove Cs, very difficult to regenerate

Typical applications:

- Low level Cs-134/7 determination of water samples by gamma spectrometry
- Removal of high levels of Cs-137 before MS
- Cs-137 decontamination of contaminated effluents

AMP-PAN now also available as prepacked cartridges, incl. 2mL

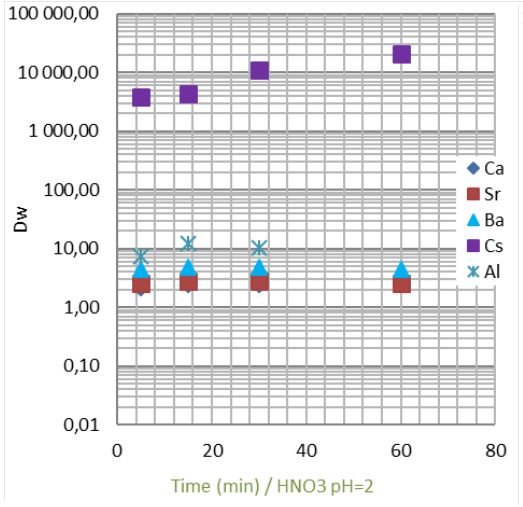
PAN Resins

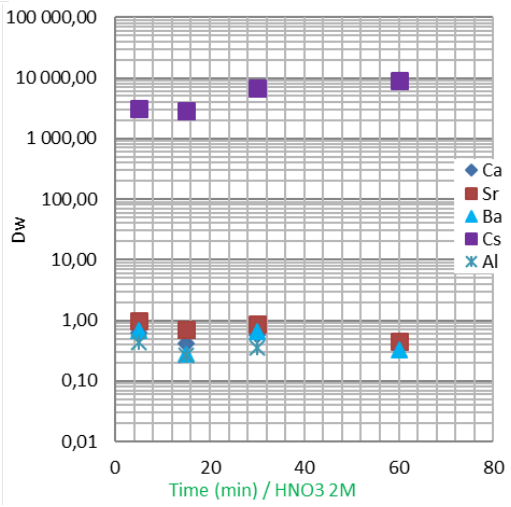
Range of PAN based resins

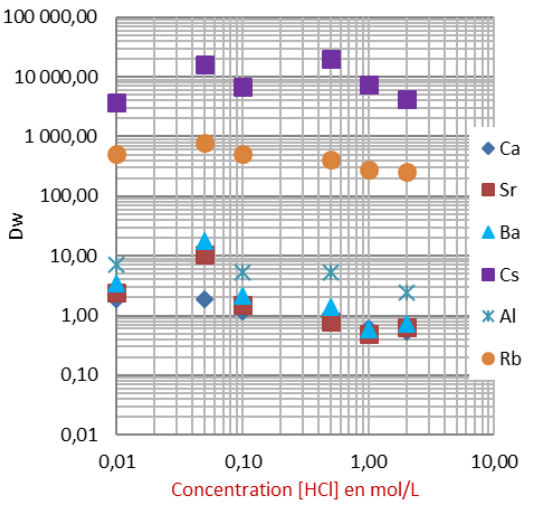
- Decontamination of effluents => radionuclides, heavy metals, pollutants…
- High content of inorganic compounds (~85%)
- Mechanical stability
- Control of particle diameter
- High porosity/active surface => fast kinetics

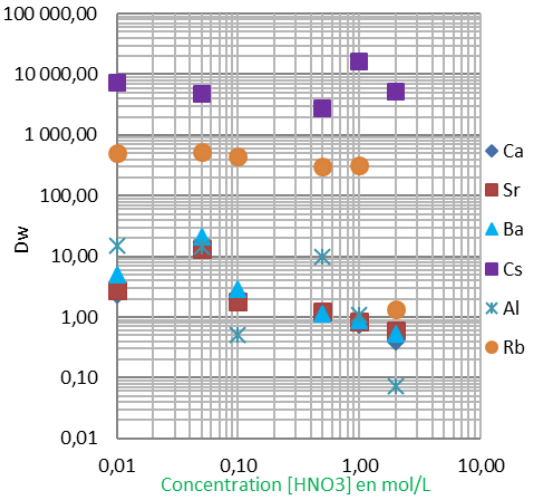


Park et al.









Cs measurements in Seawater

Procedure:

- Seawater Sample volumes: 100L,
- Acidified (pH 1-2) and raw samples,
- Column bed 25ml of AMP-PAN or KNiFC-PAN,
- Flowrate: maximum at 300ml.min^{-1},
- Gamma spectrometry measurement



Results: Yield > 90% Cs retention

MDA for 100l samples, 50-70h counting:

- 0,18 Bq.m^{-3} for ^{134}Cs,
- 0,15 Bq.m^{-3} for ^{137}Cs

Pike et al., Extraction of Cesium from Seawater off Japan using AMP-PAN Resin and Quantification via Gamma Spectrometry and Inductively Coulped Mass Spectrometry, J. Radioanal. Nucl. Chem, DOI 10.1007/s10967-012-2014-5, 2012

Kamenik J. et al., Fast Concentration of Dissolved forms of Cesium Radioisotopes from Large Seawater Samples, J. Radioanal. Nucl. Chem, DOI 10.1007/s10967-012-207-4, 2012

Cs in sea water – Hou et al.

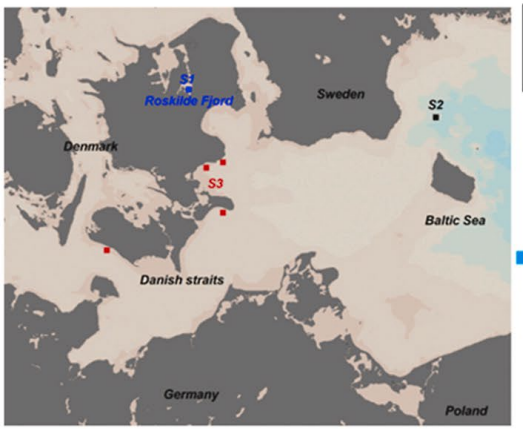
Talanta
Volume 226, 1 May 2021, 122121

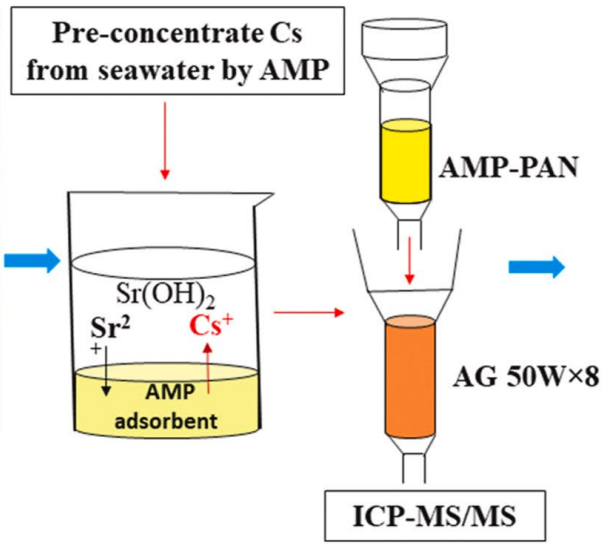


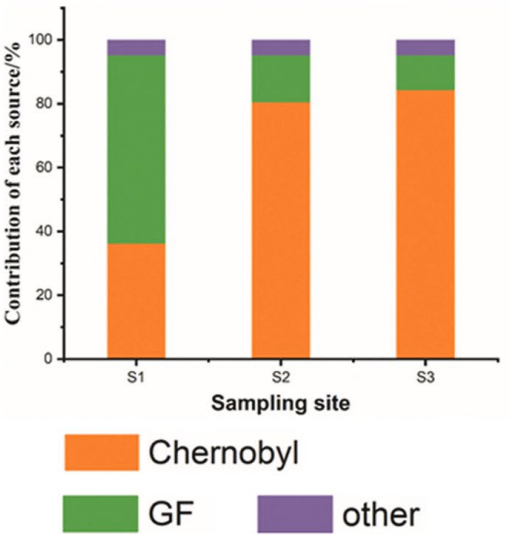
Determination of low-level ^{135}Cs and $^{135}Cs/^{137}Cs$ atomic ratios in large volume of seawater by chemical separation coupled with triple-quadrupole inductively coupled plasma mass spectrometry measurement for its oceanographic applications

Liuchao Zhu, Xiaolin Hou, Jixin Qiao

Sampling **Method development** **Application**







Calixarene based resin for Cs separation – TK300 Resin

AMP-PAN and KNiFC-PAN well suitable for Cs concentration from aqueous matrices but:

Cs elution difficult, leading to high matrix Cs containing solutions

- Use of NH_4OH, $Sr(OH)_2$ followed by AIX and CEX

Use of calixarene based resins instead

Original TK300 Resin work

- High Cs/Ba selectivity
- Load from water up to 1M HNO_3
- Interference by K
- Low Cs capacity
- Home made calixarene => upscale too difficult

Calixarene based resins

Aim:

- Separation of Cs (and Rb)
- Use of ionic liquids or short-chained alcohols,… as diluents
- Analytical application – low Cs capacity (cost of Calixarenes…)

Preparation of >15 test resins (PR) based on commercially available calixarenes

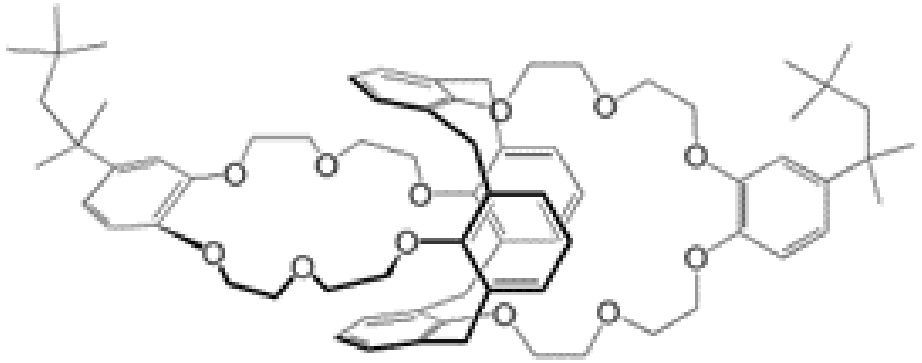
Characterisation of these resins

- D_W values of different element on test resins in HNO_3 and HCl
- Influence of interfering ions (like potassium) on Cs separation
- Breakthrough and full capacities
- Elution tests for Rb and Cs separation

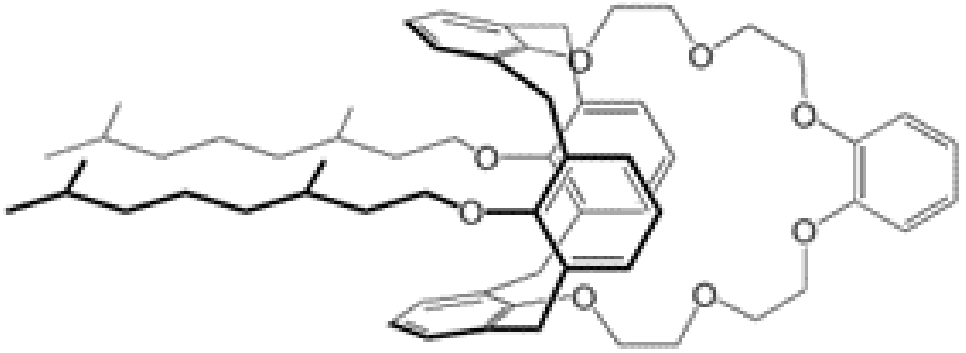
Work performed by Illarion Dovhyi, presented at last TKI/Raddec Workshop (ERA 2026) => visit our website for more data

Design fix for TK300 achieved => beta testing on-going

Tested Calixarenes



Calix[4]arene-bis(tert-octylbenzocrown-6, $C_{72}H_{92}O_{12}$ (BOBCalix)

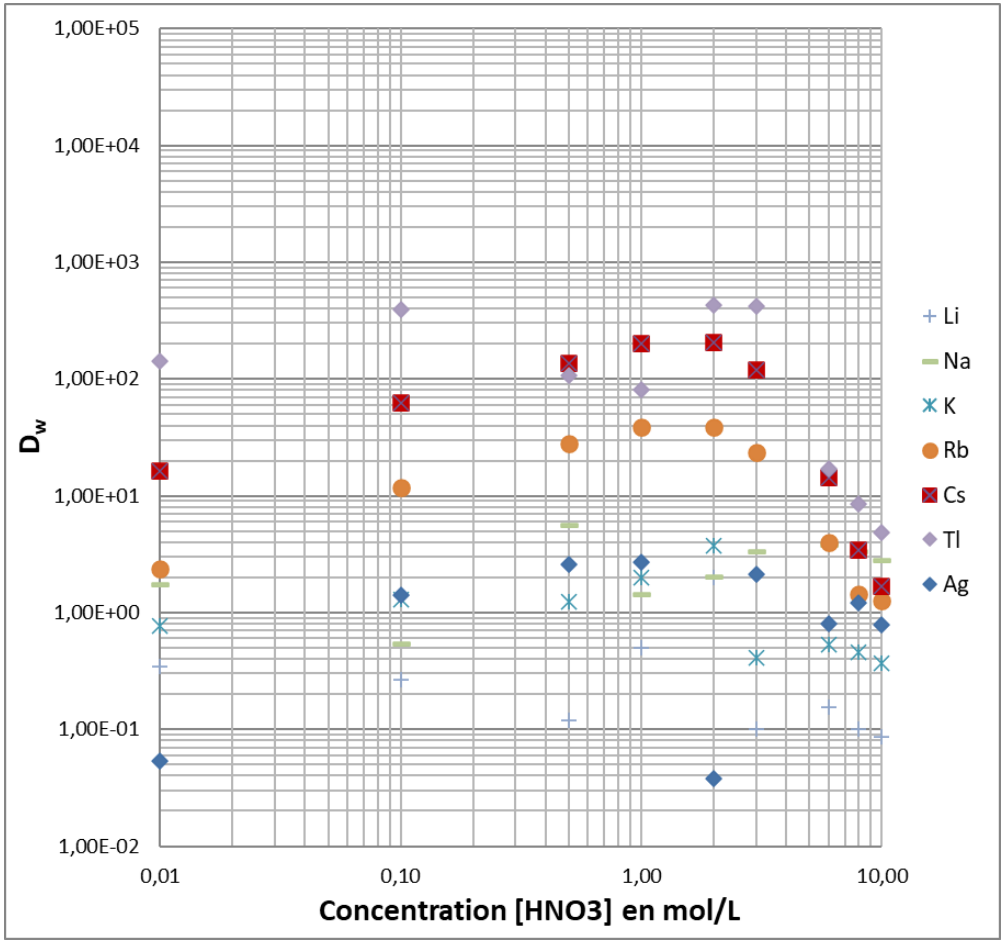


1,3-alt-25,27-Bis(3,7-dimethyloctyl-1-oxy)calix[4]arene-benzocrown-6, $C_{62}H_{82}O_8$ (MAXCalix)



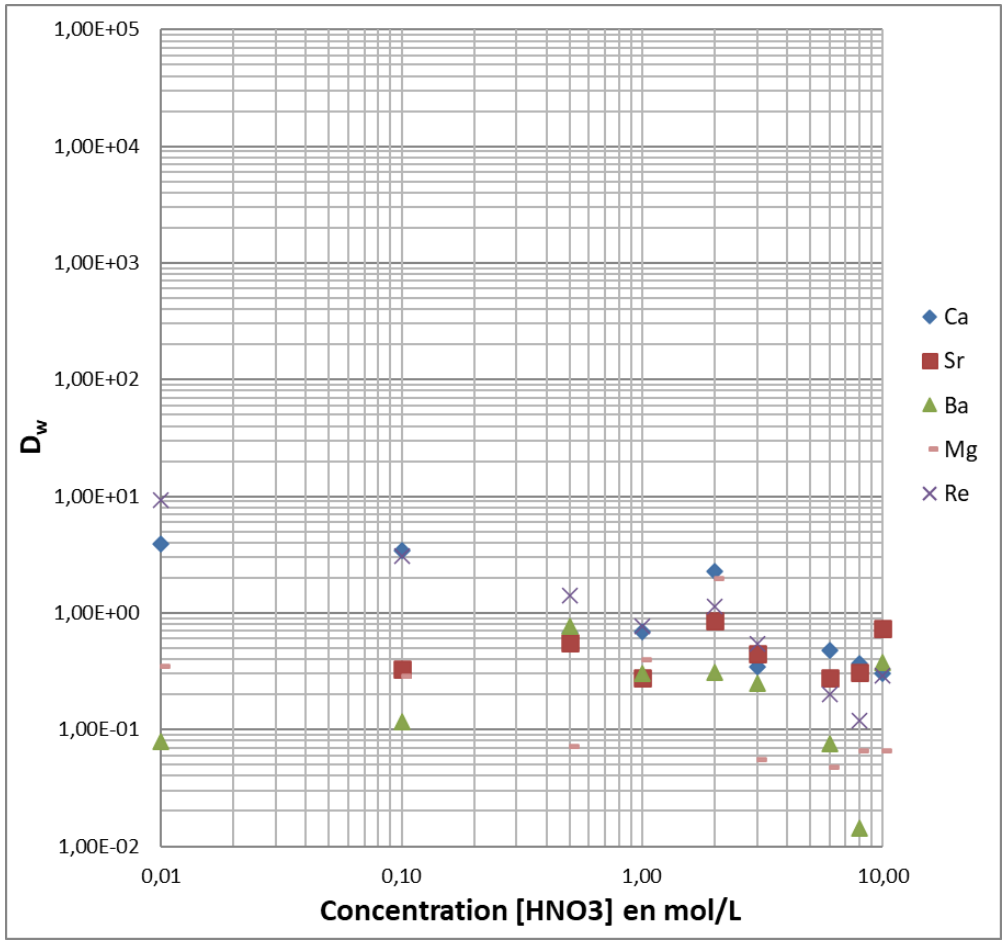
Calix[4]arene-bis[4-(2-ethylhexyl)benzo-crown-6], $C_{72}H_{92}O_{12}$ (BEBHCalix)

Dw values TK300 Resin



Distribution coefficients of selected elements on TK300 Resin in HNO_3

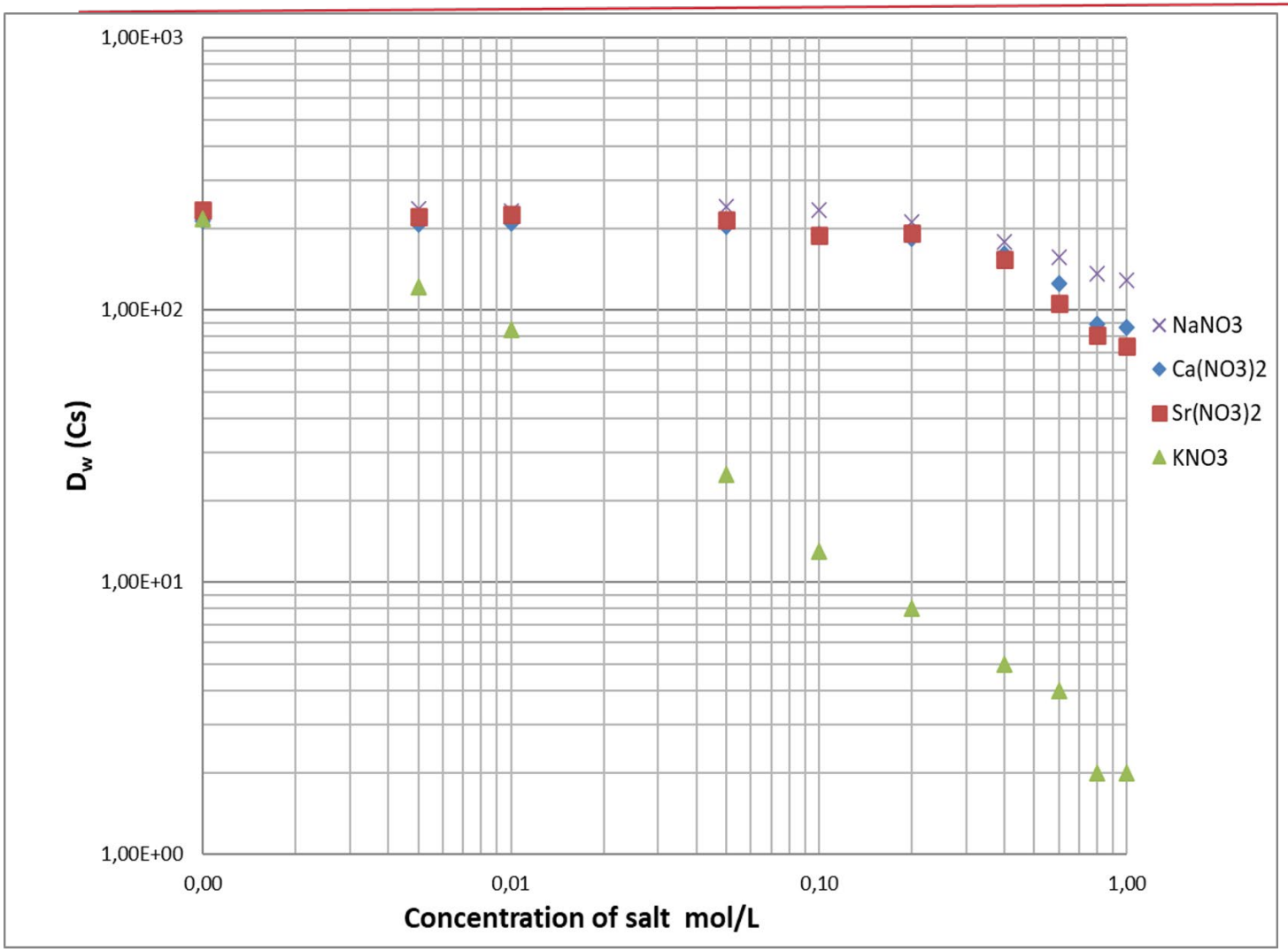
► Rb, Cs and Tl show retention in HNO_3



Distribution coefficients of selected elements on TK300 Resin in HNO_3

► low retention of alkaline earth elements

Influence of matrix elements

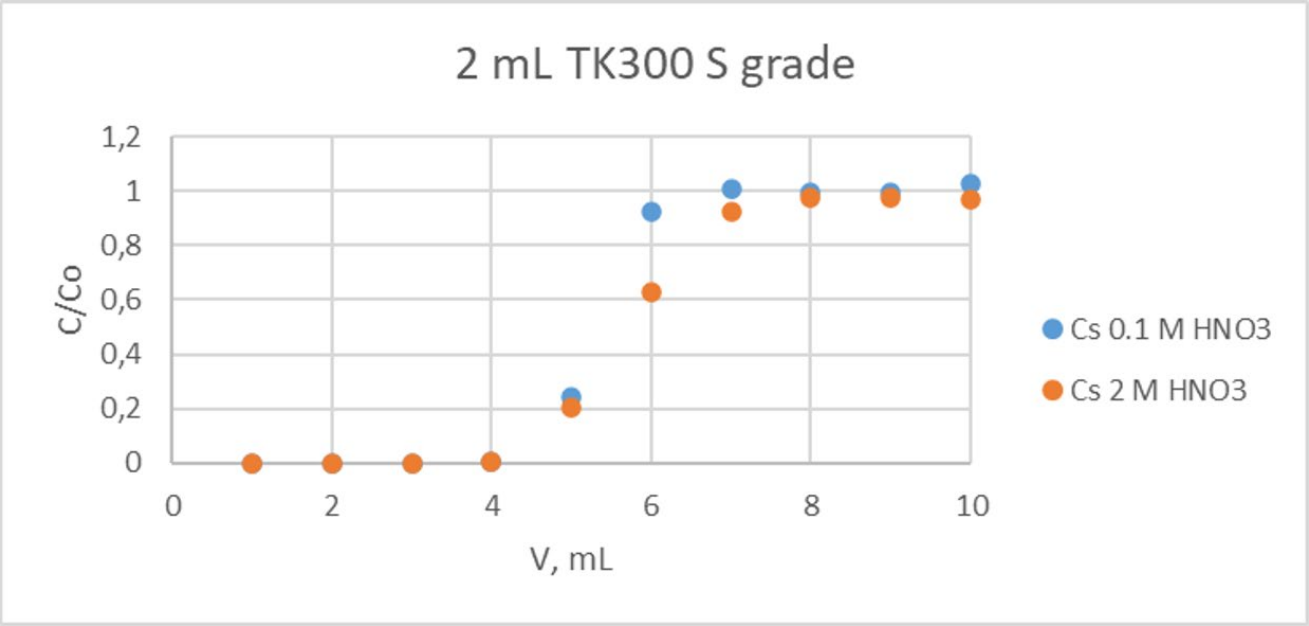


Distribution coefficients of Cs on TK300 Resin in 2 HNO_3 / salt

► high selectivity in the presence of elevated concentration of Na, Ca, Sr

►strong decrease of Dw in the presence of elevated concentration of K

Resin capacity

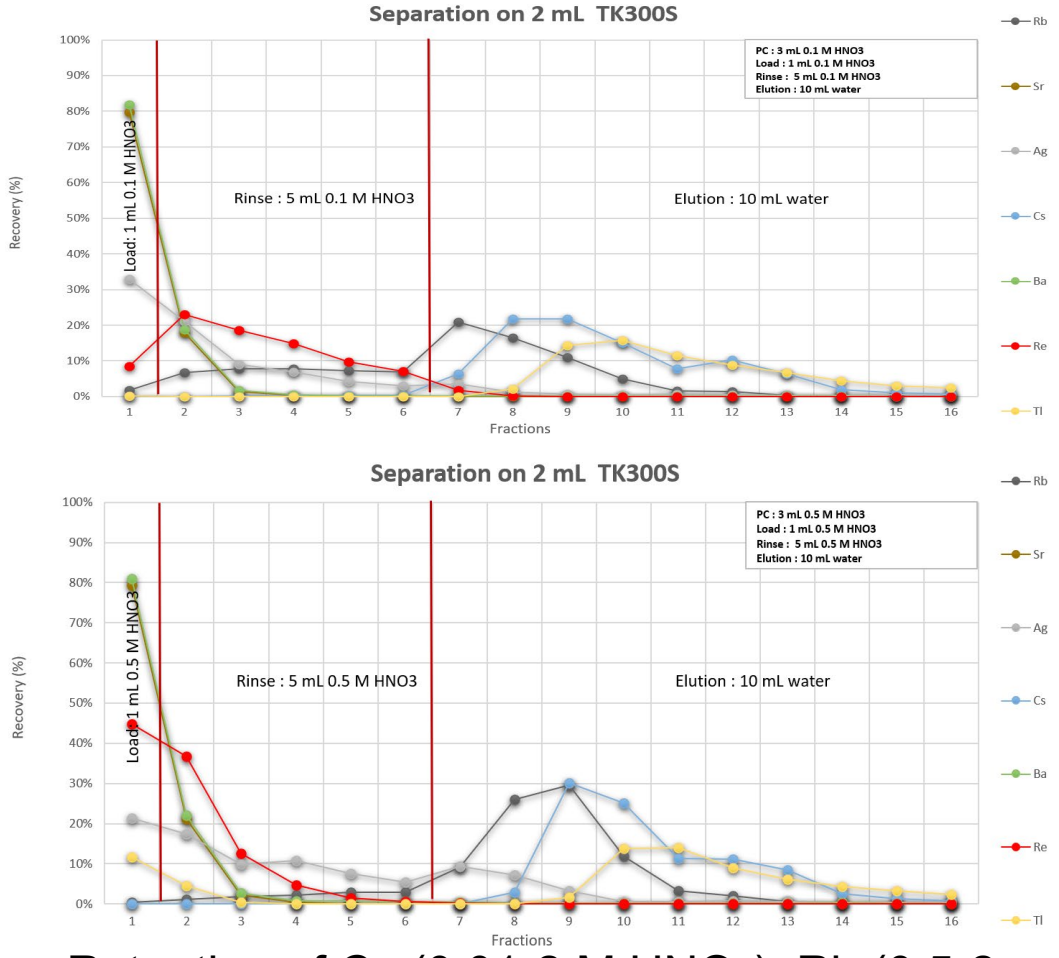


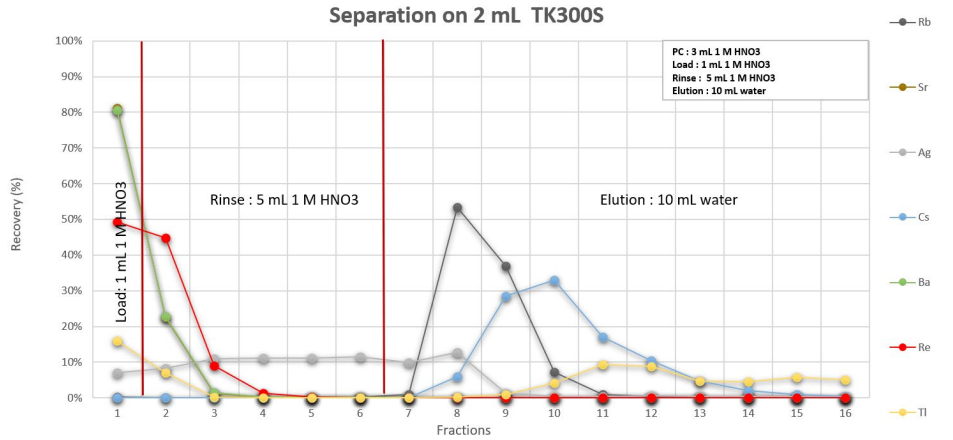
►200 ppm solution of Cs in 2 M HNO_3 was used

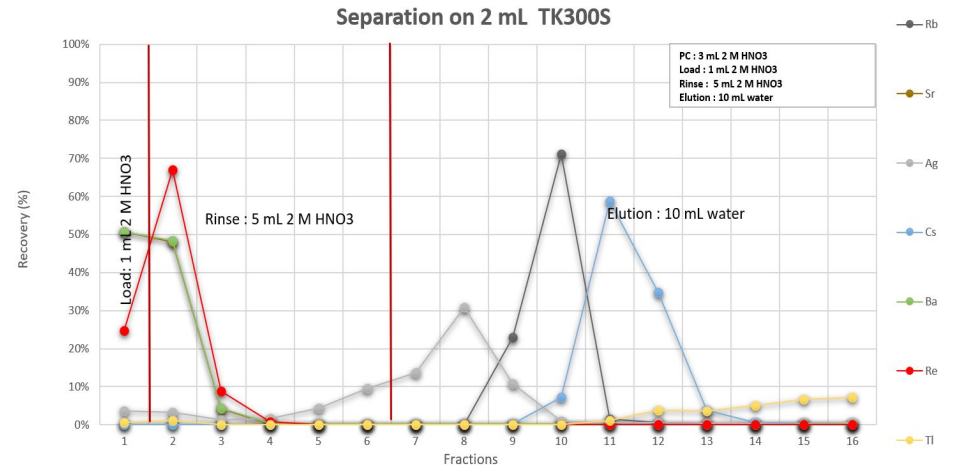
►Breakthrough capacity is close to theoretical for both in 0,1 M and 2 M HNO_3

Experiment	Breakthrough capacity, mg Cs /g resin	Total capacity, mg Cs /g resin	Theoretical capacity, mg Cs /g resin
0.1 M HNO3	1.2	1.45	1.43
2 M HNO3	1.2	1.59	1.43

Elution studies





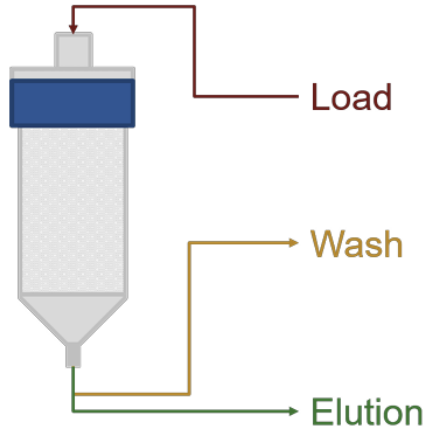


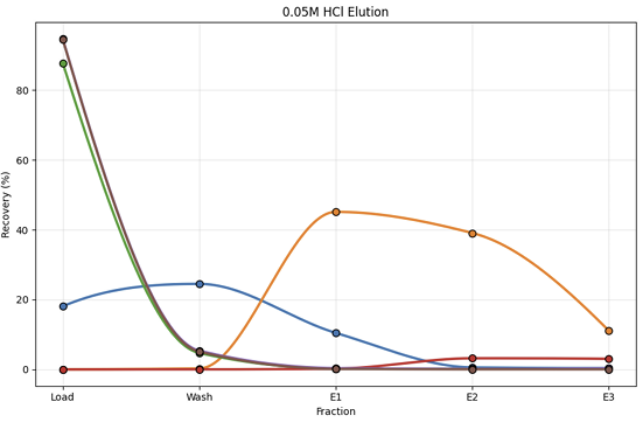
- Retention of Cs (0,01-2 M HNO_3), Rb (0,5-2 M HNO_3), Tl, Ag (2 M HNO_3)
- Low retention of Re (Tc) in pH 1-2, 0.5 M HNO_3 preferable for load to remove Tc
- Resin is very hydrophobic, precondition with 20% EtOH
- Cs below 0.5 mg recommended

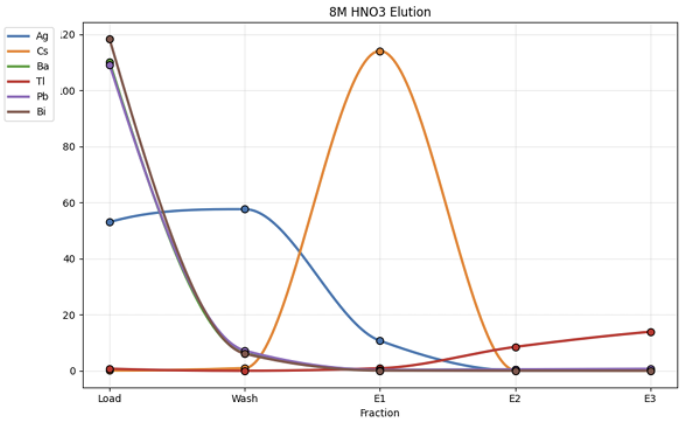
TK300 Resin

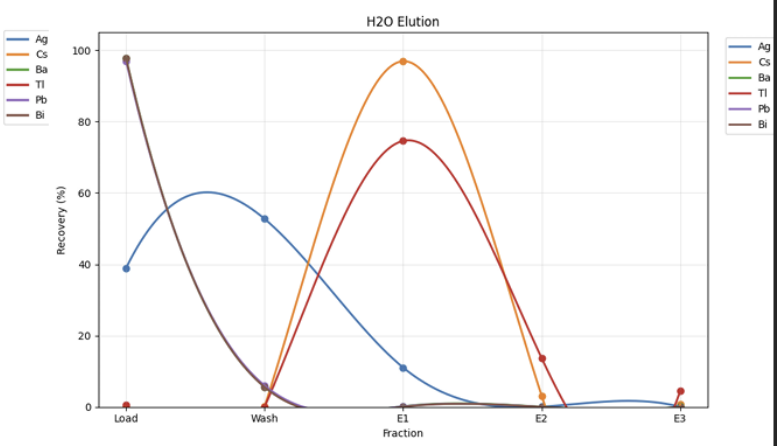
Elution profiles

- Automated separator
- Conditions
  - Load in 10ml 1M HNO3
  - Wash with 10ml 1M HNO3
  - Elution with 3 x 10ml of elution condition
- For elements with Kd >10^2
- Tl and Ag show some retention to column
  - Tl eluted out using H2O



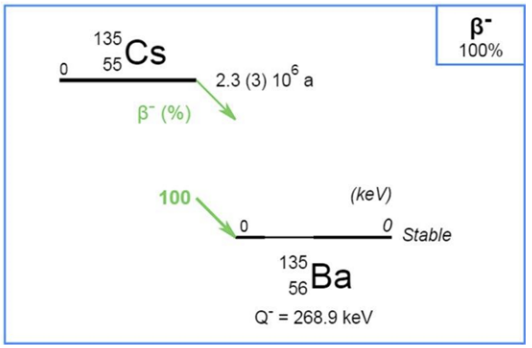




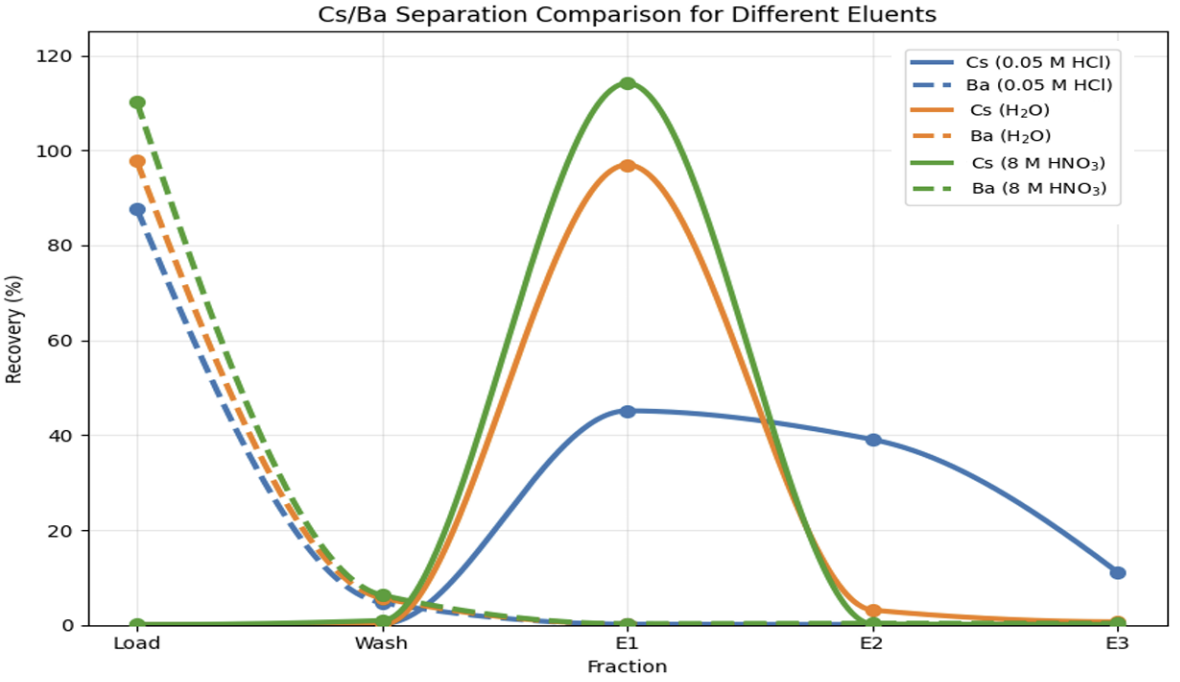


TK300 Resin

Cs/Ba separation



- Comparison of Cs/Ba from previous elution profile
- Ba consistently coming off in Load - clean separation
- Good support for mass spec measurements of Cs-135/137 isotopic ratios

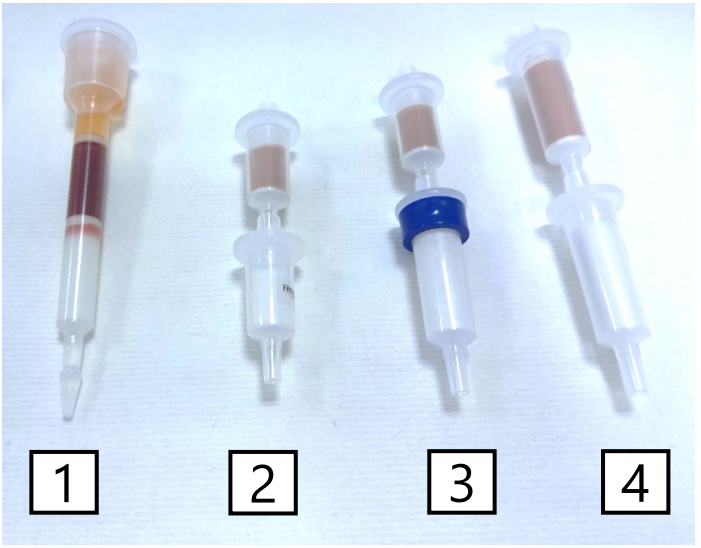


On-going: SE Resin

SE Resin Design fix

New SE Resin

TRISKEM



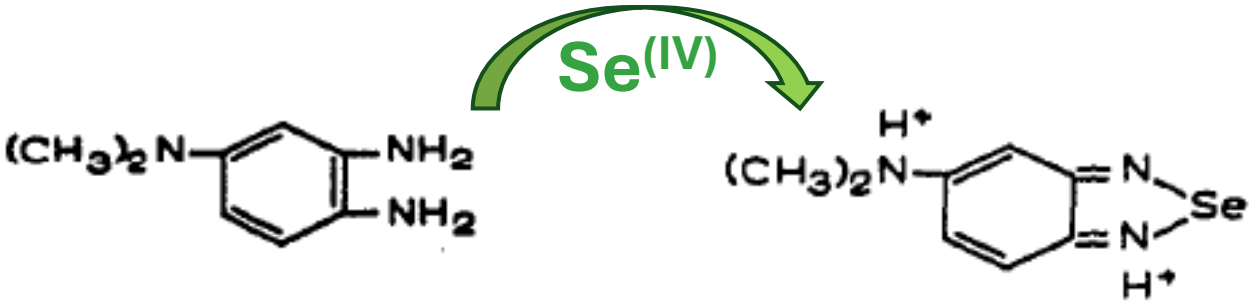
SE Resin

Se retention

New: TK-OgRem Resin

↓

extractant bleeding



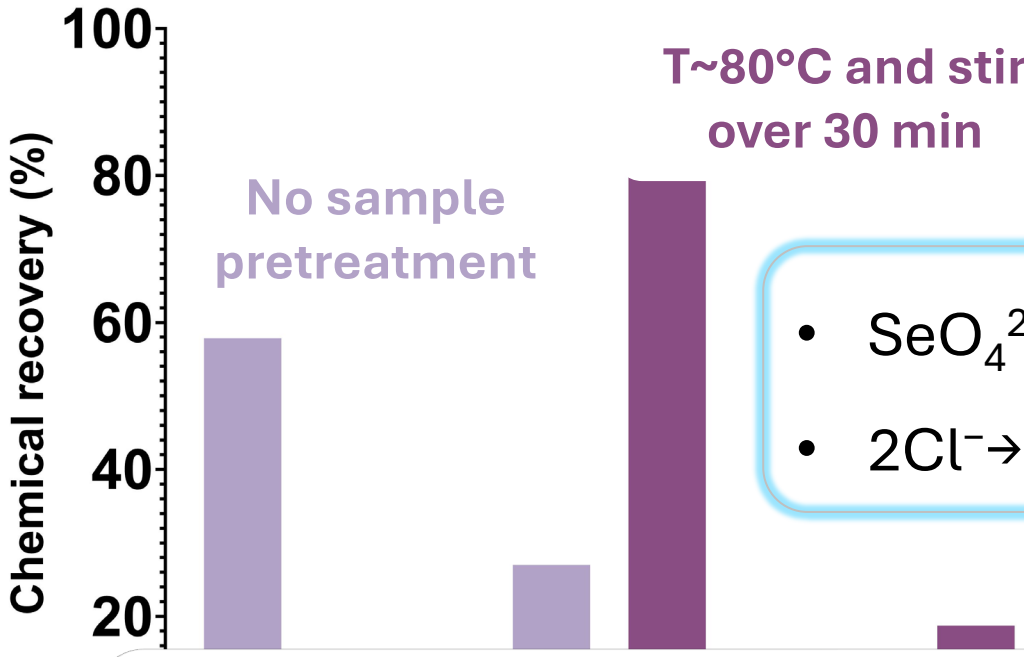
Piazselenol Chemistry

Acid media (H^+)

Influence Se oxidation state

SE Resin – redox adjustment

Influence of T for Se reduction



- $SeO_4^{2-}+2H^++2e^-\rightarrow SeO_3^{2-}+H_2O$
- $2Cl^-\rightarrow Cl_2+2e^-$

Higher $Se^{(VI)}$ retention when warming the sample before loading



1. 1 mL 2.5 M HCl
2. 5 mL 2.5 M HCl
3. 2x10 mL 1 M NaOH

SE Resin – Se reduction

Influence of [HCl] for Se reduction

Ragnar Bye and Waiter Lund, 1988 ➔ relevance of HCl concentration, temperature and time on Se reduction

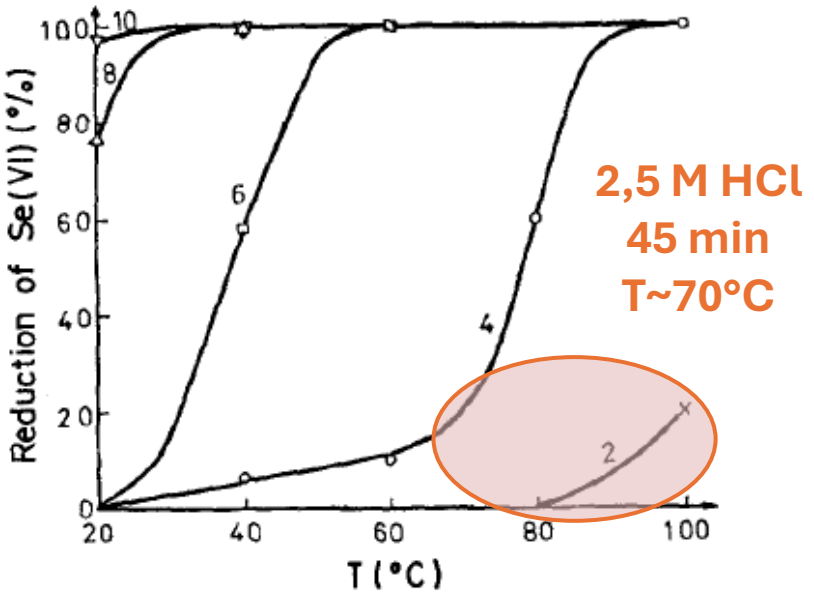


Fig. 2. Reduction of 1.6 µg Se(VI) with 10 ml HCl of various concentrations (mol/l) after 30 min in dependence on temperature

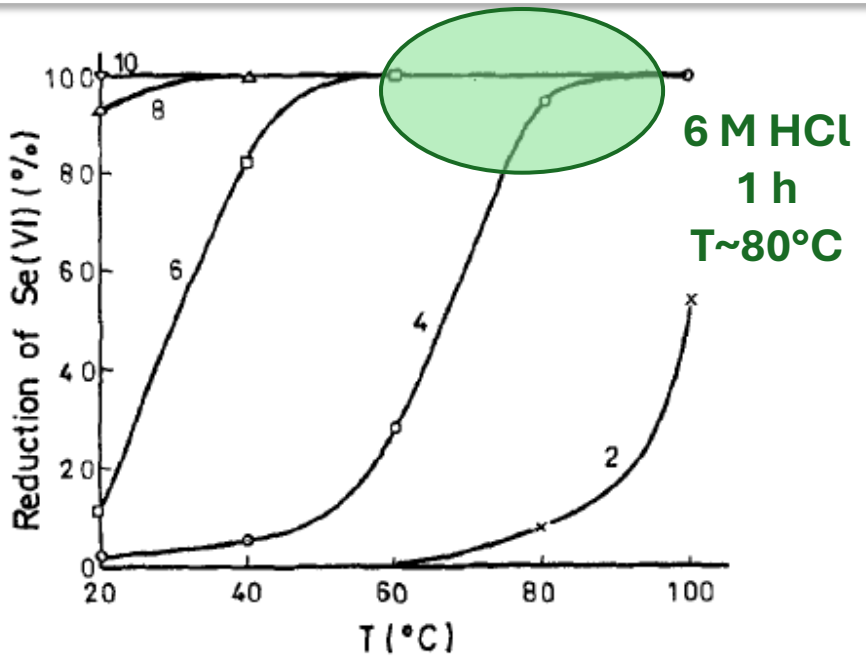
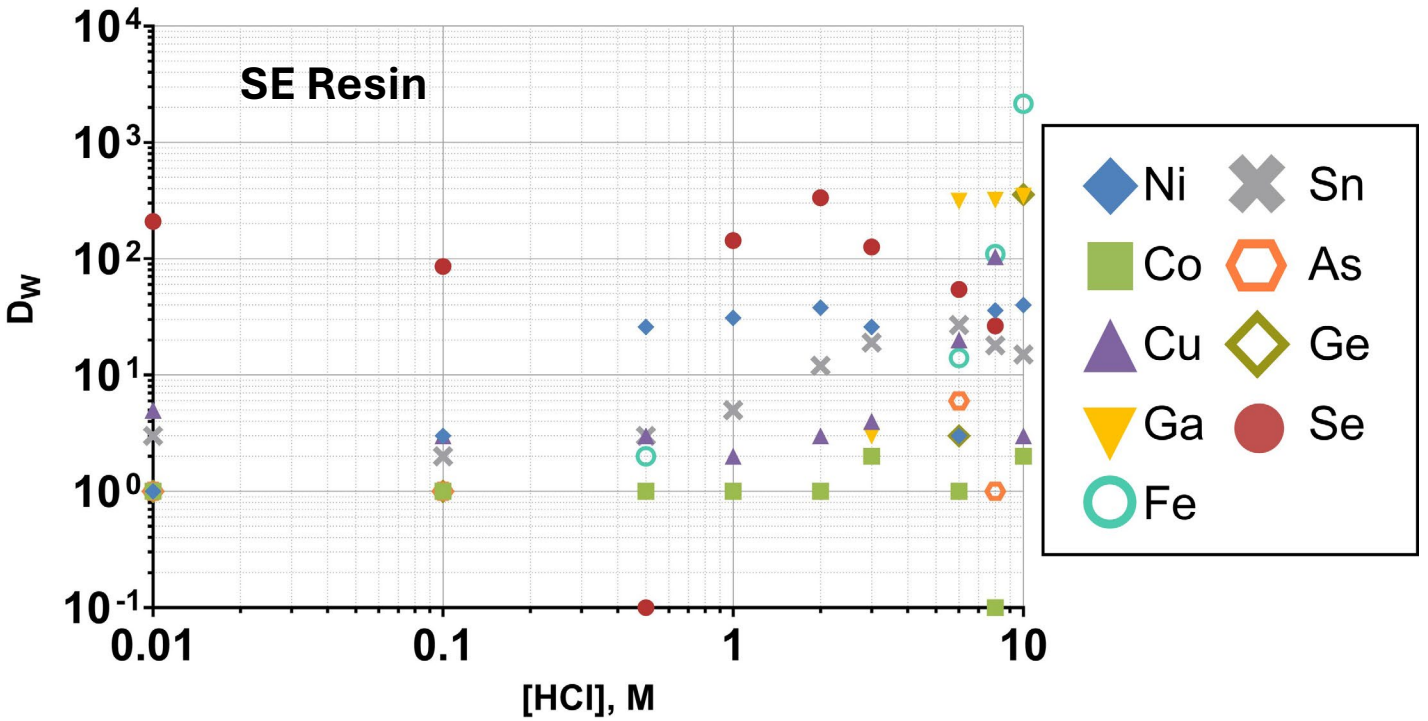


Fig. 4. Reduction of 1.6 µg Se(VI) with 10 ml HCl of various concentrations (mol/l) after 2 h in dependence on temperature

Dw values



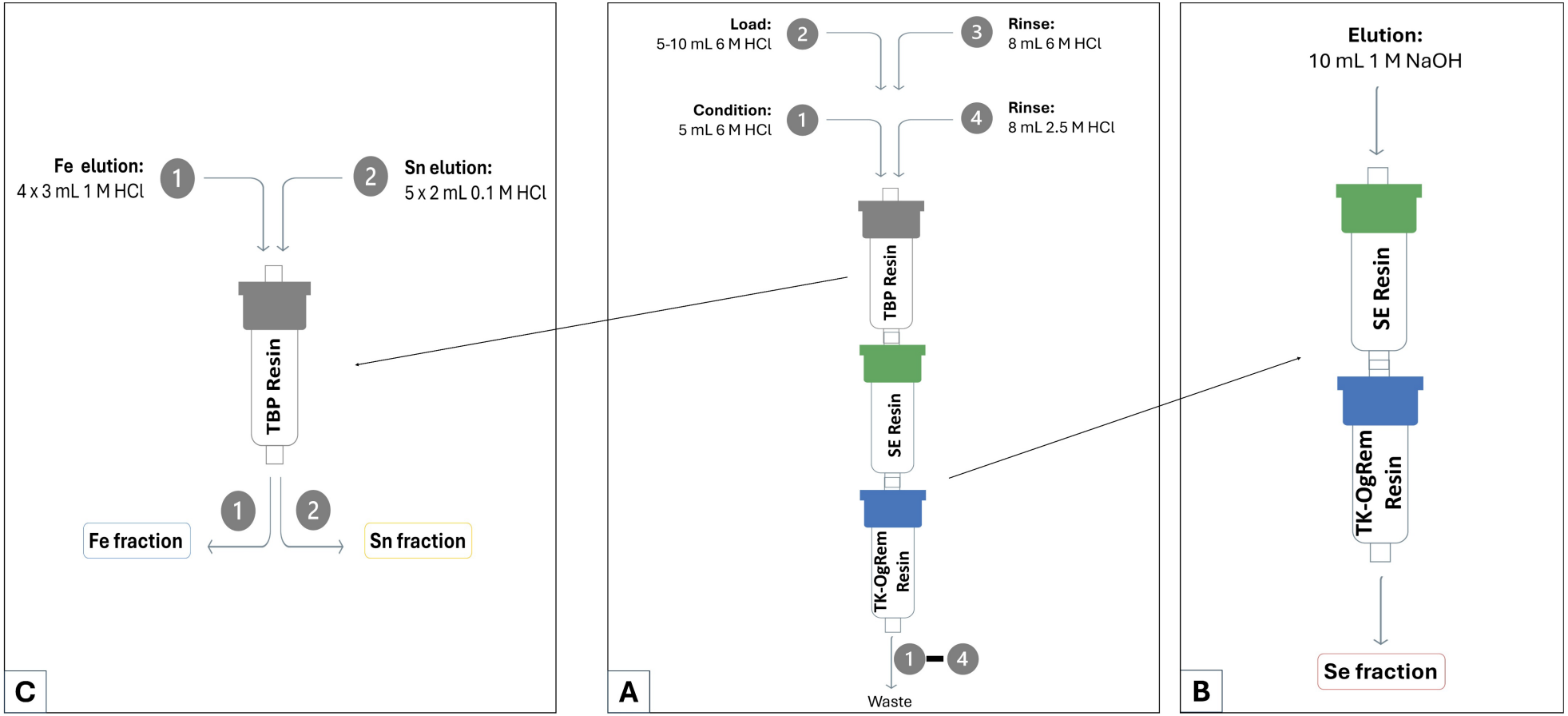
SE Resin:

Good Se(IV) retention

Amine based => Fe, Sn, Ga… also retained at high HCl

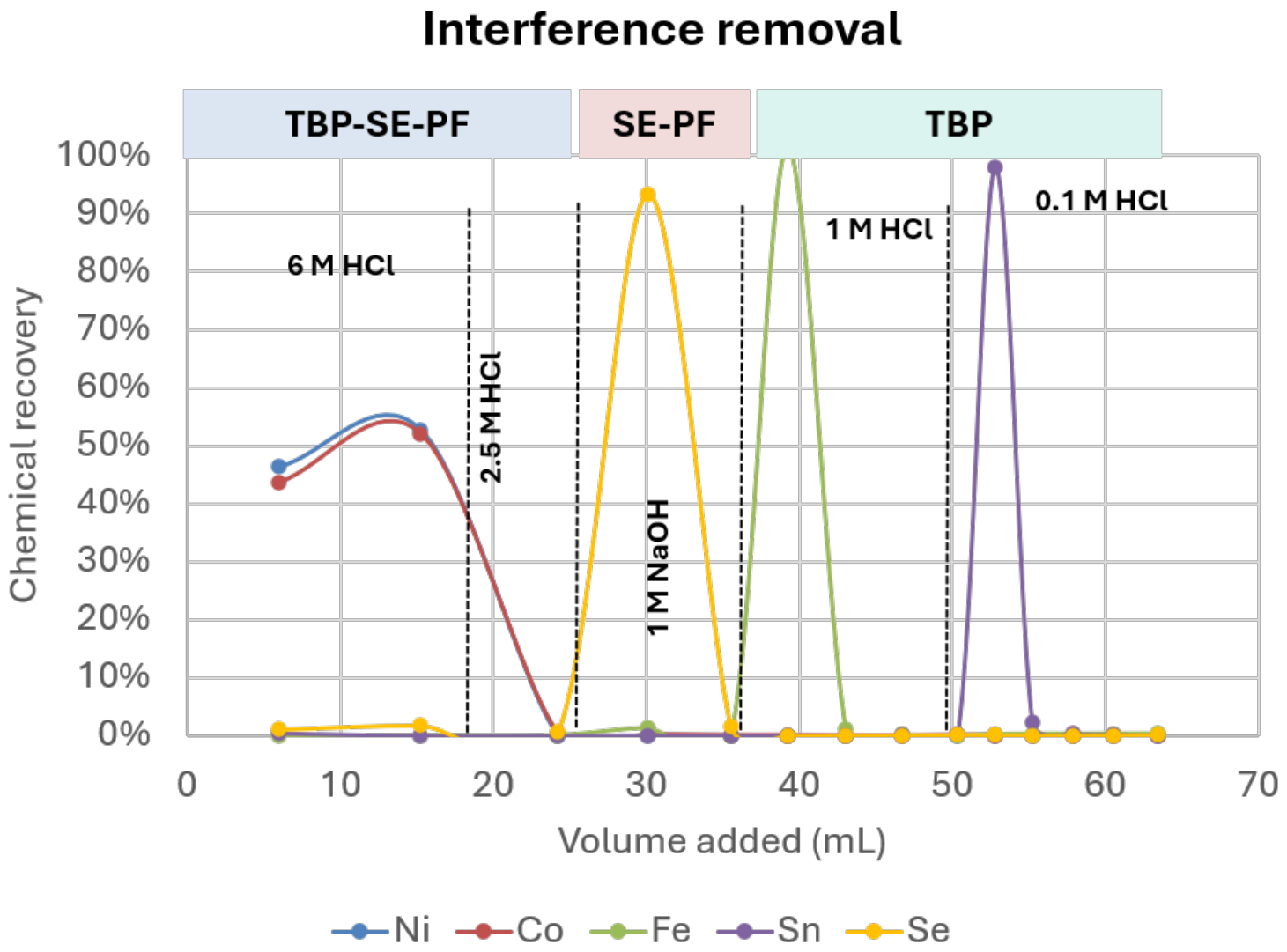
To be adressed in the separation method (e.g. TBP Resin)

Suggested method



TBP Resin upfront for Fe, Ga, Sn,… removal – integration into multi-analyte scheme?
SE Resin for Se separation
TK-OgRem for organics removal (strong colour)

Elution studies



TBP efficiently removes Fe and Sn before SE Resin

Co and Ni pass through both resins

Se passes through TBP onto SE Resin

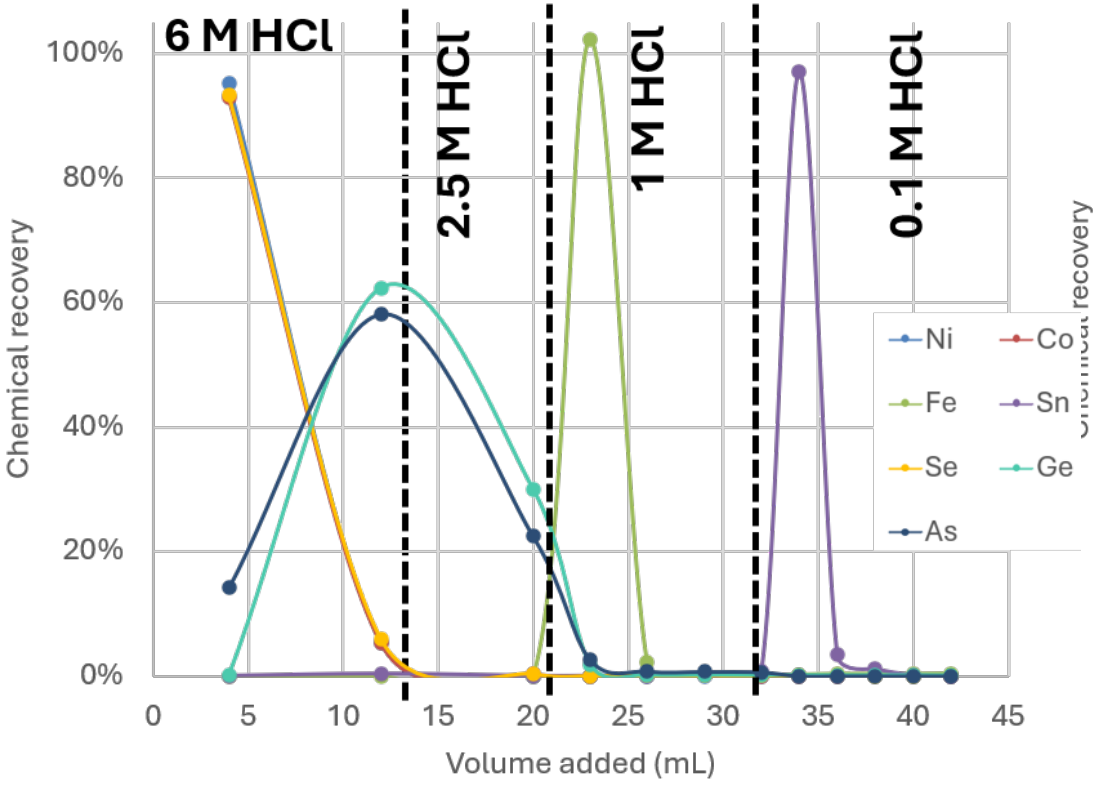
Sharp elution from SE with 1M NaOH

Alternative H_2O_2?

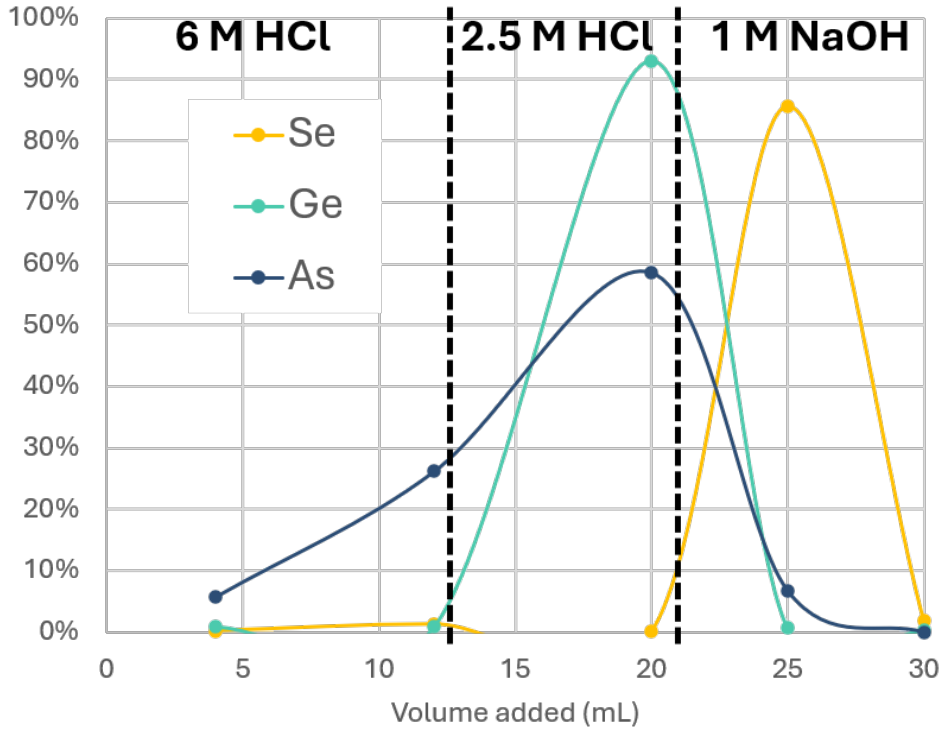
Beta testing started

Elution studies

TBP



SE-TK-OgRem



Se, Co, Ni not retained on TBP Resin, Ge and As partially retained - elution in 2.5M HCl

Fe eluted in 1M HCl, Sn in 0.1M HCl

Se and Ge retained on TK-OgRem in 6M HCl, As partially retained

As and Ge removed in 2.5M HCl

Se eluted in 1M NaOH

Production of « industrial » extraction chromatographic resins

Hydrometallurgy, some decontamination work

- Valorisation / critical metals from ‘waste’
- Decontamination / valorisation of wastes, effluents or decontamination agents (e.g. acid)
  - Example: Am-241 for isotope batteries
- Number of reuses

Range of different resins being fabricated and tested

Bigger particle size support: ~300 – 800µm

Higher amount of resins requested

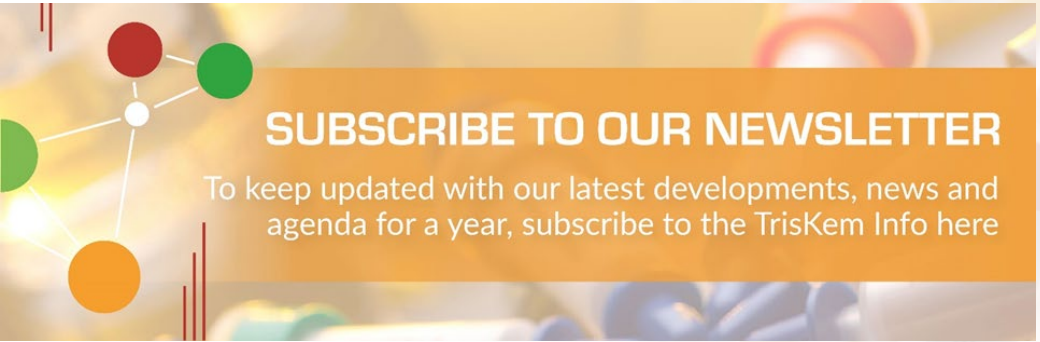
- Challenge: supply of raw materials
- Pricing

Increase of production capacity for these resins

Some other on-going projects

- Rapid tests
  - Additional impregnated PSm resins
  - Range of 'Test sticks'
    - Suitable impregnated support
    - UM => rapide isotope ratio analysis by MS (metallomics): Cu, Ca, Zn,…
    - NPL
    - Uni Barcelona (also test vials with impregnated PSm)
- Passive sampling (DGT)
- TLC supports for RN QC in nuclear medicine
  - Rapid test for RN in decomm? 2D TLC?
- Fate' of RN in the environment + bioassay
  - Separation methods
  - Mainly longer lived RN (=> therapy)
    - Ac-225/7, Lu-177(m), radioiodine,…
  - Quantification
- In-field preconcentration
  - Impregnated membranes
  - Cartridges
  - Bringing cartridges to the lab instead of water samples…
- Microfluidics
- Other 'geometries' & 'Non-resin' separation materials

Thank you for your attention!



TRISKEM
Expertise in Separation Chemistry