Johann Wilhelm Ritter – The Founder of Scientific Electrochemistry

Hermann Berg

1. His life 1776 – 1810

Johann Wilhelm Ritter (Fig. 1) was born 1776 in the little village Samitz (Silesia, former Germany). In a drugstore at Liegnitz (now Legnica) he was educated to a pharmacist. He studied from 1776 physics at the University Jena and started with experiments on galvanism by modified methods encouraged by the laboratory of L.Galvani (Fig. 2). He collected his results in his first book 1798: "Evidence that a continous galvanism accompanies the life-process in the kingdom of animals". Ritter had exchange of ideas with J.W. Goethe, Ch. Oersted, L. von Arnim, C. Fromman (his editor) *etc.* and discussions on philosophy of nature with F.W. Schelling.

Fig. 1. Johann Wilhelm Ritter, wood carving in the uniform of the Bavarian Acad. Sci.

As a private-scholar without regular wages, he presented lectures on galvanism at the court of the duke of Gotha. His wedding was 1804 with D.C. Münchgesang (4 children). In the same year he moves with his family to Munich becoming a member of the Bavarian Academy of Sciences. Here he died in 1810 as a poor man.

In his short life he worked extremely hard. Some of his publications should be mentioned:

- Beiträge zur näheren Kenntnis des Galvanismus und der Resultate seiner Untersuchungen. Jena 1. Vol. 1800/02, 2. Vol. 1802/05.
- Die Auffindung nicht sichtbarer Sonnenstrahlen außerhalb des Farbenspektrums an der Seite des Violetts. Gilbert's Annalen der Physik 7 (1801) 527.

-Galvanische Beobachtungen während der Sonnenfinsternis vom 11. Februar 1804. Voigts Magazin 7 (1804) 175.
- Das elektrische System der Körper. Leipzig 1805.
- Physikalisch-chemische Abhandlungen in chronologischer Folge. 3 Vol., Leipzig 1806.
- Elektrische Versuche an Mimosa pudica L. Denkschrift der Königl. Akademie d. Wissenschaften zu München 1811.
- Fragmente aus dem Nachlasse eines jungen Physikers. Ein Taschenbuch für die Freunde der Natur. Heidelberg 1810.

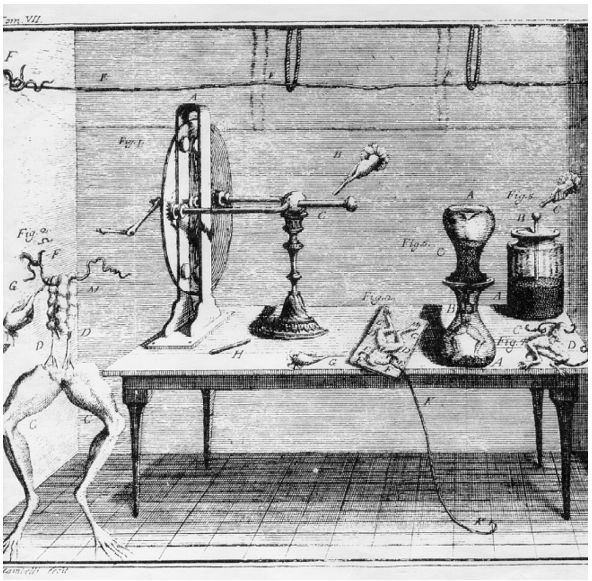

Fig. 2. Laboratory for frog experiments during the L.Galvani time. Left: frog prepared for experiment. D-D, sacral nerve; F, metal wire penetrates the spinal cord. Middle: Electrify apparatus, Right: frog preparations; inverted jar with small lead shot and frog. Inside; Leyden jar with conductor B.

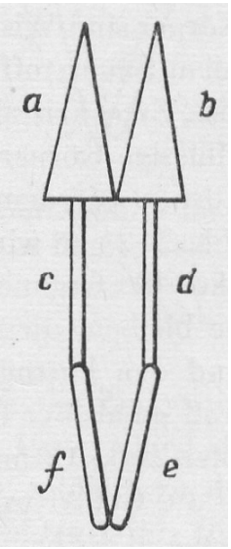

Fig. 3. Scheme of a frog experiment: ***a*** and ***b*** frog legs; ***c*** and ***d*** nerves; ***e*** and ***f*** metals connected to ***g***.

2. The Voltage-Series of Metals

Using two frog-legs and their nerves as indicator (electroscope, schematically in Fig. 3), Ritter measured not only the voltage series of metals - similar as A. Volta: gold, silver, mercury, bismuth, copper, iron, lead, and zinc. Moreover, he found the same differences in their affinity to oxygen. This result proved the electrochemical nature of galvanism.

In the experiments with mercury he observed its movement in an U-shaped capillary after connection with the poles of a voltage-pile. This was an anticipation of the capillar-electrometer of G. Lippmann (1845 – 1921) and finally also of the electrocapillary curves of J. Heyrovsky 1919 in the beginning of polarography.

3. The Analysis of Electrode Reactions

In 1794 L. Galvani (1737 – 1798) published ”De viribus electricitatis in motu muscularis commentarius” and from his frog experiments he believed that the reason why convulsions occur is the animal electricity (vis vitalis). But the physicist A. Volta (1745 – 1827) claimed that contact-electricity between two metals is necessary for this potential generation. However, both hypotheses are wrong. By way of contrast the student Ritter presented - based on his numerous experiments - this right explanation: chemical reactions between metals, and nerves, muscles or electrolytes produce these voltage differences! That means he explains galvanism in terms of chemistry first of all. For that reason Wilhelm Ostwald (1853 – 1932) in his “History of Electrochemistry” 1896 named J.W. Ritter the founder of scientific electrochemistry.

Later on E.du Bois-Reymond (1818 – 1896) measured exactly the so called “wound potential” between a wound surface and e.g. the healthy skin surface.

4. The Electrolysis of Water 1800

Ritter used the Voltaic –Pile (-battery, Fig. 4) for electrolysis the of water on gold electrodes and measured the volume relation of hydrogen to oxygen = 2.5 to 1 (Fig. 5). Their mixture exploded by ignition (named “Knallgas”). Moreover he electrolysed in the same way metal salts getting pure metals. This fundamental technique was extended later on by Ch. Grotthus, J. Berzelius, H. Davy, F. Hoppe-Seyler, H. von Helmholtz, and S. Arrhenius.

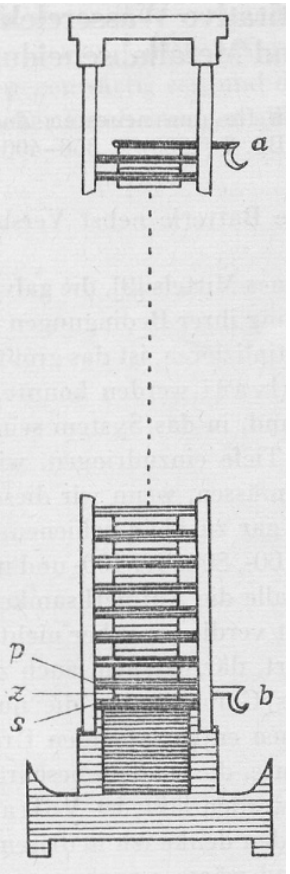

Fig. 4. Voltaic-Pile : ***a*** and ***b*** contacts; ***p*** moistened card- boards; ***s*** silver discs; ***z*** zinc discs.

//

Connected with the Voltaic-Pile, Ritter constructed in 1802 the first kind of a simple accumulator consisting of 50 copper discs- each separated by cardboards moistened by sodium chloride solution.

5. The Electric Stimulations of Organs of his own Body

Performing self-experiments, Ritter touched the poles of a Voltaic-Pile on his eyes, ears tongue, nose, hand, and other organs until the maximum of his pain limit! He feels quite another impressions produced by anodic or cathodic polarization or current intensity:

	on the cathode	on the anode
Eyes	flash + blue light	flash + red light
	Picture decreases	picture increases
Ears	lower tone	higher tone
Tongue	acid	basic
Nose	smell decreases	sneeze
Hand	stiffens	loosening

At Munich he varied the influence of electric stimulation on the plant *Mimosa pudica* L. As a consequence of all Ritter postulated that electrochemistry (galvanism) is permanently working in all living beings for instance like little Leyden jars. Hence he can be named: the founder of Bioelectrochemistry, too.

6. The Discovery of the invisible Ultraviolet Light

In February 1801 Ritter was interested in the spectroscopic results of William Herschel, who found - using a glassy prism - at one side of the visible spectrum of the sun light the heat radiation named “infrared”. For the reason of the symmetry principle Ritter expected on the violet side of the spectrum another invisible radiation. At this time the Swedish chemist Karl Scheele pointed out that silver chloride (AgCl, “horn silver”) changed from white to black in the sun light. Hence Ritter was stimulated to experiments by this observation and he used also AgCl adsorbed on paper for testing the whole visible spectrum and beyond!

His new result: “I found the strongest blackness in the distance from the violet of about half an inch (= 2.5 cm), which decreases at one and a half inch to zero”. Moreover Ritter claimed that the photo-reduction of AgCl to colloidal silver may be reversed slowly- that is from black to white by red light.

Using also the reaction of phosphorus (photo-luminescence) in this invisible region, Ritter was able to confirm his discovery published in Gilbert's Annalen der Physik 7 (1801) 527.

One year later in 1802 the English chemist William Wollaston at London detected the UV-light again.

7. Summary

J.W. Ritter published between 1798/99 the right explanation of galvanism in terms of chemistry by novel frog experiments.

During his most fruitful period 1796–1804 at Jena he detected further:

- the relation between the voltage-series and oxidation of metals	1798
- the quantitative electrolysis of water	1800
- the short wave length UV-radiation in the sun light	1801
- the mercury movement in an U-shaped capillary by polarization	1801
- the influence on his sense organs depending on voltage	1801/02
- the construction of a simple accumulator	1802
- the determination of different currents in branched wires	1804

(anticipation of the laws found by G. Ohm and G.. Kirchhoff)

8. References on J.W. Ritter's life and work

- Berg,H.: Historical roots of bioelectrochemistry. Experientia 36 (1980) 1247 – 48
- Berg, H. und Richter, K.: Entdeckungen zur Elektrochemie, Bioelektrochemie und Photochemie von Johann Wilhelm Ritter. In Ostwalds Klassiker der Exakten Wissenschaften, Bd 271. Leipzig, 1986
- Hermann, A.: Die Begründung der Elektrochemie und Entdeckung der ultravioletten Strahlen von Johann Wilhelm Ritter. Frankfurt a. M. 1968
- Ostwald, W.: Elektrochemie. Ihre Geschichte und Lehre. Leipzig 1896
- Wetzels, W.: J.W. Ritter: the beginnings of electrochemistry in Germany. In: Dubpernell, G. and Westbrook, J.(eds.): Selected Topics in the History of Electrochemistry. Princeton 1978, pp. 68 – 73

（ヘルマン ベルク・イェーナ）

//