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Radioactivity Group
Ionizing Radiation Division
Physics Laboratory

RADIONUCLIDIC METROLOGY BY LIQUID SCINTILLATION SPECTROMETRY

LS spectrometry is one of the Group's principal and powerful "workhorses". It is now very routinely used for SRM standardizations and submitted-source calibrations (principally α emitters and high-energy β emitters): ^{32}P, ^{90}Y, ^{90}Sr, ^{209}Po, ^{229}Th, ^{232}U, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu (^{241}Am ingrowth), ^{242}Pu.

NIST possesses one of the world's premier experimental LS groups. As a co-developer of the CIEMAT/NIST ^{3}H-standard efficiency tracing method for low-energy β emitters, we have wide-ranging experience and a substantial historical reference base.

Current research directions (beyond maintaining our basic capabilities) involve both applying the methods to new, important radionuclides (such as ^{117m}Sn in medicine), and more fully exploiting and refining the metrological aspects of the techniques. The maturation of the efficiency tracing techniques are such that small and previously unknown effects (and attendant measurement uncertainties) are becoming apparent. Extensive studies are underway on LS cocktail stability and composition effects, particularly for very low-energy β emitters, EC decay, etc.

some recent LS activities

LS was used to evaluate the long-term stability of carrier-free polonium solutions which was largely unknown and is an important consideration in maintaining the integrity of polonium standards. [*Radioact. Radiochem.* (1993)].

LS was used to verify the serial dilutions that were needed to prepare ^{36}Cl/Cl Accelerator-Mass-Spectrometry (AMS) standards [*J. Res. NIST* (1993)].

LS techniques were used to identify a previously unreported, relatively long-lived ^{205}Pb isomeric state in ^{209}Po decay [*Appl. Radiat. Isot. (1994)*].

LS was used to make a very precise determination of ^{222}Rn half-life [*Radioact. Radiochem. (1995)*].

In collaboration with a radon-industry instrument manufacturer, LS was used to verify a calibration bias in electret-based integral radon monitors [*J. Res. NIST* (1995)].

Photonic emission probabilities in the ^{209}Po alpha and electron-capture decay scheme branches were derived from LS activity measurements [*Nucl. Instr. Meth. Phys Res.* (1996)].

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Coupled with 1968 microcalorimetry, LS measurements were used to derive the first determination of the ^{63}Ni halflife by radioactive decay [*Appl. Radiat. Isot. (1996)*], and to verify the internal consistency of three ^{63}Ni SRMs issued by NIST over the past 27 years [*Radioact. Radiochem (1996)*].

LS was used to evaluate the long-term (6 year) stability and performance efficacy of the ^{222}Rn-in-Water standard generator [*Nucl. Instr. Meth. Phys Res.*].

LS was used to intercompare the extant French (LPRI) and U.S. (NIST) ^{3}H (tritiated water) standards [*Appl. Radiat. Isot.*].

Completed cocktail composition effect studies include: (i) effects of cocktail size on the CIEMAT/NIST method for low-energy β emitters [*Appl. Radiat. Isot.* (1996)]; (ii) effects of water fraction on the efficiency-traced assay of ^{63}Ni [*J. Res. NIST*; *Appl. Radiat. Isot.* (1996); *Radioact. Radiochem* (1996)] (iii) systematics of ^{3}H efficiency and quench indicating parameters (QIP) with cocktail size and water fraction [*Appl. Radiat. Isot.*]; and (iv) cocktail mismatch effects in direct comparative measurements and in efficiency tracing, both with and without QIP-adjusted quench corrections [*Appl. Radiat. Isot.*]. A large study on the correlated role of water fraction and ionic loading in cocktail stability is underway.

International LS intercomparisons:

^{204}Tl (BIPM)

Grand Mean (9 results)	= 55.30 ± 0.18 kBq·g^{-1}
Eff. Tracing Mean (5 results)	= 55.28 ± 0.33 kBq·g^{-1}
NIST	= 55.53 ± 0.14 kBq·g^{-1} (*)

(*) NIST result is much closer to the 9-value or 5-value <u>median</u> because of a substantial outlier.

^{63}Ni (EUROMET)

Grand Mean (10 results)	= 40.14 ± 0.19 kBq·g^{-1}
Eff. Tracing Mean (5 results)	= 40.02 ± 0.12 kBq·g^{-1}
NIST	= 40.00 ± 0.16 kBq·g^{-1}