Bureau International des Poids et Mesures

Consultative Committee for Amount of Substance: Metrology in Chemistry and Biology (CCQM)

Report of the 28th meeting
(27-28 April 2023)
to the International Committee for Weights and Measures

Comité international des poids et mesures

LIST OF MEMBERS OF THE CONSULTATIVE COMMITTEE FOR AMOUNT OF SUBSTANCE: METROLOGY IN CHEMISTRY AND BIOLOGY

as of 27 April 2023

President

Dr S.-R. Park, member of the International Committee for Weights and Measures also

Korea Research Institute of Standards and Science [KRISS], Daejeon

Executive Secretary

Dr R. Wielgosz, International Bureau of Weights and Measures [BIPM], Sèvres.

Members

Centro Nacional de Metrología [CENAM], Querétaro.

D.I. Mendeleyev Institute for Metrology, Rosstandart [VNIIM], St Petersburg.

Danish Fundamental Metrology A/S [DFM], Hørsholm.

Federal Institute for Materials Research and Testing/Bundesanstalt für Material-forschung und –prüfung [BAM] Berlin.

Federal Institute of Metrology METAS [METAS], Bern-Wabern.

Health Sciences Authority [HSA], Singapore.

Instituto Nacional de Metrologia, Qualidade e Tecnologia [INMETRO], Rio de Janeiro.

Korea Research Institute of Standards and Science [KRISS], Daejeon.

LGC Ltd [LGC], Teddington.

Laboratoire National de Métrologie et d'Essais [LNE], Paris.

National Institute of Metrological Research/Istituto Nazionale di Ricerca Metrologica [INRIM], Turin.

National Institute of Metrology [NIM], Beijing.

National Institute of Metrology (Thailand) [NIMT], Pathumthani

National Institute of Standards and Technology [NIST], Gaithersburg.

National Measurement Institute, Australia [NMIA], Lindfield.

National Metrology Institute of Japan, AIST [NMIJ/AIST], Tsukuba.

National Metrology Institute of South Africa [NMISA], Pretoria.

National Metrology Institute of Turkey /TÜBITAK Ulusal Metroloji Enstitüsü [UME], Gebze-Kocaeli.

National Physical Laboratory [NPL], Teddington.

National Research Council of Canada [NRC], Ottawa.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

RISE Research Institute of Sweden AB [RISE], Borås.

Slovak Institute of Metrology/Slovenský Metrologický Ústav [SMU], Bratislava.

VSL Dutch Metrology Institute [VSL], Delft.

The Director of the International Bureau of Weights and Measures [BIPM], Sèvres.

Observers

All-Russian Scientific Research Institute of Physical Technical Measurements, Rosstandart [VNIIFTRI], Moscow.

Bulgarian Institute of Metrology [BIM], Sofia.

Central Office of Measures [GUM], Warsaw.

Centro Español de Metrología [CEM], Madrid.

CSIR National Physical Laboratory of India [NPLI], New Delhi.

Government Laboratory [GL], Kowloon.

Government Office of the Capital City Budapest [BFKH], Budapest.

Instituto Nacional de Tecnología Industrial [INTI], San Martín, Prov. Buenos Aires.

Instituto Português da Qualidade [IPQ], Caparica.

Kenya Bureau of Standards [KEBS], Nairobi.

National Metrology Centre, Agency for Science, Technology and Research [NMC, A*STAR], Singapore.

National Physical Laboratory of Israel [INPL], Jerusalem.

State Enterprise “All-Ukrainian State Scientific and Production Center of Standardization, Metrology, Certification and Consumer' Rights Protection” [SE "Ukrmetrteststandard"], Kiev

Liaisons

Cooperation on International Traceability in Analytical Chemistry [CITAC], Trappes.

European Commission – Joint Research Centre [JRC-Geel], Geel

International Atomic Energy Agency [IAEA], Vienna.

International Federation of Clinical Chemistry and Laboratory Medicine [IFCC], Milan.

International Organization for Standardization, Committee on Reference Materials [ISO REMCO], Geneva.

International Union of Pure and Applied Chemistry [IUPAC].

1. OPENING OF THE MEETING

The Consultative Committee for Amount of Substance: Metrology in Chemistry and Biology (CCQM) held its twenty eighth meeting at the International Bureau of Weights and Measures headquarters (BIPM), at Sèvres, and on-line, on 27 and 28 April 2023.

The following attended:

Members: M. Akgöz (UME), H. Andres (METAS), Y.-K. Bae (KRISS), M. Bilsel (UME), A. Botha (NMISA/ISO-REMCO), J. Braybrook (LGC), P. Brewer (NPL), R.J.C. Brown (NPL), S.Z. Can (UME), J. Carney (NIST), M. Della Negra (DFM), L. Dong (NIM), Z. Durisova (SMU), S. Ellison (LGC), M. Fernandes-Whaley (NMISA), P. Fisicaro (LNE), C. Gonzalez (NIST), N. González Rojano (CENAM), J.A. Guardado Pérez (CENAM), B. Güttler (PTB/CITAC), N. Hanari (NMIJ/AIST), C. Haraldsson (RISE), K. Inagaki (NMIJ/AIST), Y.A. Kustikov (VNIIM), B. Lalere (LNE), S. Lee (KRISS), K.-S. Lee (KRISS), T. Macé (LNE), L. Mackay (NMIA), M. Maiwald (BAM), M.N. Medeiros (INMETRO), J. Melanson (NRC), Z. Mester (NRC/IUPAC), G. O'Connor (PTB), U. Panne (BAM), S.R. Park (President of the CCQM/CIPM/KRISS), C. Pascale (METAS), M. Pérez Urquiza (CENAM), C. Rimmer (NIST), J.M. Rodrigues Caixeiro (INMETRO), A.M. Rossi (INRIM), M. Sega (INRIM), D. Smeulders (NMIA), E. Sobina (UNIIM), R. Stosch (PTB), L.L Tay (NRC), T.L Teo (HSA), M. Valkova (SMU), A. van der Veen (VSL), J. Vogl (BAM), M. Vonsky (VNIIM), D. Wang (NIM), C. Yafa (NIMT), K. Yamamoto (NMIJ/AIST), E. Yildirim (RISE), Q. Zhang (NIM).

Observers: S. Aggarwal (NPLI), T.C. Cheung (GL), F. Dias (IPQ), J. Dumanska (GUM), T. Fernández Vicente (CEM), W.H. Fung (GL), P.A. Gatti (INTI), N. Goldovsky (INPL), F.M. Kai (NMC, A*STAR), J. Kang'iri Njeri (KEBS), B. Koleva (BIM), O. Levbarg (SE "Ukrmetrteststandard"), C. Luvonga (KEBS), D. Nagy (BFKH), Z.N. Nagyné Szilágyi (BFKH), N. Oganyan (VNIIFTRI), C. Palma (IH-LQPM), A. Petrenko (SE "Ukrmetrteststandard"), M.M. Puelles (INTI), R. Quendera (IPQ), H.K. Rotich (KEBS), C. Sanchez Blaya (CEM), L. Santos (INTI), D. Soni (NPLI), T. Stolboushkina (VNIIFTRI), M. Strzelec (GUM), I. Victorov (INPL), S. Yadav (NPLI).

Liaisons: F. Camin (IAEA), C.M. Cobbaert (IFCC), R. Koeber (JRC-Geel).

Representatives from Member States invited to attend as Observer: V. Aleksandrov (Kaz Standart).

Guests: T. Asakai (NMIJ/AIST), J. Campbell (LGC), B. Calderón Jiménez (LACOMET), M. Cleveland (NIST) B. Fu (NIM), T. Fujimoto (NMIJ/AIST), B. Garrido (INMETRO) J. Huggett (LGC), B.J. Kim (KRISS), J. Kucklick (NIST), K. Lippa (NIST), G. Miller (VCU), T. Näykki (MIKES-SYKE), S. Seitz (PTB), A. Shard (NPL), C. Swart (PTB), D.W.M. Sin (GL), M. Winchester (NIST).

Also present: M. Bedu (BIPM), T. Choteau (BIPM), A. Cypionka (BIPM), G. Dudle (BIPM), E. Flores Jardines (BIPM), R. Josephs (BIPM), S. Maniguet (BIPM), M.J.T Milton (Director of the BIPM), P. Moussay (BIPM), J. Viallon (BIPM), R. Wielgosz (BIPM / Executive Secretary of the CCQM).

2. APPOINTMENT OF A RAPPORTEUR

Dr Wielgosz noted that Dr Ellison (LGC) had served as Rapporteur at the 25th to 27th meetings and had offered to serve again for the present meeting. The meeting confirmed the appointment of Dr Ellison as rapporteur.

3. APPROVAL OF THE AGENDA

Dr Park presented the proposed agenda (*CCQM/2023-01*), which was adopted without change.

4. OPENING REMARKS OF THE CCQM PRESIDENT AND ACTIONS FROM THE 27TH MEETING OF THE CCQM

4.1 Opening remarks

Dr Park welcomed the members, observers and liaisons, thanking those who were attending online at extreme local times. Dr Park was honoured to report that he had been appointed by the CIPM as CCQM President for a further term, and looked forward to the cooperation and engagement of CCQM members. He invited those members present in person to introduce themselves; participants accordingly introduced themselves and their roles.

Dr Park acknowledged the work of CCQM members during the previous few years, under the difficult circumstances of the pandemic. He recalled the celebration of the 25th anniversary of the CCQM in 2019, and noted the growth of CCQM to include nine technical subject working groups, making the CCQM the largest and most active of the CIPM CCs. He noted the CCQM Vision agreed in 2020, and recalled the strategic aims for 2021-2030 that had been published by the CCQM in June 2021. These are available on the BIPM website, in the CCQM Strategy Document. He noted that detailed plans had been prepared by each working group to support the strategy.

Dr Park noted that there had been over 190 CCQM working group and task group meetings by videoconference in the period 2022-2023, as well as the three plenary meetings, and he thanked the BIPM staff and working group members for their support for these meetings. In addition, Dr Park drew attention to the international webinars organized under the auspices of the CCQM, including a webinar on the SARS-CoV-2 pandemic response; he was pleased to note the strong response of CCQM members, which had included swift organization of comparisons to support measurements of SARS-CoV-2, as well as the formation of a new task group to develop procedures for a response to future pandemics.

Dr Park described how the CCQM had responded to global challenges, for example by contributing to the establishment of a new value for the ozone absorption cross-section, contributing to the formation of networks for monitoring greenhouse gases, and by forming a task group to develop a strategy for analysis of microplastics. Additional workshops had included workshops on measurements for viral vectors, on metrology for quantities that could be counted, and on the use of mass spectrometric methods for ionizing radiation applications. Several of these had been run jointly with other consultative committees.

Dr Park thanked the members for all their work and support over the past three years.

In discussion, Dr Wielgosz noted that the CCQM strategy document had been published in 2021, and asked if an update would be required in response to the ongoing CIPM strategy development exercise, and in particular the focus on sector specific challenges. Dr Milton noted that the CIPM would be presenting a longer-term view of developments in metrology in approximately 2025, with some indications available in 2024; he accordingly suggested that the CCQM might usefully review the present strategy in the light of CIPM developments from 2024. This would also allow the CCQM to contribute to the emerging CIPM strategy.

4.2 Actions from the 27th meeting

The draft Report of the 27th meeting of the CCQM had been circulated to participants following the meeting and amended to take into account minor comments received by correspondence. The report had subsequently been made available on the BIPM website. The meeting approved the report of the 27th meeting.

The list of actions agreed at the 27th meeting was available separately as document CCQM/2022-67 and was additionally included appended to the Report of the 27th meeting of the CCQM. All relevant actions were complete and, where appropriate, were included on the present meeting agenda.

5. REPORTS FROM CCQM TASK GROUPS

5.1 CCQM Task Group on Stakeholder Engagement: Progress Report (R. Brown) [CCQM/23-06]

Dr Brown reported on the progress of the Task Group on Stakeholder Engagement. He recalled the principal aims for the group, which were to develop a clear strategy for stakeholder engagement. He noted the membership of the group and thanked members for their contributions. Following the 27th meeting of the CCQM, the group's terms of reference had been extended to consider implementation of some of the initial recommendations, particularly:

- To list all current and planned Task Groups that include stakeholder engagement,
- To develop proposals for focusing on different sectors during each CCQM plenary session as a plan for engagement, and
- To develop criteria for extending liaison status at the CCQM.

These tasks were completed by correspondence and the outcomes presented to the CCQM Strategic Planning WG in October 2022.

Dr Brown gave brief examples of current and planned CCQM task group activities related to stakeholder engagement, noting that activity varied across working groups. He also presented potential sectoral focus areas for future CCQM workshops, including the proposal to focus on digitalization in the first instance.

Dr Brown drew attention to the draft Criteria for extending liaison status at the CCQM (*CCQM/2023-06*) and invited comments. This was a short document that complemented CIPM-D-01, identified the types of organization likely to be suitable for liaison, and included remarks on the role of liaisons in achieving consensus within the CCQM.

Following a brief discussion, Dr Park proposed the adoption of the criteria. The criteria were approved.

In response to a question from Dr Wielgosz, Dr Brown agreed that the task group had completed its tasks; the meeting accordingly agreed to close the task group, and thanked Dr Brown and the task group members for their contribution.

5.2 CCQM Task Group on Metrology for Pandemic Preparedness: Progress Report (J. Braybrook)

Dr Braybrook reported on the activities of the CCQM Task Group on Metrology for Pandemic Preparedness since the previous meeting. He reminded the meeting of the principal aims of the task group, which were to prioritize proposed comparison activities relating to rapid, deployable infectious disease diagnostics, to document standardization approaches for priority measurands, and to develop knowledge transfer mechanisms and skills translation supporting the metrology of infectious disease diagnostics, within the international metrology community. He additionally recalled the publication of the CCQM 'Roadmap' for infectious disease response, published in 2022 following a successful workshop in 2021. Dr Braybrook noted the short- and medium-term metrology priorities identified in the roadmap, which had shaped the priorities for the task group. The task group had been formed following the workshop, and currently included two sub-groups, the first covering prioritization of comparison activities and documentation of standardization approaches, and the second considering training and best practice.

The group had met online twice in 2023, and in person on 24 April 2023, with some attending online. Both sub-groups had met. The meeting had discussed a proposed 'fire drill' exercise, to be led by the CCQM Working Group on Nucleic Acid Analysis, to trial a rapid CCQM response to an emerging pathogen. The Working Group proposed to run this as a pilot study. In addition, the group had identified further technology studies for consideration in the PAWG and EAWG.

The task group was also working on standardization approaches for performance-related specifications; this had been delayed by work on the 'fire drill' exercise but Dr Braybrook expected completion by July 2023.

The group had considered the provision of e-leaning material to be hosted on the BIPM e-learning platform. A pilot module covering a situational case study was in development and Dr Braybrook anticipated that this would be available for review later in 2023.

Dr Park asked other WG chairs for their views on implementation of the task group's proposals. Dr Melanson said that the PAWG had discussed the matter on the previous day and felt that there was a need to finalize practical details of the exact form of such a study, but Dr Melanson was confident that the WG could find a way to support the proposal. Dr Huggett said that NAWG were proposing a study to support the proposal for a rapid response 'fire drill' exercise. Dr Campbell, for CAWG, also felt that CAWG would be able to support the pandemic response priorities in future comparisons. Dr Mackay said that OAWG could contribute to support for calibration for small molecule calibrants used in pandemic response, and to e-learning modules. Dr Seitz said that EAWG needed to better understand the electrochemical factors affecting biosensor development before contributing actively. Dr Shard (SAWG) invited Dr Braybrook to provide SAWG with a brief overview of developments in sensors so that the group could understand how best to respond.

Dr Milton asked how a 'fire drill' differed from a pilot study conducted quickly. Dr Braybrook explained that the exercises were exactly that, and the intent was to take advantage of planned studies where possible and that the task group's role was to identify priorities.

In relation to the e-learning activity, Dr Wielgosz asked about the target audience and practical implementation for the modules. Dr Cleveland, the sub-group convenor responsible for the e-learning tasks, responded that the initial module would relate to the need for standardization, aimed largely at clinical stakeholders. Further developments would be intended to support RMOs, and their development would follow consultation with RMO representatives on the TG and, more widely, via a planned survey of needs. Dr Cobbaert, International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) added that from an IFCC perspective, it was critical to support the development of accurate test kits to support clinical practice.

In response to a question from Dr Park, Dr Braybrook explained that the group included representatives from stakeholders including the World Health Organization (WHO) and the PT/EQA community. He added that an advantage of running a rapid response exercise in the format of a pilot study was that it permitted participation by external expert laboratories. Dr Huggett confirmed that the proposed exercise would include a requirement for participants to identify and contact appropriate expert stakeholders, in part to ensure that these contacts would be in place in future. Dr Wielgosz also noted that it would be appropriate for the BIPM to refresh relations with WHO contacts, who had changed over time, and the present MoU provided a mechanism to do this.

In response to a further question, Dr Braybrook explained that in the event of a future pandemic, molecular methods would inevitably form the first line of response, starting with sequencing and followed by the development of appropriate nucleic acid probes. As with SARS-CoV-2, this would often be followed by development of antibody-based tests responding to pathogen proteins and peptides.

5.3 Outcomes of CCQM Workshop on Particle Metrology

Dr Fisicaro (IAWG vice chair) reported on behalf of Dr Winchester, who had been unable to join the present meeting.

The principal aims of the workshop had been to foster information exchange between the CCQM working groups and their stakeholders on the current state of particle metrology, to inform the CCQM working groups regarding activities that need to be undertaken, and to develop a CCQM action plan based on the workshop findings. The three-day workshop had included 250 registered participants in total, with about 130 attending on each day. Participants heard presentations from three plenary speakers from outside the NMI community as well as many from different measurement institutes. Following plenary presentations on challenges in airborne bioaerosol measurements, characterization challenges posed by nanoparticle polydispersivity, and optimizing characterization of metal nanoparticles in complex matrices, the participants had separated into three parallel discussion sessions. These had covered, respectively, measurements for particles suspended in air or other gases; particles suspended in water or other liquids; and particles in biological materials and pharmaceuticals. The workshop had concluded with feedback from the three discussion sessions, followed by a general discussion and formulation of recommendations.

For particles in air and other gases, three issues had been identified: extending metrological comparability, including provision of CRMs and calibration services; developing metrological and scientific understanding, including vocabulary, operationally defined measurands, procedures for

validation and technical developments for specific problems; and active engagement with stakeholders. The session on particles in liquids had identified a need for clear definition of the measurands, and had noted the large number of measurands and the consequent need for harmonization between different communities and for support for a wide range of measurement technologies. There was also a need for reference methods and materials for characterizations of particles below 30 nm in size. In the biological and pharmaceutical area, clear definition of measurands again appeared to be a problem; other problems included a need for particle surface characterization, and problems related to method dependency of particle size measurements.

The recommendations from the workshop, developed in conjunction with the CCQM Executive Secretary and the workshop steering group, were:

- To create a task group within the CCQM to foster communication between communities, consider interlaboratory comparisons, harmonize protocols, and provide sample preparation guidance, among other tasks. It was recommended that this task group be set up as a joint IAWG/SAWG task group in the first instance.
- To create a task group within the CCQM Gas Analysis Working Group (GAWG) to engage with stakeholders and address focused challenges.
- To create a task group within the CCQM Cell Analysis Working Group (CAWG) to engage with stakeholders, improve communication and knowledge sharing, and encourage development of documentary standards.

These proposals were agreed by the CCQM, with terms of reference to be developed for each Task Group and presented to the SPWG.

For further information, Dr Fisicaro noted that the workshop agenda, presentations, and other information from the workshop could be found on the workshop web page at https://www.bipm.org/en/committees/cc/ccqm/wg/ccqm-ws/2022-10-25.

5.4 Outcomes of CCQM Workshop on Metrology for Viral systems as molecular tools (J. Campbell)

The workshop, held in January 2023, aimed to explore established and emergent measurement technologies, reference materials and methods development, the regulatory landscape, and standardization needs and gaps for the broad set of stakeholder applications utilizing viral vector systems. The workshop had included four sessions, covering general challenges and opportunities for metrology for viral systems; physical titre measurement and molecular methods; functional measurement using mass, particle and microscopy methods; and standardization and control of measurements for viral vectors. The workshop had been well attended, with over 170 participants registering interest.

Dr Campbell said that a written report was in progress, with assistance from speakers, and was expected to be available by June 2023. In addition, the workshop had generated an invitation to give a presentation at PDA Viral Safety for ATMPs in Madrid in June 2023. The workshop had also suggested the formation of a task group to outline a strategic plan for studies across CCQM working groups. Dr Wielgosz invited Dr Campbell to provide draft terms of reference for such a task group for consideration by the SPWG.

Dr Campbell thanked the steering committee and the session chairs for their contribution to a successful workshop.

5.5 Outcomes of the CCU/CCQM Workshop on the metrology of quantities which can be counted (B. Güttler)

Dr Güttler reported that the CCU/CCQM Workshop on "The metrology of quantities which can be counted" had been held on 28-30 March 2023. The aims of the workshop included discussion on counting and number quantities across the metrological community; discussion on delineation between counts, other quantities where counting may be involved in the measurement, and quantities that do not involve counting; and identify needs for guidance on appropriate nomenclature, on counts and their traceability, and on the CCs and working group responsibilities for providing traceability for such quantities.

The workshop was well attended with over 300 participants. Speakers had discussed aspects of counting and number quantities within many different fields of metrology, including (for example) particle counting and applications in quantum metrology.

Dr Güttler noted that counting was of particular interest for the definition of the mole; IUPAC had recently noted that with modern technology, realization of the mole via direct counting of molecules was coming into reach with the required uncertainty. Dr Güttler felt that this might require amendment of the *mise-en-pratique* for realization of the mole. Counting was also extensively used in other fields; for example length measurement frequently used counts from interferometers for high-accuracy length measurement. A fundamental issue for all counting operations was the definition and identification of the particular entity to be counted.

As a follow up to the workshop, the existing CCU Task Group on Angles and Dimensionless Quantities in the SI Brochure intended to create a focus group including participants from the Consultative Committees which have identified specific issues to be addressed (including CCQM, CCRI and CCPR). The focus group was to make proposals to the CCU on how to clarify the text of the SI Brochure related to counting and number quantities. The Consultative Committees would then be able to build on this to clarify aspects related to counting in their respective fields. The treatment of counting and number quantities in the VIM was to be taken forward separately by JCGM-WG2:VIM, many of whose representatives had been present at the workshop.

For further information, Dr Güttler noted that available workshop presentations are available on the BIPM web site at https://www.bipm.org/en/committees/cc/ccu/wg/ccu-ccqm-ws/2023-03-28.

In discussion, Dr Milton asked whether the workshop had provided any insight into the relationship between number of entities and amount-of-substance in the definition of the mole, which was often poorly understood. Dr Güttler said that this had not been discussed in detail in the workshop but could be considered by the emerging CCU focus group. Dr Wielgosz added that at a recent meeting of the CCQM *ad hoc* Working Group on the Mole, it had been noted that not all number quantities in the CCQM area should be expressed as amount-of-substance.

5.6 Outcomes of CCRI-CCQM Workshop on the Use of Mass Spectrometry in Radionuclide Metrology: Opportunities and Challenges (M. Winchester)

Speaking on behalf of Dr Winchester, who had led the workshop, Dr Mester reported that the online CCRI-CCQM Workshop on the Use of Mass Spectrometry in Radionuclide Metrology had been held in February 2023, following on from a CCRI Webinar, "Mass Spectrometry in Radionuclide Metrology". The workshop had arisen from a recognition that mass spectrometry (MS) had emerged

as an important alternative to decay counting for determination of, for example, contamination, activity and half-life, resulting in an expansion of MS facilities for radionuclide metrology at leading NMIs. As well as describing relevant work at different institutions, the workshop was intended to elucidate the advantages of using mass spectrometry to support counting methods in radionuclides; identify stakeholder metrology; define general requirements for applying mass spectrometry in radionuclide metrology, including the requirements for establishing an SI-traceability chain for the calibration of mass spectrometry system for the measurements of radionuclides; and identify important challenges to the use of mass spectrometry in radionuclide metrology. Approximately 120 participants had attended from a range of NMIs and other institutes.

Dr Mester noted some key advantages of MS, including high precision and low activity requirement. MS implementation was, however, impeded by the need for investment in facilities, and limited expertise outside specialist institutes. A further important issue was the reliance on artefact standards for radionuclide metrology; these measurement standards were not generally appropriate for MS applications.

The workshop had resulted in formation of a CCRI task group on use of MS for radionuclides, and had invited CCQM experts to liaise and contribute. Dr Mester said that relevant CCQM WGs would share information with CCRI on relevant studies, and invite CCRI members to participate in appropriate CCQM pilot studies. Dr Wielgosz welcomed the collaboration and noted that as CCRI studies had typically focused on comparison of primary radionuclide standards, the level of CCRI participation in the first CCQM pilot study proposed was limited, but would hopefully grow. Dr Milton noted that the CCRI typically operated at high activity levels to support medical and industrial applications; this differed from the much lower levels encountered in environmental standards.

Closing the discussion, Dr Park noted that the CCRI President had expressed appreciation for the joint event and for the prospect of collaboration.

5.7 Proposal to establish a CCQM Task Group on Metrology for Li-ion Batteries (S. Seitz) [CCQM/23-14]

Dr Seitz explained the rationale for the proposal to establish a CCQM Task Group on metrology for lithium-ion (Li-ion) batteries (*CCQM/23-14*). The transport sector generated a large proportion of greenhouse gas emissions and there had been a rapid increase in production of electric vehicles, most of which relied on Li-ion batteries. This had generated a need for quality inspection of used Li-ion batteries intended for re-use, among other measurements. These included, for example, impedance measurements, lifetime measurement, measurements of chemical composition, and X-ray spectroscopy.

The principal aim of the task group would be to identify and evaluate measurands and metrological services related to Li-ion battery technology in the context of the CIPM MRA, in collaboration with other CCs of the CIPM and relevant stakeholders. The proposed terms of reference were set out in the proposal, CCQM/23-14.

Dr Seitz gave a brief indication of the proposed activities of the task group which, in addition to identifying and inviting relevant experts and stakeholders, included identification of activities conducted by other consultative committees, identification of relevant measurands, development of a ‘road map’ on implementation of relevant measurands in the CIPM MRA framework, and provision of recommendations on a mode of operation involving all relevant CCs. Dr Seitz expected that the task group would run through 2023-2024.

The meeting **approved** the formation of the Task Group and confirmed Dr Seitz as task group convenor, with Dr Wain (NPL) as deputy.

5.8 CCQM Nano- and Microplastics Measurements and Standards Task Group: Progress Report (J. Kucklick) [CCQM/23-24]

Dr Kucklick (attending online) presented the report from the Nano- and Microplastics Measurements and Standards Task Group (see *CCQM/23-24*). He gave a brief introduction to the problem of microplastic pollution in the natural environment, often arising from erosion of long-lived plastics in the environment. He recalled that the task group had been formed following a successful CCQM workshop on the topic of microplastics in April 2022. The overall goal of the task group was to prepare a written report for the April 2024 CCQM plenary, identifying activities on metrology issues related to nano- and microplastics measurement and standards.

The Task Group had met online on nine occasions and had further progressed specific tasks through email. The group had decided that more information was needed on the capabilities and activities of NMIs in the micro- and nano-plastic measurement area, and had accordingly created and distributed an online survey to gather information from NMIs and other institutes. The survey had been launched on 29 March 2023, and was sent to the IAWG and OAWG chairs as well as the chair of the Versailles Project on Advanced Materials and Standards (VAMAS) for distribution, with a closing date for response of 28 April 2023.

Dr Kucklick showed preliminary results from the survey. Of 28 responses to date, approximately 55 % considered themselves capable of microplastic measurements, 35 % were currently making such measurements in environmental matrices, and about 15 % were currently developing RMs for microplastics. Most respondents had been involved in microplastic measurements for less than five years, with a small majority who were not yet developing capabilities.

In addition to the survey, the group planned to convene a stakeholder workshop in late 2023 to gather information on wider stakeholder needs. Following the workshop, the group planned to summarize the findings and provide recommendations to the CCQM for the April 2024 meeting.

5.9 Discussion on Task Group activities

Task group activities had been discussed in response to individual presentations and no further general points were raised.

6. CCQM WORKSHOPS AND SECTOR ENGAGEMENT

6.1 Outcome of the BIPM-WMO Workshop on Metrology for Climate Action (R. Wielgosz)

Dr Wielgosz reported that the workshop had been held online as an interactive event including sessions on the GatherTown platform. There had been over 1000 registered participants, and had included 200 pre-recorded presentations. Approximately 100 recommendations had emerged from the event. A substantial report was in progress and would be published in due course. Presentations and other information were available at https://www.bipmwo22.org

Dr Wielgosz additionally reported on the CIPM Sectoral Task Group on Climate Change and Environment (CIPM STG-CENV). This group had been formed in response to Resolution 1 of the 27th meeting of the CGPM that encouraged the CIPM to establish inter-disciplinary groups to address new challenges, and following the recommendations of the BIPM-WMO Workshop. The general aim was to provide a global focal point for metrology activities related to climate change and the environment. Dr Wielgosz reported that the group would operate via a core group, and a stakeholder group meeting annually or biennially. One important activity for the Task Group was to act as a clearing-house for the recommendations from the BIPM-WMO workshop, which it would do by working with task teams among relevant CCs, WMO teams, and teams within the STG itself. Examples of CCQM teams included the CCQM TGs on ozone cross-section and on greenhouse gas scale comparisons.

Dr Wielgosz drew attention to a number of national and international initiatives the CIPM STG could link to, including the UN Conference of the Parties (COP 28 and subsequent meetings) on climate change, a WMO initiative for a globally integrated framework for greenhouse gas monitoring, and a US Federal strategy to provide an integrated US greenhouse gas monitoring information system.

6.2 World Metrology Day and the Food Analysis Sector

Dr Milton explained the background to World Metrology Day. The BIPM had started the process of recognition of the event date via UNESCO, and a proposal had gone forward to UNESCO for approval, with the help of UNESCO member states. Some of these were not yet participants in the Metre Convention, indicating an increasing recognition of the importance of measurement.

Dr Josephs provided an update on the 2023 events. A steering group had been formed in early 2023, with the aim of developing a series of promotional videos and supporting material so that CCQM members could more easily support the event. Videos would include 2-minute introductions to subjects, supported by some 10-minute recorded presentations from a number of speakers. Six presentations had been confirmed, relating to the need for reliable measurements, applications in food regulation, and measurements on microplastics in food. Other topics included measurement on allergens and food packaging materials, sustainability and alternative protein sources, and several regional perspectives.

Dr Josephs asked that CCQM members brief their communications staff to expect material from the BIPM so that it could be promoted widely.

6.3 Requirements for specific CCQM Food Analysis Sector Activities (S-R. Park)

Dr Park reported that the CIPM had highlighted food safety as one of its key metrology challenges, and had asked the CCQM to consider the evolving needs for metrology in this area.

On invitation from Dr Park, Dr Kim confirmed that the Asia-Pacific region (APMP) included a number of developing economies with a need for metrology support in food safety. Dr Mackay added that many OAWG comparisons already focused on food safety, many providing support for proficiency testing and RM certification activities. The meeting also noted that the Inorganic Analysis WG and the Nucleic Acid WG had conducted many comparisons relating to food safety and regulation and that others recognized the food sector as a key stakeholder for their work.

Noting that several CCQM working groups were addressing food safety and regulation already, the meeting agreed that the topic of evolving metrology needs for food safety should be taken up within the SPWG to consider how the CCQM could best provide input to the CIPM on the evolving needs in the field.

6.4 Addressing FAIR Digital data challenges (C. Gonzalez)

Beginning a series of three presentations reflecting the digitalization focus for the meeting, Dr Gonzalez described some of the benefits and challenges of FAIR digital data from the perspective of NIST.

NIST had initiated a 'Digital NIST' project to transform NIST Measurement Services data to enable direct machine interaction with the data. He described five levels of compliance, starting with human-readable digital documents and, at level 5, 'machine-controllable' content that was machine-readable, executable and interpretable, and could be updated automatically. As part of this initiative, NIST had adopted the FAIR principles for data. FAIR stands for Findable, Accessible, Interoperable and Reusable. This required that data is:

- capable of being located through descriptive metadata;
- capable of being accessed and read;
- capable of being transferred and interpreted accurately using standardized vocabularies; and
- capable of reliable long-term reference, via maintenance of clear provenance records, long-term preservation, and clear licensing and re-use information.

The FAIR guidelines identified specific requirements to be met for each of the four FAIR characteristics. As an example, Dr Gonzalez described the NIST repository of over 8 million mass spectra. Initially, the collection lacked globally unique standard identifiers, but it did provide a unique and persistent uniform resource identifier (URI) that provided for unambiguous identification and location. Each spectrum included comprehensive metadata describing for example, the analyte and the acquisition conditions. Finally, the data was registered and indexed for retrievability. These features satisfied the FAIR principles for 'Findability'. Dr Gonzalez gave similar details of the remaining principles, identifying some of the challenges in meeting the requirements. For example, Dr Gonzalez noted that machine-readability, of itself, need not be sufficient for 'Interoperability'; for example, many human-readable terms varied in meaning across disciplines and while a machine could access and read the information, correct interpretation required more information than the term itself. Interpretability accordingly required adherence to standardized ontologies, generally requiring subject-specific expertise to relate terms correctly.

In addition to the technical challenges posed by adherence to the FAIR principles, Dr Gonzalez pointed out that development, data validation and maintenance costs could be high, which could inhibit wide adoption of the principles. Concluding, Dr Gonzalez identified three broad areas of challenge: technical challenges such as dealing with legacy code; programmatic considerations, including identification of 'fit for purpose' approaches; and social challenges such as perceived ownership and lack of understanding of the benefits of FAIR data for the organization.

6.5 The SIRP and the path towards FAIR CMCs (G. Dudle)

Dr Dudle provided an update on the implementation of FAIR principles by the BIPM in relation to the SI reference point (SIPR). The work followed from Resolution 2 of the 27th CGPM to promote digitalization.

Dr Dudle provided an example from the application programming interface (API) for the KCDB. He noted that although the data included human-readable information such as measurement units in string format, these could not necessarily be interpreted correctly by software systems. The intent of digitalization was to permit unambiguous machine interpretation of SI data. To support this, BIPM had identified four key types of object: units, quantities, constants and vocabularies. Each member of these four types of object required a unique reference identifier in the SI system. As an example, he showed

how a text string defining a unit could be replaced by a universal resource identifier (URI) pointing to the definition of the unit in machine-interpretable form.

Quantities presented additional challenges, because of the wide range of different kinds of quantity and, for CCQM, the complexity of quantity descriptors. For example, a chemical quantity might require identification of an analyte, a matrix and, for operationally defined measurands, a measurement method.

6.6 Discussion: CCQM Sector Specific initiatives – Digitalization

In discussion, Dr Brown noted the practical difficulty of representing quantities and units. He said that some ontologies conflated units and quantities, and noted that even units could be misinterpreted, especially when prefixes were included. Dr Dudle observed that it would probably not be useful to include units in a quantity descriptor as, for example, different kinds of quantity might have the same SI units.

Dr Wielgosz suggested the formation of a steering group for a workshop on digitalization within the CCQM and asked members to consider experts who could contribute to a steering group. This was agreed. A convenor and terms of reference would be considered further by the SPWG. Dr van der Veen (VSL), Dr Botha (NMISA), Dr Gonzalez (NIST), Dr Brown (NPL), Dr Mester (NRC) and Dr Ellison (LGC) offered to participate. IFCC and IUPAC representatives both indicated support for participation and would notify representatives in due course.

6.7 Report from the Joint Committee for Traceability in Laboratory Medicine (JCTLM) (G. Miller)

Dr Miller provided a comprehensive report on JCTLM activities. He recalled the formation of the JCTLM in 2002 by IFCC, ILAC and BIPM, with the BIPM providing the secretariat. Membership currently comprised 71 members across 22 countries and regions, with 45 stakeholder members. The committee maintained two working groups, one covering the JCTLM database, and one covering education and promotion of metrology in clinical measurement.

Dr Miller reported on a workshop on 'Overcoming challenges regarding reference materials and regulations that influence global standardization of medical laboratory testing results', noting that a summary was available online (see W G Miller et. al, *Clinical Chemistry and Laboratory Medicine (CCLM)*, vol. 61, 2023, pp. 48-54. https://doi.org/10.1515/cclm-2022-0943).

The workshop had identified several challenges. First, the IVD industry needs a small number of suppliers of certified reference materials for each analyte, rather than a large number providing similar standards. In addition, change in a reference material could be highly disruptive for established measurement systems, and continuity in supply was highly important. There was accordingly a need to coordinate supply of RMs so that different NMIs did not unnecessarily duplicate supply. Production of RMs also required careful prioritization as primary materials were costly to produce. The workshop had additionally suggested that the JCTLM might assist by extending the contact of its database to include all potentially useful RMs, in addition to those fully meeting ISO standard requirements, and Dr Miller invited comment on how useful this would be.

Dr Miller noted that commutability assessment was a major expense in clinical RM production. The IFCC working group on commutability assessment had previously published papers on procedures for commutability assessment, and had recently added recommendations on establishing criteria for

commutability assessment. A suggestion at the workshop was for the CCQM to coordinate demonstrations of commutability of CRMs as part of its existing or future comparisons.

Turning to the JCTLM database, Dr Miller reported that the JCTLM had recently updated its database, greatly improving usability for the end user. He regretted, however, that it had not been possible to support development of an integrated approval system, and noted that JCTLM was seeking financial support for this development.

The JCTLM had formed a strategy task group to consider how best to meet stakeholder needs. The group was considering the value of the current database of ISO-compliant materials and of other processes to identify materials, was consulting regulators on the requirement for metrological traceability under IVD regulations, and was considering a promotional strategy to raise awareness of JCTLM. A knowledge transfer task group had also been formed to improve the acceptance rate of submissions, by identifying the most common deficiencies and providing additional guidance.

Closing, Dr Miller noted that the JCTLM Stakeholder meeting for 2023 would focus on EQA schemes for elucidating the clinical suitability of laboratory results.

6.8 Report from the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) (C. Cobbaert) [CCQM/23-25]

Dr Cobbaert, IFCC Scientific Division (SD) Chair, presented the report. The Mission for the IFCC SD had been reinforced during the IFCC General Conference in Brussels in October 2022, on the occasion of the 70th anniversary of the IFCC; the mission was to advance the science of Laboratory Medicine and to apply it to the practice of Clinical Laboratory Medicine. As of 2022 the IFCC SD had an Executive Committee that oversees the activities of seven theme-oriented Committees and 17 task-oriented Working Groups. The IFCC operated through international standards development, scientific and technical development, and provision of events to share best practice and disseminate new developments. Forthcoming events included EuroMedLab in Rome in 2023 (https://2023roma.org) and in Dubai in 2024. Other events can be found on the IFCC website (https://ifcc.org).

Dr Cobbaert described the process for selecting IFCC scientific interventions, including standardization of measurement methods and provision of measurement standards. Although this was robust and had proven successful in introducing improvements in health outcomes, Dr Cobbaert felt that there was a need for a more integral approach and educational process to clarify to IFCC WG/C chairs what is needed for IFCC endorsement and JCTLM listing of developed RMs, RMPs and/or RMSs respectively.

Concluding, Dr Cobbaert said that the IFCC was a global force for improvement in laboratory medicine, and hoped that the CCQM and IFCC would continue to work together for the benefit of patients.

6.9 Discussion: CCQM Sector Specific initiatives -Health and Life Sciences

In discussion of the JCTLM update, Dr Milton asked how practical it would be for CCQM to include commutability demonstration as part of its comparisons. Dr Wielgosz noted that this was not consistent with how the CCQM conducted studies for capability demonstration, which generally involved a small number of test materials; this point had been made at the workshop. However, since the workshop had revealed that up to 70 % of the cost of developing a CRM might be in commutability assessment, it would be beneficial to consider how CCQM studies could be conducted to assist.

Considering the possibility of a JCTLM or CCQM task group on RM issues, the meeting agreed that the most appropriate host would be the JCTLM, and **agreed** to contribute to a JCTLM task group on prioritization, supply and commutability studies for reference materials.

In discussion of the IFCC report, Dr Güttler noted that analytical science appeared to be in decline in universities – a trend also noted by IUPAC – and he hoped that IUPAC and IFCC would be able to work to improve that situation. Dr Cobbaert supported the idea of collaboration to promote education on analytical measurement and commented that the IFCC Education Division and Scientific Division should be involved in such an effort.

7. REPORTS FROM THE CCQM WORKING GROUPS

7.1 CCQM Working Group on Organic Analysis (CCQM-OAWG) (L. Mackay) [CCQM/23-16]

Dr Mackay presented the report from the Organic Analysis Working Group (*CCQM/23-16*). The group supported three key sectors: food, clinical and environment. The key technologies for the group were isotope dilution MS and quantitative NMR (qNMR). The full working group had met three times, online, since the previous meeting, with a further online meeting to discuss CCQM-K78b. The group had 12 key comparisons in progress, with a further two, on PAHs in soil and on estradiol in serum, proposed to commence in 2023-2024. Progress was generally good, though Dr Mackay expressed concern that the draft A report for CCQM-K159 was not yet available.

Dr Mackay gave a brief overview of the status of current and planned OAWG comparisons. CCQM K154.c on deoxynivalenol in acetonitrile, and CCQM K156, on perfluorinated compounds in groundwater, were complete and had been published in the KCDB. CCQM K133, on phthalates in PVC, was complete and the final report had been agreed by OAWG. CCQM-K168 had measured zearalenone, a mycotoxin, and was at draft B stage, as was CCQM K156.1, a follow up comparison similar to CCQM-K156. Of the remaining eight ongoing studies, one was at draft A stage, results had recently been received and reviewed for two, measurements were still under way for three, and three studies were planned to commence in 2023-2024.

The OAWG decided on food matrices using the well-known AOAC Food Triangle, which categorized foods based on fat, protein and carbohydrate content. This sometimes presented challenges in identifying a suitable material. For CCQM-K180, on metronidazole in meat, representing an important antibiotic in a high protein matrix, the group had been fortunate to obtain material from BVL with incurred antibiotic. Results for the study were due in September 2023.

For clinical analytes, studies could be classified by molecular mass and concentration, or by clinical need and impact. For example, (a proposed KC analyte) was considered high-impact and high need.

Environmental analysis was increasingly important as the sector grew in perceived importance. Responding to an emerging issue, the group had conducted CCQM-K156 on polyfluorinated compounds L-PFOA and L-PFOS; the report was now complete and would be submitted for WG Chairs' approval shortly. The most recent meeting had included a presentation on nano- and microplastic measurements and standards, helping to inform OAWG work in the field.

The group also maintained a series of studies on pure organic calibrants, largely coordinated by the BIPM. CCQM-K78.b had involved a study on a multicomponent organic solution. CCQM-K148b, on oxytetracycline hydrochloride, was in progress. As a salt, this material presented new challenges for

the group, and the most recent meeting had accordingly discussed best practice in purity assessment for such material. Finally, the next study in the K154 series was to be on Ochratoxin A calibration solutions; Dr Mackay noted the careful work of the BIPM team in preparing these.

Turning to measurement technology, the OAWG had heard presentations on high-resolution mass spectrometry. This provided the opportunity to undertake 'non-targeted' analysis – that is, examination of a sample for unexpected or unusual components. Traceability and calibration for non-targeted analysis presented new challenges for accurate measurement. The discussion, however, had been helpful in highlighting the need for careful measurand definition and in sharing best practice among participants.

Dr Mackay gave a short overview of stakeholder engagement and RMO activities. Stakeholders included a wide range of international bodies, regional and national regulatory bodies, standardization bodies, and stakeholders in industry, academia, and professional and scientific organizations. RMO activities of interest included, for example, European NMI participation in European Metrology Networks for safe and sustainable food and endocrine disrupters under the EU water Framework Directive.

In closing, Dr Mackay noted that it was her last CCQM meeting as OAWG chair, and thanked Dr Lippa, OAWG co-chair, for her support.

7.2 CCQM Working Group on Inorganic Analysis (CCQM-IAWG) (M. Winchester) [CCQM/23-22]

In Dr Winchester's absence, Dr Fisicaro presented the report from the Working Group on Inorganic Analysis (*CCQM/23-22*). Dr Fisicaro reminded the meeting of the principal aims and history of the WG before summarizing recent activity.

The work of the group had benefited from the relaxation of Covid-19 restrictions world-wide, but in the last year had encountered new difficulties including government restrictions on collaboration, transport of materials, and co-authorship among other concerns. The group had nonetheless met on four occasions, all online, prior to the CCQM plenary week, and a further meeting had been held in person at the BIPM headquarters on 25-26 April. Participation in the group's online meetings had continued to be high, with up to 65 participants.

Dr Fisicaro presented a summary table of completed and ongoing comparisons, subdivided by measurand. This showed good coverage of the 'measurement space' for the group. The 'measurement space' was used to ensure that comparisons provided optimal support for 'broad claim' CMCs. The group had recently surveyed participant needs for CMCs, concluding that calibration solutions and materials with high organic content were important areas for future CMCs. This had informed the group's rolling 5-year plan for comparisons, which Dr Fisicaro presented.

The IAWG were also working to advance particle metrology, in particular focusing on single particle ICP-MS. For example, Dr Fisicaro noted that CCQM-P194, on number concentration of monodisperse colloidal nanoparticles, had included the surface analysis WG. Further comparisons included more challenging nanoparticle materials; CCQM-K166, under way, was intended to include particles of different sizes. A collaborative study with the cell analysis WG was also planned.

Work to enhance traceability had included several key comparisons on purity evaluation for high-purity metals and calibration solutions. The group also had a 'road map' for purity determination of pure metallic elements (CCQM-IAWG/GD-07).

The group had recently given further consideration to statistical assessment of IAWG data and had adopted the NIST decision tree (https://decisiontree.nist.gov) for all KCRV calculations. The implications of degree-of-equivalence uncertainties for CMC claims were still under consideration.

Reporting on key and pilot comparisons, Dr Fisicaro noted that the group currently had five key comparisons at draft A stage, and one key comparison (K173.d, on assay of sodium carbonate) recently approved for equivalence. Further comparisons in progress included CCQM-K162/P208 on selenoproteins in serum, CCQM-K178/P223.f, on rare earth elements, uranium, and thorium in soil, for which samples were being distributed.

CCQM-K166/P210, on nanoparticle number concentration, had been paused owing to unanticipated sample instability; the recent in-person meeting had heard proposals for provision of a replacement test material and distribution of the material was expected in May 2023. Dr Fisicaro reported that coordination of K169/P220.d, on amount content of sodium oxalate, had been transferred from NMIJ to UNIIM.

Dr Fisicaro gave brief details of the results of some ongoing comparisons. K144/P182 had included elements across three key groups in the measurement space, demonstrating how a single comparison could support broad CMC claims. K155/P196 studied elements and tributyltin in seawater to support environmental analysis. A study on elements in rice flour (K158) had presented challenges in dry mass determination; the example shown, for potassium, showed relatively poor agreement. CCQM K160/P203, on an automotive catalyst, had shown good agreement for three elements, but surprisingly poor agreement for palladium. A small pilot study (P215) on arsenic speciation in seafood, among four participants, showed relatively poor agreement for arsenobetaine and dimethylarsenic acid (DMA), highlighting the challenges of speciation in inorganic analysis.

Three KCs were proposed, on non-metallics in pure metals, on elements and anions in urban particulate matter, and on elements in pork. A fourth, on elements in steel or metal alloy, was under consideration.

In discussion, Dr Brown noted that the IAWG written report had included two options for calculating DoE uncertainties, which he felt would be both confusing and in conflict with the spirit of the CIPM MRA, and asked whether the group had discussed the proposal. The group had decided not to use the terminology. General guidelines for IAWG member CMC claims had, however been supported. These guidelines permitted laboratories to use their reported uncertainties in CMC claims when in good agreement with the KCRV; to claim an increased uncertainty claim when agreement was only achieved after allowing for overdispersion; and recommended no claim when agreement could not be achieved even after addition of the overdispersion term.

Dr Ellison noted that if data showed appreciable disagreement, that had unavoidable effects on confidence in the KCRV and hence could not be ignored in evaluating the uncertainty for a KCRV. The effect on CMC claims was, however, a matter for expert judgement, taking account of possible causes of disagreement. He noted that the KCRV task group would be recommending additional graphical tools to assist in evaluating KC data, some designed specifically to identify important disagreement unambiguously. Dr van der Veen noted that statistical tests for mutual consistency were not sufficiently powerful to detect modest, but important, excess variance, and that even in his own field, details of methodology and uncertainty budgets frequently failed to explain the reasons for apparent disagreement within reported uncertainties. Dr Fisicaro agreed with Dr Milton that it remained important to understand the reasons for such discrepancies before submitting CMC claims. Dr Milton also felt that an increase in claimed uncertainty should be justified by a change in the uncertainty budget

and not simply by adding an arbitrary amount in order to achieve metrological consistency with a KCRV or other reference value.

7.3 CCQM Working Group on Gas Analysis (CCQM-GAWG) (P. Brewer) [CCQM/23-05]

The gas analysis WG (GAWG) had continued to meet online between in-person meetings, finding that online events greatly increased participation. The October 2022 meeting had included over 100 active participants.

Dr Brewer showed a summary of ongoing and planned comparisons. He was pleased to report that several key comparisons had recently been published, and showed selected results. CCQM-K10.2018 on volatile organic compounds ("BTEX") in nitrogen and CCQM-K118.a, a comparison on composition of hydrogen-enriched natural gas, had shown good agreement across a wide range of analytes, as had CCQM-K118.b on liquefied natural gas composition. Degrees of equivalence were shown for CCQM-K165, a comparison on dimethyl sulfide, and CCQM-K3.2019 on automotive gas. The latter showed a small number of visibly discrepant results which were being followed up by the individual laboratories concerned.

Describing advancement in the state of the art, Dr Brewer showed a comparison of results for CCQM-K68:2008 and CCQM-K68:2019 (NO_2 in air), showing clear evidence of improvement as a result of efforts to improve performance. A similar improvement was not, however, visible in comparing the results of CCQM-K74:2009 and K74.2018, a 'model 2' comparison comparing participants' reference materials for nitrogen dioxide in nitrogen. This analyte suffered from interaction with gas cylinder walls, and further work was needed to improve comparability. This work would be supported by the ongoing BIPM.QM-K6 comparison, which was in preparation.

The group had also been seeking to advance the state of the art in isotope ratio determination in CO_2. Results for CCQM-P204, presented to the meeting, demonstrated that further attention needed to be paid to measurement uncertainty for $\delta^{13}C$ determinations (using the VPDB scale), and it appeared that the variance among results increased with deviation in $\delta^{13}C$ from the reference standard. These issues would be addressed by a new task group prior to starting a key comparison.

The group had set up five task groups; three technical and two organizational. Technical task groups covered ozone cross section, greenhouse gas (GHG) scales, and advanced spectroscopy. The ozone TG was working to manage a change in the recently re-determined standard value used for ozone cross-section, and had engaged with stakeholders to set and manage a transition period through 2025-2026. This included amendment to existing standards for ozone measurement.

The GHG scales group was working to improve procedures for establishing a scale for measurement of CO_2 in air, including protocols for comparing primary standards for CO_2 in air with consistency of 0.02 μmol mol^{-1} or better. The need for accessible reference standards linked to the WMO standards was discussed at the WMO's GGMT meeting in 2022. The task group was also seeking to develop a protocol to demonstrate the equivalence of scales based on different sets of primary CO_2 in air standards over decades; Dr Brewer thanked the BIPM in particular for taking on this important but challenging task.

The advanced spectroscopy group had been set up to examine spectroscopic alternatives to mass and manometric approaches for certification. Spectroscopic methods would provide for a wider range of SI-traceable measurements in future, in particular at lower concentrations than could currently be produced using mass measurement. The work would require measurements of absorption at specific wavelengths and a pilot study was under way to examine transitions in carbon monoxide.

Organizational task groups included one on coordination of comparisons, charged with improving the number of coordinating laboratories. This followed on from the need to broaden the number of institutes acting as coordinators, as the coordination of past comparisons has fallen on a very small number of institutes.

The WG had held a workshop in statistical approaches for calculating KCRVs in October 2022, to improve understanding among GAWG members. The discussion had considered three case studies and had included different approaches to degree-of-equivalence uncertainties, in part because study participants were not always content for uncertainties to be increased because of some outlying values when their own agreement with the proposed KCRV seemed good. In response to a question, Dr Brewer and Dr Wielgosz explained that in one study, the excess variance component needed to account for overdispersion had been adjusted depending on the participant uncertainty, to avoid over-inflating smaller uncertainties where the result agreed well with the KCRV.

7.4 CCQM Working Group on Isotope Ratios (CCQM-IRWG) (Z Mester) [CCQM/23-23]

Dr Mester reported on the IRWG activities (see *CCQM/23-23*). He recalled the formation and principal aims of the working group. Since formation in 2019, the group had grown to 20 institutes, about half with established experience in isotope ratio measurement. The most recent meeting, in April 2023, had included 49 participants, including about half online. Dr Mester felt that the group was now well established and that the next four years would consolidate the group and its working practices.

Dr Mester drew attention to two points identified in the terms of reference for the WG; the difficulty of making delta scale measurements traceable to the SI, and the reliance on IUPAC for approval of sources of traceability. He felt that for consistency with CIPM guidelines, the CCQM should identify its own sources of traceability.

Dr Mester was pleased to report that IRWG had finalized the group's first key comparison, CCQM-K167, on carbon isotope ratio measurement in vanillin, using the carbon delta scale. Dr Mester showed results from the study, which showed outstanding agreement among participants; Dr Mester believed this was the best agreement so far reported for isotope ratio measurements in an interlaboratory context. The report had been posted on the KCDB and was available for CMC support.

CCQM-P212, a 'model 2' study on coherence of $\delta^{13}C$ CRMs, had been run in parallel with CCQM-K167 and had examined agreement among approximately 40 $\delta^{13}C$ CRMs from different sources. Although agreement had been good within certified uncertainties, the practice of single-point calibration left room for appreciable biases from some of the materials. Measurements were complete and a draft final report had been provided to the WG's April 2023 meeting.

Measurements for CCQM-P204, on stable carbon and oxygen isotope ratios in pure CO_2, had been completed with support from the BIPM and IAEA as the coordinating laboratories and a draft report had been considered at the April 2023 meeting. Results, presented, showed that agreement could be improved by use of common pure gas calibrants; and further work was required to better standardize the value transfer from carbonates to gas reference materials, and work was under way at the BIPM and some expert laboratories to address these issues.

CCQM-P213, on copper isotope ratio measurement in high-purity materials, was also complete and a draft final report had been tabled at the April 2023 meeting. A study on strontium isotope ratio measurements in rice flour had unfortunately been suspended because of operational constraints at the pilot institute; it was not yet clear when it would be possible to resume preparation.

The group was planning three further studies. A study on zinc isotope ratios in sediment would follow on from CCQM-P213 and would support, for example, source attribution in environmental contamination studies. A further key comparison was proposed on copper isotope primary measurements, using gravimetric mixtures to obtain absolute ratios rather than δ scale values. Finally, a new study, on lithium isotope ratio, had been proposed at the most recent meeting; details would be provided when plans were further advanced.

Dr Mester summarized the IRWG goals for 2023. These included:

- Definition of the next tranche of studies to support comparability and advance fundamental metrology issues;
- Refining the IRWG 'measurement space' and comparison planning process;
- Exploring novel isotope measurement modalities not currently practiced by NMIs to better understand emerging metrological challenges, including 'clumped' isotopes, and site specific isotope ratio measurements;
- Advancing international discussion of nomenclature and delta scale definition and realization and, in particular, work toward contributions to the IUPAC green book and gold book of nomenclature;
- Further developing inter-WG and inter-CC relations with a special focus on climate change and nuclear safety.

7.5 CCQM Working Group on Protein Analysis (CCQM-PAWG) (J. Melanson) [CCQM/23-29]

Dr Melanson reported that the protein analysis WG had met online in April 2022 and again in January 2023, for two sessions on each occasion. Each had included 40-60 participants. Additional online meetings of small groups had been convened to progress studies and other business between the two main meetings. The group had discussed the response to the SARS-Cov-2 pandemic, hearing presentations from several NMIs involved.

Dr Melanson gave an overview of the group's current comparisons. These were planned with reference to a measurement space characterized by molecular mass and structural complexity. For example, CCQM-K115.c, on peptide purity, represented moderate molecular mass with a structural modification (glycation). The study was complete, and the final report had been published in June 2022. The study had been based on haemoglobin A1c, a common blood sugar indicator, and had used a synthetic glycated hexapeptide of HbA1c (GE) as a model, and had been coordinated jointly by BIPM, NIM, and HSA. A further key comparison, CCQM-K115.2018, again on peptide purity but using a synthetic hexapeptide of HbA0 (VE), had also been finalized and published in September 2022. The two studies differed primarily in the degree of modification of the peptide, with the K115.c peptide including a terminal glycation. Participant performance had been closely similar for both studies. Visible disagreement led to the use of a derSimonian-Laird estimate for the KCRV, which included a component for the visible excess dispersion.

Measurements for CCQM-P216 (Part 2), on quantification of SARS-CoV-2 monoclonal antibody, had been completed, and the draft B report had been prepared by the coordinators; NIM, BIPM and NRC. Dr Melanson explained that two general approaches had been applied; a 'bottom-up' approach using amino acid analysis, and size exclusion chromatography (SEC) as an intact protein approach. Results showed acceptable agreement, particularly considering the high molecular mass. Dr Melanson noted

that SEC would probably be the initial characterization approach in a rapid pandemic response. There had also been good agreement for UV-VIS spectrophotometric analysis at 280 nm.

Measurements were complete for two further comparisons. CCQM-K177, on mass fraction of human growth hormone in serum, had been coordinated by PTB and was currently at the draft A stage. Preliminary results had been discussed at the January 2023 meeting. High variability had been observed both within laboratories, and across different institutes. The cause was under investigation. A draft report had also been prepared for CCQM-P219, on determination of the amount-of-substance fraction of [HbA1c/(HbA1c+HbA0)] in human hemolysate. P219 had been coordinated jointly by HSA, LNE, NIM, and KRISS. While reasonable agreement had been achieved across the NMIs in CCQM-P219, there had been significantly more variability than that observed across IFCC reference laboratories. Follow-up work was being carried out to determine the cause of the increased variability.

Finally, CCQM- K115.d/P55.2.d, on quantitation of parathyroid hormone PTH(1-84), was at the planning stage. Dr Melanson reported that no further PAWG comparisons were currently at a stage requiring CCQM approval.

Dr Melanson noted that this was the final meeting in his present term as WG chair and thanked the group participants and the vice-chair, Dr Swart, for their support during his term as chair.

Dr Wielgosz noted the results of the CCQM-P219 study and asked what the next steps were in improving agreement. Dr Melanson explained that three NMIs were conducting follow-up studies to understand whether the digest method was responsible. The study would be repeated, ideally as a key comparison, once the discrepancy was understood. The IFCC representative noted that HbA1C was also important for diabetes diagnosis and that interlaboratory studies now showed 3 % relative standard deviation using the present reference measurement procedure. Dr Wielgosz added that within JCTLM it had been emphasized that capabilities in the KCDB needed to be consistent with reference measurement procedures on the JCTLM database, as inconsistent results from different procedures could lead to severe adverse consequences for patients.

7.6 CCQM Working Group on Cell Analysis (CCQM-CAWG) (J. Campbell) [CCQM/23-26]

After a brief reminder of the cell analysis WG remit, Dr Campbell gave a summary of CAWG activities. The group had continued to meet with online meetings during the year, with in person meetings planned as required.

The group had evolved a framework for planning studies, which characterized the measurement challenge primarily by cell complexity and by morphology. Cell analysis also involved a range of different measurement services, including (for example) cell counts in different cellular matrices, number concentration of cells in biological fluids, measurements of cell surface properties, determination of antimicrobial susceptibility and biocidal properties, and cell viability assessments.

Reporting on CAWG studies, Dr Campbell reported that measurements for three pilot studies were complete, with first draft reports expected later in 2023 or early 2024. Dr Campbell gave brief details of each. CCQM P217, on enumeration of fixed peripheral blood mononuclear cells in suspension, (NIBSC coordinator with additional analysis by PTB and NIST) was intended to establish participants' ability to count suspension cells using a range of methods, and to examine uncertainties associated with a prescribed cell suspension dilution series. CCQM-P205, on enumeration of membrane-intact E. coli (led by NIM, China) aimed to compare the measurement performance of flow cytometry, which determined number of membrane-intact Escherichia coli. per unit volume, expressed as cells/mL, to a membrane filtration method which determined number of culturable viable Escherichia coli. per unit

volume. The study accordingly included viability determination ("viable E. coli.") as well as cell counting.

CCQM-P197 was being led by NPL, NIST and INRIM, and covered the determination of proliferative cell number per unit area. The study was also considering uncertainties related to cell-count measurement results.

CCQM-P222, on number concentration of particles for cellular analysis, was being led by NMIJ and PTB. The study will use 5-µm polystyrene latex (PSL) microsphere particles in suspension to establish counting capability. The study was on hold due to restrictions on sample distribution. Discussion was under way to identify practical ways to complete the study and Dr Campbell hoped that it would be possible to resume within 2023. Stability monitoring was continuing in the meantime to make sure that the materials were unaffected by the delay in commencement.

Presenting a schematic of current and future studies, Dr Campbell said that the group would be increasing the complexity of studies before moving to key comparisons over the next 5-10 years. He expected that key comparisons would initially focus on calibration materials.

Dr Campbell drew attention to the working group's role in preparing the CCQM Workshop on Metrology for Viral systems as molecular tools, reported above.

In discussion, Dr Park acknowledged that cell analysis was clearly complex and asked how members felt about the long timescale expected before key comparisons would be available for CMC support. Dr Campbell said the group would be reviewing the nature of comparisons, and while early key comparisons on eukaryotes would be too challenging, he hoped that some of the simpler studies could transition to key comparisons much sooner.

Dr Botha noted that much of the work appeared to relate to standardization, and she was pleased to see the group interacting actively with stakeholders. She asked how the group was interacting with ISO. Dr Campbell explained that the group was active in ISO TC 276 and was reporting to the ISO TC on their technical findings to inform standardization, particularly in image analysis.

Dr Wielgosz noted that International Council for Standardization in Haematology (ICSH) was an important potential stakeholder and asked how the group could engage effectively with ICSH. The IFCC representative, Dr Cobbaert, pointed out that IFCC and ICSH have a memorandum of understanding and might be able to act as a link to ICSH. Dr Campbell would follow this up with Dr Cobbaert.

7.7 CCQM Working Group on Nucleic Acid Analysis (CCQM-NAWG) (J. Huggett) [CCQM/23-32]

Dr Huggett recalled the aims of the working group and gave a brief overview of the principal sectors served by the group. Studies to date primarily related to food and clinical applications. He explained that the measurement challenges in nucleic acid analysis could be characterized by matrix complexity, type of measurement (ratio measurements being simpler than absolute quantitation) and sequence complexity, including the number of different target sequences involved. He then presented a summary of the activities of the nucleic acid working group since the last CCQM plenary.

The 15th NAWG meeting had been held online during the period, attracting four participants at the cost of shorter discussion time. The group had also met in person, with online participation,

immediately before the April 2023 plenary. Further online meetings had been held during the year to plan future comparisons and further develop the group's strategy.

Two pilot studies were complete: CCQM-P199 on HIV-1 RNA copy number quantification, and CCQM-P199.b on SARS-CoV-2 RNA copy number quantification. CCQM-P199 had been led by the NML at LGC with the support of NIBSC. HIV had been chosen as it is reported as a number concentration rather than a ratio. The final report was complete subject to formatting for publication. CCQM-P199.b had been led by the NML at LGC along with NIMC, NIBSC and NIST; again, the final report had been agreed and was being prepared for publication.

The group had several key and pilot comparisons in progress. Dr Huggett discussed these in turn, presenting available results.

CCQM-K86.d/P133.5 focused on quantification of genomic DNA extracted from a protein matrix. Organized by NIMT and TÜBITAK UME, the study materials had been mixtures of processed pure meat material (pork and beef). Dr Huggett presented results from the study, which showed good agreement for estimated mass fraction and poorer agreement for genomic DNA ratios. This had been discussed at the NAWG meeting on 22 April 2023, and could be partly accounted for by differential extraction of pork and beef DNA from the processed meat matrix. This largely cancelled in mass ratio estimation owing to calibration using the pure mixture components.

Dr Huggett showed results from CCQM-K176/P218, on determination of breast cancer biomarker HER2 copy number variation (CNV). Results for normalized ratios showed excellent agreement, well within participant uncertainties. Dr Huggett felt that the results clearly showed the potential for NAWG members to support future clinical genetic measurements.

CCQM K181/P227, on SARS-CoV-2 RNA copy number quantification, followed up CCQM-P199.b and included measurement of RNA copy number concentration in a highly concentrated stock suspension, using isotope dilution mass spectrometry. Test materials for RNA determination were prepared by gravimetric dilution, providing an independent value for RNA copy number. This in turn provided a direct test of the completeness of the transcription step in RNA quantitation using digital PCR. Dr Huggett showed results from the study, which had been discussed earlier in the week. He noted that the level was very low, at about 50 target copies per microlitre. Agreement was good by comparison with routine laboratories, but showed a marked negative bias on comparison with values calculated from IDMS and gravimetric dilution.

Dr Huggett reported that a further planned study, CCQM P94.3, was about to commence, with sample distribution expected by June 2023. The study was being led by TÜBITAK-UME and KRISS, and was on the quantitative analysis of DNA methylation of a defined human genomic DNA region. This was an important pilot study which would expand the scope of the working group to include traceability for epigenetics measurements.

Three pilot studies were proposed, covering, respectively, species identification of meat using DNA methods, viral genomic quantitation, and the previously noted rapid response 'fire drill' exercise. Dr Huggett gave brief details of each to support his request for CCQM approval. An important feature of the rapid response study would be the need for participants to conduct their own sequence studies and design their own probes for analysis, rather than relying on previously agreed probe design.

The NAWG had recently conducted an internal survey to understand participants' needs for CMC support. Most participants were seeking CMCs. The group accordingly intended to increase the number of key comparisons, to improve support for CMC claims by member institutes. Pilot studies would still be used to better understand sources of uncertainty for more complex measurements prior to key

comparisons. Commenting on challenges for KCs, Dr Huggett noted that a recent study had revealed an unexpected effect of amplicon size; in effect, different probe sequences had counted different proportions of an intentionally degraded (sonicated) genomic DNA due to the range of fragment sizes. This indicated that it would be important to start with carefully controlled samples for CMC support.

The group had also continued discussions on how to support the environmental sector. Studies envisioned in the medium term included agricultural pest measurements and nucleic acid measurements of the environmental microbiome, including biofilms and wastewater testing.

The most recent meeting had included a lively discussion of units for reporting nucleic acid results. The stakeholder community used number of copies, sometimes abbreviated 'cp', to express results. Reference to practice in other WGs identified precedents for use of community units. For publications, the group proposed to use units such as copies/mL, shortened to (for example) mL^{-1} with explanatory notes for metrology publications such as KC reports. Dr Huggett also suggested that it might be useful to approach the CCU to consider the issue of special 'pseudo-units' (such as 'copies') in the next SI brochure.

Another problem the group faced was the limited number of CMC database categories available for CMC claims and studies; Dr Huggett asked for advice on increasing the range of categories. Dr Wielgosz said that the KCDB categories were only used for grouping, and suggested that the group propose additional categories to support nucleic acid measurements.

Dr Huggett commented on publication routes for clinically relevant pilot studies. The group was increasingly publishing preprints on medRxiv for early availability, followed up by PubMed for sector relevance. He felt that this led to greater impact than publication in metrology journals.

In discussion, Dr Brown said that convention generally deprecated the use of whole words as units and suggested that the group identify a symbol for any non-SI units. Dr Wielgosz agreed, but felt that adherence to stakeholder practice had value. Dr Botha agreed with the need to relate to the stakeholder community and added that reporting should include a clear statement of the kind of quantity and, for counts, the entity counted, as well as the units. Dr Güttler noted that the issue was relevant for many other applications, and drew attention to the discussion on units for counting already under way with the CCU. Reflecting further on units, Dr Swart noted that the protein analysis group had also identified problems with units for reporting; the group, and the community, generally used milligrams per unit volume, but she noted that the molar concentration then required an accurate molar mass. This was often omitted or presented approximately in stakeholder publications, leaving molar concentration uncertain. Mr Levbarg noted that while discussing the units, we should always think first of what are the measurand and analyte, which is not always obvious in complicated measurements, such as GMO analysis.

Dr Wielgosz suggested that the *ad hoc* WG for the mole might be an appropriate forum for consideration of units within the CCQM and suggested extending the terms of reference of the *ad hoc* WG to include advice on the presentation of results for counts.

7.8 CCQM Working Group on Surface Analysis (CCQM-SAWG) (T. Fujimoto) [CCQM/23-13]

Dr Fujimoto briefly recalled the strategy of the surface analysis WG, which included organization of key comparisons to underpin CMCs, conduct of other comparisons to improve capability, provision of a forum for discussion of measurement issues in surface analysis, and underpinning the scientific validity of surface analysis results in the end-user community. He additionally gave a brief introduction

to the wide range of application areas, which included climate, health, food safety and advanced manufacturing applications.

Dr Fujimoto reported that the major achievement in the reporting period was the publication of the final reports of CCQM-K157 and CCQM-K172. CCQM-K157 involved measurement of the amount of substance of HfO_2 expressed as the thickness of nanometre films. The average degrees of equivalence uncertainties for the HfO_2 films with nominal thickness from 0.7 nm to 6.0 nm were approximately 0.026 nm and 0.099 nm, respectively. Dr Fujimoto expected most of the participating laboratories to submit CMC claims. Participants in CCQM-K172 had measured specific adsorption [mol/kg] of argon on zeolite at liquid argon temperature. The study had been organized for microporous materials (D<~2 nm) to demonstrate CMC claims for the gas adsorption method. The broad nature of evidence provided by the key comparison demonstrated that broad claims within SAWG are possible and that SAWG requires a policy for broad-scope claims.

SAWG members were also participating in the joint IAWG study CCQM-K166/CCQM-P210 on measurement of nanoparticle number concentration in liquid suspension, led by LGC, UK. The study had been paused due to unexpected instability of the test material, as reported by Dr Fisicaro for IAWG. Following the IAWG and SAWG meetings in the present week, the study was expected to resume with a new test material in May 2023.

Dr Fujimoto reported briefly on plans for future studies. The SAWG had received an update on the preparation of a study on quantitative measurement with Raman spectroscopy for mixed polymer blend samples. A study protocol was under development and a preliminary study was proposed through VAMAS, with the intention of subsequently submitting a proposal for a SAWG pilot study. The group had also discussed a proposed pilot study on the measurement of an elemental composition of an ionic liquid surface. An earlier bilateral study between NPL and BAM had indicated that an ionic liquid would provide a suitable reference material for quantification of elemental composition with XPS. An example of a suitable ionic liquid was 1-Propyl-3-methyl-imidazolium bis(trifluoromethylsulfonyl) imide, which was available commercially at high purity. A further proposal, for a follow-up of CCQM-K136, on porosity in a mesoporous material, had also been discussed. The group felt that a repeat comparison was essential to support current CMCs. The follow-up study would be coordinated by TÜBITAK-UME.

Dr Fujimoto noted that SAWG's impact was maximized by collaboration with technical bodies such as VAMAS and standardization bodies such as ISO. SAWG provided a source of traceability; VAMAS provided robust protocols tested by interlaboratory studies, and ISO provided global dissemination in the form of international standards.

7.9 CCQM Working Group on Electrochemical Analysis (CCQM-EAWG) and Classical Methods (S. Seitz) [CCQM/23-08] [CCQM/23-15]

Supplementing the written report (CCQM/23-08), Dr Seitz reported that EAWG had held a two-day online meeting 25/26 April 2022 and a one-day online meeting 11 October 2022. Forty members from 27 countries had registered for the April meeting and 34 for the October meeting. He noted that EAWG had conducted 60 comparisons since its establishment in 1999 and gave a brief breakdown by technical area. The largest number were on pH, but coulometry and electrical conductivity were also well represented, particularly among more recent comparisons.

Dr Seitz showed results of CCQM-K173, on assay of sodium carbonate, a study run jointly with IAWG. Agreement had been good, and the final report had been published.

Dr Seitz discussed CCQM-P221, on pH of a tris buffer/artificial seawater mixture. The comparison had been coordinated by NIST with LNE being the co-piloting institute. Measurements were complete, but preliminary results for 'total pH' (PH_T) showed unexpectedly poor agreement. This was being followed up, with particular attention to temperature correction.

CCQM-K19.2018.1, on pH measurement of a borate buffer, had been completed, but several laboratories had withdrawn their participation including the linking laboratories. Discussions on how to complete the activity were ongoing.

Dr Seitz gave a brief summary of studies currently in progress. Measurements were ongoing for CCQM-K170, on conductivity at 0.5 and 20 S m^{-1} and CCQM- K91.2022 on pH of phthalate buffers and draft A stage reports would be prepared in the latter half of the year. Measurements for CCQM-K96.2023 on assay of potassium dichromate and CCQM-K169 on assay of sodium oxalate were planned to start in the autumn, with the first version of the Draft A report expected in Spring 2024. A further study, CCQM-K73.2018.1 on amount content of HCl, is replaced by a series of bilaterals and the group sought CCQM approval to proceed (see item 7.13, below).

Dr Seitz described the rationale for a further study on impedance spectroscopy of conductivity cells. An earlier study, in 2014, had shown surprisingly poor agreement. EAWG proposed to investigate the effect of variations in the measurement procedures on the resistance, aiming to harmonize the procedure and improve reproducibility. PTB will coordinate the comparison.

For CCQM information, Dr Seitz drew attention to the draft terms of reference for a new CCQM EAWG Task Group on establishment of metrological traceability for seawater pH and pH_T values. The principal objectives of the TG are:

- Definition of the metrological traceability for pH and pH_T measurement results;
- Implementation of the pH and pH_T measurements in the CIPM MRA framework;
- Preparation of a liaison between international stakeholder organizations relevant to ocean pH and pH_T measurements with CCQM, such as GOA-ON or GOOS.

Dr Seitz noted the proposal to form a task group for lithium ion batteries; see item 5.7 (above).

In discussion, Dr Huggett noted that there had been considerable activity to develop biosensors for SARS-CoV-2 in the recent pandemic, but there had been little support in terms of reference materials and measurements to support the activity. He suggested that there was scope to involve members of the various bioanalysis working groups in SAWG studies on biosensors. Dr Akgöz and Dr Park agreed that it would be helpful if the EAWG could actively support traceability for electrical biosensors.

7.10 CCQM WG on Key Comparisons and CMC Quality (CCQM-KCWG) (D. Sin)

Dr Sin reminded the CCQM of the present membership of the KCWG, which included representatives from each of the regional metrology organizations and all of the CCQM working groups. She presented the publication history of Chem/Bio CMCs, which currently showed 6138 CMCs. This was a slight reduction from a peak of 6632 in 2019. A breakdown of CMCs by CCQM sector was presented.

The group had met regularly online, most recently on 18 April. The working group had received 661 claims in cycle XXIV. Review had been impeded by world events, with some RMOs not being

able to review CMC claims from the Russian Federation and Belarus, though Dr Sin reported that this had not materially affected progress owing to involvement of other RMOs.

Dr Sin reported that the new KCDB had significantly improved review times. There had, however, been some problems, such as some premature approvals and missed deadlines. In addition, over 200 claims had received fewer than the necessary three reviewers within the short review timescale, obliging the group to revert to spreadsheet review. Dr Sin felt that these problems would be overcome as experience with the system grew.

Dr Sin commented on the reduction in growth of CMC claims. This was partly attributable to removal of older CMC claims and a trend towards fewer, broader claims, and appeared to depend on individual institute preferences.

Dr Sin reminded the meeting of the need to review CMCs and noted that the 477 CMCs submitted before 2010 were being reviewed by CIPM KCDB service category to ensure that all CMC claims were backed by recent key comparisons. In the present cycle, this meant that approximately 300 gas CMCs submitted before 2010 had required review. To manage the review workload, the group had adopted a staged review process for gas CMCs; CMCs approved in 2001-2002 in categories 4.2 and 4.4-4.6 had been reviewed in 2022, and categories 4.1 and 4.3, high purity gas measurements and fuel gases respectively, would be considered in 2023. Remaining fuel and high-purity gas claims submitted up to 2010 would be re-examined in 2024.

Dr Sin thanked all the KCWG members, reviewers and BIPM staff supporting the KCWG.

Dr Brown asked about requirements for CMC review in other consultative committees. Dr Wielgosz replied that CCQM was the only group that had, so far, imposed a regular review requirement. Dr Milton confirmed that the CIPM recognized the CCQM as being particularly diligent in CMC review. He also noted that archiving of KCs was linked to CMC review where CMCs depended on particular KCs. Before considering changing the CCQM review process, however, he urged the CCQM to consider the investment in studies and CMCs; these deserved to be maintained where it was practical to do so. Dr Brewer added that the gas group would be archiving KCs only when new KCs were available to support the associated CMC claims. He also felt that recent improvements had reduced the effort required for review and felt that the effort was manageable. Dr van der Veen further noted the reliance of accreditation bodies on CMC claims, and their expectations that claims would be current. Dr Park noted that the general issue of CMC review would also be considered by the SPWG.

7.11 CCQM Task Group on Guidance for the estimation of a consensus KCRV (CCQM-TG-KCRV) (S. Ellison) [CCQM/23-30]

Dr Ellison presented the report *[CCQM/2023-30]* from the Task Group for revision of the CCQM guidance on KCRV estimation (KCRV TG). He recalled the terms of reference for the TG, noting that the initial intention was to update existing guidance rather than prepare new guidance. The group had held five meetings since April 2022. Meetings had considered technical aspects of KCRV data evaluation in detail and agreed some important directions for future guidance. Dr Ellison described the principal technical decisions to date, which included:

- Confirmation of the importance of chemical measurement expertise in choosing the KCRV;
- The need to consider asymmetry in addition to the extent and nature of the dispersion of reported values;

- Clearer identification of the 'statistical model' to be adopted, in order to guide choice of estimator;
- Adoption of a model that included allowance for overdispersion as a default choice for the majority of comparisons;
- Use of an increased range of statistical tests for overdispersion and asymmetry, to be used as guides in choosing an applicable model and estimator;
- A decision to include a new Annex on graphical methods for comparisons;
- A recommendation that KC reports should include comment on any overdispersion, together with recommendations for treatment in considering CMC claims.

Dr Ellison further explained the reason for including an estimate of excess variance when studies showed poor agreement. This followed from the fact that unexpectedly large dispersion of values led directly to greater uncertainty for any estimated reference value. This in turn led directly to larger uncertainties for the difference between laboratory results and the reference value – that is, the degree-of-equivalence uncertainty. Since the cause of the overdispersion required technical expertise, however, decisions on the consequences for CMC claims were primarily a matter for the expert working group. This was the rationale for the recommendation to include comment on overdispersion in KC reports.

Returning to the task group's remit, Dr Ellison said that the range of technical changes had proved larger than anticipated, resulting in delay in bringing forward a draft for discussion. Drafting of new text was now under way to accommodate the amendments and additions. The group would continue to meet approximately monthly through 2023 to complete the revision for CCQM review.

In discussion, Dr Seitz said that it would be valuable to have some guidance on the advice WGs might give in KC reports in relation to overdispersion or discrepant results, with particular reference to whether a given participant uncertainty was, or was not, supported by the study results. Dr Wielgosz also noted that the GAWG had frequently discussed the issue and had adopted a procedure in which an independent expert should prepare recommendations on CMC claims arising from each study. Dr van der Veen added that decisions on the implications of key comparisons for CMC claims were for the working group and not just the study coordinator. Dr Ellison noted that some basic guidance could be considered, for example based on clear cases of agreement or severe disagreement, and undertook to consider those in the development of the KCRV guidance document.

7.12 CCQM *ad hoc* Working Group on the Mole (CCQM-ah-WG-Mole) (B. Güttler) [CCQM/23-12]

Dr Güttler reported that a meeting of the CCQM *ad hoc* Working Group on the Mole had been held as an online conference in June 2022 to plan the joint CCQM/CCU workshop on "Quantities which can be counted" (see report at item 5.5). A further, very productive, meeting of about 15 participants had been held in person in the present week. The meeting had discussed follow-up from the workshop (reported separately above). One issue that was not under consideration by the CCU was the effect on the *mise-en-pratique* for the mole; Dr Güttler felt this required further consideration by the WG.

The WG had also received a report on CCU activities, and had discussed the teaching of metrology in chemistry from both a university and an IUPAC perspective. The IFCC had also expressed interest in including measurement science and metrological principles in the curriculum for clinical analysts.

Gaps in educational provision appeared to include, for example, good sampling practice, experimental design, principles of traceability and calibration, method validation and uncertainty evaluation.

Following the discussions on education, Dr Güttler proposed the preparation of terms of reference for a CCQM Task Group to address educational material on metrology, which could then undertake joint activities together with IUPAC and other organizations, such as CITAC, to integrate teaching needs in metrology in chemistry into similar activities across the major stakeholders. The aim was to ensure that the activities of CCQM reach the relevant global audience. The proposal was supported by the CCQM, and terms of reference will be submitted to the SPWG for consideration.

Dr Güttler informed the group that he would be retiring in the next year and was accordingly stepping down as Working Group chair. Dr Park thanked Dr Güttler for his long support for the CCQM and for his contribution as working group chair.

7.13 Approval of proposals for CCQM Comparisons [CCQM/23-31]

Dr Wielgosz presented the list of planned CCQM comparisons (see *CCQM/2023-31*), which had been provided in advance and updated following the WG meetings earlier in the week. The Gas Analysis WG proposed Track C (non-mandatory) key comparisons on aerosol particle number and charge for particles in the range 30 nm to 80 nm, coordinated by NPL; nitrogen dioxide in nitrogen, as an on demand comparison coordinated by BIPM; refinery gas, coordinated by VSL; natural gas, coordinated by VSL and BAM; and a Track A (mandatory) comparison on automotive gas, led by KRISS in conjunction with a regional metrology organization comparison. The Working Group on Organic Analysis proposed Track A key Comparisons on polycyclic aromatic hydrocarbons in sediment, coordinated by NIM; oestradiol in serum, with PTB and JRC coordinating; digitoxin, a high molecular weight pure organic, coordinated by BIPM and UME; and a Track C comparison on an ochratoxin A calibration solution, coordinated by BIPM and NRC. The Working Group on Electrochemical Analysis proposed a Track A key comparison on assay of potassium dichromate, to be coordinated by KRISS; a Track A key comparison on amount content of H^+ in hydrochloric acid at approximately 0.1 mol/kg, coordinated by SMU, and a pilot study on electrochemical impedance spectroscopy in conductivity measurement cells, coordinated by PTB. The Working Group on Inorganic Analysis proposed 'core' (mandatory) key comparisons on non-metallic elements in pure metals, coordinated by NRC and CENAM; Elements and anions in urban particular matter, coordinated by KRISS; and on elements in pork, again coordinated by KRISS. The Working Group on Nucleic Acid Analysis proposed to undertake pilot studies on species determination of meat (coordinated by NIMT and UME) and on inactivated whole virus SARS-CoV-2, jointly coordinated between the UK, USA and China. The NAWG also proposed a pilot study forming a trial pandemic response, involving rapid development of a method for a molecular target representing a new pathogen. The isotope ratio WG proposed key comparisons on lithium isotope delta scale measurements, to be coordinated by PTB, and on absolute copper isotope ratios using gravimetric isotope mixtures, to be coordinated by PTB and BAM, with participation as a pilot study permitted for both. SAWG proposed to run pilot studies on molar ratio of elements (N, O, F, P, S, {Cl}, {Fe} to C) at a surface and on mole fraction of Pt and Ni in Pt-Ni alloy, coordinated by BAM and KRISS respectively.

The meeting **approved** the proposed key comparisons and noted their support for the pilot studies.

8. BIPM HEADQUARTERS PROGRAMME ON METROLOGY IN CHEMISTRY (R. WIELGOSZ) [CCQM/23-04]

Dr Wielgosz reported on the programme of work on metrology in chemistry at the BIPM headquarters. The programme had three main components: coordination and support for key and other comparisons; knowledge transfer to support development of new NMI services; and liaison and coordination, including support for workshops, databases and committees. The programme was aligned with the CCQM strategy. Dr Wielgosz acknowledged the support from NMIs via the BIPM visiting scientist programme, which helped to improve BIPM and NMI technical capabilities; this in turn led to new services from the BIPM and contributed to knowledge transfer activity. Dr Wielgosz presented some programme output indicators, including NMI participation in BIPM studies, number of journal publications and e-learning courses, and numbers of visiting scientists. Most of the indicators showed increased output over time, though Dr Wielgosz noted that the number of visiting scientists had reduced during the height of the SARS-CoV-2 pandemic and was now recovering.

Reporting on the visiting scientist programme, Dr Wielgosz listed the eight visiting scientists currently at the BIPM chemistry department and listed the collaborative projects under way. There were currently eleven NMIs collaborating with the BIPM, primarily on projects in the gas area, in quantitative NMR, and in organic and bio-analysis for mycotoxins, pesticides, peptides and antibodies, which allowed the BIPM to prepare for and run comparisons for the CCQM and knowledge transfer studies.

The department had introduced new technical capabilities for comparison support. One new facility will provide on-demand comparisons of amount fraction of CO_2 in air, as recently demonstrated in CCQM-P225.a and b. Recent results showed extremely good agreement, with a relative standard deviation of the BIPM's reference facility at the level of about 5×10^{-5}. A second facility was for the measurement of ^{13}C isotope ratios in CO_2 in air for which a pilot study would be run in preparation for the BIPM.QM-K4 comparison. The IRMS facility provided values for $\delta^{13}C$ (VPDB scale) with standard deviation of about 5×10^{-3} ‰ (5×10^{-6}) at a mean $\delta^{13}C$ near 1.2 ‰ (1.2×10^{-3}), which was the same performance that could be achieved on pure CO_2.

Examples of collaborative projects included a project with TÜBITAK-UME on tetracyclines, an important class of antibiotics, which had provided pure oxytetracycline hydrochloride for CCQM-K148b. A further example was provided by CCQM-K115.d / CCQM-P55.2.d, on parathyroid hormone, had so far involved NRC, IFCC, the World health Organization via NIBSC, CDC in the US, NIM, and LNE.

BIPM was one of the leading coordinators for CCQM key comparisons, mainly for gas and isotope analysis and for purity in biological and organic analysis. The BIPM expected to coordinate six gas and isotope ratio comparisons and seven bioanalysis and organic analysis comparisons in the period 2024-2027.

The BIPM Chemistry Department were also contributing to the digitalization of the SI, in particular by supporting the development of an application programming interface (API) for the JCTLM database and the construction of a database providing machine readable data for CO_2 greenhouse gas standards. The greenhouse gas database project was supported by a visiting scientist from NOAA in the US and a joint technical project with the VSL.

Describing knowledge transfer activity, Dr Wielgosz drew attention to two e-learning modules, on metrology for clean air and on impurity content in organic pure materials. He also described training for FT-IR for scientists at NMISA and NIMT, and the ongoing development of a course in preparation

of dynamic gas standards for NO_2. An e-learning module on qNMR was under development and a 1-week summer school on qNMR was planned for 2024.

The BIPM also supports some CCQM task groups; the BIPM Chemistry Department is currently supporting those in which BIPM scientists were directly involved; for example, the GAWG Ozone Task Group and the GAWG Task Group on GHG scale comparisons.

Dr Park congratulated Dr Wielgosz on an excellent programme. He noted that the BIPM Chemistry programme benefited from the visiting scientists programme and thanked CCQM members for their support for the programme.

9. CC GOVERNANCE AND OPERATIONAL ISSUES

9.1 CCQM member review and applications

Dr Wielgosz reported that one Observer application was outstanding, and a request for further information had been made in order to start the review process. There were currently no new member applications to consider, and the SPWG would undertake a review of current members.

9.2 Organizations in liaison with the CCQM

Dr Wielgosz said that the CCQM had a policy of reviewing liaisons every four years and the last review had been in 2019. He suggested that the SPWG form a small review group to review liaisons and report back on any proposed changes. This was **agreed**. Dr Wielgosz further reported that there were no new applications for liaison. Should applications be received, they would be considered in line with the recently approved guidelines (see item 5.1, above).

9.3 Process for appointing WG Chairs/Vice Chairs

Dr Park noted that a task group had previously been convened to consider the process for appointing chairs. He hoped to have a documented procedure for the next meeting. In the meantime, he noted that appointments should be open and the process for selection should be independent and transparent.

9.4 Other governance issues

Dr Park asked about the possibility of a round-table open discussion at future meetings. Dr Wielgosz replied that a practical challenge was the large number of participants in all the CCQM working groups. Dr Milton added that preparations for the 150th anniversary of BIPM would also put considerable pressure on meeting space. Dr Brewer supported the idea of a round-table discussion at the plenary and suggested rearranging the agenda to permit this within the available time.

In the absence of a round-table session at the present meeting, Dr Park invited members to communicate with him by e-mail to raise any emerging issues, either generally or in their own region or institute.

10. DISCUSSION AND QUESTIONS ON WRITTEN REPORTS FROM REGIONAL METROLOGY ORGANIZATIONS

Written reports had been received from AFRIMETS (*CCQM/23-07*), APMP (*CCQM/23-20*) , COOMET (*CCQM/23-19*), EURAMET (*CCQM/23-21*) , GULFMET (*CCQM/23-27*), and SIM (*CCQM/23-18*). Dr Park invited representatives to comment briefly on key points in their reports.

For AFRIMETS (*CCQM/23-07*), Dr Botha said the principal focus was on capacity building, especially for food safety. A large workshop on the topic had been constructive. A subsequent survey of food testing capabilities in the region had resulted in a targeted capacity building exercise. Dr Swart asked how African NMIs could be involved in the biological WGs, noting especially the need for global response to pandemics. Dr Botha explained that current priorities for biological measurement were in standardization and it would be some time before institutes could contribute to the CCQM biological WGs.

Dr Kim commented on APMP activities (*CCQM/23-20*). APMP was handling over 200 CMC claims each year, placing a substantial load on its members. In addition, many developing economies in the region were seeking to develop capability, especially in gas analysis; APMP were accordingly running many comparisons for capacity building. APMP also operated focus group activities for stakeholder engagement, addressing food safety, climate, clean water, energy efficiency, medical metrology and digital transformation. The groups were largely operated by CCQM members.

In discussion, Dr Braybrook noted that he would welcome APMP input to the CCQM pandemic preparedness activity and invited Dr Kim to distribute the forthcoming survey widely in APMP.

Dr Kustikov added brief remarks on the COOMET report (*CCQM/23-19*). COOMET had conducted seven comparisons over the year and a further seven were planned. In the chemistry area, 51 COOMET CMCs had been reviewed and 17 new CMCs introduced. He noted that COOMET were preparing contributions for World Metrology Day 2023.

Dr Näykkii, the new EURAMET TC-MC chair, drew attention to some highlights from the EURAMET report (*CCQM/23-21*). The TC-MC had 23 European NMI members and 21 associate members (DIs). In addition to Dr Näykkii as the new TC-MC chair, Dr Rozikova (CMI, Czechia) had taken over from Dr Stoica of LNE as electrochemical analysis WG chair. The most recent meeting had noted a record number of 304 CMC claims. TC-MC was also active in a number of European Metrology Networks, including those for Energy gases, Climate and Ocean Observation, and Pollution monitoring. He closed by thanking Dr Vaslin-Reimann (LNE) for her work as TC-MC chair. In addition, he took the opportunity to thank Dr Güttler for his outstanding contribution to EURAMET, both as past Chair and as an NMI representative. Mr Levbarg commented that as of 1 February 2023, Ukraine has fulfilled its CIPM MRA-related activities via EURAMET.

Dr Pérez Urquiza noted some key points from the SIM report (*CCQM/23-18*). SIM had recently completed three comparisons and a further ten were in progress. SIM had submitted 104 CMC claims in the present cycle. Discussing training and development, Dr Pérez Urquiza said that SIM members had participated in the international workshop “Making an impact on water quality for public health and safety” in Malaysia. A project to establish a research centre in Costa Rica to develop ICP MS measurements was under way with funding from APEC. This project would be holding a workshop on nanomaterials, in conjunction with the 2023 annual meeting of the SIM Chemistry WG.

In the absence of a GULFMET representative at this point in the meeting, the meeting noted the written report from GULFMET.

11. DISCUSSION AND QUESTIONS ON WRITTEN REPORTS FROM INTERNATIONAL ORGANIZATIONS IN LIAISON WITH THE CCQM

Reports had been received from the International Atomic Energy Agency [IAEA] (*CCQM/23-28*), the European Commission Joint Research Centre [JRC] (*CCQM/23-17*), the International Union of Pure and Applied Chemistry [IUPAC] (*CCQM/23-11*), ISO TC/334- Reference Materials (*CCQM/23-09*), Cooperation on International Traceability in Analytical Chemistry [CITAC] (*CCQM/23-10*), and the International Federation of Clinical Chemistry and Laboratory Medicine [IFCC] (*CCQM/23-25*). Dr Park invited representatives to comment briefly on their written reports.

Dr Camin reported for the IAEA. She thanked members for the warm welcome and the BIPM headquarters for hosting the meeting. The IAEA was participating in the organic and inorganic working group as well as a strong activity in the gas analysis and isotope ratio WGs. The IAEA were particularly pleased to see the work on delta scales advancing. The IAEA were running a training project to develop capability for isotope ratio measurement for greenhouse gases; Dr Camin had been pleased to meet so many relevant experts at the present meeting to support the activity.

Dr Koeber (online) reported for the EU JRC. He noted the temporary absence of JRC from the CCQM due to internal policy changes, and was pleased that JRC were again present as a CCQM participant. He noted that JRC had withdrawn a large number of historical CMCs on review, with only two retained in the KCDB. He looked forward to re-establishing CMCs as new key comparisons became available. JRC's metrology interests were strongest in IAWG, NAWG, OAWG and PAWG. He drew particular attention to the forthcoming OAWG study on oestradiol, as he hoped that the study material would form the basis for new batch of the existing CRMs BCR-576, BCR-577 and BCR-578 linked to JRC CMCs. The JRC also collaborated with IFCC and JCTLM in the health sector, and continued to be active in standardization and reference material production. The JRC expected to focus on health, environment and food and feed safety in the near future, with less emphasis on industrial materials.

Dr Mester asked about JRCs isotope ratio capabilities, which had historically been an important source of standards. Dr Koeber said JRC had phased out isotope ratio activity from 2016 and there were no current plans to re-establish the capability.

Dr Mester invited members to consult the written IUPAC report (*CCQM/23-11*) for detailed information. He drew members' particular attention to the IUPAC review of the current status of analytical chemistry education and the initiation of an IUPAC project to improve university provision for analytical chemistry world-wide.

Dr Botha said that ISO TC334 (formerly REMCO) was progressing well with transformation of all the former ISO REMCO Guides to international standards. Expected 2024. A draft international standard (DIS) ballot had just been launched for a new standard giving guidance on the production of qualitative RMs. A further new standard on production of organic pure material RMS was also approaching the DIS stage and Dr Botha hoped this would proceed to publication in 2024-2025. Dr Botha noted that the present Guide 80, on production of quality control materials, was still under discussion; a decision would be made at the mid-2023 meeting of ISO TC334.

Dr Güttler noted some highlights from the CITAC report (*CCQM/23-10*). He recalled the formation of CITAC and its mission to improve metrological traceability in chemistry world-wide. Meetings during the pandemic had been online and an online workshop in early 2022 on "Assessment of Performance and Uncertainty in Qualitative Chemical Analysis" had been very successful. CITAC was, however, now able to return to in-person meetings and events. The first of these had been an in-person session on metrology in chemistry in conjunction with the Isranalytica event in January, in Tel Aviv. Dr Güttler reported that CITAC had announced its annual 'Best Chemical Metrology Paper' awards, and noted that one of the three award winning papers was from members of the CCQM Nucleic acid working group. Closing, Dr Güttler said he would be stepping down as CITAC Chair, and looked forward to Dr Mester taking over the Chair

The IFCC representative had been obliged to leave the meeting earlier; the meeting noted the written report from IFCC.

Dr Park thanked all the representatives for their written reports and summaries. There were no further questions on the liaison reports.

12. CCQM APPOINTMENTS AND MEETINGS

12.1 Appointment of CCQM WG Chairs (2023-2027)

The meeting noted that Dr Mackay, Dr Fujimoto, Dr Sin, Dr Melanson and Dr Güttler were either at the end of their terms of office as WG chairs or were stepping down for retirement or other reasons. In addition, Dr Lippa would be stepping down as vice chair of the organic analysis working group. Dr Park warmly thanked all those stepping down for their contribution. The following appointments of working group chairs and vice chairs were made:

- Dr M. Fernandes-Whaley (NMISA) was appointed as Chair of the organic analysis working group, and Dr B. Garrido (INMETRO) as vice-chair.
- Dr C. Swart (PTB) was appointed as the protein analysis working group Chair, and Dr Liqing Wu (NIM) as vice-chair.
- Dr A. Shard (NPL) was appointed as the surface analysis working group Chair and Dr Li-Lin Tay (NRC) as vice-chair.
- Dr A. Botha (NMISA) was appointed Chair of the KCWG and Dr W.-H. Fung (GLHK) as vice-chair.
- Dr .R Brown was appointed as Chair of the *ad hoc* Task Group on the mole.

12.2 CCQM WG meetings to be held in 2023

The meeting noted that the GAWG and IRWG had confirmed an intention to accept an invitation to convene in person in Uruguay in October 2023.

No other working groups had yet confirmed meeting dates and locations for late 2023. Dates and locations would accordingly be communicated when meeting arrangements were confirmed.

12.3 Dates of CCQM meetings in 2024 and 2025

The 29th meeting of CCQM will be held in the week of 22-26 April 2024, at the BIPM headquarters.

The 30th meeting of CCQM will be held in the week of 7-11 April 2025, at the BIPM headquarters.

13. CLOSING CEREMONY AND REMARKS FROM THE CCQM PRESIDENT

Before closing the meeting, Dr Park asked if anyone had comments on any aspect of the meeting. Dr Park noted that shipping of materials had been discussed as an issue in several working groups during the week, and appeared to be increasingly expensive and difficult, with customs restrictions and heavy costs for coordinators. He proposed to raise the issue with the SPWG to consider options for improving shipping.

Dr Park then led a moment of appreciation for the WG chairs and Vice-Chairs who were stepping down with effect from the present meeting. To applause from the meeting, he presented certificates and individual commemorative BIPM plaques to each of the outgoing chairs in turn, and invited their remarks.

Dr Melanson thanked Dr Park for the appreciation and looked forward to further active participation in CCQM as a working group member.

Dr Güttler thanked Dr Park for the recognition and expressed his thanks to all of the members of CCQM for the close cooperation and support he had enjoyed for 20 years as a member of CCQM.

Dr Fujimoto reflected on joining CCQM's surface analysis WG in 2006. He recalled the contributions of Dr Martin Seah, the initiator and first Chair SAWG, and Dr Peter Unger, Dr Fujimoto's predecessor as Chair. He thanked the members of the SAWG for their support during his term as Chair and wished Dr Shard well as the incoming chair of the working group.

Dr Mackay had joined the CCQM in 1999 and had chaired the organic analysis working group from 2013 to 2023. Dr Mackay was pleased that her last CCQM meeting had been in person. She had considered it an honour to lead the dedicated group of people in the working group for her time in post, and noted her particular appreciation of Dr Lippa's support as co-chair. She thanked Dr Fernandes-Whaley and Dr Garrido for taking up the chair and vice-chair roles and expressed her best wishes for them and the working group in future.

Dr Lippa and Dr Sin were not present at this point in the meeting. Dr Park nonetheless read the citations, and would make arrangements to present the certificates and plaques individually.

Dr Park thanked members for their contribution and closed the meeting.

DECISIONS AND ACTIONS FROM THE 28TH MEETING OF THE CCQM

1. The CCQM **approved** the report of the 27th Meeting of the CCQM.
2. The CCQM **approved** the proposed Criteria for extending liaison status at CCQM (CCQM/2023-06)
3. The CCQM requested the BIPM Headquarters to re-establish contact with the WHO to strengthen collaborative efforts on standardization in laboratory medicine and infectious disease diagnostics.
4. The CCQM **agreed** to close the task group on stakeholder engagement and thanked the convenor and members for their contributions.
5. The CCQM **approved** the formation of a joint IAWG/SAWG task group to foster communication on particle metrology between communities, consider interlaboratory comparisons, harmonize protocols, and provide sample preparation guidance.
6. **Action**: GAWG Chair to create a particle metrology task group within the CCQM Gas Analysis Working Group (GAWG) to engage with stakeholders and address focused challenges.
7. **Action**: CAWG chair to create a particle metrology task group within the CCQM Cell Analysis Working Group (CAWG) to engage with stakeholders, improve communication and knowledge sharing, and encourage development of documentary standards.
8. **Action**: CCQM members to brief communications staff in their institutes to disseminate information (on 19 May 2023) on the CCQM presentations for World Metrology Day at https://www.bipm.org/en/committees/cc/ccqm/ccqm-wmd-2023
9. **Action**: SPWG to consider how CCQM can best provide input to CIPM on the evolving needs for metrology in the area of food safety.
10. **Action**: Dr Campbell to provide draft terms of reference for a task group on viral vectors, for SPWG consideration.
11. The CCQM **agreed** to form a steering group for a workshop on digitalization within CCQM and noted that the SPWG would appoint a convenor and set terms of reference.
12. **Action**: The Chair of the *ad hoc* WG mole to consult with Chairs of the Bioanalysis WGs on development of guidance on units for number quantities.
13. **Action**: KCRV TG to consider more detailed guidance on implications of overdispersion for subsequent CMC claims
14. The CCQM **approved** the formation of a Task Group on metrology for lithium-ion batteries, with the terms of reference set out in CCQM/23-14, and appointed Dr Seitz as convenor
15. The CCQM **agreed** to contribute to a task group on prioritization, supply and commutability studies for reference materials to be formed within JCTLM.
16. The CCQM agreed that the CCQM EAWG should form a Task Group on establishment of metrological traceability for seawater pH and pH_T values, with the terms of reference provided by CCQM/23-15.

17. **Action**: Dr Güttler to provide draft terms of reference for a task group on educational materials on metrology for SPWG consideration

18. **Action**: SPWG to look at the process being employed for the re-review of Chem-Bio CMC claims and consider whether changes are necessary

19. **Action**: SPWG to review organizations in liaison with CCQM and CCQM Membership.

20. The CCQM **approved** the following Key Comparisons (KC) and noted the proposals for stand-alone Pilot Studies (P) as presented in document CCQM/23-31:

- EAWG: Amount content of H+ in HCl (KC) (previously approved but amended to bilateral series).

  Assay of potassium dichromate (KC);

  Electrochemical impedance spectroscopy of conductivity measurement cells (P).

- GAWG: Measurement of aerosol particle number and charge, using 30 and 50 nm particles and 80 nm polydispersed particles (KC);

  Refinery gas (KC);

  Natural gas (KC).

- IAWG Non-metallic elements in pure metals (KC);

  Elements and anions in urban particular matter (KC);

  Elements in pork (KC).

- NAWG: The specific identity examination and purity measurement of DNA extracted from meat (proposed at 27th meeting) (P);

  SARS-CoV-2 RNA copy number/ international unit quantification from inactivated whole virus (proposed at 27th meeting) (P);

  Trial pandemic response – rapid development of a method for a molecular target representing a new pathogen (P);

- OAWG: Polycyclic aromatic hydrocarbons in sediment (KC);

  Estradiol in serum (KC);

  Large MW pure organic – digitoxin (KC);

  Ochratoxin A calibration solution (KC).

- IRWG Li isotope delta measurements (KC)

Application of gravimetric isotope mixtures for obtaining absolute isotope ratios of copper (KC).

- SAWG Molar ratio of elements (N, O, F, P, S, {Cl}, {Fe} to C) at a surface (P);

  Mole fraction of Pt and Ni in Pt-Ni alloy (P).

21. **Action**: Rapporteur to provide the draft report of the meeting to the Secretary, together with collated decisions and actions.