

Rapid Determination of ^{89/90}Sr in Steel Samples

Summary of Method Strontium is separated and measured from 1-2 gram steel samples. Samples are digested with concentrated nitric, hydrochloric, and hydrofluoric acids. The digestate is evaporated to dryness, the residue dissolved in HNO₃/H₃BO₃, and a calcium fluoride precipitate is used to concentrate the strontium and remove matrix. An optional NaOH fusion may also be performed, post sample digestion, to dissolve concrete or stone included in the sample. Strontium is separated from matrix impurities and potentially interfering radionuclides in the sample using stacked 2 mL and 1 mL cartridges of Eichrom Sr Resin. Radiostrontium is measured on a low background gas flow proportional counter. Average chemical recovery of strontium, determined by gravimetric yield of stable strontium carrier, was 90–94%. Measured values of ⁹⁰Sr agreed to within 3% of reference values for 60 minute count times. The minimum detectable activity for ⁹⁰Sr in 2 g samples with 60 minute count times was 0.56 Bq/g. A single operator can prepare batches of 12 samples for the measurement of ⁹⁰Sr in less than 8 hours.

Reagents

Sr Resin, 2 mL Cartridges (Eichrom SR-R50-S)
 Sr Resin, 1 mL Cartridges (Eichrom SR1ML-R50-S)
 Nitric Acid (70%)
 Hydrochloric Acid (37%)
 Hydrofluoric Acid (49%) or Ammonium Bifluoride
 Deionized Water
 1.25M Ca(NO₃)₂
 Strontium Carrier (10 mg/mL)
 2M Al(NO₃)₃
 Sr-90 standard
 Oxalic acid
 Boric acid
 3.2M (NH₄)₂HPO₄*
 Sodium Hydroxide*

Equipment

Vacuum Pump
 Centrifuge
 Muffle Furnace*
 Hot Plate
 Analytical Balance
 Teflon Beakers (Zr Crucibles*)
 50 mL and 250 mL Centrifuge Tubes
 Cupped Stainless Steel Planchets (~5 mL volume)
 Gas Flow Proportional Counter
 Vacuum Box (Eichrom AR-24-BOX or AR-12-BOX)
 Cartridge Reservoir, 20 mL (Eichrom AR-200-RV20)
 Inner Support Tubes-PE (Eichrom AR-1000-TUBE-PE)
 Yellow Outer Tips (Eichrom AR-1000-OT)

Figure 1. Sample Preparation

Add 1-2 g steel sample to Teflon beaker*.
 *If using optional fusion, omit HF/H₃BO₃ and use Zr crucible.

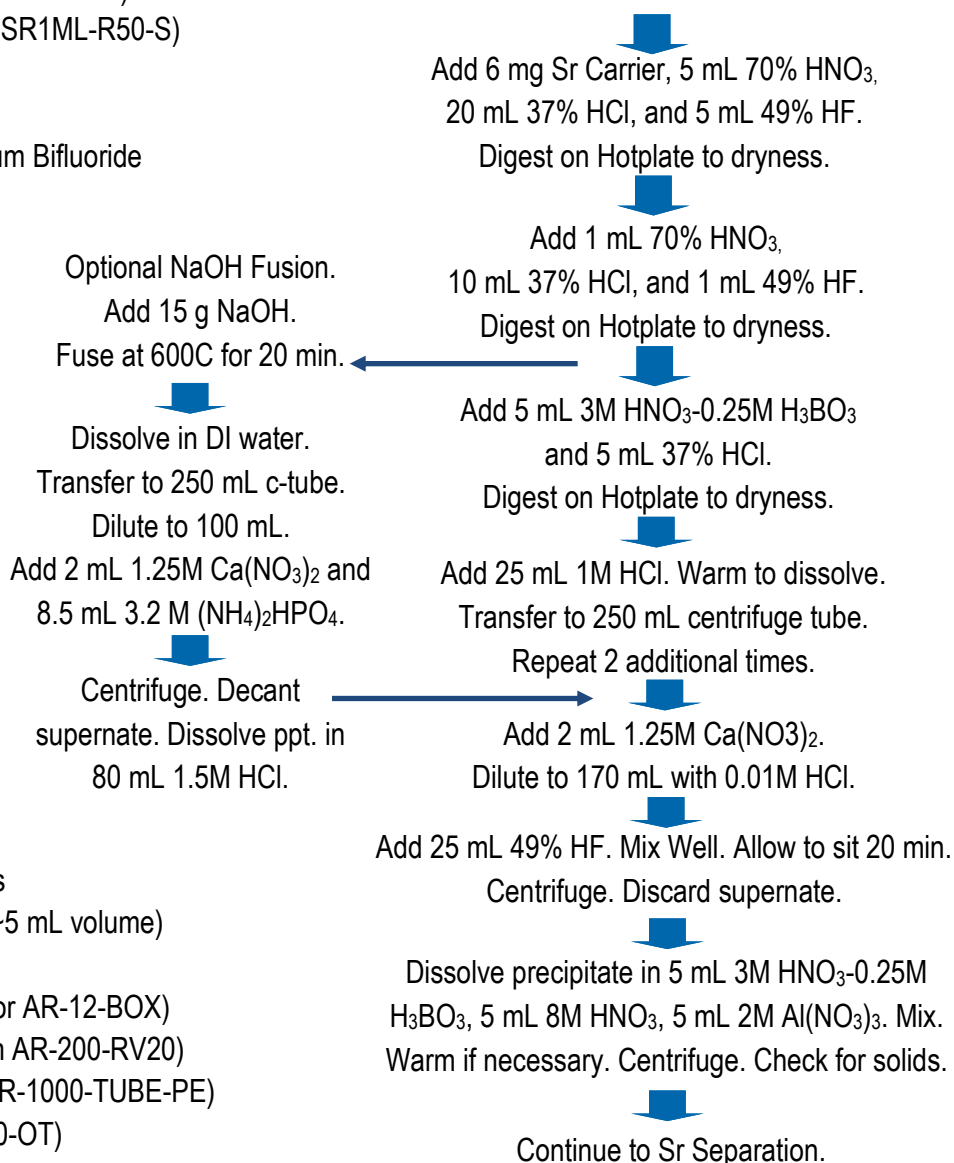
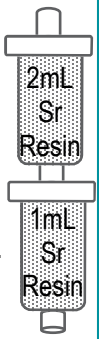
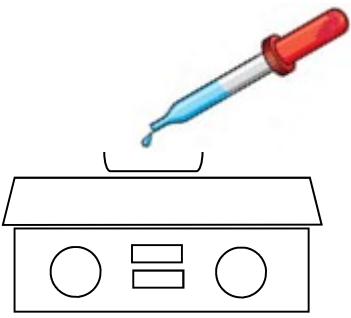


Figure 2. Strontium Separation and Measurement

<p>(1) Precondition Sr Resin with 10 mL 8M HNO₃.</p> <p>(2) Load sample.</p> <p>(3) Rinse sample tube with 5 mL 8M HNO₃.</p> <p>(4) Add tube rinse to Sr Resin.</p> <p>(5) Rinse Sr Resin sequentially with:</p> <ul style="list-style-type: none"> - 15 mL 8M HNO₃ - 10 mL 3M HNO₃ - 0.05 oxalic acid - 10 mL 8M HNO₃ <p>(6) Dispose of (1) to (5) as waste.</p> <p>(7) Strip Sr with 15 mL 0.05M HNO₃.</p>		<p style="text-align: center;">Gas Flow Proportional Counting*:</p> <p>(8) Evaporate samples to dryness on tared cupped stainless steel planchets.</p> <p>(9) Rinse Sr sample vials with 2 mL 0.05M HNO₃. Transfer vial rinse to planchets. Evaporate to dryness.</p> <div style="text-align: center; margin: 10px 0;">  </div> <p>(10) Weigh planchets on an analytical balance to determine gravimetric yield of stable Sr(NO₃)₂.</p> <div style="border: 1px solid black; padding: 5px; margin-top: 5px;"> <p>(11) Measure radiostrontium in samples on low background gas flow proportional counter.</p> </div>	<p style="text-align: center;">*(Options for ^{89/90}Sr Discrimination)</p> <p>(a) Sr fraction from step (7) can be transferred to a liquid scintillation vial. ⁸⁹Sr can be measured by Cerenkov counting (no LSC cocktail). ^{89/90}Sr can then be measured by adding liquid scintillation cocktail.</p> <p>(b) Sr fraction from step (10) can be dissolved in 10 mL 8M HNO₃ after >7 days of ⁹⁰Y ingrowth. ^{89/90}Sr can be removed on Sr Resin. ⁹⁰Y will elute in Sr Resin load and can be counted by liquid scintillation or gas flow proportional counting.</p>
---	---	---	--

*Additional discussion of ^{89/90}Sr separation and measurement options can be found in Eichrom Application Note AN-1624-10.

Method Performance for 2 g Steel Samples

Details	Sample replicates	Reference (mBq/sample)	Measured (mBq/sample)	Average % Diff.	Sr Carrier % Yield
90Sr	10	1.415	1.41 ± 0.04	2.6	90.1 ± 2.4
89Sr+90Sr	8	3.816	3.97 ± 0.09	4.1	94.1 ± 2.8

References

1) Sherrod L. Maxwell, Brian K. Culligan, Jay B. Hutchison, Robin. C. Utsey, Ralf Sudowe, Daniel R. McAlister, "Rapid method to determine ^{89/90}Sr in steel samples," *J. Radioanal. Nucl. Chem.*, 314(1), 439-450 (2017).