

RESEÑA BIOGRAFICA

Louis-Nicolas Vauquelin

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RESUMEN: Louis-Nicolas Vauquelin (1763-1829) es un ejemplo de una persona que tuvo una juventud desventajosa, pero un espíritu determinado que lo llevó a desarrollar una carrera científica extraordinaria. Fue un hábil experimentador que descubrió nuevos elementos como el cromo y el berilio y aisló muchos compuestos importantes como la asparagina, urea, y derivados del tanino. Efectuó el análisis de muchas plantas y tejidos y secreciones animales y fue considerado el mejor químico analítico de su época.

ABSTRACT: Louis-Nicolas Vauquelin (1763-1829) (Figure 1) is an example of a person that had a disadvantaged youth but a determined spirit and went on to a rich and successful career in science. He was a skillful experimenter that discovered new elements such as chrome and beryllium and isolated many compounds such as asparagines, urea, and tannin derivatives. He performed the analysis of an extraordinary large number of plants and animal tissues and secretions and was considered the best analytical chemist of his time.

Life and career¹⁻³

Louis-Nicolas Vauquelin (Figure 1) was born in Saint-André-d'Hébertot, Normandy, France, on May 16, 1763, the son of Nicolas Vauquelin and Catherine Le Chartier. His father was a poor labourer that owned a cottage and a small piece of land, but his main occupation was cultivating the land of the castle owner, the young son of the chancellor d'Aguesseau. Louis-Nicolas was first sent to the public school of this village that had been built by the owners of the château d'Hébertot for the children of the labourers. The director of the school, named Vatel, who managed it very strictly, promptly noticed that Vauquelin was a bright child that absorbed easily the learning material and possessed an extraordinary memory. He was so impressed that he put Vauquelin in charge of teaching other students. In

addition, Vauquelin received his religious education from a priest that belonged to the *Order of Prémontré*. During the time he was not in school he would help his parents working the fields. The resources of his parents were not enough for feeding his large family and for this reason at the age of fourteen the young Louis-Nicolas abandoned his village to serve in Rouen as office boy with an apothecary named Mésaize that, as was the custom at the time, also taught a course in chemistry and physics. Part of Vauquelin's responsibility was to clean the glass utensils used during the lectures.

At the pharmacy he was fascinated by the work that was being done under his eyes and by the lessons his employer gave. He would take notes of the lectures and by night would go over them again. His employer thought that what the young man was doing was against the apothecary guild's code, learning the profession without having been authorized. He took Vauquelin's notebook away and prohibited him of writing another one. Vauquelin was so hurt by this act that he abandoned his job and Rouen and returned to his village; after a short time he left on foot for Paris carrying only six livres given to him by Madame D'Aguesseau (the lady of the

castle), and a strong letter of recommendation from the village priest.

Once in Paris he worked for two years as student in a pharmacy owned by Picard, located in the street Saint-Honoré, and afterwards in another owned by Auprêtre, located in Saint-Germain. While there he became serious ill and his employer hospitalized him at the Hôtel-Dieu (a hospital for the poor). At this institution he was put in a very crowded ward where the unfortunate were happy when they were not bedded two to a bed or not located in the room were demented were kept chained. After two months, he left the hospital, hardly healthy. After much wandering about a pharmacist named Chéradame hired him, took care of him, and helped him get instructed. The young man took public courses that were offered in chemistry, physics, and botany. In order to study Latin a language current among pharmacists, he torn the pages of an old dictionary and learnt its contents while delivering or bringing merchandise for his employer. This unusual method of learning a dead language did not prevent Vauquelin in time to become a distinguished Latinist and an enthusiast reader of Virgil.

Chéradame reprimanded him many times because he would stay up late at night studying and because while he was absent from the pharmacy Vauquelin would use his facilities to experiment in chemistry. Anyhow, he recognized Vauquelin's abilities and introduced him to his cousin Antoine-François Fourcroy (1750-1809), doctor in medicine and professor of chemistry. Fourcroy offered the young man to become his *preparateur*, a position that provided lodging, food, and paid one hundred livres per year. Without neglecting his work and the study of sciences, Vauquelin found the time to study philosophy for one year and obtain the diploma of *maître ès arts*.

At that particular time, Fourcroy had not achieved yet the position of chemistry professor at the *Jardin des Plantes* and earned his living by teaching at different establishments, particularly the *Athénée des Arts*.

This was a free institution that had been founded by Jean François Pilâtre de Rozier (1756-1785) and used by members of the higher classes to learn literature, history, music paint, chemistry, and sciences. Eventually Fourcroy became professor at Jardin des Plantes and after a brilliant scientific career Napoleon appointed him Consul in 1801 and then Minister of Public Instruction (1802-1808). He published many papers on medical subjects, alone or with Vauquelin, and he is considered the originator of modern pathological chemistry.

The progressive disappearance of learning institutions that took place during the Revolution forced Vauquelin to find a new job. In 1792, after he had received his degree in pharmacy, he took charge of the pharmacy owned by Goupil, located in the street Sainte-Anne, and in 1793 he left Paris to serve as pharmacist at the hospital in Melun. On December 24, 1793, he received an order from the Committee of Public Health to become one of the eight inspectors of *Poudres et Salpêtres*⁴. A second decree, dated March 11, 1794, appointed him member of a committee charged with studying the organization of the *École des Travaux Publics* (School of Public Works), the original name of the famous *École Polytechnique*. Finally, on July 1, 1794, the Committee on Public Health created the new *École des Mines* and appointed Vauquelin to teach *docimasia* (analysis of minerals).

Vauquelin was not a good teacher, his timidity and the weakness of his voice made his teaching rather unpleasant. Although he never achieved fame as a lecturer, the respect that his work inspired and his personality gained him the esteem of his audience.^{2,3}

Vauquelin occupied simultaneously or successively the most important academic chairs in Paris. In 1801, after the death of Jean D'Arcet (1725-1801) he succeeded him at the chair of chemistry in the *Collège de France*. The law of April 3 of 1803, had reorganized the teaching of pharmacy and had created three *Écoles* in Paris, Strasbourg, and Montpellier, where

schools of medicine were already existent. Vauquelin was then appointed director and professor at the *École de Pharmacie* in Paris. Afterwards, in 1804, he took over the chair of chemical technology at the Museum of Natural History that had become vacant after the death of Antoine Louis Brongniart (1742-1804). In order to do so he resigned his chair at the Collège de France in favour of Louis-Jacques Thénard (1777-1857). In 1811 Vauquelin succeeded Antoine-François Fourcroy (1750-1809) at the *École de Médecine* after the latter passed away in 1809. Since this position required medical qualifications and Vauquelin was only a *maître en pharmacie*, he went ahead and prepared a thesis for a doctorate in medicine⁵ to fulfil the legal requirement of the position. In this thesis he demonstrated that the brain contained phosphorus organic compounds (lecithins) and that the human brain had essentially the same components as that of animals.

Vauquelin also fulfilled the position of assayer to the Mint and became a member of the *Académie des Sciences* and the *Académie de Médecine*. In his time, Vauquelin was considered one of the two greatest analytical chemists, equal to the German professor Martin-Heinrich Klaproth (1743-1817), an associate member of the *Institut de France*.

Vauquelin's work at the *École des Mines* brought him immediately to the study of minerals and their salts. He established the composition of a large number of natural products following the request of his colleague René-Just Haüy (1743-1822) who had determined their crystallographic characteristics. Among his most important works in mineral chemistry we can mention the discovery of chromium (1798)^{6,7} and *glucine* (today beryllium), the latter in collaboration with Thénard.⁸ In 1797 Vauquelin prepared a number of chromium compounds, including potassium dichromate, lead chromate, chromium anhydride, and green chromic oxide. He obtained metallic chromium in 1798.

During his tenure as professor at the Museum and at the *École de*

Médecine, he directed researches on subjects that were then called vegetable chemistry and animal chemistry. He studied many plants and the compounds that could be isolated from them, for example, tobacco, mushrooms, quinquina, acetates, citrates, sugars, gums, asparagine, and morphine. In the area of animal products he studied and analyzed secretions and physiological or pathological substances such as urine, bile, bones, brain matter, and human semen. His research work led to the publication of more than three hundred scientific memoirs.

Most of his works on animal chemistry were generally performed and published in collaboration with Fourcroy. Vauquelin never forgot the debt to his master and also extended his appreciation to his family. He remained single all his life and after Fourcroy passed away he asked his sisters, M^{mes} Leabilly and Guédon, to move in to his house and become his home keepers. He assigned them a large part of his apartment as living quarters and lived modestly in the remaining. The two sisters managed his home and took care of him during the many times he was very ill, until his death.

In 1822 Vauquelin's liberal ideas resulted in his being separated from his chair at the *Faculté de Médecine* by the minister Jean-Baptiste Villèle (1773-1854), an undeserved misfortune from which he never recovered completely. Eventually, the government repented from this injustice and conferred upon him the *Cordon de Saint-Michel* (1827).

His many activities made him very prosperous, he invested in several industrial enterprises and bought large pieces of land in his native village. In 1828 he was elected deputy by the department of Calvados that included his home village.

Vauquelin passed away at Saint-André d'Hébertot on November 14, 1829, at the age of fifty-six, after a long illness.

Among Vauquelin's students we can mention: Apollinaire Bouchardat (1806-1886), Henri Edmond Robiquet (1822-1860),

Joseph Bienaimé Caventou (1795-1877), Alphonse Chevallier (1828-1875), Anselme Payen (1795-1871), Pierre-Joseph Pelletier (1788-1843), Hippolyte Victor Collet-Descotils (1773-1815), Stéphan Robinet (1796-1861), Jean-Baptiste Queneville (1776-1838), Louis-Jacques Thénard (1777-1857), and Michel Eugène Chevreul (1786-1889). Eventually Queneville bought the chemical factory of Fourcroy and Vauquelin and with it contributed to the emerging French pharmaceutical industry.

Napoléon admitted Vauquelin to the Legion d'Honneur on his foundation.

Kersaint has given a detailed account of the chemical industry established by Fourcroy, Vauquelin, and Deserres.⁹

Contributions

Vauquelin analyzed many minerals, prepared many new compounds and studied their properties. He found that phosphorus does not glow in moist oxygen at room temperature¹⁰, that many salts presented the characteristic of salting-in, that is, their solubility increased when another salt was added¹¹; he studied the reactions of iodine and its derivatives with many compounds¹²; described a quantitative method for the analysis of stones¹³; analyzed gadolinite¹⁴; and found soda in cryolite from Greenland. Vauquelin proved that sodium thiosulfate was formed by the oxidation of a solution of sodium sulfide, and that the silver salt precipitated by silver nitrate dissolved in excess of sodium thiosulfate solution to give a liquid with a sweet taste. The results of his investigations on the reaction between silver salts and thiosulfate were eventually used in fixing photographs. Other works included a study of the respiration of insects¹⁵, tree infections¹⁶, and meteorite rocks.¹⁷

It was known that the precipitates of platinum chloride with ammonium or potassium chloride presented different colorations but these were not always yellow as expected. Fourcroy and Vauquelin investigated the residue left by the

action of aqua regia on native platinum ore and found that it precipitated a red platinum chloride. From these results they concluded that it contained a new metal: "Tout annonçait que le poudre noire contenait un metal nouveau (Everything points out that the black powder contains a new metal).¹⁸ Smithson Tennant (1761-1815) showed in 1804 that the residue actually contained two metals, osmium and iridium.¹⁹

The many investigations of Vauquelin in animal chemistry include those on the composition of semen, synovial fluid, hair, and wool grease.

Urinary stones²⁰

The composition of urinary stones and calculi had occupied scientists for many years. In 1776 Karl Wilhem Scheele (1742-1786) discovered that the main component of a bladder stone was a substance that was slightly soluble in water and that the diluted solution colored litmus paper red. The matter melted in alkali and formed a precipitate in acid solution, which dissolved in a hot nitric acid leaving a residue, which after evaporation turned a pinkish crimson. Upon heating, and depending on the temperature, it smelled like prussic acid, ammonia, or something like burning horn. Scheele named the substance *lithic acid*; subsequently others changed the name to *uric acid*. Afterwards, Torbern Olof Bergman (1735-1784) confirmed Scheele's (1734-1794) findings. Scheele's results are important because they established that uric acid was a normal constituent of human urine and that when cold it produced brick-red sediment. Thus uric acid became the first metabolite to be identified in human urine, twenty years before Fourcroy and Vauquelin isolated urea in 1799.^{21,22} Since most stones contained uric acid Scheele reached the wrong conclusion that uric acid was the only constituent.

Afterwards, Felix Vicq D'Azyr (1748-1794) discussed all the animal secretions he had observed without discussing their possible chemical composition.²³ His results led him to

assume that uric acid urinary stones were due to hyperconcentration of the urine, because man urine always contained uric acid, regardless of the presence of calculi.

In 1789 Fourcroy published his first results on the chemistry of biliary stones²⁴ and that uric acid was rich in carbon and nitrogen but poor in oxygen and hydrogen. According to Fourcroy urinary stones contained uric acids and other substances such as calcium phosphate and magnesium ammonium phosphate; in addition, human renal and bladder stones had a similar composition.²⁵

In 1800 and 1802 Fourcroy and Vauquelin published two important memoirs on the composition of urinary calculi^{26,27}, obtained after analyzing over 600 calculi. In these memoirs they changed the name lithic acid to *acide urique* (uric acid). According to their results there were twelve main species of calculi, consisting of the following substances or mixtures of them: uric acid, urate of ammonia, calcium phosphate, magnesium ammonium phosphate, calcium oxalate, and animal matter (gelatin). Uric acid was the commonest constituent. To explain the presence of calcium oxalate they proposed that oxalic acid was normally made somewhere within the walls of the urinary tract, and that it reacted with urine for form microscopic crystals of calcium oxalate. These crystals were usually very small and most of them were excreted as such. Nevertheless, some of them would become nucleation centers for calculi upon which other urinary salts were then deposited (An assumption known today to be true).²⁰

Fourcroy and Vauquelin were surprised by the fact that phosphorus was present only as phosphate, in opposition to their findings on other substances such as living tissues, bone, and pollen. These findings may be considered the first indication that other chemical forms of phosphorus may have physiological functions. They also determined that the magnesium present came from the large amounts contained in cereals.

Fourcroy and Vauquelin considered that bezoar stones were composed of a kind of resin (probably ingested) in the case of those of the Persian wild goat; common bezoars consisted sometimes of calcium or magnesium phosphate, sometimes of resinous matter of bile. Analysis performed later by others proved that what Fourcroy and Vauquelin had called *résine animale bézoardique* in bezoar stones was really derived from the resinous plants on which the wild goats feeds.²⁰

Fourcroy and Vauquelin also showed that fish-roes contains phosphorus²⁸ and that bones contain calcium and magnesium phosphates.²⁹

Quinquinas³⁰

It was long known that the bark of several species of cinchona tree had febrifugal properties. Vauquelin studied quinquinas the same as other famous chemists such as Fourcroy, Armand Séguin (1767-1835), Deschamps, and Fernand Friedrich Reuss (1778-1852), had done before him. He examined all the species available at that time in order to discover their differences and tried to find the constituents that communicated to it its febrifugal properties. Séguin had analyzed more than six hundred samples of bark and thought that he had identified the presence of vegetable gelatin and tannin. Tannin was not febrifugal so he assumed that the active component was the gelatin, but medical tests showed him to be wrong. Claude Saint Mart de La Garaye (1675-1755) had succeeded in preparing a dry extract of quinine, which was called essential salt of La Garaye. Deschamps prepared a large amount of this salt and from it isolated a crystalline material that he employed to cure certain fevers; this led to believe that the active material had been discovered. A sample of this material was sent to Vauquelin who analyzed it and found it to be a combination of calcium with a new acid, which he named *acide kinique* (quinic acid). This acid proved to be deprived of febrifugal properties. Afterwards, Vauquelin proceeded to examine seventeen samples of

quinquina that had been sent to him by travelers. From this analysis he concluded that the best quinquinas were those that were precipitated copiously by tannin, gelatin, and emetic. The febrifugal principle was actually in the precipitate produced by gallnut, which he did not analyze and thus lost the opportunity of discovering it.

Eventually in 1818, two of Vauquelin students, Pierre-Joseph Pelletier (1788-1842) and Joseph Bienaimé Caventou (1795-1877), succeeded in isolating the active principle, quinine sulfate, and demonstrated that it contained hydrogen oxygen, and carbon, but failed initially to find nitrogen.

Analysis of hair^{31, 32}

The original aim of this research was to understand the composition of hair and to find if they had analogues in animal economy.

Vauquelin boiled hair in water for several days without being able to dissolve them, although the water contained a small amount of organic matter, as could be detected by the action of gallnut and other reagents. He then tried to decompose them in a Papin machine, under the action of heat. Hair would decompose partly or totally only when a certain temperature was exceeded, as evidenced by the presence of ammonia, carbon dioxide, and fetid empyreumatic oil; the latter gave the solution a dark yellow color. In addition, large amounts of hydrogen sulfide were released, which reacted strongly with the copper metal of the digester, blackening it. The amount of gas released was strongly dependent on the temperature, showing that it was a decomposition product.

Heating black hair to a temperature that did not decompose it, released a black substance, highly divided, that took a long time to settle. This substance was composed of black oil, thick like bitumen, slightly soluble in alkali and alcohol; containing iron and sulfur attached one to the other. Red hair left a red yellowish residue, where again a large amount of oil and sulfur was present, as well as a little iron.

The solutions were nearly colorless when filtered; they were affected by concentrated acids but not by weak acids. An excess of these reagents returned to the liquors their original transparency. If these dissolutions were carefully evaporated they yielded a viscous, sticky substance that did not gel. From these facts Vauquelin concluded that hair was not a gelatinous substance.

Acids produced abundant precipitates when acted upon a solution of hair heated to a high temperature because they decomposed ammonium soap, which was not present in the previous case.

Vauquelin also dissolved black and red hairs in water containing four percent of caustic soda. During the dissolution process ammonium sulfide was released; a fact that indicated the beginning of the decomposition of black hairs, and then left a black residue formed of a thick oil, iron, and sulfur. In these dissolutions, acids yielded white precipitates, soluble in an excess of their liquors. Dissolution of hair in potassium, hydroxide, yielded a black precipitate with lead acetate because of the hydrogen sulfide they contained.

Each acid operated in a different manner upon hair. Sulfuric acid and hydrogen chloride took first a beautiful rose color and then dissolved the hair. Nitric acid yellowed the hair and dissolved it under mild heat. With black hair the resulting solution presented a floating black oily layer while with red hair it was red. In both cases, the oily layer lost its color with time and congealed upon cooling.

Analysis of the ashes of burnt hair showed the presence of iron, manganese, phosphate, sulfate, and calcium carbonate, traces of sodium chloride, and large amount of silicon.

In conclusion, the analytical results showed that hair was composed of nine different substances: organic matter that constituted the largest part; of a small amount of a white oil; iron in an unknown state; traces of manganese oxide, calcium

carbonate, calcium phosphate; an large amounts of silicon and sulfur.

Vauquelin also found that black and red hair differed only in the color of the oil they contained, and that in white hair the oil was colorless and contained magnesium phosphate, which was not present in colored hair. Vauquelin inferred from this that black hair owed its color to the oil and to the presence of combinations of iron and sulfur. Red and blonde colors were due to the presence of red or yellow oil. White hair was colorless due to the absence of black oil and iron sulfides. In addition he guessed that in hair sulfur was united to hydrogen.

Vauquelin explained that the sudden hair whitening experienced by persons who had suffered deep chagrin or surprise caused by a strong fear, was due to the sudden secretion of an acid substance that passed to the hair and resulted in color loss. On the hand, the white color that came with age was caused by a deficiency in the secretion of the coloring matter.

In addition, hair possessed an organic colored greasy matter, common to everyone, that gave it flexibility, elasticity, and strength. This substance also was responsible for the facility with which hair burned rapidly and formed soaps with alkali. Vauquelin tried unsuccessfully to isolate this substance, which he understood was neither gelatin nor albumin; he believed that it was similar to what physiologists called mucus, or animal mucilage.

Vauquelin's work on the analysis and properties of hair found an interesting sequel in Honoré de Balzac's (1799-1850) book "Grandeur et Décadence de César Birotteau" (The Rise and Fall of César Birotteau).³³ In this book Birotteau is a Parisian manufacturer of perfumes who dreams of becoming rich fast by developing a hair-restorer, *Huile Cephalique*, based on hazelnut oil and the findings of Vauquelin. He is also seen consulting several times with Vauquelin about the product he is intent in selling: "A composition which will keep your hair in good

health will sell like bread; all more if the preparation has the approval of the Academy of Sciences. My good friend Monsieur Vauquelin will perhaps help me."

*Discovery of asparagine*³⁴

Upon inspection of mass of crystals of asparagus sugar Vauquelin and Robinet noticed the presence of some unusual crystals, which they believed belonged to new substances. They were easily separated from the bulk mass of crystals because their form, transparency, and taste were different from the rest. After several crystallization steps of one of these crystalline species, they found that its crystals were totally white and translucent, had a fresh taste and were slightly nauseating, a property that resulted in much salivation. It crystallized in a shape derived from a straight rhomboidal prism, with the largest basal angle of about 130°. It was slightly soluble in water, yielding a neutral solution. Addition of a solution of gallnut, lead acetate, ammonium oxalate, barium chloride, and potassium sulfide, did not produce reaction. The substance was also insoluble in alcohol. Its solubility increased a little in a solution of potassium hydroxide.

After determining that it did not contain *terres* (silica and alumina), they looked for the presence of alkalis. For this purpose they burn a large quantity in a platinum crucible. The mass was considerably swelled and released a spicy vapor that affected the eyes and the nose, similar to the smoke of wood. It left a tasteless cinder. It was decomposed by nitric acid with release of gas; the remaining liqueur acquired a yellow tint. After treatment with nitric acid, addition of calcium carbonate resulted in the release of abundant ammonia.

Vauquelin and Robinet concluded that the substance was not an acid because it did not change the color of litmus and did not have the corresponding taste. It was also not a neutral salt because it did not contain alkali earth or alkali. It was probably composed of carbon, hydrogen, and oxygen in a particular ratio, but it probably had also some

nitrogen, because of the smell it produce on heating and the ammonia it released when treated with nitric acid.

The second crystalline species was also white but not transparent, and crystallized in a different shape, fine needles that had a slightly sweet taste, which Vauquelin and Robinet believed to be mannitol.

Discovery of chrome^{6,7}

Vauquelin received a small sample of red lead (red lead spar, *crocoite*, composed mainly of PbCrO_4) from Siberia that other chemists such as Bindheim claimed contained oxidized lead, iron, aluminum, nickel, copper, cobalt, and molybdc acid. After exhaustive chemical analyses of the sample, Vauquelin concluded that previously reported compositions were incomplete, and that the material contained a new acid metal. He wrote that came to this conclusion using the wrong starting hypothesis that molybdc acid was present and performing the corresponding analyses. He performed several comparative reactions and found results different from expected. For example, the reaction of potassium hydroxide with molybdc acid yielded a colorless solution but an orange one with the mineral, reaction with lead nitrate or silver nitrate yielded a white precipitate, against one colored orange or carmine red, respectively.

One of the most interesting experiences was trying to reduce the oxide of red lead to see if the new metal could be separated in a pure form. To do so Vauquelin reduced the mineral with powdered carbon in a carbon crucible for half an hour at high temperature. The final product was a metallic mass, gray, formed of interlaced needles. He then proceeded to study the properties of the metal, which was white gray and very fragile. When heated under a flame it became covered with a lilac layer, which turned green on cooling. It did not melt when heated in the presence of borax, although part of it, after becoming oxidized did dissolve in borax and gave a nice green color. The metal was slightly attacked by acids; nitric acid was the

only acid that produced a notable change. Distilling the acid several times in the presence of the metal disintegrated the metal into a yellow orange powder, initially green. The powder was acid, dissolved in water, combined with the alkali releasing CO_2 , and precipitated metal solutions. Vauquelin felt that by this procedure he had transformed the metal into the acid form present in the original mineral.

The new substance also had some interesting properties not observed with other elements: it became an acid colored red ruby; in the latter state it turned green under the action of light or heat. It yielded a yellow orange precipitate with lead acetate and a red brown one with cupric nitrate. It dissolved gold together with nitric acid, gave a brown precipitate with a solution of tannin, and a green precipitate with the alkaline prussiates.

For these reasons Vauquelin, in consultation with Fourcroy and Haüy decided to call the new element *chrome*, which means color, because all its combinations were colored.

According to Vauquelin, the fragility and high fusion temperature of the metal did not promise its ample as such, but the fact that in its acid form it gave combinations having beautiful colors, suggested that if were to become available in large quantities, it would be extremely appropriate for paints and enamels.

Vauquelin's predictions became slowly true. An early application of chromium compounds was as pigments, particularly chrome yellow, PbCrO_4 ; basic chromium sulfate was used for tanning hides when it was found that the reaction of chromium with the hide (collagen) raised the hydrothermal stability of the leather and also rendered it resistant to bacterial attack. The most important application of chromium, namely its use as an alloying element, was gradually developed during the nineteenth century, mainly in France, and led to chromium steel.

Vauquelin prepared a number of chromium compounds, including potassium dichromate, lead

chromate, chromic anhydride, and green chromic acid; metallic chromium was obtained in 1798.^{35,36}

Discovery of beryllium^{8,37}

Aquamarine (béryl) had been analyzed by Bindheim and found to contain 64% silicon, 27% aluminum, 8% calcium carbonate 8%, 2% and iron. Haüy had compared aquamarine with true emerald and found a complete correspondence between their structure, hardness, and density and come to the conclusion that they were the same material. To verify his conclusion Haüy requested from Vauquelin to analyze both materials and see if they had the composition. Vauquelin examined aquamarine and found in it a new earth, which he called *la terre de beryl*. His experimental procedure was the following: He first ground the mineral and fused it with potassium hydroxide and found that the resultant mass was totally soluble in aqueous hydrogen chloride (*acide muriatique*). When drying the liquid he observed that most of it jellified, with the solute retaining a large amount of water. The remaining solid was white and found to be silica. The jellified solution was treated with potassium carbonate and produced a precipitate that previous chemists had assumed was alumina. Vauquelin realized that this was not so because it was only partially soluble in potassium hydroxide. The remaining solid was dissolved in nitric acid, evaporated to dryness, and dissolved again in water, giving a solution having a yellow-red liquid, due to the iron present. The iron was then precipitated by treatment with potassium sulfide. The dissolved residue, treated with potassium carbonate, yielded a white earth that dissolved in acids releasing CO_2 . This residue was the carbonate of the oxide of the new metal. Vauquelin used the carbonate to prepare a number of salts of the new element, and found that all of them had a sweet taste. He determined that the oxide was totally soluble in sulphuric acid, it dissolved in ammonium carbonate, it decomposed salts of alumina, its

affinity for acids was intermediate between magnesia and alumina, and ammonia precipitated it from its aqueous solutions.

His first elementary analysis of emerald and beryl showed that their composition was totally different. Emerald contained 64% silica, 29% alumina, 2% calcium carbonate, 3 to 4% chrome oxide, and about 2% water. Beryl on the other hand, had 69% silicon oxide, 21% alumina, 8% of the new material, and about half percent iron. Additional analytical work done by Vauquelin at a later date led him to find that the new material was also present in emerald and that the difference in color between both stones was simply due to the coloring impurities present in each.

When Vauquelin was asked what name he proposed for the new earth, he answered: "Je n'ai pas cru devoir donner de nom à cette terre; j'attendrai que ses propriétés me soient mieux connues. D'ailleurs, je suis bien aise d'avoir sur cela l'avis de mes confrères" (I do not believe that I have to give a definite name to this earth, I will wait until I will know its properties better. Besides, I will be delighted to have the advice of my colleagues.). This suggestion was picked immediately by the editors of the *Annales de Chimie* who proposed calling it *glucine*, in these words: "La propriété la plus caractéristique de cette terre, confirmée par les dernières expériences de notre collègue, étant de former des sels d'une saveur sucrée, nous proposons de l'appeler *glucine*, de: doux, γλυχυς; vin doux, γλυχαιαζ render doux. Cette dénomination sera assez signifiante pour aider la mémoire; elle ne prendra pas, dans son étymologie, un sens trop strictement déterminé" (The most characteristic property of this earth, confirmed by the latest experiences of our colleague, is forming salts having a sweet taste; we propose naming it *glucine*, from sweet, γλυχυς; wine sweet, γλυχαιαζ yields sweet).

In a logical manner, the corresponding metal would have

been called *glucinium* (Gl) but German scientists substituted its name for *beryllium* (Be).

Miscellaneous

Fourcroy and Vauquelin investigated the acid of ants and concluded incorrectly that it was a mixture of acetic acid and malic acid³⁸; they obtained benzoic acid by the action of hydrogen chloride on cow's or horse's urine or the drainage of manure, and proposed its use in pharmacy³⁹; they investigated milk, cheese, blood, bile, etc.⁴⁰ and the coloring matter of blood, which they thought was iron phosphate with excess of oxygen and metal.⁴¹

Vauquelin and Fourcroy discovered several important organic compounds. They distinguished a number of proximate constituents (*principes immédiats*) in plants, such as acids, oils, camphor, gum, resin, tannin, starch, fiber, cork, natural rubber, etc. Pyroligneous acid was shown by Vauquelin and Fourcroy to be impure acetic acid.

Vauquelin proved that commercially available alum contained simultaneously aluminum and potassium or ammonia, combined with sulfuric acid and that the conjunction of aluminum sulfate and alkaline sulfate was necessary for producing the well-known octahedrons of alum. He also classified the available alums in two categories, depending if they had a default or excess of sulfate acid. The first group was insipid and insoluble in water, while the second was soluble in water, having a strong taste, and astringent properties. There was an additional variety, which was essentially pure aluminum sulfate, crystallizing with difficulty in brilliant plaques, mother-of-pearl colored, and that could not be made insoluble by addition of its own base. Vauquelin used the chemical rules available then to differentiate among seven categories: (a) aluminum sulfate, (b) acid sulfate of aluminum, (c) saturated sulfate of aluminum and ammonia, (d) acid sulfate of aluminum and potassium, (e) acid sulfate of aluminum and ammonia, (f) acid sulfate of aluminum,

potassium and ammonia, and (g) acidified sulfate of aluminum and potassium.⁴²

In addition, Vauquelin's study also allowed differentiating aluminum sulfate from chromium (glucidium) sulfate, because the latter did not generate alum.

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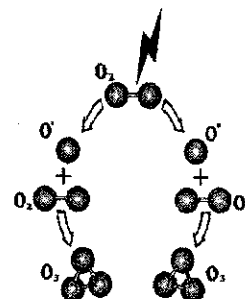
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EL OZONO Y EL AGUA OZONIZADA

El Ozono

El ozono es un gas inestable, de olor penetrante, cuyas moléculas están formadas por tres átomos de oxígeno. En la naturaleza, existe fundamentalmente en las capas altas de la atmósfera, formando la llamada "capa de ozono", que protege a nuestro planeta al impedir el paso de la radiación ultravioleta cuya energía pudiera ser perjudicial para la vida. El ozono se produce industrialmente a partir de oxígeno, mediante una descarga eléctrica silente de alto voltaje, al hacer pasar entre dos electrodos un flujo de aire u oxígeno puro.



El ozono posee un gran poder virucida, bactericida y fungicida. Su capacidad de desinfección es mucho mayor que la de otros desinfectantes que se emplean actualmente. Su elevada reactividad con un gran número de sustancias permite su aplicación en usos importantes, por ejemplo para la desinfección de agua para consumo humano, para la eliminación de color y olor, para el aumento de la biodegradabilidad de contaminantes naturales e industriales en aguas y aguas residuales, etcétera.

El agua ozonizada y sus propiedades

Teniendo en cuenta las propiedades del ozono antes mencionadas, la ozonización se ha convertido en uno de los métodos más avanzados para la desinfección de agua de consumo humano, ya que el ozono al ponerse en contacto con un agua contaminada con microorganismos (hongos, bacterias, virus, quistes de parásitos) los destruye, permitiendo la eliminación total de agentes transmisores de enfermedades y mejorando considerablemente también la calidad organoléptica del agua (al eliminar olor, color y sabor desagradables).

Se ha demostrado la gran efectividad del ozono en la destrucción de microorganismos tales como quistes de *Giardia lamblia* y bacterias como *Cryptosporidium*, *Pseudomonas*, *Salmonella* y *Escherichia Coli*, los cuales se encuentran con frecuencia en el agua. También se conoce que el ozono es capaz de reducir sensiblemente la presencia de hierro y manganeso que dan color y sabor al agua.