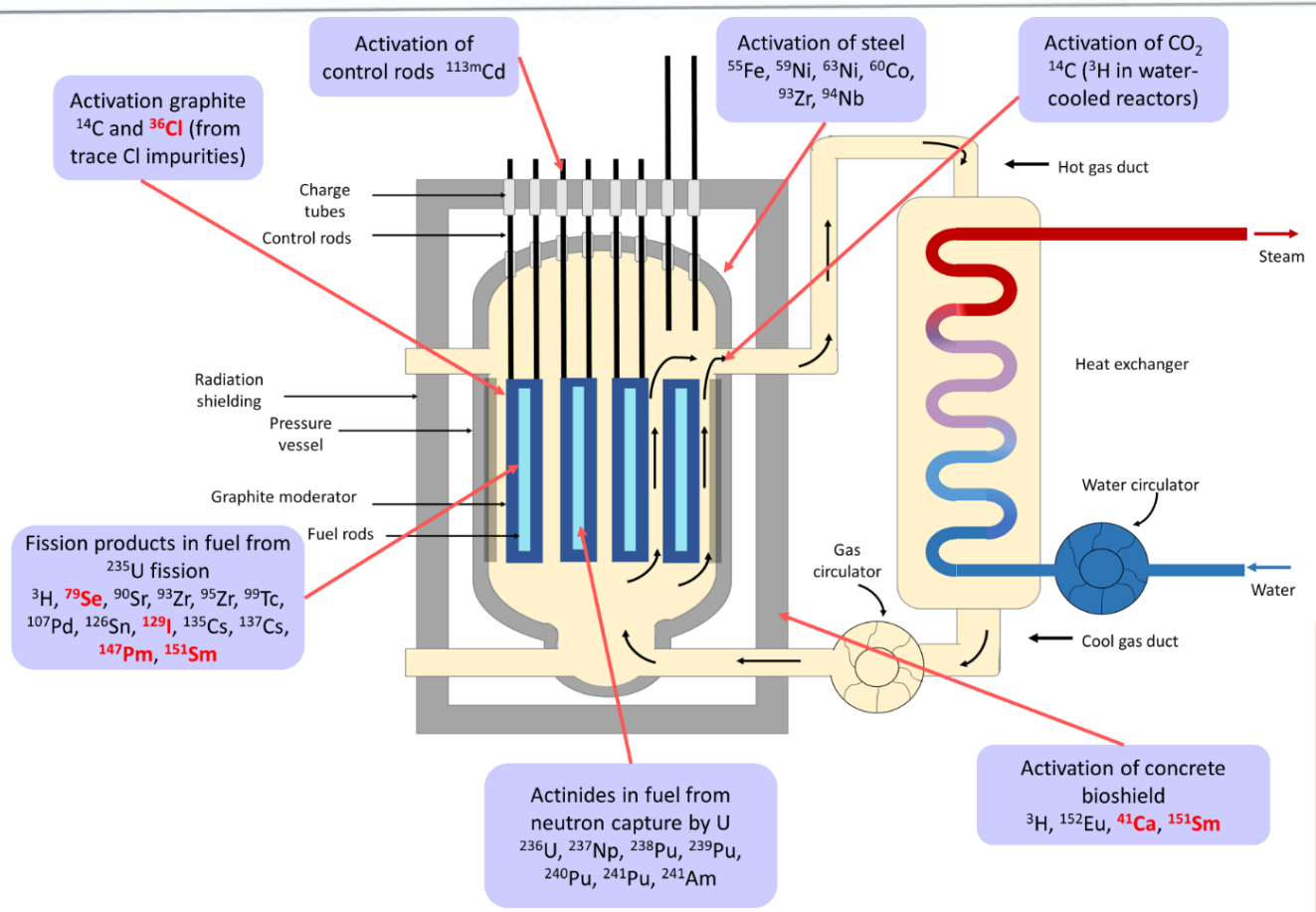
New approach for ^{36}Cl determination in solid samples using plastic scintillator materials

Inés Llopart Babot

TRISKEM
Expertise in Separation Chemistry

Quantification of ^{36}Cl in waste samples from decommissioning activities



Activation graphite - **^{36}Cl** (trace Cl impurities)

↑ volatility
↑ soil-plant transfer factor
Long half-life

Based on (Warwick et al., 2022)

Why plastic scintillators for chlorine quantification?

Accelerator Mass Spectrometry (AMS)

Ion chromatography (IC)

Liquid scintillation counting (LSC)

High counting efficiency

Plastic scintillation

Advantages

Avoid mixed waste (no LS cocktail needed)

PS can be cleaned and reused

Selective PS resins for different target radionuclides (extractant)

What is plastic scintillation (PS)? [1]

Plastic Scintillation ⟺ Liquid Scintillation

≠

Solid state of plastic scintillators

Separation and detection processes integrated

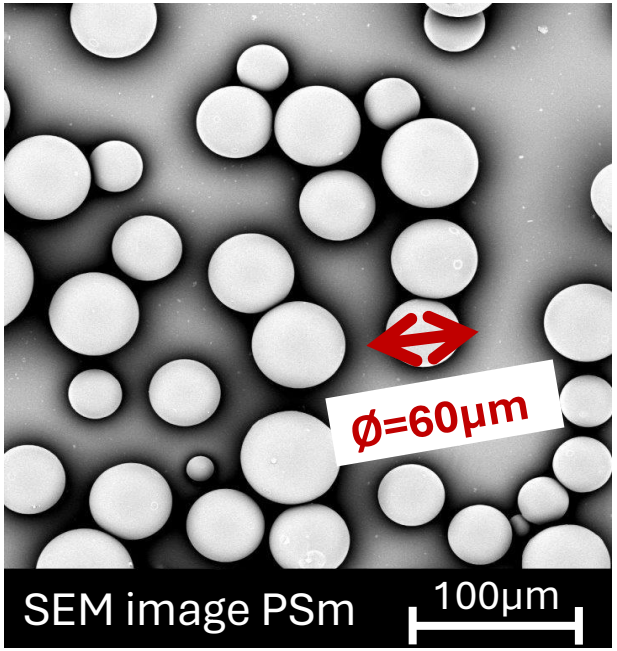
PS composition

- Polymeric solvent
- Primary and secondary scintillators

[1] Tarancón A, Bagán H, García JF (2017) Plastic scintillators and related analytical procedures for radionuclide analysis. J Radioanal Nucl Chem 314:555–572

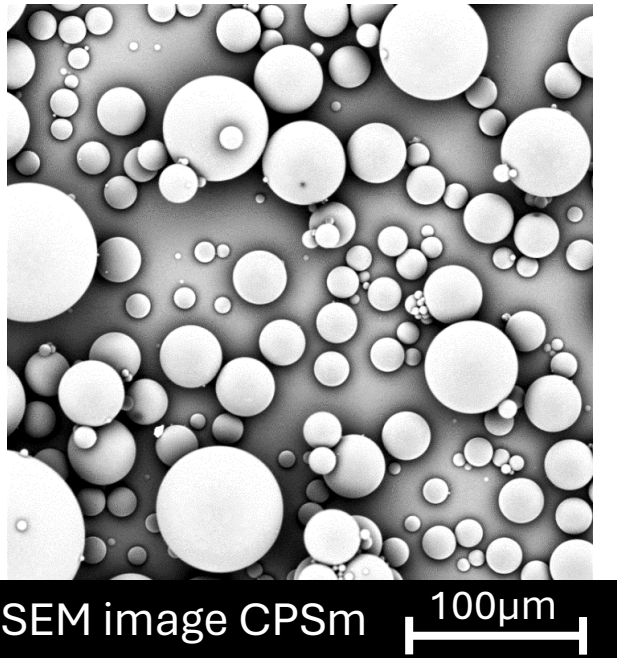
Types of plastic scintillator materials

PS microspheres (PSm)



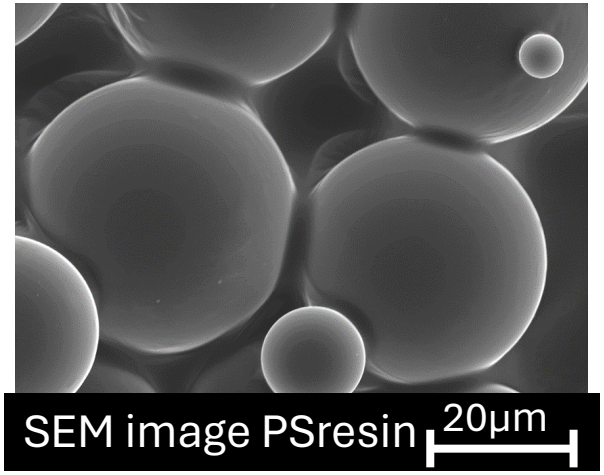
- Solvent - linear chain
- Scintillators

Cross-linked PS microspheres (CPSm)



- Cross-linked solvent
- Scintillators

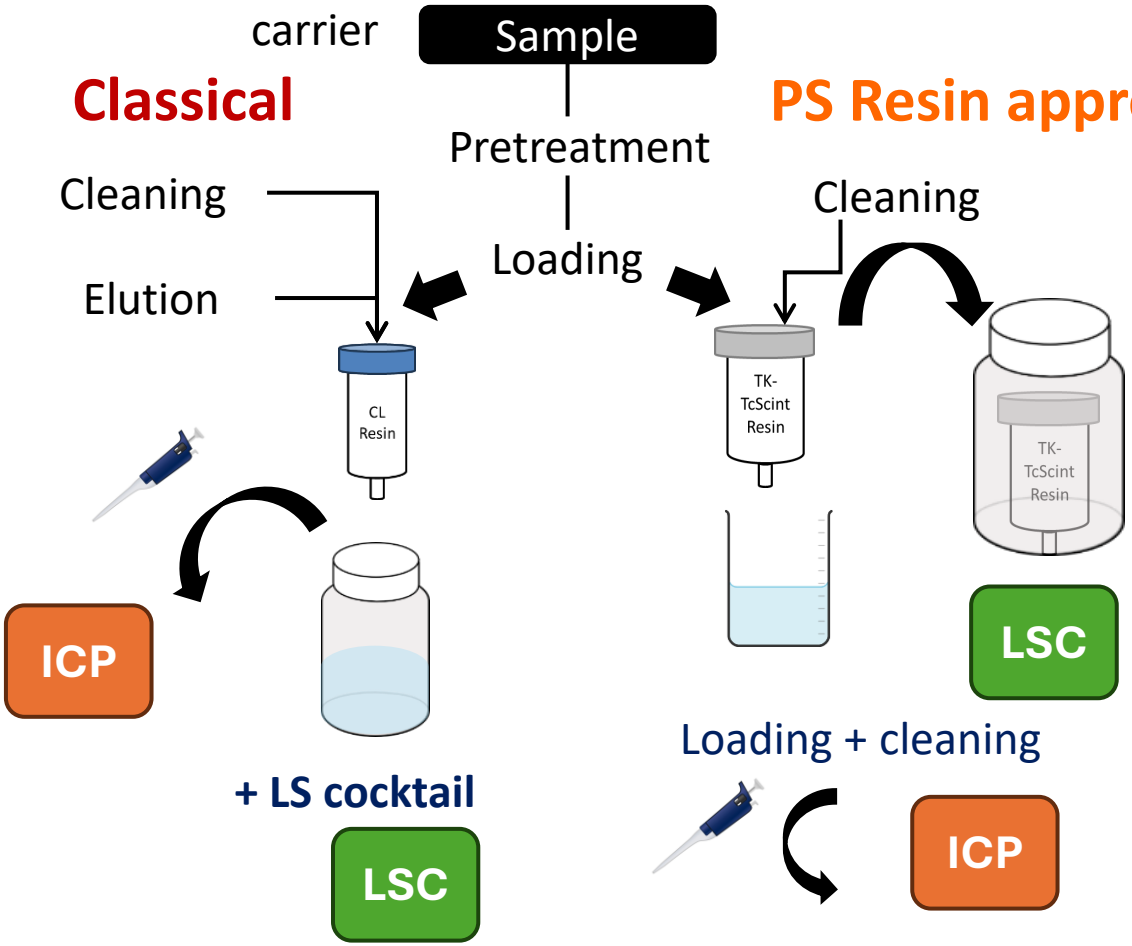
PSresin *(TK-TcScint)*



- PSm coated with extractant: Aliquat 336

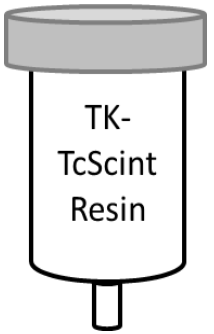
Applications of PS Resin (TK-TcScint)

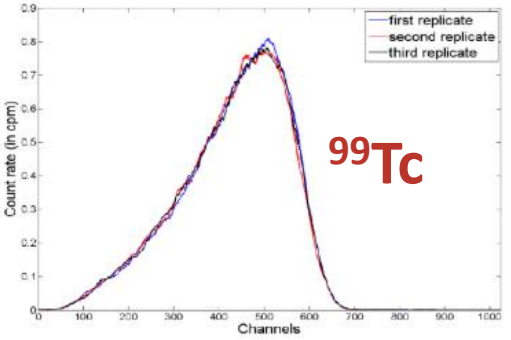
Classical method vs. PS Resin approach



^{99}Tc measurement

Sample: 10 mL 0,1 M HCl
Cleaning: 4 x 2 mL water

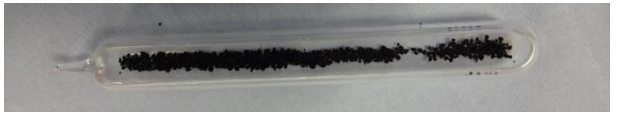




Project goals

New approach for ^{36}Cl determination **in solid samples** using plastic scintillator materials

Graphite



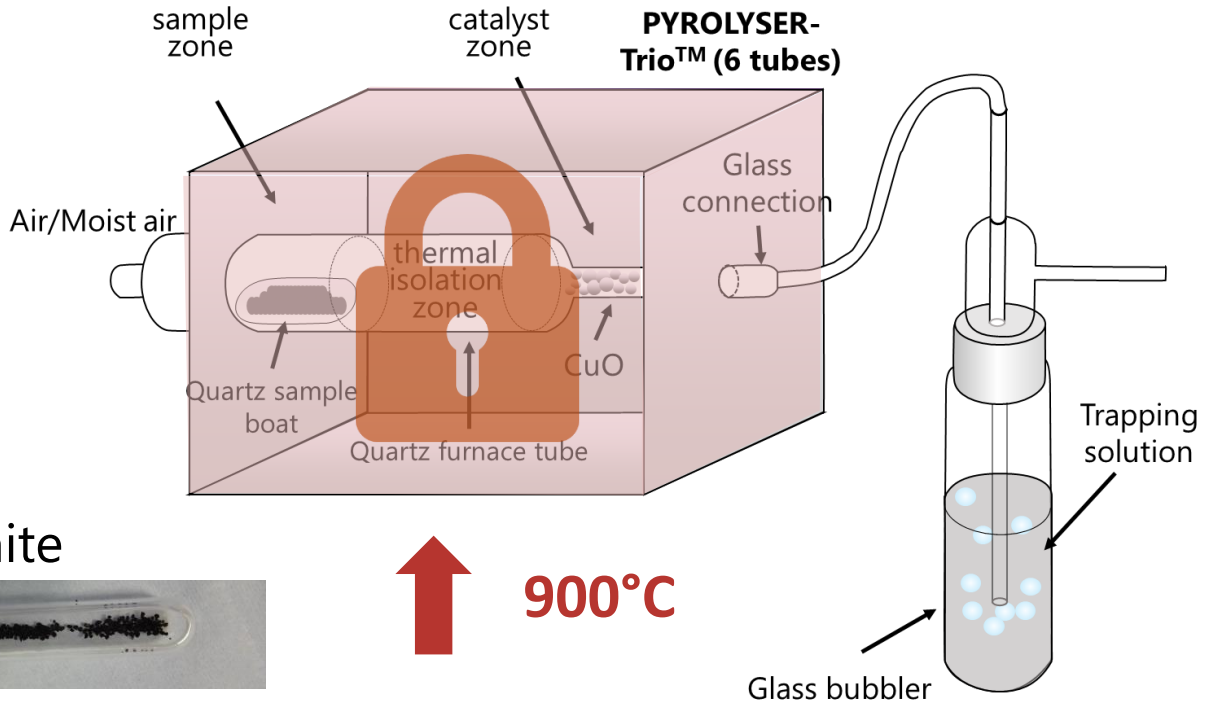
↑ Chemical recovery

↑ Removal of interferences (^{129}I, ^{14}C and ^{3}H)

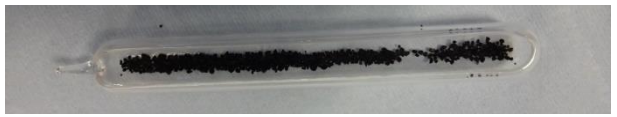
↓ turnaround time

^{36}Cl release from solid sample

Based on Warwick et al. 2010

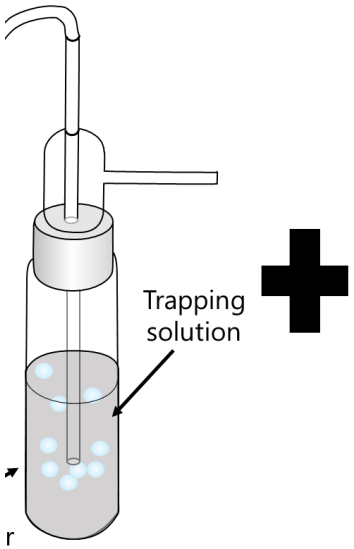


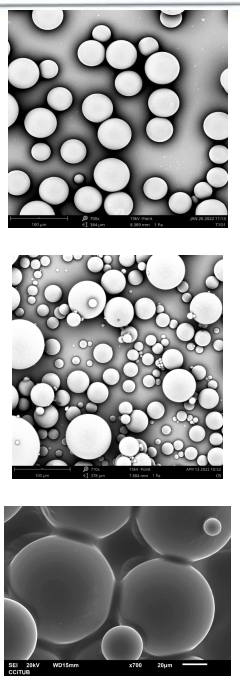
Graphite



^{36}Cl interaction with PS materials

Spiked solutions used





Mix for 2 min → Filtration

→ PSm, CPSm, PS resin

→ Remaining solution

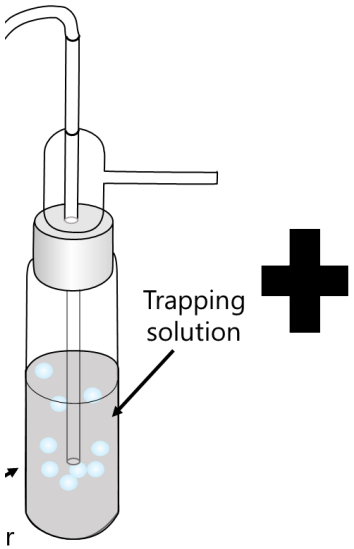
LSC

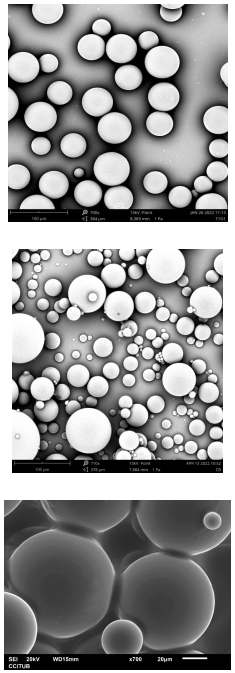
Wallac Quantulus 1220™

+LS cocktail

^{36}Cl interaction with PS materials

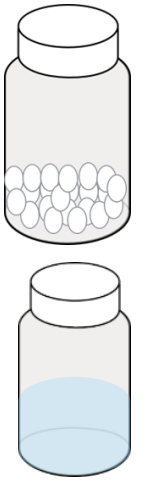
Spiked solutions used



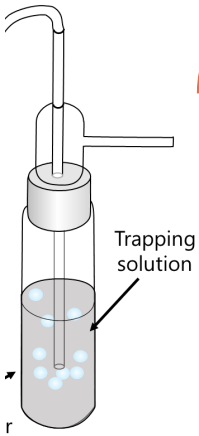


PS material	Trapping solution	^{36}Cl in PS material (%)	^{36}Cl in trapping solution (%)
PSm	4 mM $NaHCO_3$	Not detected	97 ± 5
CPSm	4 mM $NaHCO_3$	Not detected	94 ± 3
PS resin	4 mM $NaHCO_3$	40 ± 1	58 ± 2

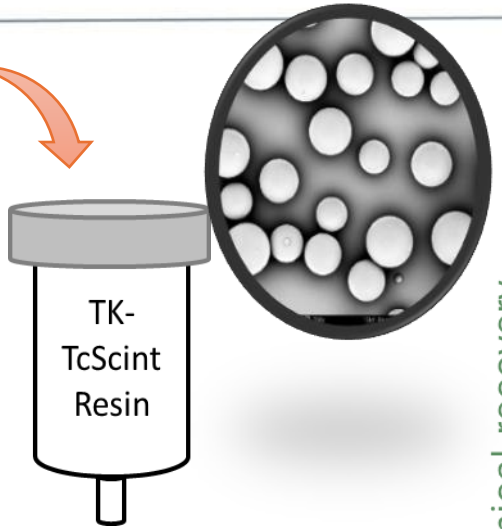
Mix for 2 min → Filtration → PSm, CPSm, PS resin / Remaining solution → +LS cocktail

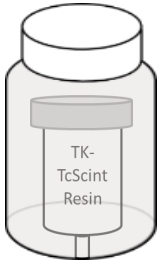


^{36}Cl interaction with **TK-TcScint Resin**



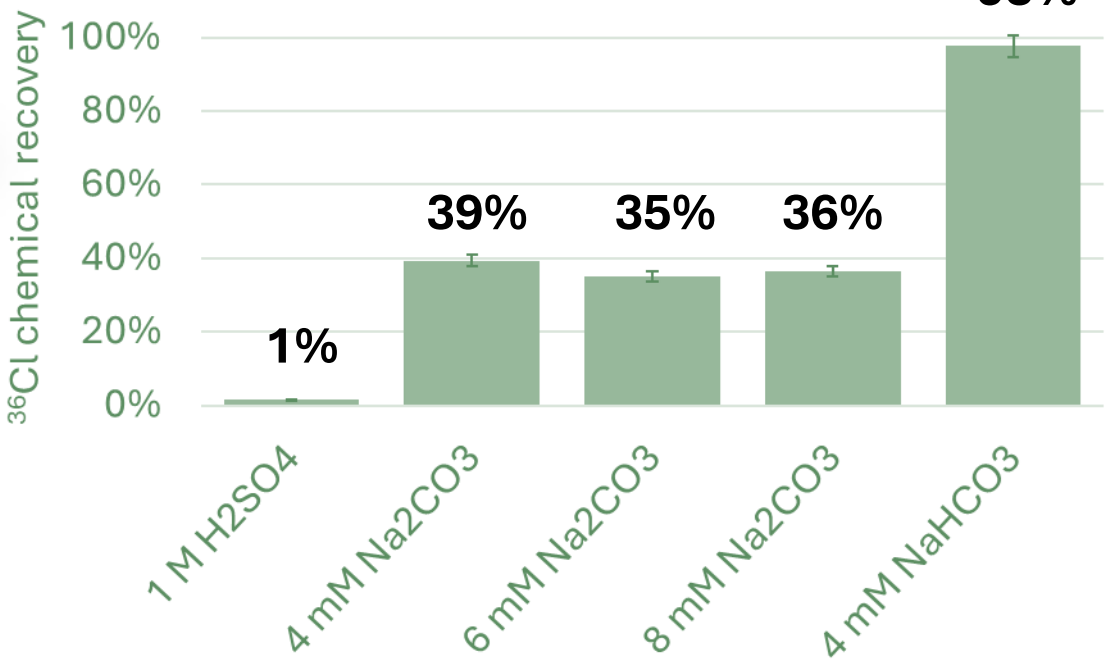
Spiked solutions used



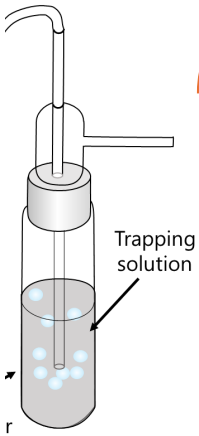


LSC

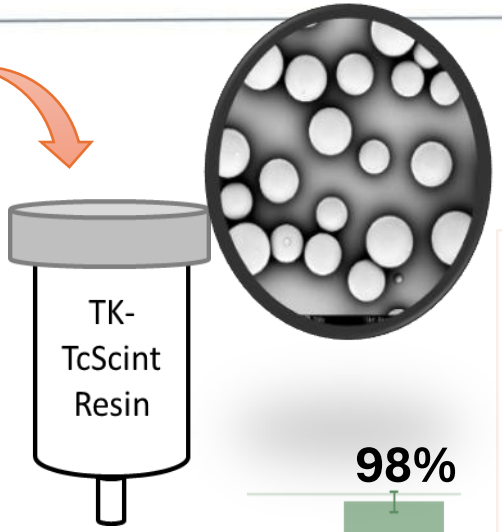
Suitable loading medium

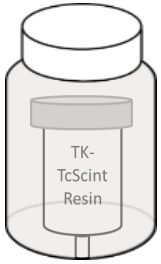


^{36}Cl interaction with **TK-TcScint Resin**

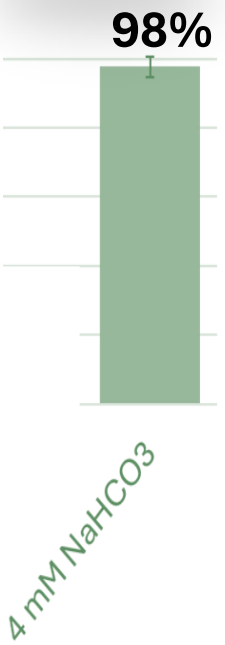


Spiked solutions used

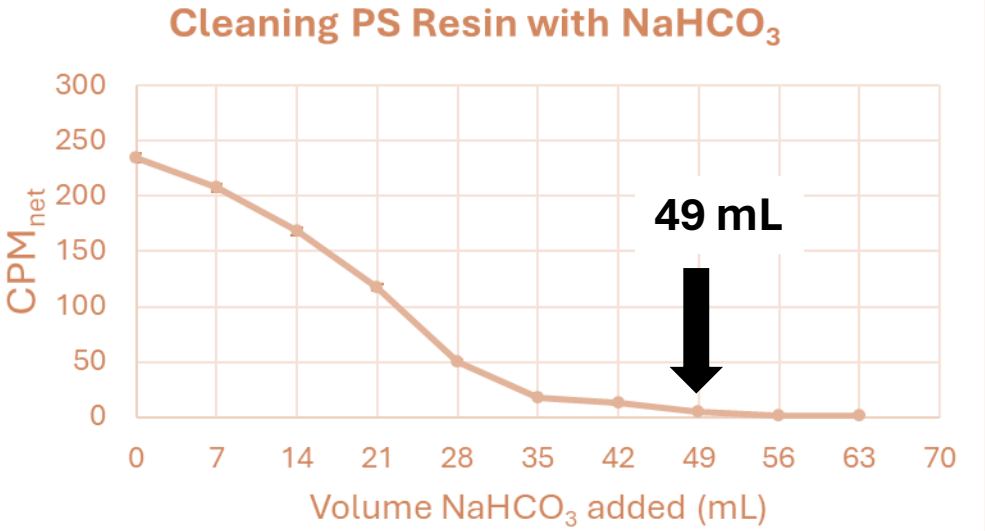




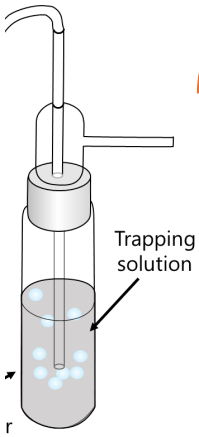
LSC

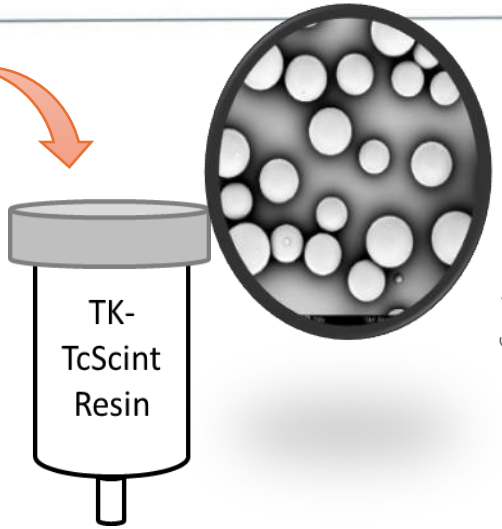


Cleaning TK-TcScint Resin

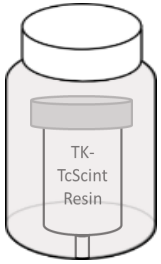


^{36}Cl release from solid sample



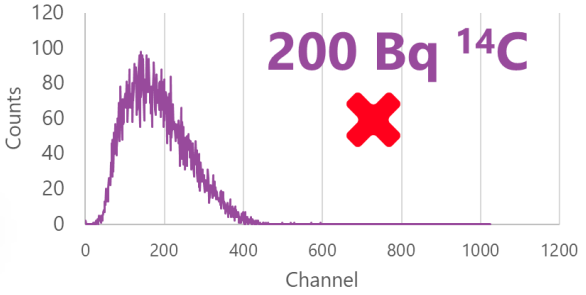


Spiked solutions used



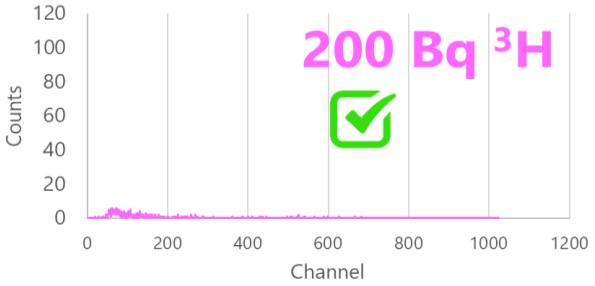
LSC

Interference removal

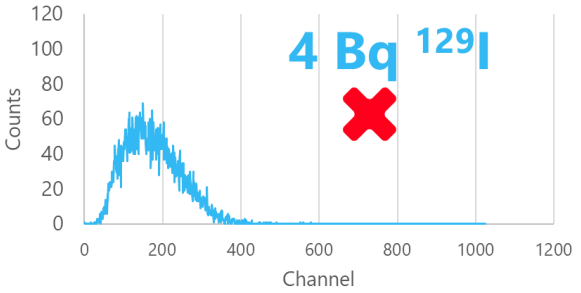


~2% retained

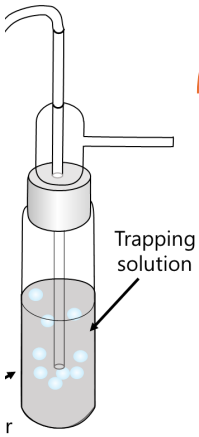
No retention



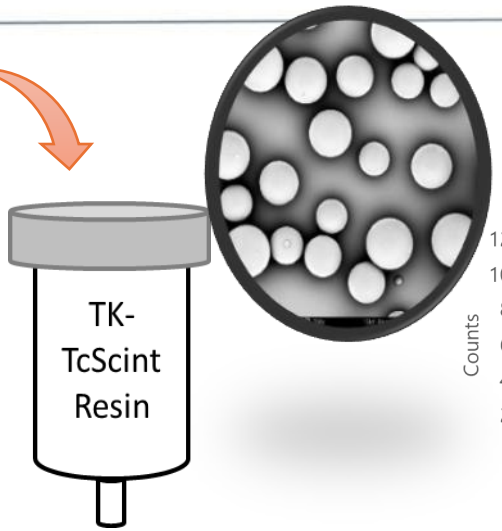
~100% retained

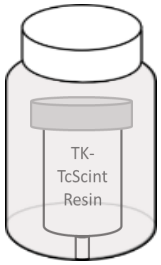


^{36}Cl release from solid sample



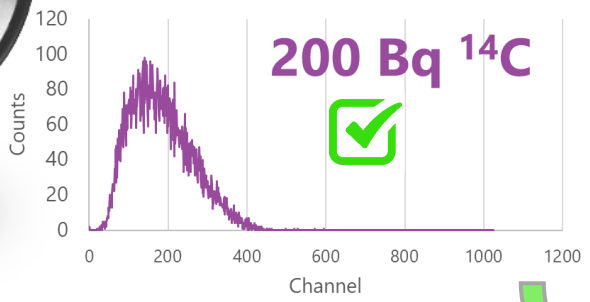
Spiked solutions used

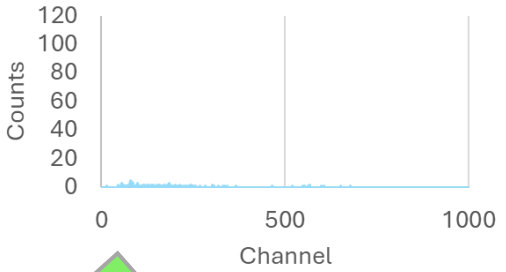


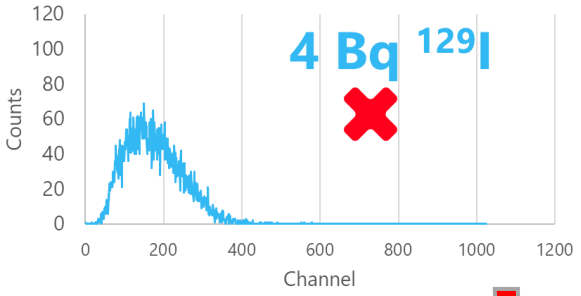


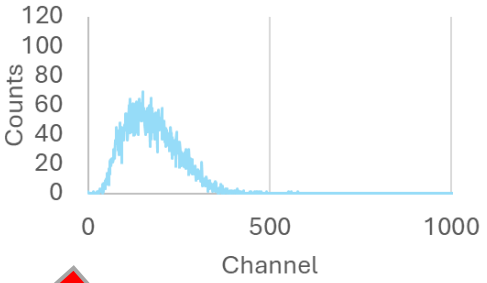
LSC

Interference removal



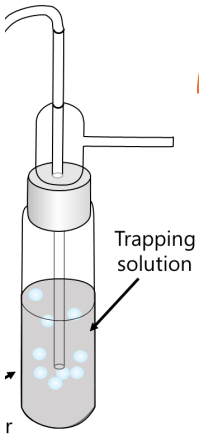




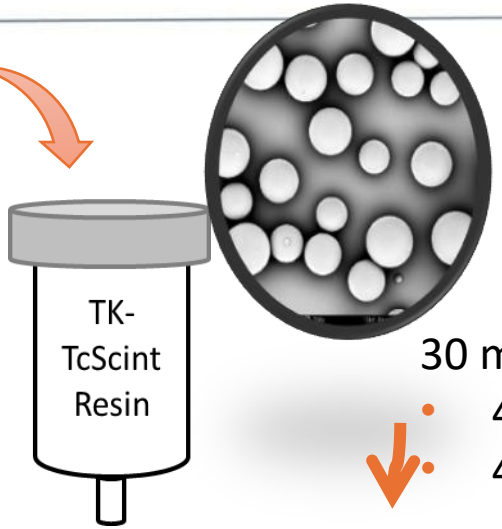


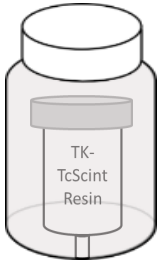
+ 14 mL RO water

^{36}Cl release from solid sample



Spiked solutions used





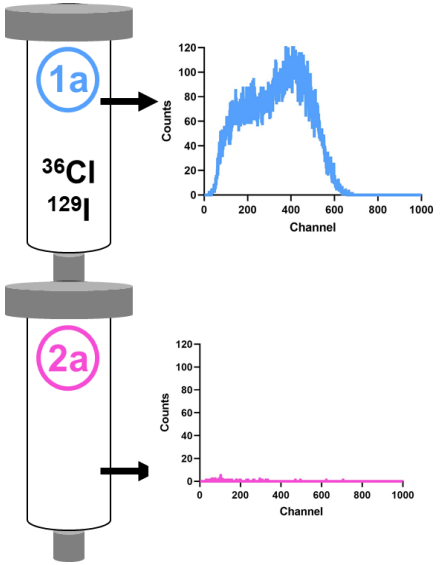
LSC

Sequential separation $^{36}Cl/^{129}I$

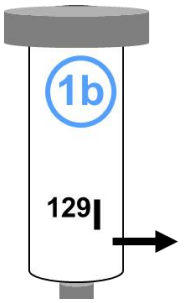
30 mL 4 mM $NaHCO_3$

4 Bq ^{36}Cl

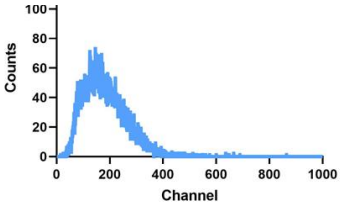
4 Bq ^{129}I

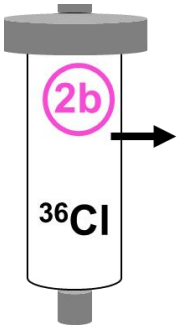


45 mL 4 mM $NaHCO_3$

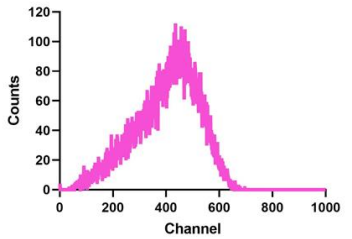


95 ± 4 % ^{129}I

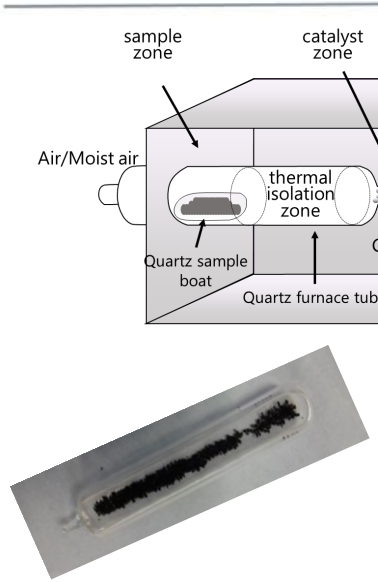


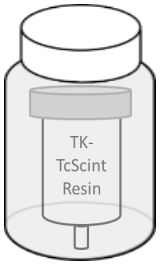


91 ± 4 % ^{36}Cl

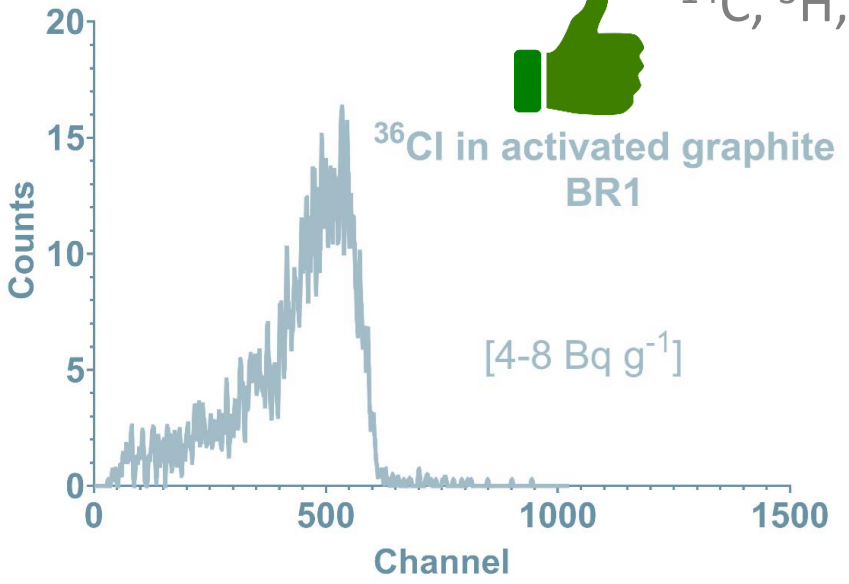


Application of TK-TcScint Resin for ^{36}Cl determination in graphite samples





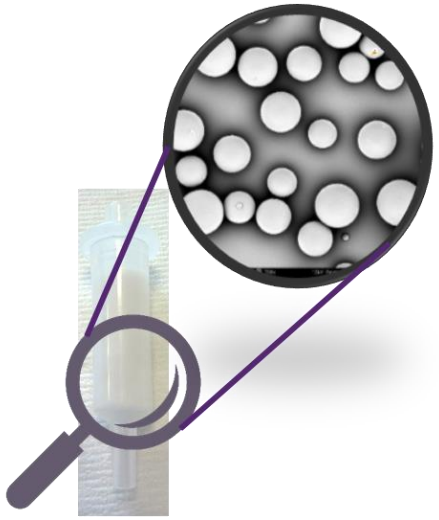
LSC



^{14}C, ^{3}H, ^{60}Co, ^{133}Ba, ^{134}Cs, $^{152,154}Eu$

Compared with calculated values through activation codes

Conclusions and outlook



NEW

New analytical method

Mixed waste

Turnaround time

Initially **TK-TcScint Resin** applied for ^{99}Tc measurement

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Contents lists available at ScienceDirect

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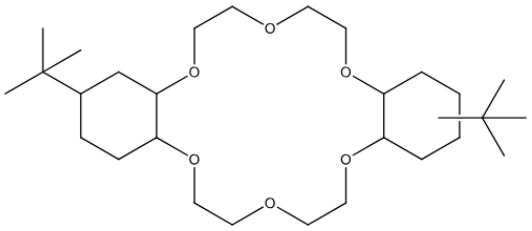
journal homepage: www.elsevier.com/locate/apradiso

Investigation of a new approach for ^{36}Cl determination in solid samples using plastic scintillators

I. Llopart-Babot [a,c,*], M. Vasile [a], A. Tarancón [b], H. Bagán [b], A. Dobney [a], S. Boden [a], M. Bruggeman [a], M. Leermakers [c], J. Qiao [d], P. Warwick [e]

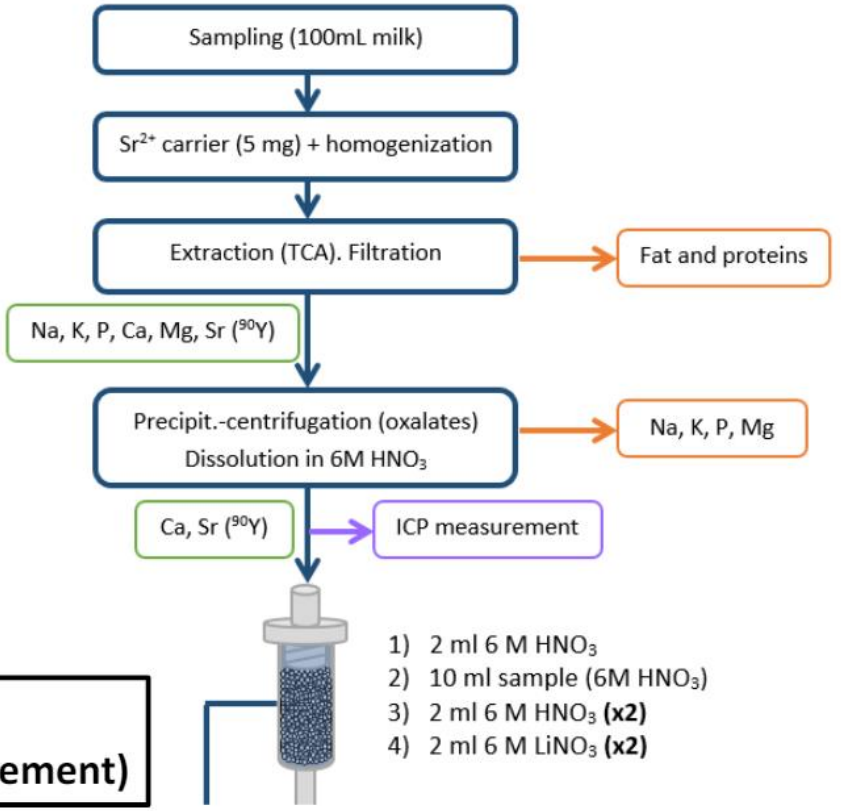
Possibility to use it for ^{36}Cl quantification

Upcoming PS Resin - **TK-SRScint**



4.4'(5')-di-t butylcyclohexane 18-crown-6 in fluorinated alcohol

Crown ether



Efficiency

^{90}Sr	86(6)%
^{89}Sr	91(6)%

5 Hours (including 1h measurement)

Presented by A. Tarancón in Raddec/Triskem Workshop 2024 (Porthsmouth)

New TrisKem tool for elements search

Types of resins that can be used for Y

DGA RESIN

LN RESIN

RE RESIN

TK100 RESIN

TK101 RESIN

TK200 RESIN

TK221 RESIN

TK225 RESIN

TK400 RESIN

ZR RESIN

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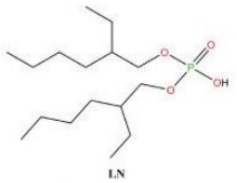

Product Sheet

LN RESIN

Applications

- Separation of Lanthanides (e.g. nca Lu-177, nca Tb-161,...)
- Separation of Actinium

Physical and chemical properties

- Density: LN resin: 0.38g/ml
- Capacity: LN: 0.16 mmol/ml resin (trivalent actinides and lanthanides)
- Conversion factor Dw/k' : LN resin: 1.75

Conditions of utilization

- Recommended T of utilization : /
- Flow rate: A grade: 0.6 – 0.8 mL/min, utilization with vacuum or with pressure for s grade resin
- Storage: Dry and dark, T<30°C

Thank you for your attention!

Any questions?

illopart@triskem.fr

TRISKEM
Expertise in Separation Chemistry