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Traceable surface sources by functionalization for initial mapping of nuclear facilities

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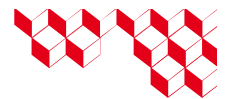
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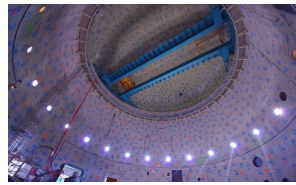
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Context and Challenges

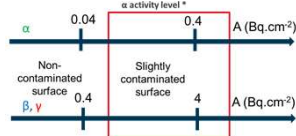
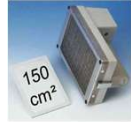


Challenges

- Discrimination between non-contaminated surfaces and **low-level contaminated surfaces**
- Very large areas
- Non-flat surfaces

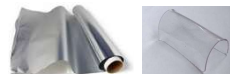


Commercial source



Needs

- Reliable contamination measurements
- Calibration of measurement systems



Aim

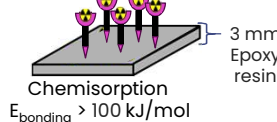
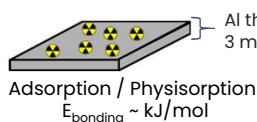
- Traceable activity and emitted flux
- Large surface areas
- Non-contaminating surface (use on-site)
- Complex shapes

Chosen substrates

- Aluminum foil
- Polymeric surfaces**

Commercial sources:
RN dried + protected

Our approach: chemical bonds
RN-surface

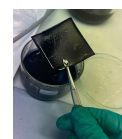
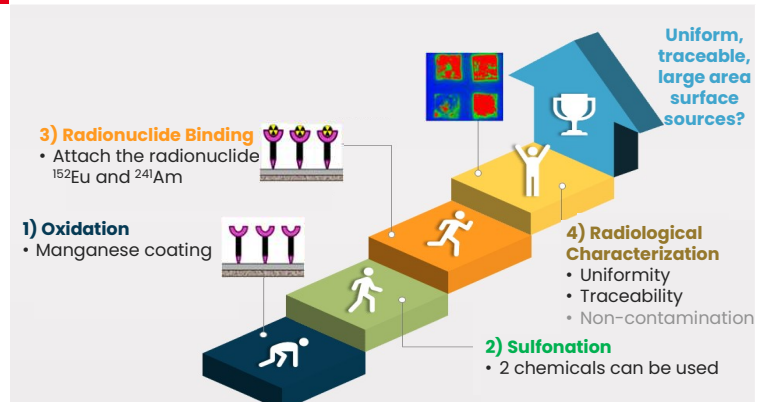


Use of functionalization

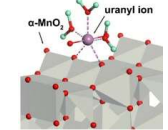
- Strong chemical bonds → **No cover layer**
- Thin sources → **Minimize self-absorption**



Our Approach



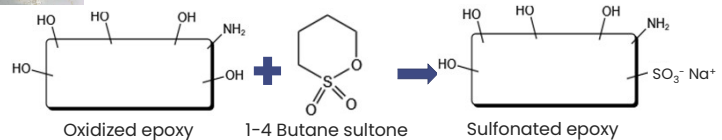
Oxidation treatment
 • Eu^{3+} , Am^{3+}
 • Reduction of Mn(VII)
 • Precipitate as an oxide layer
 • KMnO_4 and NaOH solution at $T = 80^\circ\text{C}$



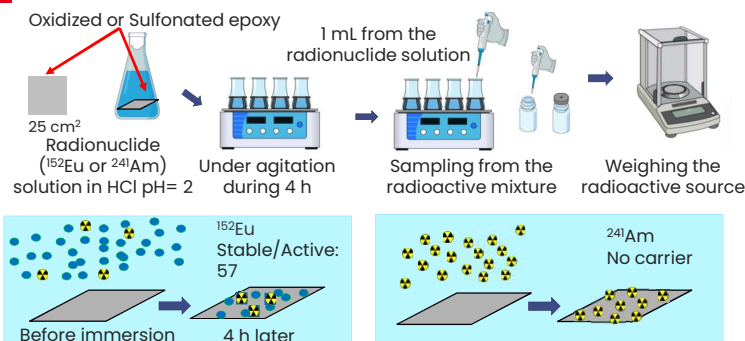
Act as cation exchanger



Sulfonation treatment
 • NaH , 1-4 Butane Sultone, and appropriate solvent (DMSO or ACN) $T = 70^\circ\text{C}$



Experimental set up & radiological characterization



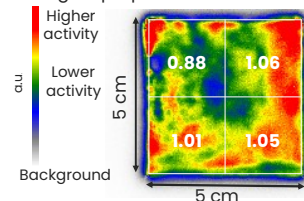
Total amount of element in solution in both cases: ~0.45 picomole

Oxidated Samples	RN	% LSC activity decrease	Max activity bound (Bq/cm²)
Oxidized (E2)	^{152}Eu	(83.5 ± 2.7)%	20.0 ± 0.6
Oxidized (F2)	^{152}Eu	(98.0 ± 2.9)%	17.0 ± 0.5
Oxidized (G2)	^{152}Eu	(96.5 ± 2.8)%	20.5 ± 0.6
Oxidized (J1)	^{241}Am	(95.5 ± 2.8)%	19.0 ± 0.6

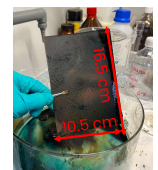
Sulfonated Samples	RN	% LSC activity decrease	Max activity bound (Bq/cm²)
Sulfonated (E3)	^{152}Eu	(55.0 ± 2.5)%	12.5 ± 0.6
Sulfonated (F3)	^{152}Eu	(87.5 ± 2.7)%	15.5 ± 0.5
Sulfonated (G3)	^{152}Eu	(86.0 ± 2.7)%	17.0 ± 0.5
Sulfonated DMSO (H6)	^{152}Eu	(76.5 ± 2.6)%	15.5 ± 0.5

Analysis after RN binding: Autoradiography

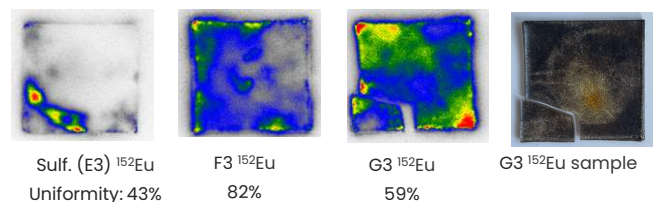
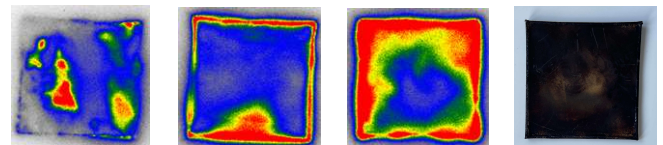
- Signal proportional to the number of emitted particles



Large area surface sources are also being produced



- Oxidized (J1) ^{241}Am : Uniformity (St. dev.): 92%



Oxidized samples resulted in higher uniformity

We have produced surface sources with activities ~17 Bq/cm².
 The surface activity **can be tuned** to meet specific needs.
Reproduce complex shapes including roughness

Upcoming studies
 • Non-contamination tests
 • ^{244}Cm binding (α)

