

National Institute of Advanced Industrial Science and Technology
National Metrology Institute of Japan



Reference Material Certificate

NMIJ CRM 5602-a

No. +++



Polycarbonate for Positron Hole-size Measurements

This certified reference material (CRM) is produced in accordance with the NMIJ's management system, and in compliance with ISO Guide 34:2000 and ISO/IEC 17025:2005. This CRM is intended for use in controlling the precision of measured data, or validating the measurement condition and results in the positron annihilation lifetime technique for polymers and insulators having a positronium component with lifetime longer than 1 ns.

Certified Value

The certified value of this CRM is given in the table below. The uncertainty of the certified value is the expanded uncertainty obtained by multiplying the combined standard uncertainty by a coverage factor (k) of 2, and it is the half-width of an interval estimated to have a level of confidence of approximately 95 %.

	Certified value (ns)	Expanded uncertainty (ns)
<i>ortho</i> -Positronium Lifetime	2.10	0.05

Analysis

The certified value of this CRM was evaluated as the mean of the longest positron lifetimes, each of which was obtained by fitting positron lifetime data for polycarbonate samples to the convolution of a model function. This function was a linear combination of three exponential decays, linked together with a resolution function. The positron lifetime data were collected by recording time intervals between the birth and annihilation of positrons emitted from ^{22}Na . The uncertainty was calculated as the combined standard uncertainty, taking account of the uniformity of the sample, the repeatability of the measurements, the positron annihilation intensity outside the sample, the total time resolution of the measurement system, the time-base accuracy of a digital oscilloscope, and the temperature fluctuation of the measurement samples.

Metrological Traceability

A measurement system with a calibrated digital oscilloscope was employed to determine the certified value, which assures traceability of the measured time of the certified value and uncertainty to the International System of Units (SI).

Expiration of Certification

This certificate is valid for one year from the date of the shipment, provided that the material is stored in accordance with the instructions given in this certificate.

Description of the Material

This CRM consists of a couple of 2.0-mm-thick square plates of polycarbonate with dimension of 15 mm x 15 mm, and is kept in a plastic container.

Homogeneity

The homogeneity of this CRM was determined by measuring positronium lifetimes for 30 plates randomly sampled from 180 plates, cut out of a polycarbonate sheet with a lateral size of 135 mm x 300 mm, and the homogeneity of the analytes was

evaluated and is reflected in the uncertainty of the certified value. Thus, this CRM is homogeneous within the range of the uncertainty of the certified value.

Instructions for Storage

This CRM should be kept in a clean light-shielded environment at a temperature between 15 °C and 35 °C. It is recommended to store this CRM in an atmosphere of dry air or nitrogen gas and keep it away from any radioactive sources.

Instructions for Use

Measure the CRM without any deformation by cutting, grinding, etc. As the surface of this CRM is brittle, handle it cautiously.

Precautions for Handling

This CRM is relatively stable under ordinary conditions but is not allowed to be left at a high-temperature environment. Refer to the safety data sheet (SDS) on this CRM before use.

Preparation

Commercially available polycarbonate obtained from a single lot was employed as the raw material for producing this CRM.

Technical Information

The relative intensity of the third component (I_3) that is due to the *ortho*-positronium annihilation is estimated to be 33 % with the assumption that the relative intensity of positron annihilation is 10 % in the two 7.5- μm -thick Kapton[®] foils between which the positron source is sealed. The certified value of the *ortho*-positronium lifetime τ [ns] is converted to a hole radius (R) of 0.294 nm based on the quantum mechanical model expressed as:

$$\tau = 0.5 \left[1 - \frac{R}{R_0} + \frac{1}{2\pi} \sin\left(\frac{2\pi R}{R_0}\right) \right]^{-1} \quad \text{where} \quad R_0 = R + 0.166 \text{ nm} .$$

The equivalent hole volume is calculated as 0.106 nm³ by using $V = (4/3)\pi R^3$.

NMIJ Analysts

The technical manager for this CRM is KOBAYASHI Y. and the production manager and the analyst is ITO K.

Information

If substantive technical changes occur that affect the certification before the expiration of this certificate, NMIJ will notify the registered customers. Customer registration on the NMIJ Website (given below) will facilitate notification. Technical reports regarding this CRM can be obtained from the contact details given below.

Reproduction of Certificate

In reproducing this certificate, it should be clearly indicated that the document is a copy.

Note

An interlaboratory comparison was carried out for this CRM. The averaged value of the reported *ortho*-positronium lifetimes was in agreement with the certified value within the range of the expanded uncertainty. The following laboratories participated in this interlaboratory comparison test:

The University of Tokyo

Osaka University, Graduate School of Engineering

Osaka University, Institute of Scientific and Industrial Research

Tohoku University

Chiba University

University of Tsukuba

Date of Shipment: Xxxxx xx, 20xx

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Tokyo Gakugei University
Japan Atomic Energy Agency
NITTO DENKO
Toray Research Center
National Institute of Advanced Industrial Science and Technology, Energy Technology Research Institute

April 1, 2020

ISHIMURA Kazuhiko
President

National Institute of Advanced Industrial Science and Technology

If you have any questions about this CRM, please contact:
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Revision history

March 21, 2013: The expiration of this certificate was extended from "March 31, 2014" to "March 31, 2019."
The description in "Information" was revised.
April 1, 2015: "Metrology Management Center" was renamed to "Center for Quality Management of Metrology."
November 20, 2017: The description in "Expiration of Certification" was changed to "one year after the date of the shipment"