Improved Dosimetry for ^{90}Y Microsphere Treatments of Liver Malignancies

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Yttrium-90 (^{90}Y) microspheres are used for the treatment of non-resectable liver cancer. The treatment has shown promising results, including the potential to downgrade the disease state to resectable. However, there is presently no U.S. national standard measurement device used for the determination of ^{90}Y microsphere activity.

A coincidence detection system (CDS) was developed to spectroscopically assay the activity of ^{90}Y microspheres by detecting the coincident 511 keV annihilation photons present in a ^{90}Y photon spectrum due to the internal pair production component of ^{90}Y decay. The CDS paired a HPGe detector with a large NaI detector. A method for correcting for counting losses that utilized a series of pulse generators was implemented into the CDS and validated. The geometric sensitivity of the CDS was characterized, and the system was shown to be able to accurately determine the activity of ^{90}Y sources. The system was used to determine the activity of a sample of resin ^{90}Y microspheres.

Two well-type ionization chambers were characterized for their response to ^{90}Y sources to investigate their use for the clinical determination of ^{90}Y microspheres activity. The activity preparation methods used with the resin ^{90}Y microspheres were investigated, and the effects of the volume dependencies of the ionization chambers on the activity delivered were analyzed. Based the results of the analysis, recommendations for measurement geometries that provided more accurate activity determinations were suggested.

The effects of the microsphere and surrounding material on the ^{90}Y dose kernel were studied with Monte Carlo transport codes MCNP5 and EGSnrc. The microsphere material was found to have little effect on the dose kernel, but the density of the surrounding material was found to greatly affect the calculated dose kernel.

The developed CDS was shown to be a possible standard activity measurement device for ^{90}Y microspheres. This work determined that well-type ionization chambers could be calibrated using sources whose activities had been determined with the CDS, for the accurate determination of ^{90}Y microsphere activity in a clinical setting. Establishing a calibration service based on this work would help reduce the uncertainty in the dosimetry associated with the ^{90}Y microsphere treatment.