INTERNATIONAL UNION OF
PURE AND APPLIED CHEMISTRY

The *IUPAC Standards Online* database is a comprehensive compilation of the Standards and Recommendations developed by the International Union of Pure and Applied Chemistry (IUPAC). Founded in 1919 to establish a common language for chemical researchers worldwide as well as to develop standards and norms for the calibration and normalization of chemical substances, IUPAC is recognized as *the* world authority on chemical nomenclature and terminology, on standardized methods for measurement, on atomic weights and the periodic table, and on many other critically-evaluated data.

The Standards contained in the database include definitions of terms, standard values, procedures, rules for naming compounds and materials, names and properties of elements in the periodic table, and many more. These Standards and Recommendations are internationally-binding for scientists in industry and academia, patent lawyers, toxicologists, environmental scientists, legislation, and others working in or for the chemical enterprise. Why are they necessary? How are they created? When are they updated? Read on and learn more about this unique and essential resource for the chemical enterprise.

Q1. Why are the IUPAC Standards and Recommendations developed?

There is more than a single purpose fulfilled by the creation of IUPAC Standards and Recommendations and all are relevant to society. These are: (i) saving resources, (ii) saving money, and (iii) saving lives. Below are three illustrative examples.

Example 1: The American NASA Mars Climate Orbiter in 1999. NASA lost the orbiter due to an incorrect conversion between metric and English (USA) units. While the financial loss amounted to about $150 million U.S. dollars, a price cannot be placed on the loss of scientific data and associated work.

Example 2: Construction of the Laufenberg Bridge over the Rhine between Switzerland and Germany in 2003. Germany used the North Sea level as its standard reference while Switzerland used the Mediterranean Sea as its reference level. The difference in levels is 27 cm. To make matters worse, when the adjustment was made the signs were applied incorrectly. The total difference applied to the two ends of the bridge was 54 cm that resulted in a costly error.

Example 3: Toxicology and health care. In a patient, blood glucose levels were read on the glucose meter (made in the USA) as 42 $mmol \cdot L^{-1}$ (not an approved unit of the International System of Units (S.I.) that was assumed by staff as 42 $mg \cdot dL^{-1}$ (an approved S.I. unit), which is equivalent to 758 $mg \cdot L^{-1}$. The drastic ramification was a diagnosis of hypoglycemia rather than hyperglycemia, nearly costing the patient his life. The problem arose because the glucose meter used did not conform to IUPAC international standards. The USA is one of a few hold-out countries against adopting the metric or S.I. system, even in medical equipment. The International Committee of Medical Journal Editors has demanded that all measurements associated with medicine are to be reported in metric units and temperatures in degrees

Celsius. This example emphasizes the importance of the adoption of an internationally agreed-upon standard scientific language around the globe. For details see the editorial, "S.I. for Dummies," printed in the *Journal of Medical Toxicology* Vol. 3, No. 3, pp. 87-88 (2007) by Dr. Christian Tomaszewski (link).

Q2. How are the Standards and Recommendations developed? What level of global consensus is achieved and how is it achieved? Are other scientific bodies involved? What about the general public?

Experts in the various fields of science throughout the world work together in the IUPAC Divisions and Commissions on a volunteer basis to develop the Standards and Recommendations.

Global consensus is reached through the participation of international representatives serving on the IUPAC Divisions and Commissions; representatives from the IUPAC National Adhering Organisations (including national chemical societies); representatives from six other scientific organisations with serving on IUPAC (for example: the International Union of Crystallography, the International Union of Nutritional Science, the International Union of Pure and Applied Physics, the International Union of Biochemistry and Molecular Biology, the International Bureau of Weights and Measures, International Union of Pharmacology, etc.); and through a public review period of several months

Following this extensive consultation, approved feedback, and approved scientific review, it is assumed that each respective community supports the consensus.

The general public is not usually directly involved aside from the public review of Provisional Recommendations during which time the public can submit comments and suggestions. National newspaper articles often highlight relevant IUPAC work such as the discovery of new elements and how they are named.

Q3. What is the usual timeline from start to finish?

After extensive consultation as noted above, an IUPAC Division approves the final text of the proposed Standard or Recommendation and the manuscript is sent to the IUPAC Inter-divisional Committee on Terminology, Nomenclature and Standards (ICTNS) for further review. In the case of a formal Recommendation, the manuscript is posted for five months to invite and encourage comments from the general public. In parallel, the manuscript is sent to as many as twenty-five additional expert reviewers. The time elapsed to publication in the IUPAC journal *Pure and Applied Chemistry* (*PAC*) is twenty-four months.

In the case of a Technical Report, which is not a policy document of IUPAC but rather a report on the subject of a specific study, such as critical assessments of methods and techniques, the total time elapsed between Division approval and ICTNS review is about fifteen months. For any changes to the International System of Units (S.I.) itself, the International Bureau of Weights and Measures (BIPM) and its hierarchical structure outside of IUPAC may take several years to

achieve consensus. A current example is the ongoing discussion to change the definition of the mole.

Q4. How are the Standards and Recommendations used and valued?

The guidelines for good practice with respect to nomenclature, terminology, units, and symbols are embodied in the IUPAC Green Book along with other IUPAC Color Books. In general, the vast majority of scientists and most scientific journals adhere to the IUPAC recommendations for international practice. There are some exceptions usually associated with individuals who cannot adjust to change and some countries whose political history appears to shun international consensus. The potential impact of not following IUPAC Standards and Recommendations was noted earlier.

In terms of value, a number of peer-reviewed journals will only accept papers that follow the IUPAC policy. In addition, the UNESCO and EU Customs Union recognise the IUPAC system as their official policy.

Q5. How often are the Standards and Recommendations updated?

There is no single simple answer. Whenever an IUPAC Division or Commission believes that an update is required to a Recommendation or a Technical Report, then the changes are made via the process described above. As an example, the atomic masses of the elements are updated every one or two years. However, the frequency of the discovery of a new element is rare, but when a discovery is verified, such as announced at the end of 2015, the update is put in place.

For the Color Books, because sophisticated work is involved, the updates may be done every five or six years or longer.

All the work of IUPAC is done on a volunteer basis almost entirely by more than a thousand scientists from around the world who serve on IUPAC Divisions, Commissions, Standing Committees, and Task Groups. For information on Membership or to learn more about IUPAC, visit the IUPAC web site www.iupac.org or contact the IUPAC Secretariat at:

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