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Classical isothermal microcalorimetry for radionuclidic standardizations: recent work on ^{32}P, ^{90}Sr, and ^{103}Pd brachytherapy sources

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Abstract

The NIST laboratory's current re-interest in the use of calorimetry for radionuclidic metrology derives directly from the need to provide standardizations for rather large, GBq-range, brachytherapy sources. A commercial "isothermal [*sic*] microcalorimeter" has been adapted and evaluated for use in performing such classical calorimetric-based standardizations. This dual-cell, near-isothermal (heat flow) calorimeter operates at near-ambient temperatures; utilizes specially-fabricated source-holder cells that are used to maximize the energy absorption of the ionizing radiation; and incorporates resistance heaters within these measurement cells to obtain very-accurately-determined, independent power calibrations. Evaluations were initially performed on two different types of intravascular brachytherapy sources that contain nuclides that decay by pure β emission, *viz.*, (*i*) a stainless- steel-jacketed ^{90}Sr-^{90}Y source with a highly-refractory ceramic-like inner matrix, and (*ii*) a "hot-wall" balloon catheter source that consists of a thin film of ^{32}P enveloped between polyethylene walls. The measured thermal power was related to source activities through the use of calculated average energies per decay, and was compared against "known" source activities that were determined from previous radioanalytical destructive assays. Monte Carlo calculations for the energy deposition in the measurement cells were used to assess and correct for possible power losses due to escaping ionizing radiation. This verification work clearly demonstrated, quantitatively, that the calorimeter was sufficiently efficacious for performing primary standardizations to within combined standard uncertainties (k=1) of about ± 1 %. This was achieved in large part, by completing the development of the instrumentation and the protocol for better-than-0.1 % "absolute" power calibrations (based on joule heating with 0.001 % precision resistors). More recently, the calorimeter was used to provide primary standardizations for a new generation of aluminum-cored ^{90}Sr-^{90}Y intravascular sources and for seeds containing ^{103}Pd, a 17-day electron-capture-decaying nuclide that is used for the treatment of prostate cancer. The latter two standardizations were again confirmed by destructive, liquid-scintillation-based, assays.

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