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HISTORY OF CHEMISTRY AND CHEMICAL TECHNOLOGY

Theodor Grotthuss (to 220th Anniversary of His Birthday)

Theodor Grotthuss, a talented scientist, physicist, and chemist from the Baltic region, went down in history as the author of an original theory of electrolysis of aqueous solutions and of studies in the field of photochemistry and analytical chemistry. The theoretical ideas presented in his works largely foreshadowed the physical theory of solutions, concepts of electrolytic dissociation, and understanding of the phenomenon of luminescence and chemical action of light. Grotthuss made first observations in the field of electrochemistry of organic compounds. A major contribution to the study of the scientific legacy of Grotthuss and his life was made by J.P. Stradins, a known Latvian electrochemist and historian of science [1–5].

Baron Christian Johann Dietrich von Grotthuss, more known as Theodor Grotthuss, was born on January 24, 1785, in Leipzig, during a trip of his parents abroad. His family, belonging to an ancient house, owned a small estate Geduchi (Geduchai) in northern Lithuania, at the very border with Kurlandia. At this estate passed the youth and most part of the scientist's life. His father died soon after his birth, and Grotthuss was brought up by his mother and numerous teachers. Despite the humanitarian orientation of his home education and the obvious talent for music, the youth was strongly interested in natural sciences and self-educated using his father's library. In the spring of 1803, the eighteen-years-old Grotthuss first went to West Europe to be educated in natural sciences, and primarily in chemistry. The first stop was in Leipzig, but, at that time, the city was not yet among prominent centers of chemical science. Therefore, Grotthuss moved in the autumn of the same year to Paris, where he entered as an external student the Ecole Polytechnique, one of the best educational institutions of that time. Among Grotthuss's teachers are primarily named A.-F. de Fourcroy (1755–1809), a scientist, statesman, science popularizer, member of the Paris Academy of Sciences (since 1785), and an honorary foreign member of the St. Petersburg Academy of Sciences (since 1802); and also C.L. Berthollet (1748–1822) and L.N. Vauquelin (1763–1829), members of the Paris Academy of Sciences. Grotthuss

spent in Paris only a year, and the aggravation of relationships between France and Russia forced him, a Russian citizen, to move to Italy in September 1804.

After A. Volta (1745–1827), an Italian physicist, created the first chemical dc power cell (1799), scientists from many countries, and those from France and Italy in the first place, studied, with varied success, the electrolysis process. Grotthuss knew from lectures delivered by Fourcroy, Berthollet, and Vauquelin about difficulties encountered in explanation of electrochemical phenomena. Having acquired a power cell, Grotthuss carried out numerous experiments on electrochemical decomposition of aqueous solutions. He spent the whole year of 1805 in Naples and finished there his best-known study in September 1805. He, a twenty-years-old youth who had not received any systematic education, managed to be the first to give an interpretation of the electrolysis process and current transport in solutions. According to Grotthuss, electric energy is transferred through formation of chains of polar molecules in solutions. The decomposition of water at electrodes occurs via liberation of molecular fragments at places of direct contact between the chains and the electrodes [1, 2, 6–9]. This first study under the title "On Decomposition of Water and Substance Dissolved in It under the Action

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of Galvanic Electricity," published in French in Rome in the end of 1805, made him famous. Already in April 1806, Grotthuss's work was published in France in the journal *Annales de Chimie*; in the same year, it was published in British journals and, as a separate edition, in France in scientist's motherland at the town of Mitava (Elgava), the capital of Kurlandia. This work by Grotthuss was included, in Russian translation, into the collection of works [9]. Before that, the study had not been published in Russia, but Grotthuss's hypothesis was discussed in detail in the first Russia's textbook on physical chemistry [10].

From November 1805 till the end of 1806, Grotthuss lived in Rome and other Italian cities, improved his knowledge of Italian and mathematics, and commenced examination of bioluminescence. The young scientist spent nearly the whole year of 1807 in Paris, where he continued his scientific activities and, in particular, tried to reveal the role of galvanic electricity in formation of metallic dendrites. In addition, Grotthuss carried one of the first studies in organic electrochemistry. In 1807, Grotthuss was elected an honorary member of the Paris galvanic society. In the autumn of 1807, he left Paris and went home via Munich and Vienna. Since 1808, he never left Russia. As mentioned in Stradins's monograph [1], Grotthuss neither finished his education nor got scientific training or obtained a scientific degree. However, the talented young man was actively engaged in self-education, made acquaintance with a number of leading scientists of that time, comprehended the most topical problems in the fields of science he was interested in, and carried out investigations that got him a deserved fame. In 1814, Grotthuss was elected a corresponding member of the Munich Academy of Sciences.

Grotthuss lived without break at his mother's estate and encountered severe difficulties in obtaining scientific information, only being in correspondence with several scientists, and possessed only the simplest equipment. The only Grotthuss's far travel, to St. Petersburg for six months in 1812, occurred when he was compelled to go by the approaching French troops. During these months he made friends with A.I. Sherer (1772–1824), a professor of chemistry and later (since 1815) a member of the St. Petersburg Academy of Sciences. Sherer was the author of the first original textbook of chemistry in Russia, in which he, in particular, presented the oxygen theory developed by A.L. Lavoisier (1743–1794). A regular correspondence between Grotthuss and Sherer continued till the end of Grotthuss's life. A number of papers by Grotthuss were published in the journal published for a while by Sherer.

In 1817, Kurländiche Gesellschaft für Literatur und Kunst (Kurlandian Society of Literature and Fine Arts) was organized at Mitava. In conformity with its regulations, the society was to be engaged in historical-literature, scientific, and educational activities. During the first years of existence of the society, the natural-science area of these activities was predominant. Grotthuss became one of the most active members of the society. He repeatedly reported on his research activities at meetings of the society and published some of his works in the *Annual Report of the Society*. In particular, the most important of his investigations, "On the Chemical Action of Light and Electricity," was published in German in the first volume of this edition (1819). In this paper, occupying the central position in his scientific works, his ideas concerning the origin of photochemical and electrochemical phenomena were presented. Grotthuss was the first to establish that only absorbed light causes chemical transformations, he also noticed the proportionality of the photochemical effect to time. Important results of photochemical studies were also published by Grotthuss in one of his earlier papers "On an Absorbent of Light and Some General Considerations Concerning the Phosphorescence and Colors" (1815). Photochemical studies by Grotthuss have been analyzed by B.Ya. Dain [11] and Stradins [1].

The second in importance to Grotthuss's investigations in the field of electrochemistry, theory of light, and photochemistry are his studies of combustion of gas mixtures, carried out in 1809–1812. The widely diverse scientific activities of the Baltic scientist are discussed in ample detail in a monograph devoted to him [1]. Among prominent Grotthuss's publications, mention should be made of the collection of his physicochemical works [12] (only the first volume was published) and a separate volume, including works by Grotthuss, in the series of publications, *Klassiker der exacten Wissenschaften* (1906), founded by W. Ostwald. After this book was published, the attention of physical chemists and historians of science to Grotthuss's works became markedly closer. Grotthuss's activities were highly appreciated by Russian academician P.I. Walden (1863–1957). He believed that works by Grotthuss "...are exactly formulated predecessors of our modern molecular-kinetic and electrolytic theories" [13]. At the same time, Grotthus had to defend repeatedly, frequently without any good reason, his priority in separate issues.

Beginning at the age of 17, the scientist suffered from a severe hereditary abdomen illness, whose true nature remained unclear. On March 14, 1822, Grotthuss shot himself being in the state of a deep depres-

sion. He had virtually no disciples and followers. The interest in most of the problems Grotthuss studied arose only in the late XIX century, when physical chemistry formed as an independent scientific discipline. The list of Grotthuss's scientific works was given in the monograph [1], with some supplements made in [4]. The main publications by Grotthuss were listed in a reference bibliographic publication by Poggendorff [14]. The material concerning the life and scientific activities of Grotthuss is included, together with his scientific biography [1], in quite a number of reference publications [5, 15, 16] and monographs [6, 8, 17].

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A. G. Morachevskii