New Developments in Triskem

ICRM2025 Aude Bombard 21/05/2025



24th International Conference 19on Radionuclide Metrology Par and its applications Fra

19-23 May 2025 Paris France





- Triskem presentation
- New developments
 - □Scintillating resins
 - TK100/1 (Radium) with TK102
 - Extraction chromatography
 - resins: TK200 and TK201 Resins
- On-going developments
 - **C**s Calixarene based resins
 - □New impregnated membrane
 - filters

□ Passive sampling - DGT



- Based in Rennes (France)
- Independent company since 02/07
 - Formerly part of Eichrom Europe
 - ISO 9001 since 2007



Ireland Éire

Portuga

France

Barcelona

España Spain tal

Roma

- Staff: 23
- R&D: Development of new resins, techniques and applications
- Products used in several domains
 - Purification
 - Decontamination



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New Developments – Scintillating resins



- Plastic scintillating beads impregnated with selective extractant
- Developped by university of Barcelona by García, Tarancón, Bagán
- « TK-ElScint » product line
 - 1st product: « TK-TcScint »
 - Quaternary ammonium + phase modifier (similar selectivity to TEVA)
 - Environment/decommissioning => Tc-99, Cl-36 by LSC
 - 2nd product: « TK-SrScint »
 - Sr selective TK102 based resin
 - Environment/decommissioning => Sr-90 and Pb-210 by LSC
- More products under development

Results (Garcia et al., TKI UGM Cambridge 2018)

| 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) |





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New Developments – <u>TK100/1 Resin</u> (Radium) with TK102 Resin

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



Rapid Analysis of Radium-226 in Water Samples by ICP-000

https://www.agilent.com/cs/library/applications/8800 ICP-**Application Note** MS_5991-8324EN_radium_analysis.pdf Nuclear, environmental Applied Radiation and Isotopes 126 (2017) 35-39 Authors Applied Radiation and Contents lists available at ScienceDirect Ben Russell¹, Elsie May van Es^{1,2}, Applied Radiation and Isotopes Glenn Woods³, David Read^{1,2} journal homepage: www.elsevier.com/locate/apradiso 1. National Physical Laboratory, RADIUM Teddington, UK 2. Chemistry Department, University Development of an optimised method for analysis of ⁹⁰Sr in CrossMark of Surrey, Guildford, Surrey, UK decommissioning wastes by triple quadrupole inductively coupled plasma mass spectrometry B. Russell*, M. García-Miranda, P. Ivanov National Physical Laboratory, Hampton Road, Teddington, TW11 OLW, UK





- Good Ra separation when loading from dilute
 Bi partially retained from 0.05M HNO₃/HCl
 Ra eluted in 3M HNO₃
- When eluting Ra in 3M HNO₃, Ba, Pb, Sr remain retained
- Further Ba removal via TK102 possible
- Tl and Ba eluted in $8M HNO_3$

• No retention of U, Th, Pt, Ir,...

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TK102 Resin – Sr and Pb separation

- •Modified version of SR Resin
 - •Same crown-ether
 - •Solvent, inert support and ratios => different
 - •Higher Sr, Pb and Ba retention than SR Resin
 - Less bleeding of organic materials
- •Work by I. Dohvyi (Poster during ERA14), M. Bas, S. Khalfallah, N. Vajda, S. Happel
- •Originally optimisation for Ra/Ba separation





TK102 Resin – extra 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 HNO₃



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| Resins/ Information | TK200 Resin | TK201 Resin |
|------------------------|---|---|
| Extraction system | TOPO based High retention of actinides (Higher than UTEVA, TEVA) | Tertiary amine (weak Anion Exchanger) based $R^1 \xrightarrow{N} R^2$ R^3 |
| Applications | * U removal from Pu (Wang et al.) * Tc-99 in water samples (Ni Yuan et al.) * Ga-68 production (in combination with ZR Resin) * Actinide separation from water samples | * Actinides separation * Tc separation: Environmental monitoring / Decommissioning Similar selectivity to TEVA but easier to elute (Use of NH₄OH or 2M HNO₃) * Cu separation : On-going development/ Radiopharmacy |

TK200 Resin - U/Pu separation

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



Figure S1. Analytical procedure for determination of plutonium isotopes (²³⁸Pu, ²³⁹Pu,



Publications using TK201 for Tc-99 Horstmann et al.





Fig. 3 Schematic description of the integrated filtration, clean-up and preconcentration procedure, performed prior to the on-line ExC-IC-ICP-MS method, when samples required it.



Fig. 2 Schematic depiction of the on-line ExC-IC-ICP-MS method using a modified automated single platform system for total metal analysis, a cation suppressor, aerosol desolvation nebulization system and an ICP-MS.



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- 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 NH₄OH, Sr(OH)₂ followed by AIX and CEX
- Use of calixarene based resins instead
- Original work: TK300 Resin
 - High Cs/Ba selectivity
 - Load from water up to 1M HNO₃
 - Interference by K / Low Cs capacity
 - Home made calixarene finally too difficult to upscale
- Use of ionic liquids or short-chained alcohols as diluents to obtain 2 types of resins:
 - > High acid concentration load/ weak acid concentration or water as elution medium
 - >Weak acid concentration load medium/ high acid concentration elution medium

Calixarene based resins for Cs separation (2/3)

- 13 test resins (PR) based on commercially available calixarenes prepared and characterized
 - ✓ D_w values of different element on test resins in HNO₃ and HCl
 - ✓ Influence of interfering ions (like potassium) on Cs separation
 - \checkmark Breakthrough and full capacities
 - \checkmark Elution tests for Rb and Cs separation
- Work performed by Illarion Dovhyi, presented at last TKI/Raddec Workshop (18.04.2024) => visit our website for more data



Calix[4]arene-bis(tertoctylbenzocrown-6, C₇₂H₉₂O₁₂ (BOBCalix)

1,3-alt-25,27-Bis(3,7dimethyloctyl-1oxy)calix[4]arene-benzocrown-6, C₆₂H₈₂O₈ (MAXCalix)

Calix[4]arene-bis[4-(2ethylhexyl)benzo-crown-6], C₇₂H₉₂O₁₂ (BEBHCalix)

Calixarene based resins for Cs separation – Conclusions (3/3)

- \Box Calixarene based test resins show high selectivity for Rb and Cs in wide range of HNO₃ and HCl concentrations.
- \Box Four test resins show high-capacity for Rb/Cs separation from 0,01M 1 M HNO₃ medium and Rb and Cs elution with 10 M HNO₃
- \Box Two test resins with high-capacity for Rb/Cs separation from 3 M HNO₃.
 - > Elution of Rb and Cs with water strongly dependent on initial concentration of analytes
 - \blacktriangleright Difficulties to elute Cs from 1 µg/L solutions with water, requires NH₄⁺
- \Box Near 50% Cs sorption on 6 test resins even in 1 M KNO₃ => robust against K interference

□Test resins with elevated Cs capacity : ≥**14mg.g**⁻¹;

Cs separation from sea water samples seems possible

On-going work:

- > Optimisation of elution conditions
- Choice of test resins (one IL based one non-IL based) for beta testing and later-on commercialisation
- Beta testings on real samples



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Under development: range of impregnated membrane filters

- Development of impregnated membrane filters
- □ First filters under beta testing:
 - TK100 (DGT of Sr, Pb, Zn, LN in soil samples)
 - ➤TK201 (determination of Tc-99 in aqueous samples)
 - ≻25mm and 47mm
- Example: membrane filter for gross alpha measurement :
 - pH 2, 10mL/min, typically 100mL samples
 - ➢ High retention of actinides



Alpha sprectrum, Am-241 & Pu-239, ~50mBq each



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On-going developments

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 New impregnated membrane filters

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TK100 discs

□Wagner et al.

- Passive sampling via DGT (Diffusive Gradiant in Thin films) => 'bio-availability'
- Published: Sr and Pb isotope ratios in soil samples, Zn also possible

On-going: with Sr-90 and CU Discs





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Rapid tests

- Impregnated PSm resins
- ➢ Range of 'Test sticks'
 - Suitable impregnated support
 - JCU => rapide isotope ratio analysis by MS (metallomics)
 - Uni Southampton/NPL
 - Uni Barcelona

Separation of DTM

- SE Resin => Se-79
- Zr-93, Fe, Mo, Nb,...
- Microfluidics

Decontamination

- PAN based materials (e.g. AMP-PAN)
- Fate of RN in the environment
 - Separation methods
 - Mainly longer lived RN (=> therapy)
 - Ac-225/7, Lu-177(m), radioiodine,...
 - Quantification
- In-field preconcentration
 - Impregnated membranes
 - Cartridges
- Other 'geometries' &
- 'Non-resin' separation materials Nuclear medicine...

Thank you for your attention

Come and visit our booth for more information support@triskem.fr contact@triskem.fr



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