Measurement of the absolute gamma-ray emission intensities from the decay of $^{103}$Pd

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MEASUREMENT OF THE ABSOLUTE GAMMA-RAY EMISSION INTENSITIES FROM THE DECAY OF $^{103}$Pd

**Introduction**

Palladium-103 is a radioisotope of interest in medical applications which is used in brachytherapy implants for the treatment of prostate cancer. It decays through electron capture to excited levels of $^{103m}$Rh, and especially (99.959%) to the 39.748 keV metastable state. The radioactive equilibrium between $^{103}$Pd (half-life = 16.991 (19) d) and $^{103m}$Rh (half-life = 56.114 (12) min) is reached within about 9 hours.

$^{103}$Pd is a radioisotope of interest in medical applications which is used (half-life = 56.114 (12) min) is reached within about 9 hours. The radioactive equilibrium between $^{103}$Pd and $^{103m}$Rh is achieved by a global Monte Carlo simulation, following the recommendations of the supplement 1 of the Guide to the expression of uncertainty in measurement.

**Sources preparation**

The palladium chloride solution was standardized by liquid scintillation, using the RCTD1 counter of LNHB. Each source was measured 10 times for 1 minute, allowing relative counting uncertainty of 6·10$^{-4}$. The impurity checking on the initial solution did not reveal any impurity and the detection limit was less than 2·10$^{-4}$ Bq.Bq$^{-1}$. A complementary measurement was performed one month after the activity measurement, to benefit from the $^{103}$Pd decay: Rhodium-101 (half-life = 3.30 (10) a) was detected with an activity detection limit was less than 2·10$^{-4}$ Bq.Bq$^{-1}$.

For each energy $E_i$, the photon emission intensity, $I_{i}$, is derived from the count rate in the relevant peak, $n_{ij}$: $I_{i} = \frac{n_{ij}}{\varepsilon_{ij} \cdot A}$, where $A$: source activity (Bq), $\varepsilon_{ij}$ represents different correction factors.

**Activity measurement**

The palladium chloride solution was standardized by liquid scintillation, using the Triple-to-Double Coincidence Ratio (TDCR) method. The detection efficiency was calculated taking into account the asymmetry of the photomultiplier tubes, by considering the three individual TDCR values, i.e. T/AB, T/BC and T/AC. The absorption of the photons was calculated by Monte Carlo simulation, following the recommendations of the supplement 1 of the Guide to the expression of uncertainty in measurement.

**Photon emission intensities**

The absolute photon emission intensities were derived from gamma- and X-ray spectrometry using HPGe calibrated detectors, with different measuring conditions to cross-reference the results.

**Sources**

Initial solution: Palladium chloride in ammonium hydroxyde Mass activity ~ 37 GBq.g$^{-1}$. Dilution to 10 MBq.g$^{-1}$ using 3 mol.L$^{-1}$ HCl

In addition, the emission intensities of four other gamma rays are also derived with a significant reduction of the uncertainties.

**Half-life**

The half-life of $^{103}$Pd was measured by gamma-ray spectrometry on a high-purity germanium (HPGe) detector, using an aliquot of the diluted solution, for 50 days. The measurement was carried out by following the $^{103}$Pd main line (357.43 keV).

**Conclusions and perspectives**

The 357.43 keV photon emission intensity is 0.02464 (16) per 100 disintegrations, in agreement with the tabulated data and obtained with a lower uncertainty. In addition, the emission intensities of four other gamma rays are also derived with a significant reduction of the uncertainties.

Three gamma emissions (62.43 keV, 295.00 keV and 497.08 keV) from the third, fourth and fifth excited levels have significantly higher intensities than the tabulated data. Conversely, for the emission from the metastable level (39.75 keV), the present result is 7% lower than the tabulated value. Also, the L- and K-X-ray emission intensities are weaker (around 10%) than the tabulated data.

This would suggest that the intensity of the electron capture towards the first excited level should be weaker, while the electron capture branches to levels 3, 4 and 5 should be more intense. Another possibility would be an electron capture branch towards the stable level.

The present results provide new information and should give some useful clues to be exploited in a future evaluation of the $^{103}$Pd decay scheme.

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