

Greeting from Director of MCM



Dr. Akiko Takatsu
Director of MCM

Chemical analyses and material characterizations are key technologies of our daily life. The Research Institute for Material and Chemical Measurement (MCM), one of four research institutes in NMIJ, is in charge of supporting the reliable measurements in the field of chemical, biological and material sciences.

Our activities include development of state-of-the-art analytical techniques and measurement sciences, and supplying higher order standards. We also provide high-quality calibration services and certified reference materials (CRMs). We are now supplying around 300 kinds of CRMs, such as pure substances, standard solutions, standard gases, environmental and biological materials, and advanced materials, in which many kinds of characteristics, such as elements, hazardous organic substances, bio-molecules, thermal properties, are certified. Maintaining databases, some of which are heavily used worldwide is one of our duties, also. Our knowledge and experiences in chemical analyses and material measurements

are used in collaborations and consultations for industries to help upgrading their products, assure measurement quality, and upskill in analysis.

We also promote international comparability of measurements in our area through international frameworks and cooperations, and contribute to international metrology communities.

I would appreciate your kind support and cooperation.

Introduction of MCM

The Research Institute for Material and Chemical Measurement consists of twelve research groups. Recent research topics and activities of each group are introduced as below.

● Inorganic Standards Group

Basic research and application studies for inorganic analysis using potential primary methods, such as the Harned cell method, coulometric analysis, titrimetric analysis, gravimetric analysis, isotope dilution mass spectrometry, and neutron activation analyses, are conducted. The group develops, maintains, and supplies various inorganic CRMs such as pH standard solutions, electrolytic conductivity standard solutions, elemental standard solutions, high-purity inorganic standards, and industrial material standards for inorganic analysis, to meet domestic needs.

● Environmental Standards Group

In order to ensure analytical reliabilities in the field of environmental and food testing, the group is embarking on the research activities for establishing reliable analytical techniques (RATs) for trace elements, developing matrix-type CRMs based on the RATs, and providing support programs for improving technical skills of analysts in testing laboratories.

● Gas and Humidity Standards Group

The group develops and supplies various kinds of gas standards metrologically traceable to the International System of Units (SI) as well as humidity standards ranging from trace amounts at ppb level of moisture to high humidity at a dew point of 95 °C. The group conducts studies on the preparation methods of gas standards based on high-precision mass measurement and high-sensitivity spectroscopy via cavity ring-down spectroscopy (CRDS). This group also develops gas standards for greenhouse gases, which are topical issues, in cooperation with other observational institutes in Japan.

● Organic Analytical Standards Group

This group develops accurate quantification methods for micro-organic compounds, such as pesticides, organic pollutants, such as polychlorinated biphenyls (PCBs), and moisture. Based on these methods, highly reliable matrix-type and calibration CRMs for food, environmental and industrial product analyses are developed. The group also organizes a proficiency testing (PT) for residual pesticides.

● Organic Primary Standards Group

The group develops techniques for assessing purity or concentration of organic compounds (e.g., freezing point depression method, quantitative NMR, and titrimetry) to establish traceability to the SI. Our research results are applied in the form of CRMs and of calibration services. Since the needs for such traceable organic reference materials are growing rapidly, this group aims to establish more efficient development and supply system that can provide reliable standards promptly and inexpensively.

● Bio-medical Standards Group

Focusing on a variety of biomolecules ranging from low-molecular-weight compounds, such as steroid hormones and amino acids, to biological macromolecules, such as proteins and nucleic acids, the group develops accurate analytical techniques and certified reference materials to ensure the reliability of bioanalyses and clinical chemical measurements.

● Surface and Nano Analysis Research Group

The group is focusing on the development of the surface/interface and the nanoscale analysis techniques, with use of the microbeam of X-rays, electron beams, and ion beams. The group is developing the CRMs to calibrate the nanoscale measurement, and supplying the thickness calibration services of nanostructured thin films.

● Nanostructured Materials Characterization Research Group

The group is promoting researches on metrological and practical standards relevant to analysis of surfaces, chemical compositions at a shallow depth, and nanopores of various materials to fulfill immediate needs in nanotech industry. Researches on related analytical techniques, such as mass spectrometry, scanning tunneling microscopy, and X-ray analysis, are also being conducted.

● Particle Measurement Research Group

The group researches the measurement of particles and polymers. To facilitate accurate and precise measurement of particle properties, including particle size, this group provides standards of particles and polymers, including some at the nanometer scale. In addition, this group develops technologies to measure particle properties with high precision as well as new reference materials and calibration techniques and conducts international standardization activities including contribution to ISO standards.

● Thermophysical Property Standards Group

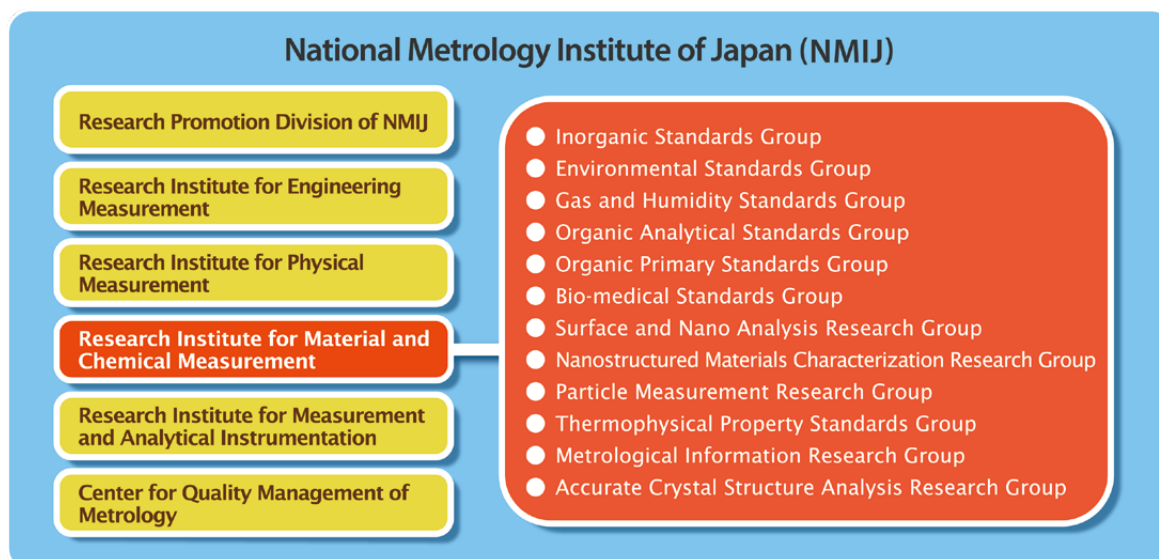
Modern society requires a great deal of energy consumption. To solve various heat-related problems, the group develops measurement technologies for thermophysical properties of functional materials and supplies SI-traceable thermophysical property standards and provides a database of thermophysical property data.

● Metrological Information Research Group

The group is composed of four sub-teams. The polymer analysis team conducts activities such as provision of CRMs of polymer additives. The spectral database team is compiling and maintaining "Spectral Database for Organic Compounds (SDBS)," and opening it to the public through the internet for free of charge. The mission of the software accreditation team is research and development of software evaluation technology in legal metrology. The applied statistics team is researching the evaluation of measurement uncertainty and statistical methods for the interlaboratory comparisons.

● Accurate Crystal Structure Analysis Research Group

Accurate structure analysis at the atomic level is indispensable in understanding the mechanisms of physical properties of crystalline materials. The group develops precise evaluation techniques for the measurement and analysis with X-ray diffraction and with solid-state NMR, and aims to establish fundamental methodology for the characterization of materials with high reliability.



New scheme for efficient supply of organic standard solutions by combination of NMR spectroscopy and chromatography

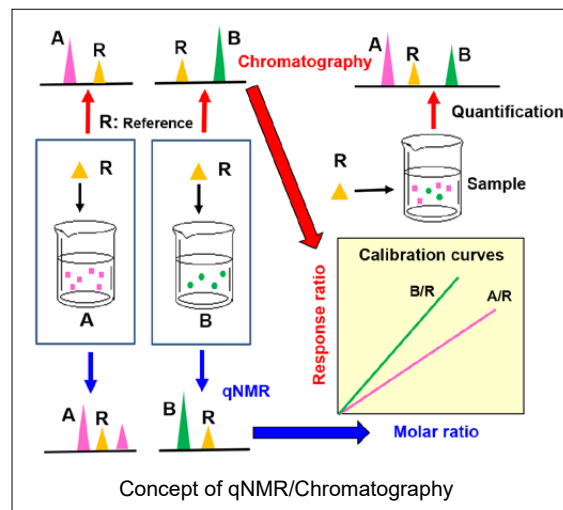
Yuko Kitamaki, Taichi Yamazaki, Naoki Saito, Miho Kuroe, Masahiko Numata and Toshihide Ihara

To keep quality of our lives, adequate evaluation of food function and safety, or environmental risk based on reliable analyses is required. For the purpose, certified reference materials having accurate property values are essential. NMIJ has devised a quantitative analytical technique for rapid development of organic reference materials by nuclear magnetic resonance (NMR) spectroscopy.

Recently, we built up a combination of the quantitative NMR (qNMR) and chromatography to establish an efficient analytical method with the cooperation of National Institute of Health Sciences. Although chromatography is applicable for separation analysis of complex mixture, reference material standard for each analyte is necessary. On the other hand, quantification by NMR is based on "mole". Therefore, simultaneous quantitative analysis of multiple components using only one reference material can be realized by the combination, qNMR/chromatography.

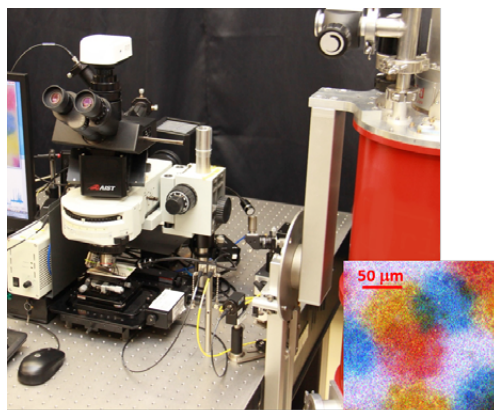
Because supply of reference materials for drinking water quality standards is an urgent need, we have been trying to apply the technique for evaluating reference materials (standard solutions) of regulated items such as chlorophenols, haloacetic acids and an anionic detergent. We will start the calibration service for these items after 2017. Moreover, we will apply the technique for quantification of components in food or environmental samples.

Reference: Y. Kitamaki, et al., *Anal. Chem.*, 2017, 89 (13), pp. 6963-6968.



Photon microscope for extremely low-level color imaging with superconducting spectral photon sensor

Kazuki Niwa, Kaori Hattori and Daiji Fukuda



Photon microscope system (main) and single photon imaging result of the test patterns (corner)

An optical microscope is one of the effective tools to analyze properties of substances by measuring reflection, fluorescence or luminescence from a target. However, the sensitivity could not be enough especially in measuring low density substances or measuring at high magnification, because of insufficient light intensity. In order to overcome this restriction, NMIJ has developed a "photon microscope", which enables color imaging in a few photon level. In this microscope, the highly sensitive photon detectors, which are based on superconducting transition edge sensors (TES), are installed instead of a CCD camera. The TES measures incoming photon energy as resistance change in its superconducting transition. Observed signals are proportional to the energy, thus the wavelength of each photon can be determined. A performance test of the photon microscope has been performed with an object of three-colored ink test patterns printed on a plane and a clear color image was successfully obtained at extremely

low power of 0.16 fW, which corresponds to $1/10^{12}$ of the intensity of firefly light. Besides, single photon counting spectra well reflected optical properties of the target material, which would be finger prints of the target species. This high sensitivity and single photon spectroscopy would be a powerful tool to measure low level fluorescence and luminescence from living cells and nano-materials.

More detail (in Japanese): http://www.aist.go.jp/aist_j/press_release/pr2017/pr20170405/pr20170405.html

Featured events

APMP Mid-Year Meetings 2017 & MEDEA Workshop

APMP Mid-Year Meetings 2017 was held from 22nd to 26th May 2017 at Hatten Hotel, Malacca in Malaysia, hosted by the National Metrology Institute of Malaysia (NMIM). Joint APMP/APLMF workshop on Modernizing National Metrology Infrastructure which was organized by PTB called "Metrology-Enabling Developing Economies in Asia" (MEDEA) Project was concurrently implemented. Representatives from more than 24 economies in Asia Pacific and Europe attended the meetings and workshops. Dr. Kishimoto, TCQS Chair, Dr. Zama, TCPR Chair and Dr. Shimada, TCFF Acting Chair attended the meetings as representatives of NMIJ.

APMP Secretariat has been transferred from NMIA, Australia to NMIJ, Japan since 2016 General Assembly (GA), and Dr. Takatsuji has been serving as a Chair of APMP. Dr. Takatsuji led the main meetings during the Mid-Year Meeting in Malacca, and all meetings and workshops were completed successfully.

Upcoming 2017 GA will be held from 24th November to 1st December 2017, hosted by CSIR-National Physical Laboratory India (NPLI) in New Delhi.

The 2017 KRISS-NMIJ Summit



They also discussed the promotion activities toward the redefinition of the SI, and agreed to promote mutual collaboration between NMIJ and KRISS in the future.

The 15th KRISS-NMIJ Summit was held on 7th July 2017, in Incheon, Korea. The NMIJ dispatched six delegates to the summit, including the Director General of NMIJ, Dr. Takashi Usuda. There were nine participants from Korea Research Institute of Standards and Science (KRIS) including Dr. Sang-Ryoul Park, the President of KRIS. After presentations on the current status, R&D activities, and strategic plan of each institutes, both parties reviewed the progress of their research-cooperation programs.

Director General of DSS, Thailand visits NMIJ

Dr. Suthiweth T. Saengchantara, Director General and other delegates of Department of Science Service (DSS, Thailand) visited NMIJ on 29th August 2017. After the greetings from Dr. Yukinobu Miki, Senior Vice-President of AIST and Dr. Takashi Usuda, Director General of NMIJ, they discussed the future collaboration in the material and chemical measurement field. They also visited some research laboratories of the Research Institute for Material and Chemical Measurement.



The 40th Japan-Korea Cooperation Committee for Legal Metrology



metrology. All participants made an agreement to start cooperation on smart metering especially focusing on legal metrology.

The NMIJ hosted the 40th Japan-Korea Cooperation Committee for Legal Metrology at Karuizawa, Japan, on 7th September. The 20 representatives from six institutes, i.e., NMIJ, Ministry of Economy, Trade and Industry (METI) and Japan Electric Meters Inspection Corporation (JEMIC) from Japan, and Korean Agency for Technology and Standards (KATS), Korea Testing Certification (KTC) and Korea Association of Standards and Testing Organizations (KASTO) from Korea, exchanged information and opinions concerning legal

The Emerging Scientist Workshop 2017

The NMIJ hosted the Emerging Scientist Workshop (ESW) 2017. It was held from 30th August to 1st September 2017 at AIST Auditorium. Totally 50 young researchers from NMIJ, KRISS (Korea) and NIM (China) participated in the workshop. They presented their research results in the short oral and poster session, and had lab interaction and discussed about the future collaboration among the institutes in the group session during these three days. Many researchers of NMIJ also joined the session and had exciting interaction with the young researchers.



Also 9 participants from 5 Asian NMIs joined the discussion in the workshop as observers. They were invited under the JST "Japan-Asia Youth Exchange Program in Science (SAKURA Science Plan)".

Activities on SI redefinition

A national committee was established to inform the redefinition of SI in Japan, and the first meeting was held in July 2017. We invited high school teachers and university professors involved in science education as members and actively exchanged opinions.



NMIJ submitted new values of Avogadro and Boltzmann constants to CODATA, due by 1st July 2017, for their consideration of special adjustment. Dr. Kenichi Fujii, member of CODATA Task Group on Fundamental Constants (TGFC) and Dr. Kazumoto Hosaka attended 23rd CCU meeting held in September 2017 at the BIPM. Prior to the meeting, NMIJ submitted our position of the redefinition to CCU.

At the occasion of his visit to other NMIs and NCSLI meeting in MD, USA, Dr. Takashi Usuda, Director General of NMIJ, had discussions on redefinition of the SI and realization of primary standards after the redefinition. Since realization of primary standards, especially kilogram, can not be achieved by an NMI alone, NMIJ considers to strengthen collaborations with other NMIs.

Peer review and international comparisons

The NMIJ dispatches peer reviewers to other NMIs on their requests (if available). In the period from May to October 2017 twelve researchers from NMIJ visited three NMIs as on-site peer reviewers. Also, NMIJ has participated in the following international comparisons.

NMIJ Participants	KCDB Code	Field	Title	Pilot Lab
Dr. M. Abe	EURAMET.L-K5.2016	Length	Calibration of 1-D CMM artefacts: Step Gauges	NPL
Dr. S. Matsuyama	ACRM action plan #11	PAHs concentrations in plastics	PAHs in High Impact Polystyrene (HIPS)	KRISS
Dr. A. Kurokawa	CCQM-P190	Surface Analysis	Thickness Measurement of nm HfO ₂ Films	KRISS
Dr. H. Nozato Dr. W. Kokuyama	CCAUV.V-K4	Vibration	Comparison of low-shock acceleration	NIM and NMIJ
Dr. K. Kinoshita	CCPR-K2a.2016	Spectral responsivity, 900 nm to 1600 nm	Comparison of spectral responsivity in A/W using InGaAs photodiodes	NPL
Dr. T. Asakai	CCQM-K34.2016	CCQM, EA WG	Assay of potassium hydrogen phthalate	NIM
Dr. H. Abe	CCT-K8	Humidity	Comparison of humidity standards	INTA

Visitors

Many foreign guests visited NMIJ for technical discussions and a series of training. Ongoing and future collaborations were discussed with the guests listed below.

Name	Affiliation	Visiting Date	Visiting Topic
Dr. Yong Moon Choi	KRISS, Korea	15 May 2017 - 14 May 2018	Guest Researcher: Reynolds number effect to the Standard Pitot tubes of ISO 3966, etc.
Dr. Seok Hwan Lee	KRISS, Korea	16 May	Technical visit to gas and liquid flow standards groups
Dr. Po-Er Hsu	ITRI-CMS, Chinese Taipei	18 May - 10 Aug.	Error analysis of high performance coordinate measuring machine
Prof. Yuri Pashkin	Lancaster University, GB	13 June	Josephson traveling wave parametric amplifier
Mr. Dean Jarrett	NIST, USA	1 - 21 July	Graphene-based quantized Hall resistance measurement
Mr. Lorenzo Marcos Muñiz	CENAM, Mexico	3 - 4 July	Technical visit on vibration calibration
Dr.-Ing. Monthol Homklintian	NIMT, Thailand	3 - 7 July	Technical assistance for development of RF attenuation primary standard in NIMT
Ms. Gayani Dissanayake and 11 others	Central Environmental Authority, Sri Lanka	18 July	Project for monitoring of the water quality of major water bodies (JICA)
Dr. Jinsang Jung	KRISS, Korea	24 - 28 July	Discussion and experiments on airborne particle number concentration
Dr. Kim Hye Won Mr. Kang Hyeong Gu	NDMI, Korea	9 August	Technical visit on low-frequency vibration and seismometer
Dr. S.T. Saengchantara and 4 others	DSS, Thailand	29 August	Future collaboration between DSS and NMIJ
Mr. Michael Jason Aguila Solis Mr. Gerry Boy Canaya Garinggan	NML, Philippines	30 Aug. - 3 Sep.	Training on calibration of gauge block by mechanical comparator
Dr. Seong Jai Cho and 9 others	KRISS, Korea	5 September	Future collaboration between KRISS and NMIJ
Dr. Seung Kwan Kim Dr. Kee Suk Hong	KRISS, Korea	8 September	Future collaboration between KRISS and NMIJ
Dr. Kanokwan Nontapot	NIMT, Thailand	12 - 13 Sep.	Discussion of precise measurement methods for laser power and laser energy
Dr. Chung Jin Wan and 22 others from KOLAS Labs	KRISS and KOLAS Labs, Korea	13 September	Technical visit to some standards labs
Dr. Daniel Lisak	NCU, Poland	23 Sep. - 27 Oct.	Development of portable trace-moisture analyzer

Selected research reports

- 1) R. Doihara, T. Shimada, K.-H. Cheong, Y. Terao, "Evaluation of hydrocarbon flow standard facility equipped with double-wing diverter using four types of working liquids", *Metrologia*, **54**, 262–279, 2017
- 2) H. Yoshida, T. Ebina, K. Arai, T. Kobata, R. Ishii, T. Aizawa, and A. Suzuki, "Development of water vapor transmission rate measuring device using a quadrupole mass spectrometer and standard gas barrier films down to the 10^{-6} g m⁻² day⁻¹ level", *Review of Scientific Instruments*, **88**, 43301, 2017
- 3) T. Sakaidani, R. Kobayashi, N. Namekata, G. Fujii, D. Fukuda, S. Inoue, "Investigation of third-order dispersion of long-range surface-plasmon-polariton waveguides using a Hong-Ou-Mandel interferometer", *Optics Express*, **25**, 9490-9501, 2017
- 4) K. Niwa, T. Numata, K. Hattori, D. Fukuda, "Few-photon color imaging using energy-dispersive superconducting transition-edge sensor spectrometry", *Scientific Reports*, **7**, 45660, 2017
- 5) S. Nakamura, Y. A. Pashkin, M. Taupin, V. F. Maisi, I. M. Khaymovich, A. S. Mel'nikov, J. T. Peltonen, J. P. Pekola, Y. Okazaki, S. Kashiwaya, S. Kawabata, A. S. Vasenko, J-S Tsai, and N. Kaneko, "Interplay of the inverse proximity effect and magnetic field in out-of-equilibrium single-electron devices", *Physical Review Applied*, **7**, 054021, 2017
- 6) Y. Kitamaki, N. Saito, T. Yamazaki, S. Otsuka, S. Nakamura, Y. Nishizaki, N. Sugimoto, M. Numata, T. Ihara, "Determination of PAHs in solution with a single reference standard by a combination of ¹H quantitative NMR spectroscopy and chromatography", *Analytical Chemistry*, **89**, 6963-6968, 2017
- 7) N. Nonose, T. Suzuki, K. Shin, T. Miura, A. Hioki, "Characterization of a new candidate isotopic reference material for natural Pb using primary measurement method", *Analytica Chimica Acta*, **974**, 27-42, 2017
- 8) M. Ohata, K. Nishiguchi, "Direct analysis of gaseous mercury in ambient air by gas to particle conversion-gas exchange ICPMS", *Journal of Analytical Atomic Spectrometry*, **32**, 717-722, 2017
- 9) Q. Wang, S. Ri, H. Tsuda, M. Koyama, K. Tsuzaki, "Two-dimensional Moire phase analysis for accurate strain distribution measurement and application in crack prediction", *Optics Express*, **25**, 13465-13480, 2017
- 10) A. Masuda, T. Matsumoto, K. Takada, T. Onishi, K. Kotaki, H. Sugimoto, H. Kumada, H. Harano, T. Sakae, "Neutron spectral fluence measurements using a Bonner sphere spectrometer in the development of the iBNCT accelerator-based neutron source", *Applied Radiation and Isotopes*, **127**, 47-51, 2017