Historical Articles

Albert Ladenburg (1842-1911) – The Distinguished German Chemist and Historian of Chemistry of the Second Half of the XIX Century (To the 110th Anniversary of His Death)

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Abstract. Albert Ladenburg (1842-1911) was an outstanding German chemist and historian of chemistry of the second half of the 19th century. He ascertained the formula of ozone as O₃ and proposed a triangular prism structure for the molecule of benzene. He studied the structure of aromatic hydrocarbons and organic compounds of silicon and tin, and devoted his work to explaining the structure of alkaloids and their synthesis. The purpose of this paper is to familiarize readers with the important events in the life of Ladenburg and his writing and research activities, in particular some of his experimental results, as well as his selected publications.

Keywords: A. Ladenburg, Organic chemistry, Ladenburg's prism formula for benzene, Coniine, Germany – XIX century.

In the minds of all chemists now living, and of all those who, in the future, trace the development of the science of our time, the name of Ladenburg is, and always will be, closely associated with the chemistry of those interesting and wonderful products of nature’s laboratory, the vegetable alkaloids.
Frederic Stanley Kipping (1863-1949).

1. THE IMPORTANT EVENTS IN THE LADENBURG’S LIFE

Albert Ladenburg was called a great man with highets achievements, “who his life worthily devoted to the advancement of knowledge”, and “an indefatigable worker and investigator”. One hundred and ten years have passed since his death, but in that time little has appeared in the literature about this eminent man. He went down in the history of chemistry as a researcher of the structure of aromatic hydrocarbons and organic compounds of silicon and tin. One of his achievements as an experimenter was the synthesis of alkaloids and the elucidation of their structure.

Albert Ladenburg was born into a renowned Jewish family in Mannheim on July 2, 1842, as the second son of Dr. Leopold Ladenburg (1809-1889), a
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lawyer, and his wife Delphine, née Picard (1814-1882). His grandfather Wolf Haium Ladenburg (1766-1851) founded the private Banking House Ladenburg in Mannheim in 1785. At the age of 15, after study at a Realgymnasium at Mannheim, he continued his education (1857-1860) at the Polytechnische Schule in Karlsruhe. In 1860, at eighteen years of age, he went to Heidelberg, where his interest in chemistry was inspired and directed by Robert Bunsen (1811-1899). In the Bunsen's laboratory he met, among others, Carl Graebe (1841-1927), and Hermann Wichelhaus (1842-1927), who remained his close friends. Here he also met the British chemist Henry Roscoe (1833-1915), who often visited Bunsen. He also attended lectures on mathematics at the University and studied physics under Gustav Kirchhoff (1824-1887). On June 2, 1863, he "took the Ph.D. degree at Heidelberg University, summa cum laude in chemistry, physics, and mathematics." During this time, he met Emil Erlenmeyer (1825-1909), which led to a lifelong friendship between them. Then he worked in a small private laboratory of Georg Ludwig Carius (1829-1875), außerordentlicher professor at the University. In the spring of 1865 he went to Ghent, where he spent a semester to work in the University Laboratory of August Kekulé (1829-1896). Figure 1 is a photograph taken in Ghent. From left to right, standing: August Mayer (1844-?), Wilhelm Körner (1839-1925), Kekulé’s private assistant and secretary, Esch, Semmel, Behrend, and Ladenburg. Seated, from left to right: Théodore Swarts (1839-1911), Kekulé, and Carl Glaser (1841-1935), Kekulé’s private assistant. In 1866, after his stay in Ghent, he went briefly to London, where he visited the British chemist Edward Frankland (1825-1899), after which he moved to Paris. Following the advice of Kékulé, he asked Marcelin Berthelot (1827-1907) for permission to become one of his students. His "request was granted forthwith, but when he proceeded to inquire where he should work, he was shown a large, empty room, devoid of all fittings, of which he would be the sole occupant." However, he did not use Bertholet’s offer and started work under Charles Adolphe Wurtz (1817-1884) in his laboratory at the Faculté de médecine de Paris. He met there, among other, Charles Friedel (1832-1899), Joseph Caventou (1795-1877), Alfred Joseph Naquet (1834-1916), and Armand Gautier (1837-1920). In the years 1866-1867, he worked for 18 months with Friedel. He carried out with him series of researches in the laboratory in the École nationale supérieure des mines de Paris. After obtaining his habilitation, on January 8, 1868, he became Privatdozent at the University of Heidelberg. The British chemist and historian of chemistry Thomas Edward Thorpe (1845-1925) wrote about his stay in Heidelberg at that time as follows: “At Heidelberg, as in many other centres of chemical instruction, there was a small Chemical Society, composed of the Extraordinary Professors, the Privat-docenten, and assistants, together with the senior or more active students in the various laboratories who were elected into it by favour of the teachers. In my time it numbered amongst its members Erlenmeyer, Ladenburg, [August Friedrich] Horstmann [(1842-1929)], [Ernst] Ludwig [(1842-1915)], [Emil] Cohen [(1842-1905)] (the mineralogist), Rose, and [Adolph] Emmerling [(1842-1906)]. Its president was Bunsen, and the occasions on which he took the chair were the red-letter days of the session.” In the fall of 1868, Ladenburg attended the Naturforscherversammlung (Meeting of Naturalists) in Frankfurt am Main. There, he met Kekulé and the Russian chemist Aleksandr Mikhailovich Butlerov (1828-1886), whom he "knew already from Heidelberg" and with whom he "had entered into closer relations at a dinner given by Erlenmeyer." On March 30, 1870, he was appointed extraordinary professor at the University of Heidelberg, and on October 25, 1872 he went to Kiel as full professor of chemistry and director of the new chemistry laboratory at the University. He became the successor of Karl Himly (1811-1885), and he worked there for seventeen years. He "was presumably the first nonbaptized chemist who

Figure 1. Ladenburg with August Kekulé and the group of his assistants and students at the Ghent University (Public domain, from reference 12).
Albert Ladenburg (1842-1911) received a full professorship in chemistry at a German university.\textsuperscript{25-26} In the academic year 1884/1885 he was the Rector of this University.\textsuperscript{27}

On September 19, 1875, he married Margarethe Pringsheim (1855-1909),\textsuperscript{28} the daughter of the Nathanael Pringsheim (1823-1894), professor of botany at the University of Berlin.\textsuperscript{29-31} The spouses had three sons: Erich (1878-1908), Rudolf (1882-1952) and Kurt (1884-1901).\textsuperscript{32}

On October 1, 1889 he went to Breslau in Silesia in the Kingdom of Prussia (now, Wroclaw, Poland), where he started working as a professor of chemistry at the Königliche Universität zu Breslau (Royal University of Breslau). He, as the successor of Carl Jacob Löwig (1803-1890), became the director of the Chemische Institut (Institute of Chemistry).\textsuperscript{33}

In 1901, the Ladenburg's youngest son, Kurt, died prematurely at the age of 17. Seven years later, his eldest son Erich, a physicist\textsuperscript{34} who made a scientific career at the Royal University of Breslau, died tragically. He drowned in a sailboat accident on Lake Müggel.\textsuperscript{35-36} His third son, Rudolf, became a German-American atomic physicist.\textsuperscript{37}

In 1905, he had to undergo amputation of the right leg.\textsuperscript{38} The German chemist Walter Herz (1875-1930), professor of physical chemistry at the University of Breslau, wrote about it as follow: "Ladenburg not only lost his right foot as a result, but also the whole right leg up to the middle of the thigh. His friends fearfully wondered whether this new, large wound would now heal and whether the now 63-year-old man would still be able to learn to walk with an artificial leg. The healing progressed slowly, but in the autumn of 1905 Ladenburg was ready to return to his office thanks to the loving care of his wife. Everyone who saw him was surprised at how well he had recovered from this severe blow."\textsuperscript{39}

Nevertheless, he continued the duties of his Chair until October 1, 1909, when he resigned from teaching due to illness. Towards the end of his life, he wrote a autobiography, which his son Rudolf published under the title Lebenserinnerungen in Breslau in 1912.\textsuperscript{40} It is worth emphasizing that this book does not contain “a single mention of antisemitism or even prejudice”.\textsuperscript{41} Ladenburg was not “practicing” Jew and was “fully assimilated” German. He “was in fact an atheist; for reasons that he does not explain, he finally underwent baptism in 1891.”\textsuperscript{42} According to a document written by him two years earlier, dated November 16, 1889, and stored in the Archives of the University of Wroclaw, he called his confession Evangelisch reformierte (Evangelical Reformed).\textsuperscript{43}

Ladenburg died on August 15, 1911 in Breslau. Herz in his obituary wrote: “When I went to the laboratory early on August 15, I first sent a telegram congratulations on the [Rudolf] Ladenburg wedding at a post office. When I arrived at the laboratory, I had barely started my work when the telephone notification arrived that Ladenburg had gone to sleep on the night of August 14th to 15th (at 1:00 am). He did not live to see his son’s wedding.”\textsuperscript{44}

He was buried on August 18th. At his funeral, der Geistliche der reformierten Hofgemeinde (the Clergyman of the Reformed Court Community) Pastor Renner, the mineralogist Carl Hintze (1851-1916), and the Lord Mayor Dr. Georg Bender (1848-1924) spoke at his grave alternately.\textsuperscript{45}

Two of his obituaries were published in 1911 by anonymous authors in the Chemical News,\textsuperscript{46} and American Chemical Journal.\textsuperscript{47} Two year later, on October 23, 1913, the English chemist Frederic Stanley Kipping (1863-1949) delivered a lecture in memory of Ladenburg at a meeting of the Royal Society.\textsuperscript{48}

2. LADENBURG’S PARTICIPATION IN THE SCIENTIFIC CELEBRATIONS

In August 1877, he attended celebrations of the 400th Anniversary of the University in Uppsala (Sweden) as a representative of the University of Kiel.\textsuperscript{49} Twenty-three years later in 1900, he visited Berlin to participate in the conference devoted to the 200th Anniversary of the Königlich Preußischen Akademie der Wissenschaften (Royal Prussian Academy of Sciences). Figure 2 is a photography made during this celebration.\textsuperscript{50} The American biochemists Benjamin Harrow (1888-1970) inserted this photo on the one of first pages of his book entitled Eminent Chemists of Our Time. He also wrote that it “showing several eminent chemists was taken at one of the international scientific gatherings.”\textsuperscript{51}

![Figure 2. Ladenburg with the group of the prominent chemists](Public domain, from reference 50).
Photograph was published by Harrow thanks to the kindness of the Dutch chemist Ernst Julius Cohen (1869-1944). Ladenburg is first from the left in the second row; to his left are the Danish chemist Sophus Mads Jørgensen (1837-1914), the Finnish chemist and historian of chemistry Edvard Hjlett (1855-1921), the German chemist Hans Heinrich Landolt (1831-1910), the German chemist Clemens Alexander Winkler (1838-1904), who discovered germanium in 1886, and T. E. Thorpe. Seated from the left to right in the front row are the Dutch chemist Jacobus Henricus van ‘t Hoff (1852-1911), who won the Nobel Prize in Chemistry in 1901, the Russian – German chemist Friedrich Konrad Beilstein (1838-1906), the Scottish chemist William Ramsay (1852-1916), who found neon, argon, krypton, and xenon in air and was awarded the Nobel Prize in Chemistry in 1904, the Russian chemist D. I. Mendeléeff, who discovered the Periodic Law in 1871, the German chemist Adolf von Baeyer (1835-1917), who received the Nobel Prize in Chemistry in 1905, and T. E. Thorpe. Seated from the left to right in the second row are the Danish chemist Sophus Mads Jørgensen (1837-1914), the Finnish chemist and historian of chemistry Edvard Hjlett (1855-1921), the German chemist Clemens Alexander Winkler (1838-1904), who discovered germanium in 1886, and T. E. Thorpe. Seated from the left to right in the front row are the Dutch chemist Jacobus Henricus van’t Hoff (1852-1911), who won the Nobel Prize in Chemistry in 1901, the Russian – German chemist Friedrich Konrad Beilstein (1838-1906), the Scottish chemist William Ramsay (1852-1916), who found neon, argon, krypton, and xenon in air and was awarded the Nobel Prize in Chemistry in 1904, the Russian chemist D. I. Mendeléeff, who discovered the Periodic Law in 1871, the German chemist Adolf von Baeyer (1835-1917), who received the Nobel Prize in Chemistry in 1905, and the Italian chemist Alfonso Cossa (1833-1902).

Ladenburg in the further part of his book described certain incident, which happened during banquet given by the organizers in this occasion and involving Ladenburg. “In 1900 the Prussian Academy celebrated its two hundredth anniversary, and the University of Petrograd sent Mendeléeff as its delegate. At the banquet van’t Hoff presided over one of the side tables, with Ladenburg (the Breslau representative) to the right, and Mendeléeff to the left over him. Mendeléeff was an inveterate smoker, and simply chafed because he could not smoke alternately. Ladenburg tells us that immediately after the soup Mendeléeff began to pump those around him as to whether he could be allowed to smoke. They answered him that was out of the question. But he repeated his question after the first, and after the second courses. Then dear old van’t Hoff, who hated to see anyone suffer so, stepped in with the risky suggestion that he also would join in a smoke. And the two went to it, to the great relief of Mendeléeff, who from then on proved an enjoyable companion. But the sad side of the incident was that van’t Hoff, who had begun to show incipient signs of tuberculosis, had been expressly forbidden smoking.”

3. LADENBURG’S WORKS

The list of works published by Ladenburg includes 276 papers and books published over forty-seven years from 1865 to 1912. The majority of these are the articles presenting the results of his experimental works, published in Berichte der deutschen chemischen Gesells-
chaft as well as in other German, French and British journals. Among them are his original articles devoted to the problems of the isomerism of benzene derivatives, the researches on organic compounds of tin, the studies of ozone, as well as accurately determination of the atomic weight of iodine.

A large number of the results of the experimental research carried out by him were published in Justus Liebigs Annalen der Chemie, Zeitschrift für angewandte Chemie and Journal für praktische Chemie. A few his articles were published in French in Comptes Rendus Hebdomadaires Des Séances De L’Académie Des Sciences and Annales de Chimie et de Physique. One of his articles entitled Contribution to the characterisation of racemic compounds was published in the Journal of the Chemical Society, Transactions in 1899.

His first paper in the field of organic chemistry entitled Eine neue Methode der Elementaranalyse (A New Method of Elemental Analysis) was published in 1865. There he described the results of several experiments, for instance, with naphthalene and with diethyl ether. At the end of an article (p. 24), written in February 1865 in Heidelberg, he wrote thanks to Carius for making it possible to carry out experiments in his laboratory: “Finally, I would like to express my thanks to Professor Carius, in whose laboratory the experiments described have been carried out, for his assistance, which he has given me very generously.”

In the Kekulé’s laboratory, he carried out two studies on benzene derivatives, the results of which were published in 1866, one on Synthèse de l’acide anisique et de l’un de ses homologues (Synthesis of Anisic Acid and One of its Homologues) and the other in collaboration with Fitz called Sur quelques dérivés de l’acide paroxybenzoïque (On Some Derivatives of Paroxybenzoic Acid). In the same year, from the Wurtz’s laboratory, he published with Carl Leverkus (1804-1889) a paper entitled Sur la constitution de l’anethol (On the Constitution of Anethol).

In the years 1866-1867, he and Friedel published several papers with the results of studies of the structure of aromatic hydrocarbons, and organic silicon compounds such as mixed silico-acetic anhydride, siliconchloroform, and silicon chloroiodosulphide. One of the studies was devoted to revealing the analogy between carbon and silicon.

The experimental work of Ladenburg and Friedel was continued also in the years 1868-1870. The fruits of this collaboration were a three papers Ueber das intermediäre Anhydrid von Kieselsäure und Essigsäure (About the Intermediate Anhydride of Silicic Acid and Acetic Acid), Einige Derivate des Radicals Silicoallyl (Some
Silicoallyl Radical Derivatives), and *Sur l’acide silico-propionique* (On Silicopropionic Acid).

Ladenburg’s research interests also focused on synthesis of alkaloids. In 1879, he carried out the artificial production of atropine (C_{17}H_{23}NO_{3}), and in 1894, he and M. Scholtz synthesized piperic acid (C_{12}H_{10}O_{4}) and piperine (C_{17}H_{19}NO_{3}), which was the main alkaloid of black pepper. In 1880, he also isolated hyoscynamine (C_{17}H_{23}NO_{3}) and hyoscyamine (C_{17}H_{21}NO_{4}) also called scopolamine.

In 1886, he for the first time synthesized in the laboratory an optically active compound identical with the alkaloid conine (C_{6}H_{5}N) found in the hemlock plant. Kipping wrote about this achievement of Ladenburg as follows: “The synthesis of dl-conine, followed by the resolution of the synthetic alkaloid into its optically active components, the culminating point of these researches, was perhaps the greatest of Ladenburg’s successes.”

At a time when the Kekulé formula for benzene was the subject of much controversy, Ladenburg 152 years ago, in 1869, proposed a triangular prism structure for the molecule of this compound, that was symmetrical, but didn’t contain double bonds, and turned out to be erroneous. In 1876, he summarized his views on the structure of the benzene molecule in his book entitled *Die Theorie der aromatischen Verbindungen* (The Theory of Aromatic Compounds). Thirty-five years later, an anonymous author wrote: “His prism formula for benzene, although now practically universally rejected, has been of great use in the development of chemistry in that, as early as 1868, it showed the necessity of taking into account steric considerations in the formulation of the constitution of chemical compounds.”

Experimental studies carried out in the 1970s confirmed that Ladenburg prism can be obtained in the laboratory. In 1973, a pure sample of “the simple molecule C_{6}H_{6}, known as prismane [tetracyclo[2.2.0.0^{2,6}.0^{3,5}]hexane], in which six carbon-hydrogen units are disposed at the corners of a triangular prism”, was synthesized by the American organic chemists Thomas J. Katz, and Nancy Acton from the Department of Chemistry at Columbia University.

The chemical literature review results indicate an interest in Ladenburg’s works, for instance, information about some of his articles appeared in the *Gazzetta Chimica Italiana* in 1872. His experimental studies and their results were introduced to readers, among others by Ed. Willm and Maurice Hanriot (1854-1933) in 1889, H. E. Roscoe and Carl Schorlemmer (1834-1892) in the years 1888-1890, Julius Wilhelm Brühl (1850-1911), E. Hjel, and Ossian Aschan (1860-1939) in 1900, Amé Picket (1857-1937) in 1904, as well as Hans Meyer (1871-1942) in 1916, and 1922. In the 1960s, the results of selected Ladenburg studies in the field of organosilicon chemistry were discussed by Richard Müller from Institute for Silicone and Fluorocarbon Chemistry in Radebeul/Dresden (Germany). At the beginning of the 21st century, these results were presented by Dietmar Seyferth from Department of Chemistry at Massachutets Institute of Technology (U.S.A.).

### 4. OTHER WORKS OF LADENBURG IN CHEMISTRY

Ladenburg, at the age of 27, became famous for his book on the history of chemistry. It was published first in German and later in three other languages. In 1869, the first edition of his *Vorträge über die Entwicklungsgeschichte der Chemie in den letzten hundert Jahren* (Lectures on the History of the Development of Chemistry Over the Last Hundred Years) was published in Braunschweig. One year later, the German chemist Hermann Kolbe (1818-1884) praised this book in his article published in the *Journal für Praktische Chemie*. He wrote as follow: “Far from wanting to give a truthful, strictly scientific development of the chemical theories (which task young Ladenburg ... has recently undertaken with seriousness and diligence...)”.

The fourth German edition of this book appeared thirty-eight years later under the title *Vorträge über die Entwicklungsgeschichte der Chemie von Lavoisier bis zur Gegenwart* (Lectures on the History of Chemistry from Lavoisier to the Present Day). He dedicated the book from this edition to his wife.

In 1900, the first English edition of Ladenburg’s book was published with the title *Lectures on the History of the Development of Chemistry since the Time of Lavoisier*. The revised editions of this book appeared in 1911. The translator was the chemist Leonard Dobin (1858-1952), lecturer on Chemical Theory and assistant in Chemistry at the University of Edinburgh.

In the preface to the English Edition of this book written in September 1899 in Grassendale, Southbourne-on-Sea, Ladenburg wrote: “Thirty years after the appearance of the first edition of this book, an English translation of it is now being prepared. I regard this as a favourable indication of the permanent value of the book, since it is evident that the standpoint then adopted is intelligible at the present day and is still unsuperseded. Moreover, it may be concluded that the exposition of the subject is not marred by national prejudices. The English edition is a faithful translation, and, so far as I am able to judge, it is written in a good style. For these features my best thanks are due to the translator.”
The first French edition of Ladenburg’s *Histoire Du Développement De La Chimie Depuis Lavoisier Jusqu’à Nos Jours* (Lectures on the Development of Chemistry from Lavoisier to the Present Day) was published in 1909, and the second, in 1911. The translator was Arthur Corvisy, associate professor of physical sciences at the Lycée Gay-Lussac and Professeur Suppléant at the School of Medicine and Pharmacy.

In 1917, the first Russian edition of his *Lektsii po Istorii Razvitiya Khimii ot Lavuaz’ye do nashego vremeni* (Lectures on the History of the Development of Chemistry from Lavoisier to our Time) was published in Odessa. The translator of the fourth German edition of this book was Evgeny Semonovich Elchaninov (1879-1922), privat-docent of the Novorossiysk University.

In the years 1882-1895, Ladenburg worked intensively on his *Handwörterbuch Der Chemie* (Concise Dictionary of Chemistry), which was published in thirteen volumes in Breslau. The general register created on the basis of the registers of individual 13 volumes of this book was published in 1896. Among the co-authors are the names of 50 chemists who participated in the creation of this great work in different years during thirteen years.

One of Kekulé’s works was published by Ladenburg in 1904 in the *Ostdalys Klassiker der Exakten Wissenschaften* series. In the years 1907-1910, three papers written by French chemists Louis Pasteur (1822-1895), Wurtz, and Berthelot and Léon Péan de Saint-Gilles (1832-1863) were translated from French into German by Ladenburg and his wife and published in the same series.

5. CONCLUSION

Albert Ladenburg was one of the prominent chemist of the second half of the XIX century. In the years 1880-1910, he was elected a member of three academies of sciences. He became a member of the *Nationale Akademie der Wissenschaften Leopoldina* in 1880. He was elected a corresponding member of the *British Association for the Advancement of Science* in 1887, and the *Académie des sciences de Paris* on December 13, 1909. On January 6, 1910, he became a corresponding member of the *Königlich Preußischen Akademie der Wissenschaften*. He was a corresponding member of the *Philadelphia College of Pharmacy*. On April 26, 1892, he became an honorary member of the *Manchester Literary and Philosophical Society*, and on August 4, 1884, he was appointed Doctor honoris causa of Medicine at the University of Bern. On February 2, 1888 he became an honorary and foreign member of the *Chemical Society of London*. In the years 1901-1911, he was a foreign corresponding member of the *Académie Nationale De Médecine* in Paris.

In 1899, the *Pharmaceutical Society of Great Britain* awarded him the Hanbury Gold Medal for his work on alkaloids and their derivatives. It is awarded every five years, in memory of the British botanist and pharmacologist Daniel Hanbury (1825-1875). “The medal was formally received by Baron [Wilhelm] von Mirbach ([1871-1918]), representing the German Embassy, and a letter was read from Dr. Ladenburg expressing his thanks for the honour done him, and regretting that he had been unable to be present to receive the medal personally.”

In 1905, he was awarded the Davy Medal “for his researches in organic chemistry, especially in connexion with the synthesis of natural alkaloids.” It is named after the English chemist Humphry Davy (1788-1829) and is awarded annually since 1877 to an outstanding researcher in the field of chemistry by the *Royal Society of London*. Two years later, in 1907, he nominated Berthelot and Mendeleev for the Nobel Prize in Chemistry. However, the award went to the German biochemist Eduard Buchner (1860-1917) “for his biochemical researches and his discovery of cell-free fermentation.” Later, in 1909-1911, he worked at the University of Breslau.

After Ladenburg, not only his papers and books survived. In addition, several of his portraits were produced. One of them was included by the German chemist Richard Anschütz (1852-1937), professor of chemistry at the University of Bonn, in his biographical book on Kekulé. Three other photo appeared in the articles written by Herz, Kipping, and Colin Archibald Russell (1928-2013). The photographer Adèle Perlmutter (1845-1941) from Vienna photographed him in 1869, and in the years 1870-1880 his portrait was taken by a photographer Emil Bühler in Mannheim. Another two of his portraits can be found in the *Österreichische Nationalbibliothek* collection, and in a book written by the American chemist Henry Monmouth Smith (1868-1950).

In 1911, the 100th Anniversary of the Royal University of Breslau was celebrated. On this occasion, a book entitled *Festschrift zur Feier des hundertjährigen Bestehens der Universität Breslau, Zweiter Teil, Geschichte der Fächer, Institute und Ämter der Universität Breslau 1811 – 1911* was published, in which one of the chapters written by Ladenburg and Buchner was devoted to the history of the Institute of Chemistry at the University. The authors also presented short biographical notes of chemists who obtained their habilitation there.

The great achievements of Ladenburg in the field of alkaloids synthesis were noticed by English pharmacists. On October, 1899, William Martindale (1840-1902),
President of the Pharmaceutical Society of Great Britain said about it: “Dr. Ladenburg was best known to English pharmacists by his synthetic work in the production of homatropine.[152] By splitting up atropine he obtained tropic acid and tropine as derivatives; the latter he combined with amygdalic acid to form a compound which is easily converted into oxy-toluyl-tropine or homatropine, an artificial alkaloid which, with its salts, has proved of the greatest service to ophthalmic surgery.”[153]

Walter Herz wrote about Ladenburg’s great achievements in chemistry as follows: “Like only a few, Ladenburg has been granted forty years of great success in developing his science. His contributions to the constitution of benzene, his investigations into the heterocyclic compounds, his successes in the synthesis of alkaloids, and his critical-historical chemical achievements. His uncommon scientific versatility was evident in his work on racemy, his excellent treatises on ozone and iodine, and his critical-historical perspective in his valuable history of chemistry.”[154]

It is worth emphasizing that Ladenburg was put “in the first rank of chemists as a theorist.”[155] Moreover, he was not only an experienced experimental chemist, but also an excellent pianist. His acquaintance with the great German pianists and composers such as Clara Schumann (1819-1896) and Johannes Brahms (1833-1897) began at his young age.[156] In a letter written to Schumann in Ischl, a city in Austria in June 1895, Brahms informed her about the meeting with Ladenburg: “…Professor Ladenburg from Breslau spent the Whitsun holidays here with his wife, we were very cozy together and talked a lot about you.”[157]

This outstanding German chemist and historian of chemistry took forever a firm place in the history of chemistry. His name is associated with the beginning of intensive research in the field of organic synthesis. The results of his original experimental studies have been published in scientific journals in Germany, France and Great Britain. His Vorträge über die Entwicklungsgeschichte der Chemie has been published many times, not only in Germany but also in Great Britain, France and Russia. His multi-volume dictionary Handwörterbuch der Chemie has served many generations of chemists around the world. His name is given to “a distilling flask with bulbed neck”, the so-called Ladenburg flask.[158] For example, one of its varieties is a flask with three-bulb.[159]

REFERENCES

1. F. S. Kipping, J. Chem. Soc., Trans. 1913, 103, p. 1871. https://doi.org/10.1039/CT9130301871
2. Quoted in ref. 1 (Kipping), p. 1871.
3. The Hanbury Medal. The British Medical Journal, 1899, 2(2024), p. 1030. Retrieved from https://www.jstor.org/stable/20262133
4. A. A. Baker, Jr. Ladenburg, Albert, 2020. Retrieved from Encyclopedia.com. website: https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/ladenburg-albert
5. L. Ladenburg, Stammtafel der Familie Ladenburg, Druck von J. Ph. Walter, Mannheim, 1882, p. 10. Retrieved from http://dl.unib.uni-freiburg.de/digit/ladenburg1882
6. H.-E. Lessing, Mannheimer Geschichtsblätter, 2008, 15, p. 7. Retrieved from https://verlag-regionalkultur.de/media/pdf/1a/94/e1/bib-35-559.pdf
7. See ref. 5 (Ladenburg), pp. 1, 10.
8. Wolf Hayum Ladenburg, 2015. Retrieved from http://alten-han-solo.net/osfia/tng_wordpress/get-person.php?personID=20472
9. See ref. 1 (Kipping), p. 1872.
10. Quoted in ref. 1 (Kipping), p. 1873.
11. R. Anschütz, August Kekulé. Leben und Werken, Band I., Verlag Chemie, G.M.B.H., Berlin, 1929, p. 272. Retrieved from https://archive.org/details/b29931654_0001/page/n3/mode/2up
12. Kekule und Mitarbeiter in Gent (Belgien), 1866. Public Domain. Retrieved from Wikimedia Commons website: https://commons.wikimedia.org/wiki/File:August_Kekule_Gent_ca1866.jpg
13. See ref. 11 (Anschütz), p. 272.
14. J. Gillis, De Brug. Tijdschrift Van De Rijks-universiteit Te Gent, 1958, 2(2), p. 68. (in Dutch). Retrieved from https://doi.org/10.1021/ed038p118
15. J. Gillis, J. Chem. Educ, 1961, 38(3), p. 120. https://doi.org/10.1021/ed038p118
16. W. Göbel, Friedrich August Kekulé, 1 Auflage, BSB B.G. Teubner Verlagsgesellschaft, Leipzig, 1984, p. 65. https://lib.ub.uni-freiburg.de/digit/RUG01/000/055/720/RUG01-00055720_2010_0006_AC.pdf
17. J. C. Poggendorff, Biographisch-Literarisches Handwörterbuch zur Geschichte der Exakten Wissenschaften, Dritten Band (1858-1883), Herausgegeben von B. W. Feddersen, A. J. von Oettingen, I. Abtheilung (A-L), Verlag Von Johann Ambrosius Barth, Leipzig, 1898, p. 763. Retrieved from https://archive.org/details/bub_gb_jgcjAQAAMAAJ/page/n767/mode/2up
18. A. J. Rocke, The Quiet Revolution. Hermann Kolbe and the Science of Organic Chemistry, University of California Press, Berkeley, 1993, Chapter -7, p.
Albert Ladenburg (1842-1911)
94. J. Daintith, A Dictionary of Chemistry, Sixth Edition, Oxford University Press, Oxford, 2008, p. 312.

95. A. Ladenburg, Theorie der aromatischen Verbindungen, Druck Und Verlag Von Friedrich Vieweg und Sohn, Braunschweig, 1876. Retrieved from https://reader.digitale-sammlungen.de/de/fs1/object/display/bsb11332404_000005.html

96. Quoted in ref. 46 (Anon.), p. 528.

97. T. J. Katz, V. Acton, J. Am. Chem. Soc. 1973, 95(8), p. 2738. https://doi.org/10.1021/ja00789a084

98. Gazzetta Chimica Italiana, v. II. Ufficio Tipografico Di Michele Amenta, Palermo, 1872, p. XV. Retrieved from https://babel.hathitrust.org/cgi/pt?id=mdp.39015061319305

99. Ed. Willm, M. Hanriot, Traité de Chimie Minérale Et Organique. Comprendant La Chimie Pur Et Ses Applications, Tome IV. Chimique Organique, G. Masson, Éditeur, Paris, 1889. Retrieved from https://archive.org/details/b28121715_0004/page/12/mode/2up

100. H. E. Roscoe, C. Schorlemmer, A Treatise on Chemistry, Volume III. The Chemistry of the Hydrocarbons and Their Derivatives or Organic Chemistry, Part III, D. Appleton and Company, New York, 1890. Retrieved from https://archive.org/details/treatiseonchemis35roscrich

101. H. E. Roscoe, C. Schorlemmer, A Treatise on Chemistry, Volume III. The Chemistry of the Hydrocarbons and Their Derivatives or Organic Chemistry, Part IV, D. Appleton and Company, New York, 1888. Retrieved from https://archive.org/details/treatiseonchemis34roscrich

102. H. E. Roscoe, C. Schorlemmer, A Treatise on Chemistry, Volume III. The Chemistry of the Hydrocarbons and Their Derivatives or Organic Chemistry, Part V, D. Appleton and Company, New York, 1889. Retrieved from https://archive.org/details/treatiseonchemis35roscrich

103. J. W. Brühl, E. Hjelt, O. Aschan, Die Pflanzen-Alkaloiide, Druck Und Verlag Von Friedrich Vieweg und Sohn, Braunschweig, 1900. Retrieved from https://archive.org/details/diepflanzenalk00bbruoft/page/n5/mode/2up

104. A. Pictet, The Vegetable Alkaloids. With Particular Reference to Their Chemical Constitution, (H. C. Biddle, Trans.), First Edition, John Wiley & Sons, New York, Chapman & Hall, Limited, London, 1904. Retrieved from https://archive.org/details/b28082199/page/n5/mode/2up

105. H. Meyer, Analyse und Konstitutionsermittlung Organischer Verbindungen, Springer-Verlag, Berlin Heidelberg, 1916, pp. 302, 308.

106. H. Meyer, Lehrbuch der Organisch-Chemischen Methodik, Springer-Verlag, Berlin Heidelberg, 1922, pp. 365, 374

107. R. Müller, J. Chem. Educ. 1965, 42(1), pp. 42-44. https://doi.org/10.1021/ed042p41

108. D. Seyrefther, Organometallics, 2001, 20(24), pp. 4979-4981. https://doi.org/10.1021/om0109051

109. A. Ladenburg, Vorträge über die Entwicklungs geschichte der Chemie in den letzten hundert Jahren, Druck und Verlag von Friedrich Vieweg und Sohn, Braunschweig, 1869. Retrieved from http://dfg-viewer.de/show?tx_dlf%5B5%5D=0&tx_dlf%5Bid%5D=https%3A%2F%2Fdigital.ub.uni-duesseldorf.de%2Foaip%3Fverb%3DGetRecord%26metadataPrefix%3Dmets%26identifier%3D5276578&tx_dlf%5Bpage%5D=7&cHash=8902af09f006d3eebdbb52233656ae8

110. H. Kolbe, J. Prakt. Chem. 1870, 2(1), 173-183. http://doi.org/10.1002/pract.18700020114

111. See ref. 18 (Rocke), Chapter-14, note no. 85.

112. Quoted in ref. 110 (Kolbe), p. 175.

113. A. Ladenburg, Vorträge über die Entwicklungs geschichte der Chemie von Lavoisier bis zur Gegenwart, Vierte Vermehrte und Verbesserte Auflage, Druck und Verlag von Friedrich Vieweg und Sohn, Braunschweig, 1907. Retrieved from http://dfg-viewer.de/show?tx_dlf%5B5%5D=0&tx_dlf%5Bid%5D=https%3A%2F%2Fdigital.ub.uni-duesseldorf.de%2Foaip%3Fverb%3DGetRecord%26metadataPrefix%3Dmets%26identifier%3D5276578&tx_dlf%5Bpage%5D=5&cHash=4979-4981. https://doi.org/10.1021/om0109051

114. A. Ladenburg, Lectures on the History of the Development of Chemistry since the Time of Lavoisier, Translated from the Second German Edition, (L. Dobbin, Trans.), Published by Alembic Club, Edinburgh, 1900. Retrieved from https://archive.org/details/lecturesonhistor00ladeuoft

115. A. Ladenburg, Lectures on the History of the Development of Chemistry since the Time of Lavoisier, Translated from the Second German Edition, Revised Edition, (L. Dobbin, Trans.), The Alembic Club, Edinburgh, The University of Chicago Press, Chicago, 1911. Retrieved from https://archive.org/details/lecturesonhistor00ladeuoft

116. Quoted in ref. 114 (Ladenburg), p. IX.

117. A. Ladenburg, Histoire Du Développement De La Chimie Depuis Lavoisier Jusqu'à Nos Jours, Traduit sur la 4e édition allemande, (A. Corvisy, Trans.), Libraire Scientifique A. Hermann & Fils, Paris, 1909. Retrieved from https://gallica.bnf.fr/ark:/12148/bpt6k91843j/f3.image.texteImage
118. A. Ladenburg, *Histoire Du Développement De La Chimie Depuis Lavoisier Jusqu'à Nos Jours*, Traduit sur la 4e édition allemande, (A. Corvisy, Trans.), Seconde édition française augmentée d'un Supplément Par A. Colson, Libraire Scientifique A. Hermann & Fils, Paris, 1911. Retrieved from https://archive.org/details/histoiredudvel00ladeuoft

119. A. Ladenburg, *Lektssii po Istorii Razvitiya Khimii ot Lavuaz'ye do nashego vremeni*, Perevod s 4-go izdaniya, Ye. S. Yel'chaninova, s prisoyedineniyem otherka i storii khimii v Rossi akad. P. I. Val'dena, Mathesis, Odessa, 1917, (in Russian). Retrieved from http://193.233.14.50/reader/.../index.html

120. A. Ladenburg, *Handwörterbuch der Chemie* Herausgegeben von Professor Dr. Ladenburg Unter Mitwirkung von Berend, Biedermann, Drechsel, Emmerling, Engler, Gnehm, Heumann, Jacobsen, Pringsheim, v. Richter, Rügheimer, Salkowski, Tol-lens, Weddige, Wiedemann, Erster Band, Verlag Von Eduard Trewendt, Breslau, 1882. Retrieved from https://archive.org/details/bub_gb_NLIEAAAAYAAJ

121. A. Ladenburg, *Handwörterbuch der Chemie*, Dreizehn Band, Verlag von Eduard Trewendt, Breslau, 1895.

122. A. Ladenburg, *Handwörterbuch der Chemie Herausgegeben Unter Mitwirkung von Abel, Ahrends, Alexander, Anschütz, Balbiano, Baurath, (...)*, Wol-lhy, Generalregister, Verlag Von Eduard Trewendt, Breslau, 1896. Retrieved from https://archive.org/details/handwörterbuchde01ladegoog/page/n6/mode/2up

123. A. Kekulé, Über die Konstitution und die Metamorphosen der chemischen Verbindungen und über die chemische Natur des Kohlenstoffs. Untersuchungen über aromatische Verbindungen, Herausgegeben von A. Ladenburg, Ostwalds Klassiker der Exakten Wissenschaften, Bd. 145, Verlag von Wilhelm Engelmann, Leipzig, 1904. Retrieved from https://archive.org/details/bub_gb_Uj4EAAAAYAAJ_2/page/n17/mode/2up

124. L. Pasteur, Über die Asymmetrie bei natürlich vorkommenden organischen Verbindungen, 2 Vorträge gehalten am 20. Januar und 3. Februar in der Société chimique zu Paris, übersetzt und herausgegeben [translated and edited by] von M. und A. Ladenburg, Ostwalds Klassiker der Exakten Wissenschaften, Bd.28, Verlag von Wilhelm Engelmann, Leipzig, 1891. Retrieved from https://archive.org/details/bub_gb_TqwFAAAAIAAJ/page/n1/mode/2up?q

125. K. A. Wurtz, Abhandlung über die Glycole oder zweiatomige Alkohole und über das Aethylenoxyd als Bindeglied zwischen organischer und Mineral-chemie, Aus dem französischen Übersetzung mit Anmerkungen versehen von M. u. A. Ladenburg, Ostwalds Klassiker der Exakten Wissenschaften, Bd. 170, Verlag W. Engelmann, Leipzig 1909.

126. M. Berthelot, L. Péan de Saint-Gilles, Untersuchungen über die Affinitäten. Über Bildung und Zersetzung der Äther, übersetzt und heraus-gegeben von M. und A. Ladenburg, Ostwalds Klassiker der Exakten Wissenschaften, Bd. 173, Verlag von Wilhelm Engelmann, Leipzig, 1910.

127. Leopoldina. Nationale Akademie der Wissenschaften. *List of Members*. 2020. Retrieved from https://www.leopoldina.org/en/members/list-of-members/list-of-member/member/Member/show/albert-ladenburg/

128. *Report of the Seventieth Meeting of the British Association for the Advancement Science*. John Mur-ray, London, 1900, p. 106. Retrieved from https://archive.org/details/reportofbritish00sctie/page/106/mode/2up

129. Liste des membres depuis la création de l’Académie des sciences. Les membres du passé dont le nom commence par L., n.d. Retrieved from https://www.academie-sciences.fr/fr/Liste-des-membres-depuis-la-creation-de-l-Academie-des-sciences/les-membres-du-passe-dont-le-nom-commence-par-l.html

130. *Mitglieder der Berliner Akademie – alphabetisch*. 2020. Retrieved from https://www.bbw.de/die-akademie/akademie-historische-aspekte/mitglieder-historisch/mitglieder-der-berliner-akademien-alphabetisch?tx_bbw_historicmemberlist%5Bcontroller%5D=HistoricMember&tx_bbw_historicmemberlist%5BoverwriteDemand%5D%5Bcharacter%5D=L&cHash=a1367dfc03e116dbed063c8ef15be95f

131. See ref. 39 (Herz), p. 3635.

132. *Memoirs and Proceedings of the Manchester Literary & Philosophical Society* (Manchester Memoirs). Volume XLIX, Manchester, 1905, p. lxiv. Retrieved from https://archive.org/details/memoirsprocee-49190405manc/page/n303/mode/2up

133. *List of the Officers and Fellows of the Chemical Society*. 1900. Burlington House, London, p. 9. Retrieved from https://archive.org/details/b24857853/page/8/mode/2up

134. *Comité des travaux historiques et scientifiques*, n.d. Retrieved from https://cths.fr/an/societe.php?id=345&proso=y#L

135. *Standard Measuring Instruments, Science, New Series*, 1899, 10(243), p. 259. Retrieved from https://www.jstor.org/stable/1626170
136. See ref. 3 (The Hanbury Medal). p. 1030.
137. The Royal Society Medals. The British Medical Journal, 1905, 2(2341), p. 1310. Retrieved from https://www.jstor.org/stable/20287360
138. W. Huggins, Sir, Proceedings of the Royal Society. A Mathematical, Physical and Engineering Sciences, 1906, 77(515), p. 119. https://doi.org/10.1098/rspa.1906.0007
139. E. F. Lange, R. F. Buyers, The Scientific Monthly, 1955, 81(2), p. 87. Retrieved from https://www.jstor.org/stable/21857
140. Nomination Archive. Nomination for Nobel Prize in Chemistry, 2020. Retrieved from https://www.nobelprize.org/nomination/archive/show.php?id=508
141. The Nobel Prize in Chemistry 1907. Eduard Buchner, 2020. Retrieved from https://www.nobelprize.org/prizes/chemistry/1907/summary/
142. Eduard Buchner. Biographical, 2020. Retrieved from https://www.nobelprize.org/prizes/chemistry/1907/buchner/biographical/
143. See ref. 11 (Anschütz), p. 507.
144. See ref. 39 (Herz), p. 3597.
145. See ref. 1 (Kipping), p. 1872.
146. C.A. Russell, Br. J. Hist. Sci. 1988, 21(3), p. 276. Retrieved from https://www.jstor.org/stable/4026830
147. Ladenburg, Albert, n.d. Retrieved from Digiporta Digitales Porträarchiv website: http://www.digiporta.net/index.php?id=991281888
148. Ladenburg, Albert, n.d. Retrieved from Digiporta Digitales Porträarchiv website: http://www.digiporta.net/index.php?id=268632181
149. Ladenburg, Albert, Österreichische Nationalbibliotek, n.d. Retrieved from https://digital.onb.ac.at/rep/osd/?1104B2E1
150. H. M. Smith, Torchbearers of Chemistry. Portraits and Bibliography of Scientists Who Have Contributed to the Making of Modern Chemistry, Academic Press Inc., Publishers, New York, 1949, p. 142.
151. A. Ladenburg, E. Buchner in Festschrift zur Feier des hundertjährigen Bestehens der Universität Breslau, Zweiter Teil, Geschichte der Fächer, Institute und Ämter der Universität Breslau 1811 – 1911, (Ed.: G. Kaufmann), Ferdinand Hirt, Königliche Universitäts- und Verlagsbuchhandlung, Breslau, 1911, pp. 451-457. Retrieved from https://www.bibliotekacyfrowa.pl/dlibra/publication/104025/edition/96447/content
152. A. Ladenburg, Ber. dtsch. chem. Ges. 1880, 13(1), p. 1086. https://doi.org/10.1002/cber.188001301300
153. Quoted in ref. 3 (The Hanbury Medal), p. 1030.
154. Quoted in ref. 39 (Herz), p. 3636.
155. Anon., Nature, 1911, 87, p. 282. https://doi.org/10.1038/087282a0
156. See ref. 39 (Herz), p. 3598.
157. B. Litzmann, Clara Schumann, Johannes Brahms, Band 2: Briefe aus den Jahren 1872-1896, Erste Auflage, Dearbooks, Bremen, 2013, p. 587.
158. Ladenburg flask. Merriam-Webster.com Dictionary, n.d. Retrieved from Merriam-Webster website: https://www.merriam-webster.com/dictionary/Ladenburg%20flask
159. flask, distillation, ladenburg’s, n.d. Retrieved from National Museum of American History website: https://americanhistory.si.edu/collections/search/object/nmah_897