Carl Schorlemmer (1834-1892) – The Red Chemist

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Abstract.
This article presents the life and work of Carl Schorlemmer, one of the least remembered chemists in Organic Chemistry from the second half of the 19th century. His decisive investigation of alkanes as a basis for an organization of Organic Chemistry, other experimental investigations, his theoretical points of view, his activity as a historian of Chemistry and his relations with socialism are discussed.

Keywords: History of Chemistry – Organic Chemistry – Carl Schorlemmer – Alkanes – Historiography of Chemistry – Chemistry and Socialism.

INTRODUCTION.

On July 1, 1892, chemist Carl Schorlemmer, professor of Organic Chemistry at the University of Manchester, who died on June 27, 1892, at his home in Manchester, aged 57, was buried in the Southern Cemetery in Manchester. The *Manchester Guardian* newspaper reported his death on June 28th; there is the obituary published in *Nature* by his friend Roscoe[1], the biographical article (1893) by Professor Harold Dixon (1852-1930)[2], the detailed biographical text by A. Spiegel in *Berichte*[3], but the obituary that is recorded in History is the article published by Friedrich Engels (1820-1895) in the July 3, 1892 edition of the newspaper *Vorwärts*, the official organ of the German Social Democratic Party:

"Organic Chemistry was finally in a position to become a true science, based on an isolated pile of data, more or less incomplete, on the composition of organic compounds. Schorlemmer chose the simplest of these bodies as the object of his research, convinced that they lay the foundations of the new science: bodies initially formed by carbon and hydrogen, but by replacing part of the hydrogen with other simple groups or compounds, they transform into the most various substances. These are paraffins, the most important of which are found in petroleum, and from which alcohols, fatty acids, ethers, etc. can be obtained. What we know about these paraffins today we owe mainly to Schorlemmer. He analyzed the already known compounds of the paraffin series, separated them from each other, and obtained many of them for the first time in a pure state; the bodies possible according to the theory, but still unknown, he synthesized them too. He thus became one of the founders of current scientific Organic Chemistry"[4]. We should not be surprised by Engels' facility with scientific terminology, it results from long and detailed studies on science and especially the History of Science.

Engels' text, from which we extract only a part, is doubly important, both from a scientific and political point of view, with regard to the interaction between socialism and natural science. This possible relationship allows us to analyze some aspects of the practice of scientific research.

Schorlemmer is not much remembered in the history of 19th century Organic Chemistry, but that does not mean he is any less important. Apparently, the occupation with hydrocarbons, even more so with alkanes, seems to be a restricted topic, but Schorlemmer's exhaustive research work shows that this is not the case, that the topic is quite comprehensive.

ORIGIN AND TRAINING

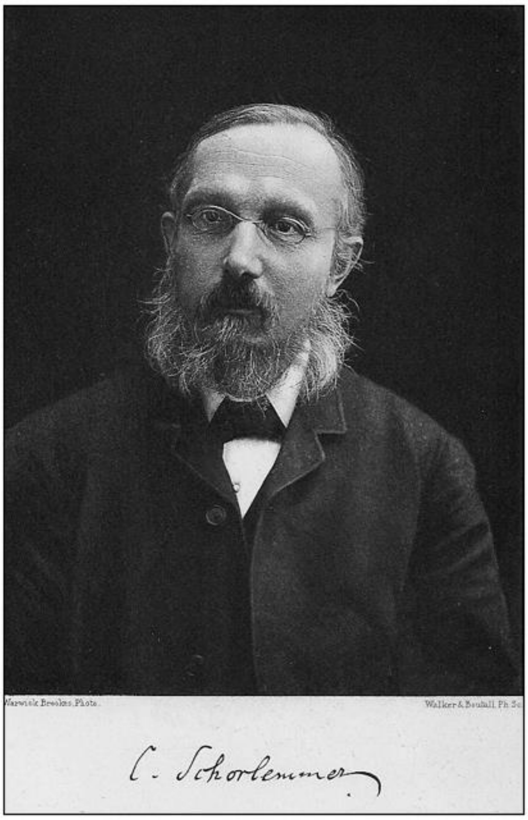


Fig. 1 - Carl Schorlemmer (1834–1892), photographed by an unknown author. Courtesy of the Oesper Collection for the History of Chemistry, University of Cincinnati.

The oldest son of carpenter Johannes Schorlemmer, Carl Schorlemmer was born on September 30, 1834 in Darmstadt – the city that gave us other notable chemists, such as Liebig and Kekulé, and gave its name to element 110. After elementary school at the *Volksschule*, he attended the *Realschule*, and from 1850 to 1853, under his mother's influence and against his father's wishes, the School of Crafts (*Höhere Gewerbeschule*) in Darmstadt, where he learned the foundations of science. The father was against new studies, he wanted his son to occupy himself with practical activities.

At the suggestion of his friend Wilhelm Dittmar (1833-1892), in 1854 he went to work as a pharmacist's apprentice with the pharmacist Lindenborn in Gross-Umstadt, near Darmstadt. After two and a half years of activity, he passed the exam to practice as a pharmacist, which allowed him to take over a pharmacy in Heidelberg, *Schwan-Apotheke* (Swan Pharmacy). As a pharmacist, he attended classes taught by Robert Bunsen (1811-1899) at the University of Heidelberg, and his interest in Chemistry led him to leave pharmacy and enrol at the University of Giessen in 1859, where he studied with Heinrich Will (1812-1890) and also with Hermann Kopp (1817-1892), who transmitted to him his enthusiasm for the history of Chemistry. He only attended university for one semester: in 1859 he moved to England. He was 25 years old at the time, and from a young age he openly defended socialist ideas, which closed his path to academic life in his country, leading him to emigrate.

ARRIVAL IN ENGLAND.

Fig. 2 - Carl Schorlemmer (1834–1892), photographed by Carl Spielmayer. From “The Rise and Development of Organic Chemistry” (1894). Courtesy of the Wellcome Foundation, London.

Like many German chemists who carried out their professional career partially (A.W.Hofmann, H.Caro, C.A.Martius) or entirely (P.Griess, L.Mond, H.Müller) in England, because of the advanced chemical industry that already existed there, also Schorlemmer went there, although for other reasons. Schorlemmer's entire scientific career was spent in England, and almost all of it in Manchester. As soon as he arrived, he was an assistant to the Scottish chemist Robert Angus Smith (1817-1894), an independent analyst in Manchester and one of the pioneers of Environmental Chemistry (creator of the concept of 'acid rain’, 1852; chief inspector of the Alkali Inspectorate, 1863). Smith had studied with Liebig in Giessen from 1839 to 1841[5]. In 1861 luck smiled at Schorlemmer: he had become the assistant of Professor Henry Enfield Roscoe (1833-1915) at Owens College, the future University of Manchester, whose occupant, Wilhelm (William) Dittmar, almost a fellow countryman of Schorlemmer (he was from Gross-Umstadt), who had accepted an invitation from the University of Edinburgh. Before leaving for Scotland, he recommended the name of his friend Schorlemmer to Roscoe. From 1861 to 1873 Schorlemmer was Roscoe's 'demonstrator' and assistant, and in 1874 he became the first professor of Organic Chemistry at Owens College, a position he held until his death, thus taking over all teaching of Organic Chemistry, with Roscoe having the responsibility for Inorganic Chemistry (Owens College was founded in 1824, and after merger with other institutions it gave rise to Victoria University in Manchester in 1903). From assistant and collaborator, he became a close friend of Roscoe. Owner of an exceptional memory and vast knowledge, he was an excellent teacher, and his classes were highly appreciated by his students (he was then the only teacher of Organic Chemistry in England).

He remained single and died of lung cancer. A convinced socialist since his youth, he was a member of the Social Democratic Party of Germany (1889), and a close friend and scientific advisor to Friedrich Engels (1820-1895), who worked in Manchester in the family business (1844, 1856-1870), and Karl Marx (1818-1883). He spent holidays with Marx and Engels in London, traveled abroad with Engels and was one of thirteen people who attended Marx's funeral in London.

Fig. 3 - Sir Henry Enfield Roscoe (1833–1915), photographed circa 1880 by Walery (Stanislaw Ostorog, 1863–1929). Courtesy of the Wellcome Foundation, London (image in the public domain).

In 1879 he became a naturalized British citizen. He was a member of the Manchester Literary and Philosophical Society (1870), of the German academy *Leopoldina* (1887), since 1871 of the Royal Society (at the age of 34 a notable achievement), and of the American Philosophical Society (1878). He received an honorary doctorate from the University of Glasgow. In 1895, the Schorlemmer Memorial Laboratory, designed by the famous Victorian architect Alfred Waterhouse (1830-1905)[6], opened at Owens College. In Germany, the Merseburg Polytechnic (1954/1994) was named after “Carl Schorlemmer” (1964), and there is a bronze statue of Schorlemmer in Merseburg, by Heinz Beberniss (1920-2012), erected in 1972. In the decades from 1950 to 1970, in the former

German Democratic Republic, Schorlemmer's life and work once again aroused the interest of historians, sometimes with hagiographic and out-of-context conclusions, because of his involvement with socialism.

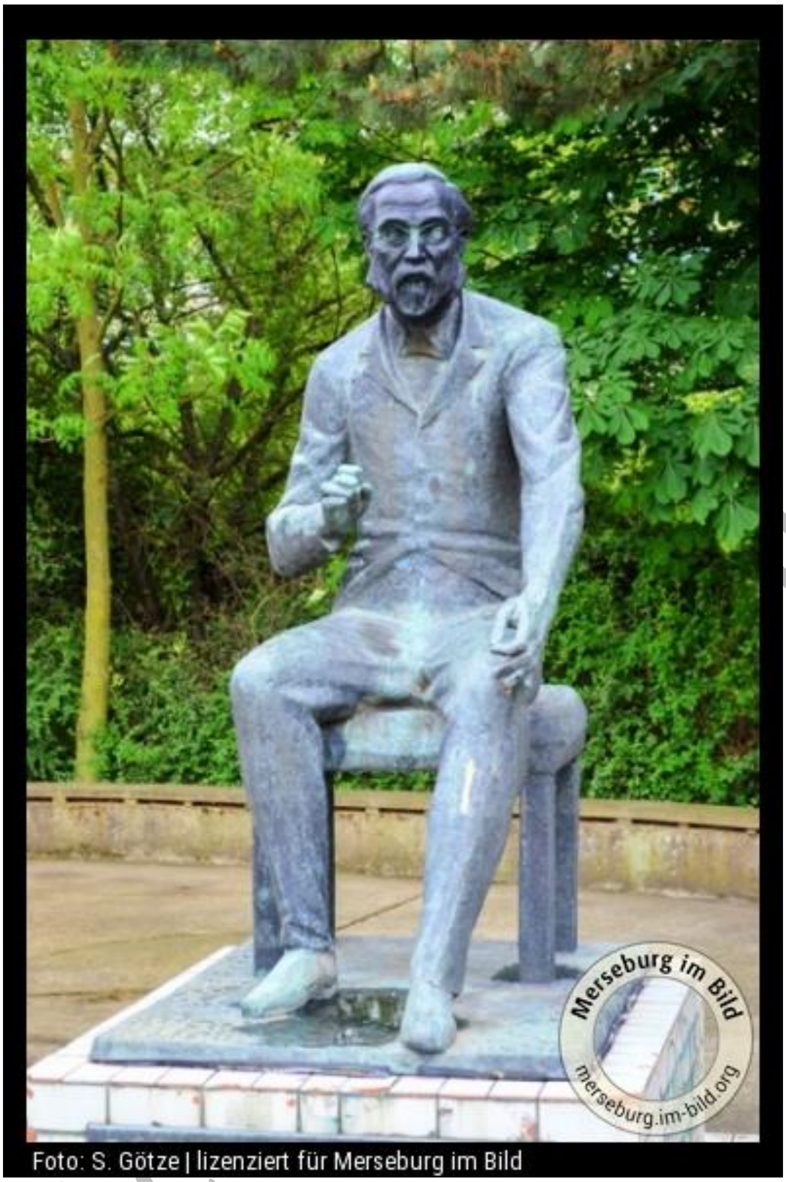


Fig. 4 - Statue in honor of Carl Schorlemmer, created by Heinz Beberniss (1920–2012) and erected in 1982 in front of the main entrance of the Leuna Industrial Complex in Merseburg. Courtesy of and photographed by www.merseburg-im-bild, reproduced with permission.

SCHORLEMMER'S SCIENTIFIC WORK.

Schorlemmer's experimental work in Organic Chemistry is not very vast, but exhaustive in the subjects it explores, also clarifying a series of theoretical aspects. His researches were published in more than 120 articles, which can be distributed into three groups:

- investigations of hydrocarbons, mainly alkanes;
- investigation of other compounds in some way linked to hydrocarbons: alcohols, aldehydes, carboxylic acids and others;
- dyes and other loose items.

Investigations into hydrocarbons of the C_nH_{2n+2} series (alkanes).

Speaking of Schorlemmer brings to mind alkanes, and occupation with alkanes brings to mind Schorlemmer, the great authority on alkanes. From 1861 to 1871 Schorlemmer systematically studied alkanes (the name “alkane” was a proposal by August Wilhelm Hofmann, 1866), both from an experimental and theoretical point of view, and from the set of observations and conclusions regarding a group of compounds apparently little reactive, an impressive corpus of knowledge emerged about a group of organic compounds, to which as research progressed, Schorlemmer included what was already known about these compounds before him. The first alkane to be discovered was “swamp gas”, our methane, collected in 1776 by Alessandro Volta (1745-1827) from the marshy waters on the shores of Lake Maggiore, where it is formed by anaerobic decomposition of submerged vegetables. John Dalton (1766-1844) also collected “swamp gas” (marsh gas, fire gas) from swampy waters, as shown in the mural by Ford Madox Brown (1821-1891) in Manchester City Hall.

In 1809, the chemist and mineralogist Johann Nepomuk von Fuchs (1774-1856) discovered in the oil of Tegernsee, in Bavaria, a solid residue that he called *Bergöl* or *Bergfett* (literally “mountain oil”), analyzed in 1820 by the pharmacist Johann Andreas Buchner (1783-1852). Better known became paraffin, discovered in 1830 by Karl von Reichenbach (1778-1869) in wood tar, and studied in 1832 in Giessen by Jules Gay-Lussac (1810-1877), son of Louis-Joseph Gay-Lussac and a student of Liebig, who determined a formula C_nH_{2n+2}, compatible with alkanes, but which Gay-Lussac interpreted as a mixture of C_nH_{2n} and hydrogen. The name ‘paraffin’ is from Reichenbach, meaning ‘little reactivity’ (*parum affinis*). The structure was determined in 1849 by Benjamin Brodie (1817-1880). The mineralogist Wolfgang Franz von Kobell (1803-1882), from the University of Munich, considered *Bergfett* to be identical to paraffin.

The first synthetic alkane was obtained in 1848 by Hermann Kolbe (1818-1884), who by electrolysis of sodium acetate obtained a C_2H_6 compound that he called “methyl” (our ethane). In 1850, Edward Frankland (1825-1899), treating methyl iodide CH_3I with sodium also obtained a compound C_2H_6, calling it 'methyl methide', also our ethane. Thus Schorlemmer himself in “Rise and Development of Organic Chemistry”[7] reports that the second simplest alkane, ethane, was thought to exist in two forms:

$$\text{dimethyl}\quad \begin{matrix}CH_3\\CH_3\end{matrix}\quad \text{(Frankland)}\qquad\qquad \text{ethyl hydride}\quad \begin{matrix}C_2H_5\\H\end{matrix}\quad \text{(Kolbe)}$$

Schorlemmer himself obtained ethane using the Frankland method, reacting diethylmercury with sulfuric acid, confirming the equality between the two forms[8].

Thus, this was the knowledge about alkanes when Carl Schorlemmer began his systematic investigations into hydrocarbons with the formula CnH_2n+_2 in 1861. He began his studies with the lighter fractions obtained from the distillation of coal tar, initially finding that the lighter fractions were identical to the light fractions from petroleum distillation[9]. The valid theory at the time, the type theory, reinforced by Edward Frankland's misinterpretations when studying hydrocarbons, predicted the existence of two series of compounds with the general formula C_nH_{2n+2}, alkyl hydrides and radicals.

In the case of C_7H_{16}, often cited by Schorlemmer, there were many possibilities of a hypothetical isomerism, for example:

C_7H_{15} H	C_2H_5 C_5H_{11}
heptyl hydride	ethylpentyl

To analyze the behaviour of light tar compounds, he isolated pentane, hexane, heptane and octane, observing that when they react with chlorine, they all form monochlorides. He also suggested that Reichenbach's paraffin is a superior member of this series of compounds.

The chemical literature cites the study of the chlorination of methane by Marcellin Berthelot (1827-1907), giving rise to methyl chloride, which in turn allows many other derivatives to be obtained, and the method can be applied to methane homologues, thus being a general method of obtaining organic compounds[10]. Before Berthelot, the same method had been used by Schorlemmer to obtain heptyl acetate and heptyl alcohol, from the corresponding hydride[11].

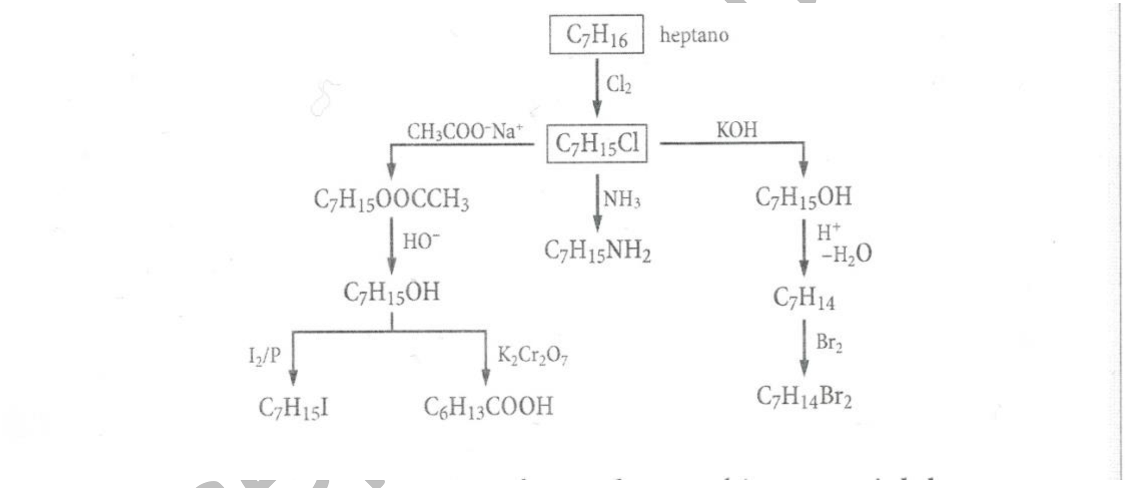


Fig. 5 - Organic compounds derived from heptane.

In the context of these investigations, Schorlemmer published in 1863 one of the most interesting articles in the history of Organic Chemistry, showing the incredible synthetic possibilities of heptane, normally considered to be very unreactive[12]. The Table shows the compounds obtained from 'heptyl hydride', with chlorination as the first step, according to a method developed by Hugo Müller (1833-1915), a German chemist active in London[13]. In a more theoretical field of this investigation, Schorlemmer managed to prove in 1864, with the aid of chlorination reactions, that there are no two series of C_nH_{2n+2} compounds in the hydrogen type[14]. Analyzing the halogenation products, for example, 'heptyl hydride' and 'ethylpentyl', the formation of the same chloropentane is always observed. Chlorination of 'ethylpentyl' does not form ethyl chloride and pentyl chloride. There is, therefore, only one series of hydrocarbons with the general formula C_nH_{2n+2}, that is, ‘hydrides’ and ‘radicals’ are identical[15]. This discovery was fundamental for a correct systematization of alkanes.

Just as he studied heptane and heptane derivatives from different sources (petroleum and coal tar), Schorlemmer also studied amyl compounds derived from pentane obtained from petroleum[16], and compared them with the same compounds obtained from fusel oil that accompanies amyl alcohol, obtained by Scheele in 1775 by fermentation (today it is known that it is isoamyl alcohol). He found that in both cases the physical constants of derivatives such as amyl chloride (B.P. 101°C), amyl alcohol (B.P. 132°C), ethyl ester (M.P. 140°C) were identical. These studies seem at first glance to be of no greater importance, but this step-by-step process involving qualities and composition/structure of derivatives of simpler compounds in Organic Chemistry were essential in helping to establish the foundations of this discipline. Schorlemmer arranged the data in a table[17]:

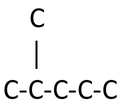
AMYLIC COMPOUNDS

	FROM FUSEL OIL		FROM PETROLEUM PENTANE	
	M.P.	density	M.P.	density
C_5H_{12}			34°C	0,6263 at 17°C
$C_5H_{11}Cl$	101°C	0,8750 at 20°C	101°C	0,8777 at 20°C
$C_5H_{11}O$				
C_2H_3	140°C	0,8733 at 15°C	140°C	0.8752 at 15°C
$C_5H_{12}O$	132°C	0,8148 at 14°C	132°C	0,8199 at 14°C

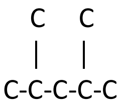
Based on this possibility of systematization, in 1868 Schorlemmer proposed a classification of these compounds into groups: alkanes with one, two or three carbons do not present isomers; those with more than four carbons are classified into groups: in the first group, the carbon atoms form normal chains; in the second group, one carbon atom is linked to three others (isopropyl group); in the third group, there are two isopropyl groups; in the fourth group, one carbon atom bonds to four others.

C-C-C-C-C

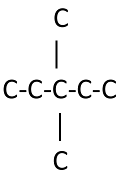
1st group


$$C{-}\overset{\overset{\displaystyle C}{|}}{C}{-}C{-}C{-}C$$

2nd group


$$C{-}\overset{\overset{\displaystyle C}{|}}{C}{-}C{-}\overset{\overset{\displaystyle C}{|}}{C}{-}C$$

3rd group


$$C{-}C{-}\underset{\underset{\displaystyle C}{|}}{\overset{\overset{\displaystyle C}{|}}{C}}{-}C{-}C$$

4th group

Thanks to this theoretical innovation by Schorlemmer, it was possible to understand the isomers of alkanes, and include alkanes synthesized by other chemists, such as Wurtz, Erlenmeyer, Butlerov, Friedel, Ladenburg, in the list of these compounds. Schorlemmer has already noticed the difference in reactivity at carbons 1 and 2 of the chain: in octane, for example, the substitution ratio at carbons 1 and 2 is 1:5 (current data: 1:4.3). It was also possible to establish a relationship between boiling points and structure, along the lines predicted by Hermann Kopp (1817-1892) in 1845[20]. This relationship is also useful for the classification of new alkanes. The amount of information obtained allows us to evaluate the great importance of Schorlemmer's article for the evolution of Organic Chemistry. The growing acceptance of Kekulé's structural theory drove alkane research forward, and Carl Magnus von Hell (1849-1926) in 1889 synthesized the hitherto longest alkane, hexacontane $C_{60}H_{122}$. Friedrich Krafft (1857-1923) had synthesized in 1888 a series of higher normal-chain paraffins[21]. A theoretical explanation for all these phenomena was not possible in the context of classical Organic Chemistry, but they could all be explained by the Ingold-Hughes electronic-structural theory, as first and second order nucleophilic substitutions (SN_1 or SN_2) and involving free radicals or carbocations as intermediates.

Oil.

Schorlemmer's research on alkanes began with the light fractions obtained in the destructive distillation of coal, mainly the C4 – C8 fraction. Then, for comparison, he researched petroleum distillation derivatives[22]. Samples of North American oil had already been studied by Théophile Jules Pelouze (1807-1878) and Auguste Cahours (1813-1891), who in 1861/1862 isolated pentane, hexane and heptane[23]. Lacking larger quantities of Pennsylvania oil, Schorlemmer used samples of Canadian oil. After distillation and several purification procedures, four compounds were obtained[24] from the fraction distilling below 129° C:

Amyl hydride	$C_{10}H_{12}$	B.P. 39° C	(pentane)
Hexyl hydride	$C_{12}H_{14}$	B.P. 68º C	(hexane)
Heptyl hydride	$C_{14}H_{16}$	B.P. 98º C	(heptano)
Octyl hydride	$C_{16}H_{18}$	B.P. 119º C	(octane)

The chemical behavior of normal-chain paraffins was subsequently studied and published in several articles in *Philosophical Transactions*:[25] Part I, in 1872; Part II, in 1878; Part III, in 1880; Part IV (with T. E. Thorpe, on *Pinus* heptane), in 1883. In summary, the conversion of paraffin successively into chloride, then into primary or secondary alcohol, then into carboxylic acid or ketone, by known methods is discussed.

Coincidentally, at the same time that Schorlemmer began to study saturated hydrocarbons, the petroleum industry began, in 1846 in the Caucasus and Canada, in 1854 in Galicia (Austria), in 1858 in Germany and the United States. Exploration and the oil industry had scientific guidance from chemists such as Dimitri Mendeleev (1834-1897), Vladimir Markovnikov (1838-1904), Alexander Butlerov (1828-1886), Carl Engler (1842-1925). There was no direct participation by Schorlemmer in the oil industry.

Schorlemmer's other research activities

Although Schorlemmer is considered the "chemist of alkanes", much more of his research must be recorded, often in some way linked to alkanes. It is not intended to present an exhaustive list of Schorlemmer's experiments, but some interesting cases deserve a more detailed comment.

In 1868, he independently demonstrated that there are two alcohols derived from propane, propyl alcohol and isopropyl alcohol, obtained simultaneously but in different proportions. Initially, propane is treated with chlorine, obtaining 1-chloropropane and 2-chloropropane (the latter predominates). The reaction of these with caustic soda forms propyl alcohol (new preparation method) and isopropyl alcohol respectively:

$$CH_3CH_2CH_3 \rightarrow CH_3CH_2CH_2\text{-}Cl \rightarrow CH_3CH_2CH_2\text{-}OH$$

$$CH_3CH_2CH_3 \rightarrow CH_3\underset{Cl}{C}HCH_3 \rightarrow CH_3\underset{OH}{C}HCH_3$$

He also found that the main product is, however, propylene dichloride, and that in the case of later alkanes there is always a substitution by chlorine on carbons 1 and 2. In the reaction of alkanes, substitution only occurs on carbon 2 (it is known today that minimal substitution also occurs on carbon 1). Alcohols could be identified through their oxidation products[26]. As before, the electronic-structural theory of Organic Chemistry explains these facts, which for Schorlemmer were empirical data, although proven. Schorlemmer also carried out chlorination at higher temperatures, between 100 and 200 ºC, when trichlorohydrin $C_3H_3Cl_3$ and tetrachloropropane were formed, among other products that were not identifiable at the time[27]. In "sextane" (= hexane) and other alkanes it was not possible to replace more than six hydrogen atoms with chlorine (a fact also observed by Pelouze and Cahours).

He also developed a procedure for converting isopropyl derivatives into normal propyl derivatives[28].

Alcohol obtained from castor oil.

One of the natural products most studied by chemists is castor oil (*Ricinus communis L.*), perhaps because it has been used for thousands of years, but I believe that the motivation was the uncertainty about which products were formed during its decomposition. Schorlemmer also played a part in solving the problem. Schorlemmer wrote: "There is perhaps no other known compound that is more frequently and exhaustively studied by various chemists, and yet whose structure is clouded by obscurity, than the alcohol obtained by distilling castor oil in the presence of caustic soda.[29]" The most accepted by chemists of that time were caprylic alcohol (octanol) and enanthic alcohol (heptanol).

For his doctoral thesis (1856), French pharmacist Jules Bouis (1822-1886)[30] studied castor oil in detail, including oxidation with a weak solution of nitric acid, in which sebacic acid and an alcohol are formed, which he identified as caprylic alcohol (octanol). He prepared derivatives of caprylic alcohol and studied its properties (1855)[31]. In another decomposition of castor oil, Bouis obtained not caprylic alcohol, but enanthic alcohol (heptanol)[32]. The Englishman Ernest Chapman also reports in 1865, as recorded by Schorlemmer, the formation of caprylic alcohol and enanthic alcohol in the decomposition of castor oil[33]. And where is Schorlemmer's participation? Hermann Kolbe (1818-1884), from the fragments obtained in the oxidation of the oil, suggests that a secondary alcohol must be formed, probably methylhexylcarbinol, which upon oxidation leads to a ketone. Schorlemmer considers Kolbe's interpretation correct, stating his conclusions in an article (1868)[34].

In Bouis's opinion, the first to chemically investigate castor oil was Alexandre Bussy (1794-1882), with his collaborator Louis René Le Canu (1800-1871)[35], in 1848. By distillation under reduced pressure, they obtained from the decomposition of the acid ricinoleic (the main constituent of castor oil, about 90%) heptanal and undecylenic acid, a reaction of commercial interest.

Friedrich Krafft (1852-1923), reviewing this entire subject, published an article on the distillation of castor oil under reduced pressure[36].

Ricinoleic acid $\rightarrow$ $CH_3\text{-}(CH_2)_6\text{-}CH_2OH + HOOC\text{-}(CH_2)_8\text{-}COOH$ Bouis, 1855

Ricinoleic acid $\rightarrow$ $CH_3CH(OH)\text{-}C_6H_{13} + HOOC\text{-}(CH_2)_8\text{-}COOH$ Kolbe, 1868
Schorlemmer

Ricinoleic acid $\rightarrow$ $CH_3\text{-}(CH_2)_5\text{-}CHO + CH_2{=}CH\text{-}(CH_2)_8\text{-}COOH$ Busy, 1848

[in our notation]

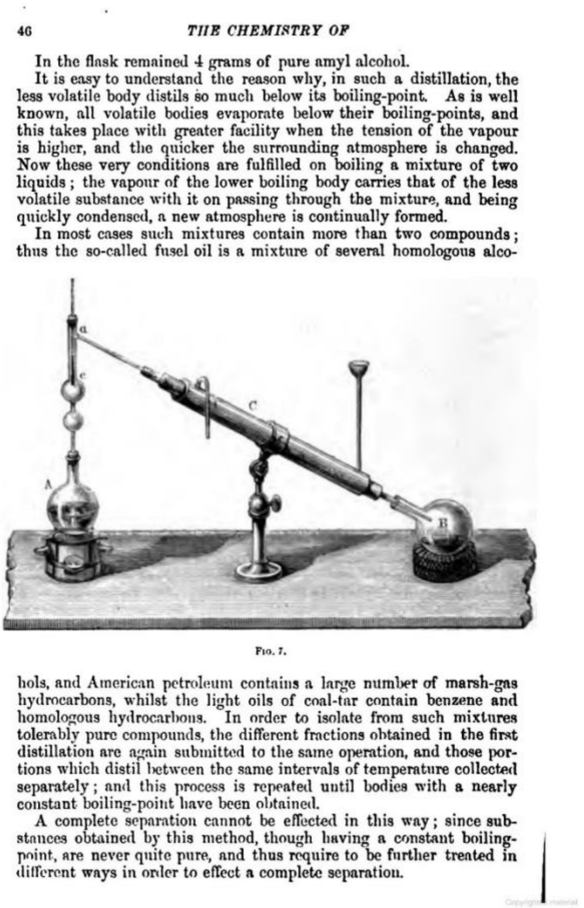
Formation of cetyl alcohol.

Let us finish this part of the description of Schorlemmer's work with an unusual procedure for the formation of cetyl alcohol. Warming sebacic acid, $C_{10}H_{18}O_4$, with barium hydroxide, $Ba(OH)_2$, the hydrocarbon C_8H_{18} and several other compounds are formed. A white crystalline compound, after purification, showed the properties of alcohols, and after analysis, it was found to be cetyl alcohol, $C_{16}H_{33}OH$. The obtaining of octane from sebacic acid finds other records in Organic Chemistry, including by Schorlemmer himself, but the formation of cetyl alcohol in this reaction is indeed surprising[37] (cetyl alcohol was discovered in 1817 by Chevreul).

Other research

In addition to the themes mentioned, Schorlemmer and collaborators dealt with others, although less intensively. With his student R. S. Dale he studied the aurine dye, and its transformation into rosaniline[38], with eight publications between 1871 and 1879; there are studies on suberone[39] (1874), on suberic and azelaic acids[40] (1879). There are also isolated investigations into a new method of obtaining methane (1873), into the boiling points of some paraffins and their derivatives (1872), among others.

SCHORLEMMER AUTHOR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In the flask remained 4 grams of pure amyl alcohol.

It is easy to understand the reason why, in such a distillation, the less volatile body distils so much below its boiling-point. As is well known, all volatile bodies evaporate below their boiling-points, and this takes place with greater facility when the tension of the vapour is higher, and the quicker the surrounding atmosphere is changed. Now these very conditions are fulfilled on boiling a mixture of two liquids; the vapour of the lower boiling body carries that of the less volatile substance with it on passing through the mixture, and being quickly condensed, a new atmosphere is continually formed.

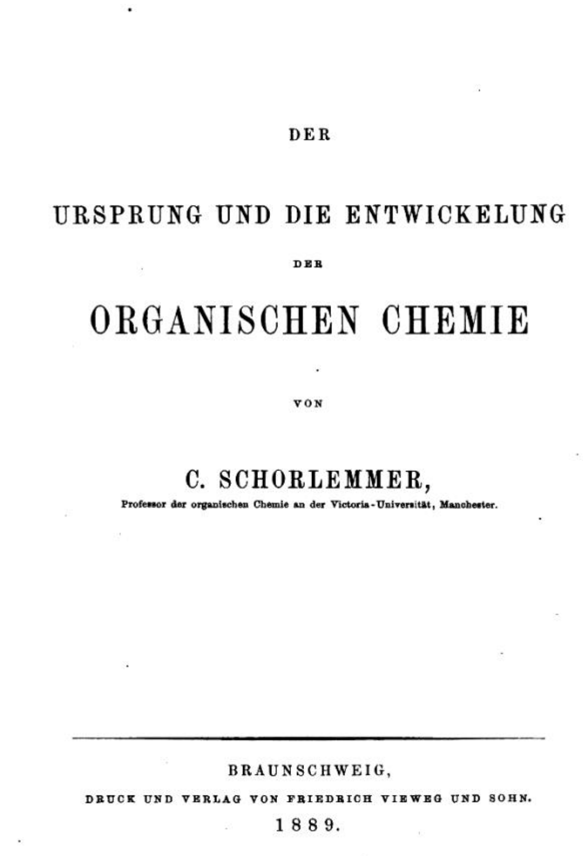
In most cases such mixtures contain more than two compounds; thus the so-called fusel oil is a mixture of several homologous alcohols, and American petroleum contains a large number of marsh-gas hydrocarbons, whilst the light oils of coal-tar contain benzene and homologous hydrocarbons. In order to isolate from such mixtures tolerably pure compounds, the different fractions obtained in the first distillation are again submitted to the same operation, and those portions which distil between the same intervals of temperature collected separately; and this process is repeated until bodies with a nearly constant boiling-point have been obtained.

A complete separation cannot be effected in this way; since substances obtained by this method, though having a constant boiling-point, are never quite pure, and thus require to be further treated in different ways in order to effect a complete separation.

Fig. 6 - Page 46 of Carl Schorlemmer's book, "The Chemistry of Organic Compounds", depicting equipment for fractional distillation.

From the beginning of the 1880s Schorlemmer began to dedicate himself more and more to his texts, leaving aside his laboratory activity. In addition to smaller writings, he left two major works of permanent importance in the historiography of Chemistry, one of them in partnership with his colleague and friend Henry Enfield Roscoe (1833-1915). Roscoe and Schorlemmer published from 1877 onwards an exhaustive treatise on Chemistry, simultaneously in German and English, "*Ausführliches Lehrbuch der Chemie*" in German, "*A Treatise on Chemistry*" in English. The first volume was initially published in German, in 1877, by *Friedrich Vieweg & Sohn*, Braunschweig, and in 1878 in English, by *D. Appleton and Company*, New York. Volume II followed in 1879, volume III in 1884, volume IV in 1886. Volume V was published in 1896, after the death of Schorlemmer, who was replaced by Julius Wilhelm Brühl (1850-1911), professor at Heidelberg. In volumes VI (1898), VII (1900), VIII (1901) and IX (1901), Julius Brühl replaced Schorlemmer in what is now "*Roscoe-Schorlemmers Ausführliches Lehrbuch der Chemie*". Mention should also be made of the collaboration, from volume V onwards, of the Finns Edvard Hjelt (1855-1921) and Ossian Aschan (1860-1939). Volume I has a 34-page preface on the history of chemical science, and in the other topics there is always information of a historical nature.

The second work of importance is a work linked to the History of Chemistry, more precisely to the history of the chemistry of carbon compounds, "*The Rise and Development of Organic Chemistry*", published in Manchester in 1879. In 1885 a French translation appeared, "*Origine et Dévelopement de la Chimie Organique*", published in Paris, translated by Alexandre Claparède (1858-1913); a German edition dates from 1889 ("*Der Ursprung und die Entwicklung der Organischen Chemie*", in the *Ostwalds Klassiker* series no. 259), which served as the basis for the second English edition (1894), edited by Arthur Smithells (1860-1939), a student of Schorlemmer.



DER

URSPRUNG UND DIE ENTWICKELUNG

DER

ORGANISCHEN CHEMIE

VON

C. SCHORLEMMER,
Professor der organischen Chemie an der Victoria-Universität, Manchester.

BRAUNSCHWEIG,
DRUCK UND VERLAG VON FRIEDRICH VIEWEG UND SOHN.
1889.

Fig. 7 - Front page of "Der Ursprung und die Entwickelung der Organischen Chemie", published by Friedrich Vieweg in Braunschweig, 1889.

Another work by Schorlemmer that was important in its time was a textbook on Organic Chemistry, "*Lehrbuch der Kohlenstoffverbindungen oder der Organischen Chemie*" (which is also part of the "*Ausführliches Lehrbuch*"), published in Braunschweig in 1871. It is a very detailed text, written in a simple style, easy and pleasant to read.

Schorlemmer's first publications were translations into German of works by Henry Roscoe: in 1867, "*Elementary Lectures in Chemistry*", a kind of abstract for the later "*Treatise on Chemistry*". And in 1870 "*Spectrum Analysis*", published in English in 1869 (*Macmillan*, London).

SCHORLEMMER AS HISTORIAN OF CHEMISTRY

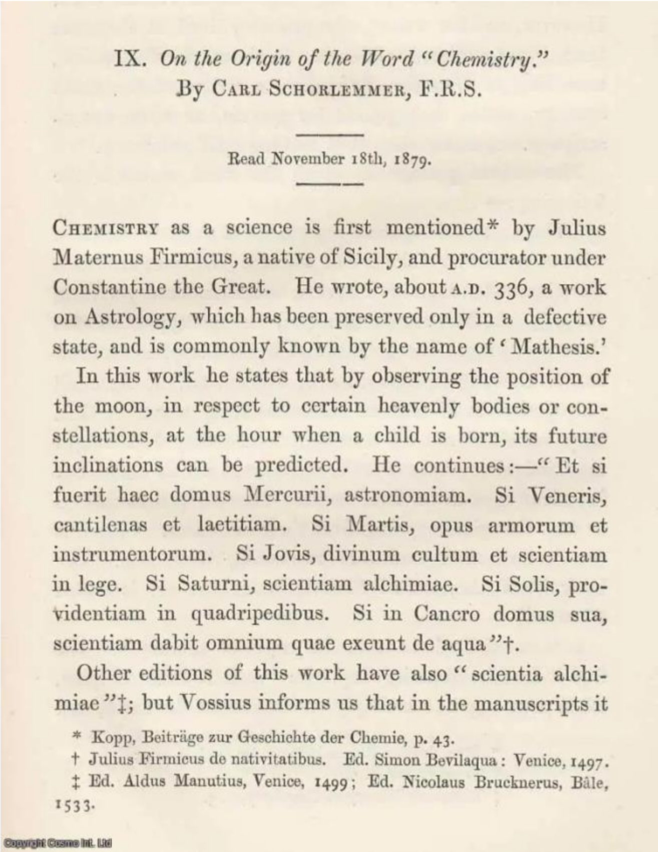
During the short period of studies in Giessen, Schorlemmer was a student of Hermann Kopp (1817-1892), perhaps the most important historian of Chemistry in the 19th century ("*Geschichte der Chemie*", 4 volumes, 1843/1847, with three supplements, and other texts), who was his inspiration in this field: he dedicated his "*Rise and Development of Organic Chemistry*" to Kopp.

Organic Chemistry had recently abandoned the dualism of the *Naturphilosophie* of Friedrich von Schelling (1775-1854) and his followers (in the sciences, names such as Hans Christian Oersted [1777-1851], Johann Wilhelm Ritter [1776-1810], Karl Wilhelm Kastner [1783-1857]), the theory of radicals was gradually converted into the theory of types (incorporating radicals into different types), when Schorlemmer decided to deal with the history of this branch of Chemistry, in 1879. Schorlemmer's experimental work in turn removed types from the scene, paving the way for carbon chain structures, in accordance with the proposals of Kekulé or Couper. The extensive text (more than 600 pages) "*Lehrbuch der Kohlenstoffverbindungen oder der Organischen Chemie*" (1871) does not present any historical data. The first 33 pages of the "*Ausführliches Lehrbuch*" (1871) present a summary of the History of Chemistry from Greek Antiquity up to the times of Liebig[41]. For historian Karl Heinig, Schorlemmer's biographer[42] (1974), the purely empirical data that followed the results explained by *Naturphilosophie* (the "plague of science", in Liebig's words), caused disenchantment in Schorlemmer, who found a viable alternative in adopting a point of view of dialectical materialism, and for Heinig this work by the "red chemist" would be the first chemical history in accordance with this ideology. The greatest concern was dedicated to "the basic laws of scientific development, the context in which isolated sciences interact with each other, theoretical questions about the role of hypotheses and theories, and the connection between theory and *praxis*"[43].

Chemical transformations must be seen as being dynamic, and in the wake of Heraclitus' thought, for whom the only real and eternal thing is transformation, that is, the dynamic visualization of chemical phenomena. At the same time that Schorlemmer's work appeared, many organic chemists wrote the history of their specialty, limiting themselves, however, to the simple report of empirical facts. Schorlemmer takes sides in these discussions, returning to value the philosophical aspects contained in experiments, banned from the practice of Chemistry because of the exaggerations of *Naturphilosophie*. He defends his points of view in the face of the discordant or even contrary point of view of the majority of organic chemists of the time, for example, condemning the exaggerated importance given to pure and simple empirical fact, an exaggeration that for Engels is "the surest way to arrive at from natural sciences to mysticism"[44]. He sought to overcome pure empiricism and remaining mechanism, a task which was facilitated by his great erudition and ease in finding connections between facts.

For Schorlemmer, the history of Chemistry is not just a report of what happened, but a discussion of the processes that led to the development of theories and experimental procedures, a discussion based on the economic and philosophical conceptions in force at each time. Knowledge of the history of Chemistry is essential for understanding Chemistry itself, and at the time in question, Organic Chemistry investigated subjects that involve dynamic situations, tautomerism for example[45].

For Schorlemmer, without a theoretical basis it is not possible to achieve scientific progress, which was particularly important at a time when “new discoveries emerge in science every day”. And as a historian, he sought to show that the development of science requires certain assumptions, such as, in his opinion, dialectical argumentation. Quoting Schorlemmer, “a new science does not appear suddenly, like Minerva from the head of Jupiter, nor does it appear in its full beauty, like Venus born from the foam of the waves”.[46] Schorlemmer defends the position that “a scientific theory is not a dogma, but changes over time, in accordance with the laws of dialectics”[47].



IX. *On the Origin of the Word “Chemistry.”*
By Carl Schorlemmer, F.R.S.

Read November 18th, 1879.

Chemistry as a science is first mentioned* by Julius Maternus Firmicus, a native of Sicily, and procurator under Constantine the Great. He wrote, about A.D. 336, a work on Astrology, which has been preserved only in a defective state, and is commonly known by the name of ‘Mathesis.’

In this work he states that by observing the position of the moon, in respect to certain heavenly bodies or constellations, at the hour when a child is born, its future inclinations can be predicted. He continues:—“Et si fuerit haec domus Mercurii, astronomiam. Si Veneris, cantilenas et laetitiam. Si Martis, opus armorum et instrumentorum. Si Jovis, divinum cultum et scientiam in lege. Si Saturni, scientiam alchimiae. Si Solis, providentiam in quadripedibus. Si in Cancro domus sua, scientiam dabit omnium quae exeunt de aqua”†.

Other editions of this work have also “scientia alchimiae”‡; but Vossius informs us that in the manuscripts it

* Kopp, Beiträge zur Geschichte der Chemie, p. 43.
† Julius Firmicus de nativitatibus. Ed. Simon Bevilaqua: Venice, 1497.
‡ Ed. Aldus Manutius, Venice, 1499; Ed. Nicolaus Brucknerus, Bâle, 1533.

Fig. 8 - First page of Carl Schorlemmer’s paper, “Origin of the Word Chemistry”.

In addition to his masterwork, Schorlemmer published three articles on historical topics: “Origin of the Word Chemistry” (1882)[48], “The History of Creosote, Cedriret and Pittacal” (1889)[49], “On the History of Artificial Preparation of Indigo” (1881)[50]. The second of these articles is particularly rich in historical and chemical information, from the perspective of the time.

When he passed away, Schorlemmer left an incomplete 1100-page manuscript of a work on the History of Chemistry, entitled “*Beiträge zur Geschichte der Chemie*”, the result of years of research. The manuscript covers the history of Chemistry from Antiquity to the mid-17th century, and in Rolf Gelius' opinion, in it Schorlemmer “surpasses the heights of historical-scientific efficiency”. Some historians want to see in these “*Beiträge*” the intention of writing a universal history of Chemistry from a Marxist point of view, but Gelius does not share this interpretation. The administrator of Schorlemmer's legacy, Louis Siebold (1838-1901), tried to continue the work, but soon gave up. The manuscript, preserved in Manchester's *John Rylands University Library*, remains unpublished to this day[51].

SCHORLEMMER, SCIENCE AND SOCIALISM

Fig. 9 - Stamp issued by the former German Democratic Republic in 1970, commemorating the 150th birthday of Friedrich Engels (1820–1895).

Schorlemmer, “the first Marxist among chemists and the first chemist among Marxists”, did not suddenly awaken to the interests of the working class, but, as we have already said, since his youth he defended socialist thought, to which he always remained faithful, which made an academic career in his homeland unfeasible. In 1889 he formally joined the Social Democratic Party of Germany. His friendship with Engels and Marx, for whom he was a scientific ‘advisor’, has also been mentioned.

Marxist-oriented historiography wants to see in Schorlemmer's research typical examples of “dialectic-materialist” research. In fact, there is nothing different about Schorlemmer's laboratory activity when compared to the activity of other researchers of the time, far from socialism, such as Dumas, Wurtz, Hofmann or Kekulé. Nor can it be said, as Karl Heinig would have it, that in his experimental data he “saw beyond” the ‘greats’ of his time, such as Liebig, Hofmann or Emil Fischer[52]. The only difference that could be pointed out, but which would not lead to a different working methodology, would be the status of the structure, considered by Schorlemmer, as well as by Butlerov, as being real, while Kekulé and Couper considered the structure to be a model or abstraction.

In fact, there is no “socialist science”, as the criteria of scientificity are independent of ideologies. What ideological positions can influence is “doing science”, from choosing the topic to applying the research results. Defenders of a “socialist science” refer to ideas already present in Hegel, the conversion of quantity into quality, present, for example, in the homologous series of alkanes. Karl Marx writes, when dealing with the concept of 'surplus value', that “here, as in the natural sciences, the validity of the rule discovered by Hegel in his 'Logic' that quantitative only transformations become, at a given point, qualitative transformations”[53]. Schorlemmer writes about this, citing Engels’ “Anti-Dühring”: “Each new member comes into existence by the addition of a unit – CH_2 – to the immediately preceding molecule” and that “this quantitative modification in the molecule each time produces a qualitatively different body”. This idea is quite common in Organic Chemistry, it exists, for example, in the variation of melting points and boiling points of a homologous series as the molecular mass increases, a subject studied by Hermann Kopp (1817-1892) since 1841, and by other organic chemists. This Hegelian idea also exists outside of science, in literature for example, as in the beautiful passage by José Saramago (1922-2010), taken from “Memorial do Convento” (1982, English translation “Baltasar and Blimunda”, 1988): “In total I heard that five hundred arrived. So many, Blimunda is amazed, and neither one nor the other knows exactly how many there are five hundred, not to mention that the number is the least exact of all the things in the world, it is said five hundred bricks, five hundred men, and the difference there is between brick and man is the difference that is thought not to exist between five hundred and five hundred... ”[54].

SOME CONCLUSIONS ABOUT SCHORLEMMER’S EMPIRICAL WORK

At first glance Schorlemmer appears to be one of the many organic chemists active in the second half of the 19th century, chemists that Thomas Kuhn would define as practitioners of “normal science”. However, a more in-depth analysis shows that this is not the case. Schorlemmer's empirical and experimental activity leads us to conclusions that go beyond the mere accumulation of information about organic compounds.

The apparently exclusive occupation with a restricted group of organic compounds (aliphatic hydrocarbons, mainly alkanes) seems to suggest the investigation of a few similar compounds, but the detailed study of the properties of these simplest compounds in Organic Chemistry, to which Schorlemmer subjected these compounds, extends to other compounds, with other chemical functions, as seen before with the study of heptane. It is evident that Organic Chemistry can be structured from these simplest compounds, alkanes.

Schorlemmer also shows that organic compounds such as alkanes can be obtained, with exactly the same properties, from different natural materials, such as petroleum and mineral coal. In this case of alkanes, an approximation between Organic Chemistry and Inorganic Chemistry is observed, going against Lavoisier's ideas that there is no fundamental difference between inorganic and organic compounds.

Going a little further, Schorlemmer showed that not only can different organic compounds be obtained from different species or genera, but that there are organic compounds that can be obtained from both the inorganic and organic worlds, and presents as an example (iso)amyl alcohol, obtained either from pentane in petroleum or coal, or through fermentation processes, which are clearly organic.

We have a further proof that there is no “vital force”, expanding the proofs of Friedrich Wöhler with the synthesis of urea (1828), and Hermann Kolbe, with the total synthesis of acetic acid (1845).

With these examples, we can say that Schorlemmer's experiments go beyond the limits of Organic Chemistry, inserting it into the theoretical field of 19th century Chemistry. As we have said before, historians faithful to Marxist ideas want to see an ideological component in Schorlemmer's experimentation, which would lead to a “socialist science”, something that simply does not exist. The Hegelian concept of converting quantity into quality could be a starting point for a “socialist science”. What we understand here by “socialist science” has nothing to do with the refusal to accept the theory of resonance or Mendelian genetics by official Soviet science authorities. The theory of resonance, initially accepted, was later rejected as being ‘ideologically untenable’, primarily by the president of the Academy, Alexander Nesmeyanov (1899-1980), which did not prevent all Soviet scientists from sharing this refusal. A conversion of quantity into quality is visible in the gradual variation of the boiling points of alkanes with increasing molecular weight, or the number of carbon atoms in a normal chain:

Number of carbons	Compound	B. P. (°C)
1	methane	-161
2	ethane	- 87
3	propane	- 42
4	butane	0,5
5	pentane	36
6	hexane	69
7	heptane	98
8	octane	125
9	nonano	151
10	decane	171

In fact, this gradual variation of physical constants (M.P., P.E., density) as a function of molecular mass (indirectly with the number of carbon atoms) had already been studied since 1841 at the University of Heidelberg by Hermann Kopp (1817-1892), a scientist who has nothing socialist about him. Kopp's studies were purely experimental, with attempts to establish mathematical expressions to calculate boiling points. Kopp's most comprehensive study on the relationship between physical constants and molecular weight, in several homologous series (alcohols, carboxylic acids, ethers) moves away from the idea of a simple conversion of quantity into quality, as the 'molecular weight' of the compounds is being considered, and not their structure, something still unknown at the time of Kopp's studies[55]. Also in Schorlemmer's time, the effects of structure on the variation of physical constants were still unknown: see, for example, the variation in the M.P. of alkanes with a normal chain, remembering that the chain is not linear.

CONCLUSION

The majority of chemists active in the second half of the 19th century were concerned with Organic Chemistry, the area of Chemistry that was then developing the most, perhaps stimulated by the gradual development of a theoretical basis for understanding the behavior of organic compounds, also due to the infinite variety of natural products awaiting study, and the growing interest in pharmaceuticals and dyes, or, simple scientific curiosity.

Some of these many organic chemists were distinguished by some particularity. In Schorlemmer's case, through the exhaustive investigation of the simplest organic compounds, the alkanes, the basis is laid for a classification of organic compounds, and later for their systematic nomenclature. The systematic study carried out by Schorlemmer ended up leading to theoretical aspects, as an example of the evolution of the theory from radicals to types and later to structures, inserting Organic Chemistry into the field of Chemistry as a whole.

The idea that a theory is necessary for the development of a science, combined with his dialectical-materialist worldview based on Hegel's philosophy, led him to what some historians have come to call “socialist science”, in fact an experimentation based on theoretical concepts, not necessarily materialist or dialectical, which differed from a solely empirical experimentation, such as that of Hermann Kolbe (1818-1884), enemy of any theory in experimentation, defender of an empiricism that borders on dogma, which did not prevent him from leaving as a legacy an immense scientific production, of great importance in the development of Organic Chemistry.

This comparison shows the importance of different ways of approaching the universe of organic compounds. It shows the importance of researchers like Schorlemmer, and others who also distinguished themselves by a different approach or a particular aspect in their practice of “normal science”.

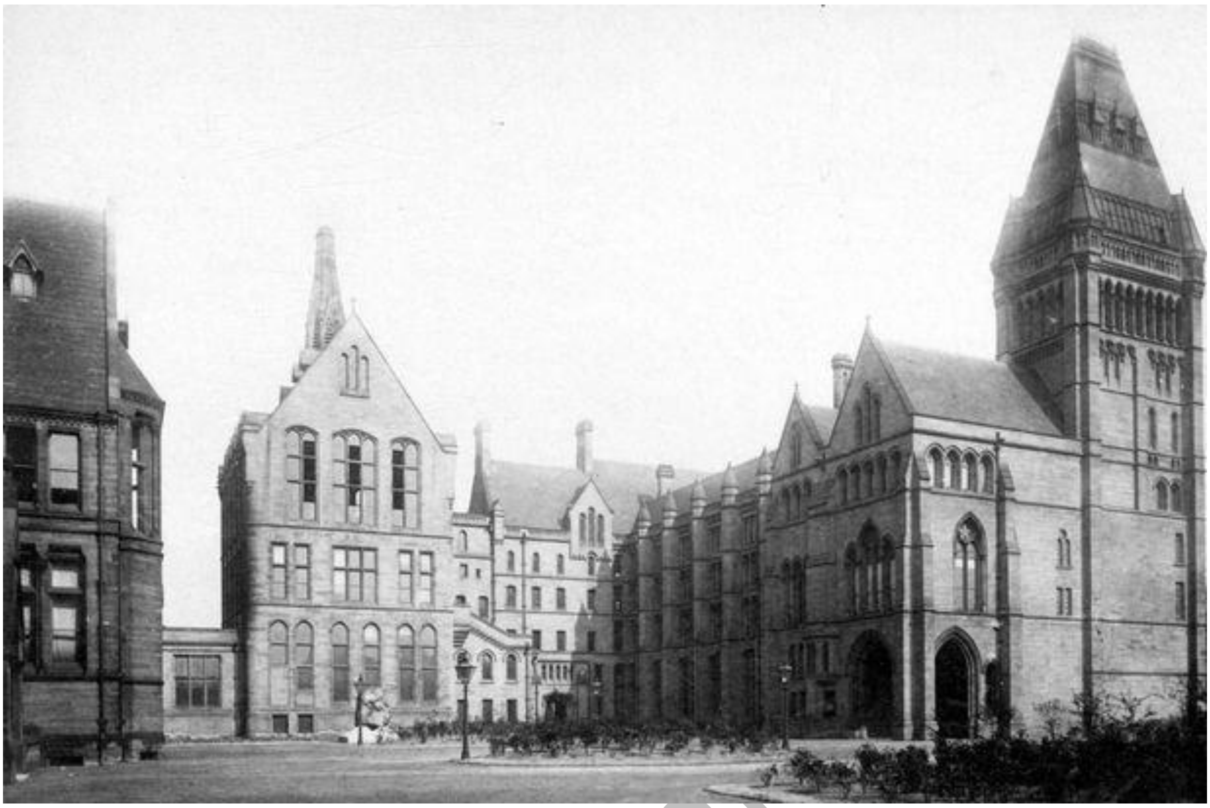


Fig. 10 - Owens College, Manchester, from “The Owens College, Manchester (founded 1851): A Brief History of the College and Description of the Various Departments”, by Philip Joseph Hartog (1864–1947). Published by J. Cornish, Manchester, 1900 (page 58).

Also, one cannot forget Schorlemmer's concern for social issues, witnessed by his membership in the German Social Democratic Party. It is not without reason that he felt himself at home at *Owens College*, which offered studies to those who found themselves excluded from Oxford and Cambridge, because they did not have possessions or did not belong to the social elite. With 62 students, *Owens College* opened its doors in 1851, founded with resources donated by Manchester merchant John Owens (1790-1846), who died unmarried. Owens friend, the manufacturer George Faulkner (c.1790-1862) refused to be his heir, to allow the foundation of a College independent from the religious ties which existed in Oxford and in Cambridge. Faulkner was the first chairman of the trustees of the *Owens College*. Since 1880 the *Owens College* is part of the *Victoria University* of Manchester[56].

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