# $^{203}$Hg – Comments on evaluation of decay data by A.L. Nichols

Evaluated: April 2001
Re-evaluated: January 2004

## Evaluation Procedures

*Limitation of Relative Statistical Weight Method* (LWM) was applied to average numbers throughout the evaluation. The uncertainty assigned to the average value was always greater than or equal to the smallest uncertainty of the values used to calculate the average.

## Decay Scheme

The simple and consistent decay scheme is dominated by beta decay to the first excited state of $^{203}$Tl, followed by a single gamma transition to the ground state.

## Nuclear Data

The single well-characterised gamma ray at 279.1952(10) keV and the 46.6-day half-life of $^{203}$Hg make this radionuclide of some value as a standard in the calibration of γ-ray detectors.

## Half-life

Half-life adopted from the evaluation of Woods et al (2004) for the IAEA-CRP: Update of X- and Gamma-ray Decay Data Standards for Detector Calibration. The measurements of 1968La10, 1972Em01, 1980Ho17, 1980RuZY, 1983Wa26 and 1992Un01 were considered.

| Reference | Half-life (days) |
|---|---|
| 1968La10 | 47.000(30)* |
| 1972Em01 | 46.760(80)* |
| 1980Ho17 | 46.582(2)# |
| 1980RuZY | 46.600(10) |
| 1983Wa26 | 46.612(19) |
| 1992Un01 | 46.619(27) |
| Recommended value | 46.593(7) |

* Removed from evaluated data set due to large deviation from mean.
# Uncertainty adjusted to ± 0.008 to reduce weighting below 0.5.

Woods evaluation for IAEA-CRP (2004WoZZ): recommended half-life of 46.594(12) days (using above dataset).

## Gamma Rays

Energy
The gamma-ray energy and uncertainty recommended by 2000He14 were adopted. This energy is in good agreement with the nuclear level energy of the first excited state of $^{203}$Tl as specified by 1985Sc23 and 1993Ra11.

Emission Probability

The 279.1952 keV gamma transition is of mixed M1 + E2 multipolarity, and $\alpha_{tot}$ of 0.2271(12) and $\alpha_K$ of 0.1640(10) have been adopted from the evaluation of 1985HaZA, in good agreement with various measurements (1962Ta06, 1964He19, 1974Ha29, 2000Sc05). A small uncertainty was assigned to these two parameters because of the high degree of confidence in the data. The gamma transition probability of 0.9999(1) was deduced as described below, and used in conjunction with $\alpha_{tot}$ to calculate an absolute emission probability of 0.8148(8).

Multipolarity and Internal Conversion Coefficients of 279.1952 keV Gamma Ray

The comprehensive assessment of 1985HaZA provides accurate estimates for $\alpha_{tot}$ of 0.2271(12) and $\alpha_K$ of 0.1640(10), and a multipolarity of close to 25%M1 + 75%E2. These values have been adopted, and used to calculate the other $\alpha$ components in terms of the recommended value of $\alpha_{tot}$. The selected data set used by 1985HaZA to determine $\alpha_{tot}$ and $\alpha_K$ is included in the table below (see footnotes); not all measurements are listed (see 1985HaZA for further details).

**Internal conversion coefficients for 279.1952 keV gamma ray – selected measurements**

| | 1956Wa30 | 1958Ni28 | 1960Pe22 | 1961Su10 | 1962Ta06* | 1963Bu09* |
|---|---|---|---|---|---|---|
| $\alpha_{tot}$ | - | - | 0.227(8) | - | 0.2273(24)# | - |
| $\alpha_K$ | 0.164(5)# | 0.163(3)# | 0.164(6)# | 0.164(4)# | 0.1642(21)# | 0.165(9)# |
| $\alpha_L$ | 0.049(2) | 0.0487(12) | - | - | - | |
| $\alpha_{M+}$ | - | - | - | - | - | |

| | 1963Cr14 | 1964He19 | 1972Sa34 | 1972WaYL* | 1974Ha29 | 2000Sc05 |
|---|---|---|---|---|---|---|
| $\alpha_{tot}$ | - | - | 0.149(9)<br>0.156(9) | 0.2267(16)# | 0.2279(24)# | 0.2250(12) |
| $\alpha_K$ | 0.162(3)# | 0.163(3)# | - | | 0.1653(17)# | - |
| $\alpha_L$ | - | 0.0484(6) | - | | 0.0475(13) | - |
| $\alpha_{M+}$ | - | 0.0153(4) | - | | - | - |

* Data adjusted by 1985HaZA from the published values.
# Values adopted in an evaluation by 1985HaZA.

**Internal conversion coefficients of 279.1952 keV gamma ray – theoretical values and 1985HaZA evaluation**

| | 1978Ro22* | 1985HaZA‡ | Recommended Values |
|---|---|---|---|
| $\alpha_{tot}$ | 0.231(7) | 0.2271(12) | 0.2271(12) |
| $\alpha_K$ | 0.161(5) | 0.1640(10) | 0.1640(10) |
| $\alpha_L$ | 0.053(2) | - | 0.0476(2) |
| $\alpha_{M+}$ | 0.017(5) | - | 0.0155(2) |

* Interpolated values for 25%M1 + 75%E2, with 3% uncertainty.
‡ Hansen used three $\alpha_{tot}$ and nine $\alpha_K$ values (see previous table) to derive recommended values, which were originally selected from six $\alpha_{tot}$ and twenty-eight $\alpha_K$ values respectively.

## Beta-particle Emissions

Energies

The beta-particle energies were calculated from the proposed decay scheme. The nuclear level energies of 1993Ra11 and the Q-value were used to determine the energies and uncertainties of the beta-particle transitions to the first excited state (dominant) and ground level.

Emission Probabilities

The beta-particle emission probabilities were calculated from the limits set on the beta transition to the ground state by 1955Ma40 and 1956Wo09. Beta-decay branch to ½$^+$ Ground State of $^{203}$Tl:

| | 1955Ma40 | 1956Wo09 | Recommended Values |
|---|---|---|---|
| $P_\beta$ ($5/2^-$ --> $1/2^+$) | <0.00004 | <0.0003 | 0.0001(1) |
| log $f^{1u}t$ | - | >11.3 | 11.6(4) |

A value of 0.0001(1) was recommended from these studies. Hence, the beta-particle emission probability was defined as 0.9999(1) for the transition to the first excited state of $^{203}$Tl ($5/2^- \rightarrow 3/2^+$).

## Beta-particle Emission Probabilities

| **$E_b$(keV)** | **$P_b$** |
|---|---|
| | Recommended Values* |
| 212.6(12) | 0.9999(1) |
| 491.8(12) | 0.0001(1) |

* Recommended emission probabilities derived from the postulated limit of the beta branch to the $^{203}$Tl ground state.

## Atomic Data

The X-ray data have been calculated using the evaluated gamma-ray data, and the atomic data from 1996Sc06, 1998ScZM and 1999ScZX.

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