PRIKAZ KNJIGE BOOK REVIEW

Drago Grdenić

Povijest kemije
[The History of Chemistry]

Novi Liber/Školska knjiga, Zagreb, 2001

The book *History of Chemistry* (Novi Liber and Školska knjiga, Zagreb, 2001) was written by the member of the Croatian Academy of Sciences and Arts and professor emeritus Drago Grdenić. This extensive book has XIII + 931 pages and covers the history of chemistry from its earliest beginnings to the middle of the 20th century. Professor Grdenić wrote the book for almost a decade; the manuscript was completed in the autumn of 1998 and the book came off the presses at the end of 2001. The year 1959, however, was the real inception of the book, for it was then that the author started lecturing on the history of chemistry to the fourth-year chemistry students of the Faculty of Science and Mathematics in Zagreb.

After his retirement, Professor Grdenić could fully devote himself to writing this book in the peaceful ambience of the small town of Baška on the island of Krk. He put into the book his views on the historical course of chemistry and the material, spiritual, technological and philosophical foundations that influenced its development, which is the subject of the first three chapters.

The author follows the development of chemistry through Greek natural philosophy (III), Alexandrian protochemistry (IV), Arabic alchemy (VII), European (medieval) alchemy (VIII), iatrochemistry (IX), phlogiston theory (XI), the chemistry of air (XII) and modern chemistry (XIII–XVII) from Lavoisier to the mid 20th century. One chapter is dedicated to Chinese alchemy (VI) and one to Indian alchemy (V). These two alchemies, for a number of reasons, did not evolve into chemistry but there are indications that both had influenced Arabic alchemy. The Arabs were in contact with China and India, they even ruled over a part of India. They brought to Europe gunpowder from China and zero from India, giving us our current numerical system. It is likely that the Arabs in turn influenced India and China. Alchemy is a word of Arab origin – *al* being the definite article in Arabic.

The main goals of the alchemists were to find a way of turning less valuable metals into gold and to concoct the elixir of life. If these objectives of the alchemists are generalized into preparation of costly products from cheap raw materials and preparing drugs that will cure people and prolong their lives, then the goals of modern chemists are very similar to those of the alchemists. It is noteworthy that the methods of nuclear physics make it possible to turn less valuable metals into gold; however, the process is far from being cost-effective.

I have no intention to retell the book, it has to be read, but I will only point to some details that I find interesting. Chapter IV is concerned with Alexandrian protochemistry (1^{st} – 6^{th} century). Professor Grdenić took over the term *protochemistry* from Joseph Needham (1900–1995), an English biochemist, sinologist and historian of science. Needham introduced the term because he thought that the goals of protochemists were not the same as those of alchemists. Though protochemists were trying to transform common metals into gold, they were not concerned with discovering the elixir of life, which was the foremost aim of all alchemies, Indian, Chinese, Arabic and European alike. Protochemists discovered distillation, and they employed sublimation, extraction, dissolution and crystallization. They also invented a number of devices and utensils for chemical experiments. The term protochemistry has not been generally accepted. Thus, for example, in *The Fontana History of Chemistry* (Fontana Press, London, 1992), written by William H. Brock, an extensive book with XXIII + 744 pages, the author uses the term *Alexandrian alchemy* and treats it within the framework of Greek alchemy. Brock also supports the thesis that the central theorem of alchemy is *conversion of less valuable metals into gold.* One, however, tends to accept the term protochemistry, without entering in the dispute about the aims of alchemists, because the first, rudimentary chemical laboratories appeared in Alexandria.

In Chapter IV, Professor Grdenić also discusses the origin of the word chemistry and mentions Needham's idea that it is of Chinese origin -*jin* (Modern Chinese) -*kien* (Old Chinese) -*kim* (dialect), the Chinese word for *gold*, object of gold making.

The period of chemistry up to Lavoisier is presented following the modern views on the history of chemistry, unlike some older historians of chemistry who seemed to be ashamed of the past and spoke about many past events in chemistry as about misconceptions that retarded the progress of chemistry. The modern approach to the history of chemistry regards *alche-*

my as the foundation of chemistry and critically evaluates past events in terms of the general progress of chemistry.

Professor Grdenić presents the *phlogiston theory* in accordance with its modern interpretations. The phlogiston theory appeared towards the end of the alchemic era and was developed by Georg E. Stahl (1660–1734) in his book *Fundamenta chymiae* (1723). This was the first applicable chemical theory after Aristotle's view on chemical reactions as transformation of elements. The value of the theory lies in its unification of many known facts that at first glance appeared to be very different: combustion, rusting of metals and emission of animal heat and its restoration by food. The end of the phlogiston theory marks the beginning of modern chemistry. The decisive step in this direction was made by Antoine L. Lavoisier (1743–1794) when he applied *precise* measurements to combustion. Lavoisier's *Traité élémentaire de chimie* (Paris, 1789) deserves to be mentioned as the first work of the new chemistry.

The survey of the development of modern chemistry extends over 4 chapters (XIV – XVII), which also include an outline of the *development of structural theory*, which in my opinion is the most important chemical theory in the last century and a half. Foundations of modern chemistry were laid in the 19th century – of the numerous achievements let mention be made of the following two: (i) the Periodic Table of the Elements, proposed in 1869 by Dmitry Ivanovich Mendeleev (1834–1907). Mendeleev called it the *natural system of the elements* because the positions assigned to the elements in the table were those which *naturally* belonged to them under the law of the periodicity of their properties; and (ii) Jacobus Hendrikus van't Hoff (1852–1911) and Joseph-Achille Le Bel (1847–1930) proposed in 1874 the *three-dimensional structure of molecules* and founded stereochemistry, the branch of chemistry concerned with the spatial distribution of the atoms in a molecule. Van't Hoff was the first chemist to be awarded the Nobel Prize for chemistry (1901). Since 1901, Nobel Prizes have been awarded for scientific achievements in physics, chemistry, medicine and physiology, literature, peace and (since 1969) economics. Alfred Bernhard Nobel (1833–1896), a Swedish chemist and inventor of dynamite, established the Foundation from which the prizes are paid out.

The next two chapters (XVIII, XIX) give a survey of the development of inorganic chemistry (the author was professor of inorganic chemistry and studied the chemistry of mercury compounds and determination of their structure) and physical chemistry.

The last chapter (XX) deals with the *unification of chemistry*, which is based on *quantum chemistry* as a fundamental chemical theory. The quantum theory was founded at the beginning of the 20th century. The first to apply it in chemistry (1927) were Walter Heitler (1904–1981) and Fritz London (1900–1954), when they used the wave equation, worked out by Erwin Schrödinger (1887–1961), to study the chemical bond in a hydrogen molecule and its cation. They found that electrostatic forces were responsible for the formation of the covalent chemical bond. This work marked the beginning of quantum chemistry, which influenced the entire development of chemistry. Quantum chemistry offered the explanation of the origin of the chemical bond and improved our understanding of chemical reactions. It is noteworthy that the promising beginnings of quantum chemistry were followed by its apparent failure to meet the expectations. The problem, however, was not the theory but the fact that precise calculations required for a quantitative approach to chemistry were unfeasible. The end of the 20^{th} century saw a rapid development of computer technology, personal computers began to be widely used, and the Internet was launched. Computer suddenly became the most important tool of modern chemists. Almost silently, a revolution happened to chemistry, which is based on combinatorial (virtual) libraries of compounds, molecular modelling, robotics and theoretical chemistry (including quantum chemistry), all of which help to prepare compounds with desired properties. We must remember that chemistry is an experimental discipline; *the aim of chemistry is to prepare compounds.*

The book ends with a sub-chapter on determining the structure of molecules by X-ray diffraction. This comes as no surprise, since the X-ray structure analysis used to be in the centre of Professor Grdenić's scientific interest during his whole career and it had an appreciable influence on the development of chemistry in the 20^{th} century. It enabled precise determination of the structure of small molecules, as well as of very large and biological molecules. X-rays were discovered in 1895 by Wilhelm C. Röntgen (1845–1923). This discovery won him the first Nobel Prize for physics in 1901. The most valuable result of the X-ray structure analysis is the research into the structure of deoxyribonucleic acid (DNA), which in 1953 inspired James D. Watson (b. 1928) and Francis H. C. Crick (b. 1916) to propose the double helix, for which they were awarded the Nobel Prize for medicine in 1962.

Several Croatian chemists and scientists are mentioned in the book. Naturally, mention is made of our Nobel Prize laureates for chemistry Lavoslav (Leopold) Ružička (1887–1976) and Vladimir Prelog (1906–1998), as well as of Rugjer Bošković (1711–1787). It is a pity that the book does not contain a chapter dedicated to the development of Croatian chemistry.

Professor Grdenić cites the definition of chemistry that was proposed in 1970 by the Division of Chemical Education of the American Chemical Society in conjunction with the International Union of Pure and Applied Chemistry, the roots of which go as far back as to the very first congress of chemists (Karlsruhe, 1860): *Chemistry is the overall study of the preparation,* *properties, structure and reactions of chemical elements and their compounds, as well as the systems that they form*.

This book reveals why chemistry is such an exciting and interesting science and why almost nothing is possible without chemistry. We learn why chemistry is the central natural science and we recognize its importance, which can be described as: *chemistry is the only science that enables preparation of new substances, substances which do not exist in nature and which often surpass all the known substances in nature.*

Professor Grdenić should be congratulated on this splendid book as well as on his perseverance to complete it and have it published.

Nenad Trinajstić