IUPAC

A. Gavriella Saputra[1], A. Victoria Kumala[1], B. Sebastian Natsir[1], C. Mandie Lunardi[1], N. Rafael Tjie[1], M. C. Alexandra Sumual[1], Norbertus Krisnu Prabowo[2*]

[1]SPK SMAK PENABUR Kelapa Gading, Jakarta, Indonesia
[2]Department of Chemistry Education, State University of Jakarta, Indonesia
*Corresponding Author: norbertuskrisnu@gmail.com

I. Introduction

IUPAC (International Union of Pure and Applied Chemistry) is a significant organization in the field of chemistry. This prompts exploration into how IUPAC has evolved since its establishment in 1919 and what key historical milestones have shaped its development into a global force in the field of chemistry. Additionally, the essay seeks to investigate the roles and impacts of IUPAC on the scientific society. The exploration encompasses various facets, including the historical evolution of IUPAC, the key projects it spearheads, and notably, the products of IUPAC. The aim is to shed light on the role IUPAC plays in shaping the landscape of global chemical research and fostering collaboration among nations in the pursuit of advancements in both pure and applied chemistry.

Keywords: Chemistry Society, IUPAC, Literature

II. How has the evolution of the International Union of Pure and Applied Chemistry (IUPAC) since its establishment?

IUPAC, established in 1919, holds a distinguished global position in advancing chemical research and establishing standardized nomenclature as a fundamental aspect of the world scientific community [1]. The keyword, IUPAC, gives approximately 450 thousand hits in Google Scholar and 107 million hits in Google Search, indicating that it is an impactful and a well-known keyword, especially among scientific communities. The organization's founding principles emphasize collaboration across geographical and linguistic boundaries, fostering scientific excellence on an international scale. A primary objective of IUPAC is to provide guidelines for the systematic naming of chemical compounds [2] and technical reports [3], ensuring a universally accepted language for representing structures to enhance consistency and clarity in scientific communication.

With a membership spanning the globe, IUPAC has grown significantly and includes nations from various continents, reflecting the international nature of modern scientific research. This diverse membership promotes a broad exchange of ideas and expertise, contributing to the quality and impact of research conducted under the organization's guidance. As IUPAC continues to evolve, its commitment to promoting the understanding and application of chemistry globally remains unwavering [4]. At the core of IUPAC's mission is the establishment of guidelines for systematically naming chemical compounds, creating a universal language for effective global communication in scientific research.

IUPAC is the international federation of national organizations that surround the advancement of modern chemical science. It is also often referred to as the "*United Nations of Chemistry*" with 57 countries currently under its union [5]. Many important milestones were set while these chemists continued on their progressive expansions and standardizations of chemistry, one particularly notable one is the agreement between physicists and chemists on the choice of carbon-12 as a unique element of reference in the atomic weights table in 1961 [6,7]. The union was also presented with globally related topics such as atmospheric and water pollution, effectively shifting their organization into a better benefit for mankind [8].

Between 1965 and 1975, the International Union of Pure and Applied Chemistry (IUPAC) underwent structural changes to accommodate the growth of specialized and interdisciplinary fields [9]. Notably, the biological chemistry division disappeared, while the Macromolecular Division and the Analytical Chemistry Division adapted to emerging trends. The Applied Chemistry Division played a crucial role in interdisciplinary projects, exemplified by the Commission on Pesticides and shifts in food control perspectives. Additionally, new commissions on water and air quality reflected evolving environmental concerns. The organization took quicker actions for nomenclature in newly emerging areas concerning chemistry both organic as well as inorganic [10, 11].

IUPAC has embraced the advancements in digital chemistry in the 21st century by introducing the International Chemical Identifier, known as InChI, designed to cater to the needs of global chemistry communities. In the year 2000, IUPAC initiated the development of machine-readable international chemical identifiers (InChIs). These identifiers operate as textual labels, indicating specific chemical substances. Essentially, InChI is a character string generated by a computer algorithm [12]. These identifiers play a crucial role by providing a convenient method for comparing and differentiating chemicals across diverse applications, spanning from the development of new materials to addressing legal and regulatory matters. InChI stands as the flagship protocol, epitomizing IUPAC's commitment to digitalization. It has been widely adopted by numerous large and small databases, including *ChemSpider* and *PubChe*, establishing itself as the world's foremost way to describe a molecular structure with very little ambiguity.

III. The roles of IUPAC

The International Union of Pure and Applied Chemistry (IUPAC) plays a crucial role not only in establishing chemical terminology and nomenclature but also in standardizing chemical measurements. This involves implementing various strategies and regulations to ensure precision and consistency in scientific, business, and academic contexts. IUPAC provides recommendations on determining essential measurement features, such as the limit of quantification in chemical assessments. These guidelines contribute to the accuracy and reliability of chemical measurements. The organization is actively involved in constructing universal standards for reference samples and buffer solutions, which are essential for conducting effective pH evaluations. This ensures consistency and reliability in the measurement of acidity and alkalinity [13]. These collective efforts ensure consistency in chemical measurements with high accuracy and precision, facilitating better information sharing among scientists.

Additionally, IUPAC plays a pivotal role in advancing the field of chemistry through its comprehensive scientific publications and resources. The journal "Applied Chemistry" is notably renowned for disseminating crucial research findings and discussions spanning various branches of chemistry. Furthermore, IUPAC's commitment to education is evident through "Chemistry Teacher International," offering innovative teaching approaches and educational resources to enhance the quality of chemistry education [14]. The "Silver Book" series, or IUPAC NIST Solubility Data Series, provides meticulously reviewed solubility data for chemical compounds, serving as a reliable resource for researchers [15]. Accurate solubility data is essential for scientific investigations, and this series ensures information reliability. Moreover, IUPAC's "Special Topics" series delves into specific areas within chemistry, offering recommendations, technical reports, and in-depth research to deepen understanding in specialized domains, providing valuable insights for researchers and professionals [16].

IV. Social Impacts

IUPAC is dedicated to promoting diversity in chemistry and encourages people of all ages to participate in research by recognizing and awarding young chemists. Everyone has a right to contribute to research and be a part of the development of chemistry regardless of their gender. Despite that, there is a noticeable gender gap in the field of sciences, including chemistry. Less than 30% of the world's researchers are women according to UNESCO Institute for Statistics [17]. In 2017, IUPAC collaborated with ten additional international unions and organizations in the fields of natural sciences, computing, and mathematics. This collaboration initiated a three-year project, financially supported by the International Science Council (ISC), formerly known as ICSU. The primary objective of this project was to assess the gender disparity in science and propose strategies to diminish the gap between men and women in these domains. [18].

IUPAC has given out many awards to promote chemistry. There are some awards offered by IUPAC to recognize achievements in chemistry such as the Thieme-IUPAC Prize in Synthetic Organic Chemistry, the Franzosini Award, and IUPAC Prize for Young Chemists. Moreover, the International Chemistry Olympiad (IChO) has also been partnering with IUPAC since 2007, with a joint goal of promoting promising and passionate chemistry students to encourage them to explore deeper into the world of chemistry. IUPAC supports by providing financial support to enable the participation of students from low-income countries and to contribute to the promotion of IChO's goals and activities [19].

V. IUPAC's position and strategy

The International Union of Pure and Applied Chemistry (IUPAC) has strategically redirected its focus towards green chemistry and sustainability, signifying a crucial step in addressing environmental challenges and advocating for a more sustainable future. This shift underscores the integration of chemical principles with environmental consciousness. Notably, IUPAC's commitment to green chemistry is evident in collaborative initiatives such as the "*Sustainable Chemistry*" project, developed in partnership with the Organization for Economic Cooperation and Development (OECD). This project aims to raise awareness and encourage the adoption of sustainable practices in member countries, positioning IUPAC as an active contributor to the global dialogue on sustainable chemistry. This evolution towards green chemistry not only promotes responsible and eco-friendly practices within the field but also establishes chemistry as a crucial player in addressing global challenges, showcasing a collective effort between IUPAC and OECD to drive positive change and advance sustainable approaches with a focus on the long-term impact of chemical processes on the environment [20].

Recently, a working group from IUPAC, focusing on Systems Thinking in Chemistry for Sustainability, unveiled an interactive digital learning tool called "*The Planetary Boundaries*." This tool was developed to assist chemists and educators in comprehending the challenges of Earth system sustainability, connecting chemistry to sustainability through a systems thinking approach. This integration not only enhances understanding but also promotes solutions rooted in a holistic perspective. The tool, now accessible at https://planetaryboundaries.kcvs.ca/, underscores the vital role of chemistry in regulating nine Earth system processes and understanding their control variables [21].

VI. Conclusion

The pivotal roles of IUPAC in advancing the chemical sciences globally are:

- Standardization of Nomenclature / Guidelines for Systematic Chemical Naming.
- Promoting sustainability and green chemistry and international collaborations.
- Recognition of Excellence through awards and educational support.
- Providing guidance to chemistry ethical practices.
- Advancement of Digital Standards in the 21st-century chemistry.
- Shaping the future of chemistry through research and publications to address global challenges and contribute to science policy.

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