"NOTITIA CŒRULEI BEROLINENSIS NUPER INVENTI" ON THE 300th ANNIVERSARY OF THE FIRST PUBLICATION ON PRUSSIAN BLUE

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Introduction

Prussian Blue (ferric hexacyanoferrate (II)), discovered accidentally in 1706 in Berlin by Johann Jacob Diesbach (1) and Johann Konrad Dippel (2), remains an intensively investigated material. Currently, more than 200 scientific publications with Prussian Blue as a research subject are published annually. Johann Leonhard Frisch (see below) and Diesbach produced Prussian Blue in the years following the invention (3).

Three hundred years ago, in 1710, and four years after the discovery of Prussian Blue, the first publication on this new pigment appeared in the *Miscellanea Berolinensia* (4). Here we provide an English translation of this text and report the story of this first publication as it can be traced from the original sources. Following this material is a short biography of the author of that first publication, Johann Leonhard Frisch.

History of the First Publication on Prussian Blue

Published in only seven volumes in 34 years between 1710 and 1744, the *Miscellanea Berolinensia ad incrementum scientiarum—Miscellanea Berolinensia* for short—was the primary journal of the Royal Prussian Society of Sciences up to the reorganization of the Society in 1744. These volumes published in Latin appeared at irregular intervals, in the years 1710, 1723, 1727, 1734, 1737, 1740, and 1743–1744.

The Royal Prussian Society of Sciences was founded on July 11, 1700, in Berlin by the Elector and Margrave of Brandenburg, Friedrich III. One day later, Gottfried Wilhelm Leibniz was appointed as the first president of the Society. In January 1701 Elector Friedrich crowned himself as Friedrich I, the first king in Prussia. The formation of the Society of Sciences was the result of a combined effort of four people: Leibniz in Hannover, the court preacher Daniel Ernst Jablonski (5), the archivist Johann Jacob Chuno (6), and Electress Sophie Charlotte (7) in Berlin. The annual publication of some *Miscellanea* or *Collectanea*, as they were variously called, was an early goal of the Society of Sciences, first mentioned in a "Pro Memoria" Leibniz wrote for the King in the beginning of 1702 (8). However, for some years no action directed toward this goal is recorded. A second mention of the annual publication of Miscellanea occurs as late as December 1706, during a meeting of the Society of Sciences in Berlin headed by Leibniz after a 19-month absence from Berlin (9). During this meeting, plans for publication were affirmed; and from the spring of 1707, the members of the Society submitted texts for the *Miscellanea Berolinensia* to Chuno.

Johann Christoph Hartmann from Frankfurt an der Oder, a town about 80 km east of Berlin, was chosen in June 1707 as publisher of the *Miscellanea*. In October, the Collectanea texts were sent from Berlin to Leibniz in Hannover for proofreading. In March 1708 Leibniz returned the texts to Berlin. When Hartmann then declined to continue the collaboration in April 1708, a new

publisher of the *Miscellanea*, Johann Christoph Papen, was found. Printing was finally expected to start but was delayed again in July 1708, because the chosen type set was too worn, and a new set had to be molded. On February 14, 1709, Leibniz headed a conference of the Society in Berlin. Here the final decisions regarding the publication of the *Miscellanea* were made. The printing finally started in May 1709 (10), performed by the printer Johann Wessel. (Printing and publishing were different professions.)

An article on Prussian Blue was not yet among the submitted manuscripts. In fact, this text is first mentioned in a letter dated November 9, 1709, from Frisch in Berlin to Leibniz in Hannover. In this letter, Frisch sent Leibniz a "Latin narrative on a blue dye" (11). He also mentioned that the title could easily be changed to "Berlin Blue [*Berlinisch Blau*]." Thus, it may be that *Preussisch Blau* ("Prussian Blue") was the original name and it was changed to Berlin Blue at the request of Leibniz. In fact, Prussian Blue was usually called *Berliner Blau* in German, whereas in many other languages Prussian Blue (e.g., *Bleu de Prusse* in French, *Azul de Prusia* in Spanish, *Blu di Prussia* in Italian) is more common. Only in recent years has the German Preussisch Blau been used more often, possibly from the literal translation into German of scientific texts that are now primarily in English.

Johann Theodor Jablonski (12), secretary of the Society of Sciences, also corresponded with Leibniz, the president, in Hannover. In a letter dated January 11, 1710, he reported to Leibniz on the status of the printing process of the *Miscellanea*. He also remarked that the texts Leibniz had ordered to be added at the end would be appended and that among them would also be the *caeruleum* of Frisch (13). On January 30, 1710, Frisch reported to Leibniz in another letter that court councilor Chuno had added the "notitia caerulei Berolinensis" to the pieces that were to be appended to the *Miscellanea* (11). The Frisch text and a second one were later added as "serius exhibita," i.e., addenda.

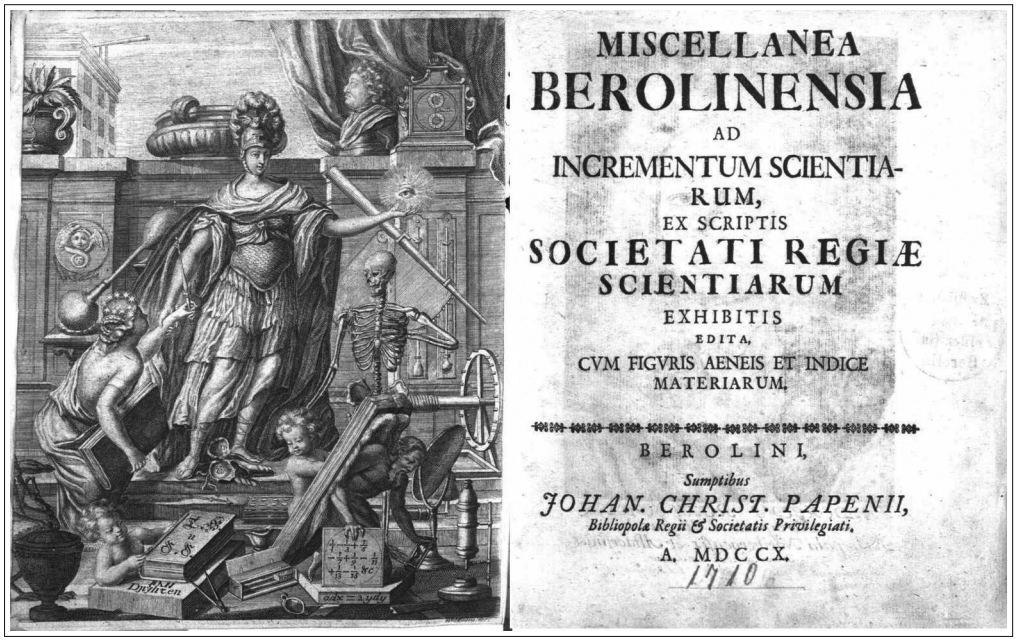

Figure 1*. Frontispiece and title page of the first volume of the Miscellanea Berolinensia from 1710.*

Finally, after more than two years of preparation and one year of printing, the first volume of the *Miscellanea Berolinensia* was ready in May 1710. (The full name was *Miscellanea Berolinensia ad incrementum scientiarum ex scriptis Societatis Regiae Scientiarum exhibitis edita, cum figura aeneis et indice materiarum*.) Figure 1 shows the frontispiece and title page of the book. The copper engraving of the frontispiece was devised by the Swiss painter and first director of the Berlin Academy of Arts, Joseph Werner (14), and drawn by his son Christoph Joseph Werner (15). Johann Georg Wolfgang (1664–1744) produced the engraving.

In May 1710 the sale of the *Miscellanea Berolinensia* started at the Leipzig *Jubilate* Fair. At this time,

the book was still not available in Berlin because in that city a book first had to be presented to the King in an official ceremony. This ceremony did not take place until early June.

This first volume of the *Miscellanea Berolinensia* contains 60 scientific contributions on 425 pages (including the 31 pages with figures at the end), among them 12 articles written by Leibniz. The articles dealt with a wide variety of subjects. The contents of only three are connected with chemistry. Leibniz wrote the first of these, which deals with the solution of a Greek and a German alchemical riddle with some remarks on alchemy (16); a second article, also by Leibniz, reports the history of the discovery of phosphorus (17); and the third article is the one by Frisch on Prussian Blue. Frisch also authored an etymological article (18). The number of printed copies of the *Miscellanea* could not be established. However, of these, the Royal Prussian Society of Sciences bought 50 from the publisher to be distributed at the Royal Court (seven books) and among the members of the Society and in the Prussian government (43 books).

The *Miscellanea Berolinensia* never became an annual publication. In fact, the second volume was not published until 13 years later.

Translation of the "Notitia Cœrulei Berolinensis nuper inventi"

The first page (page 377 of the *Miscellanea*) of Frisch's article on Prussian Blue was displayed as a figure in Ref. 3 The following English translation of the original Latin text is based on two German translations, the first from Mümler (19), published in 1781 (20), and the second, more precise one from Manfred Kraft (21), completed in 2009.

Notice of the Newly Invented Berlin Blue.

Painters who mix their colors with oil have few blue colors at their disposal, and these are of such quality that artists justifiably require better choices. Although one of the commonly used colors can be mixed with oil, it is not stable for a long time and changes to a greenish, pale, rust-colored, or even ugly color. [Au. note: Perhaps this is azurite $Cu_3(CO_3)_2(OH)_2$, a deep-blue mixed copper carbonate-hydroxide mineral that is unstable in the open air and can change to green malachite.] Another choice of blue is stable and beautiful enough, to be sure, but also sandy; this deficiency, so cumbersome in fine artistic work, cannot be avoided, even if it is ground for a year. [Au. note: This may be smalt, a copper oxide-containing glass powder.] The best of all, which is usually called ultramarine or azurinum and is produced from lapis lazuli, discourages many artists because it is high-priced and also does not mix well with other colors. Hence, it can only show its beauty where the artist wants to convey light, and for shadows it is useless. This new blue color, invented some years ago here in Berlin, has undergone careful examination by different painters and now is made public; it is expected to address if not totally satisfy this urgent need of the artists. It possesses none of the disadvantages described above. Even in oil, it shows brilliance. It is durable and a special hue even in water, oil, or other media used in painting. Even *aqua fortis*, as chemists call it, which pits or dissolves everything, does not change or bleach this color but instead makes it more brilliant. [Au. note: Aqua fortis, literally "strong water," is a concentrated solution of nitric acid in water.] Just as some blue pigments can be used for glazing on enamel painting and are not destroyed by what I would describe as a "dry fire," so this new color withstands a "wet fire" (a name which can be properly used for the strong and all-destroying aqua fortis) better than most other colors. Therefore, it gives even less cause for concern with the simpler and more common tests of painters, such as the one involving lemon juice, etc. It is also not affected by changes of location, air, or weather. It is stable in quicklime, decorating the white color as a gemstone decorates gold. [Au. note: This is not the case: Prussian Blue is unstable in alkaline media.] This pigment is made from the finest materials and can be ground to the finest powder. Whatever is not reduced to sufficiently small particles by the first grinding can be pulverized a second or a third time. However, with each grinding the dried powder should be moistened with pure water. This procedure is usually only required for those who want to have it for more convenient use in the smallest kind of painting work, that of miniature painting. Other painters can break it up simply with the small knife they use for mixing the colors on the palette. Because of this fineness, it covers the spots wonderfully on which it is applied with the brush, and it can be spread better than other colors. Additionally, it not only can be applied over the more common blue colors and at elevated spots, but also can be shaded in wrinkles, grooves, and cavities of the painting. There are two varieties of this color: a darker one, more useful for creating shadows, and a lighter one, which is not mixed with white lead or another white color, but emerges during production. Thus, the darker color grade is made from the lighter one by shrinking, or as some say, by concentrating. Ordinary painters, who like this color because of their mixing practices, seldom use the lighter grade; they seek out only the darker grade and mix it with white according to the desired degree of lightness. To the trained eye, it can easily be seen that a color made lighter by mixing the darker grade with a white color lacks the brightness and beauty of

the one that is naturally lighter. By the way, this pigment is harmless and contains no arsenic or anything unhealthful, but rather medicinal ingredients. Sugary objects painted with this color can be eaten without risk. Painter apprentices can draw their paint brushes with which they apply this paint onto paintings through their mouths without danger. This cannot be done with other paints without endangering life. Finally, because the color is easy to produce, the price hardly reaches the tenth part of that of the very expensive ultramarine. And the quantity of stock of this color, which can be purchased in Berlin from the book dealer of the Royal Society of Sciences, is as large as the lavish artists can demand for their paintings that will be decorated with this color.

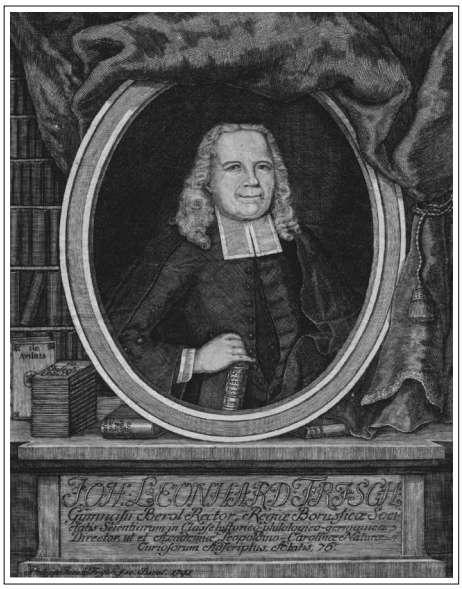

Figure 2*. Johann Leonhard Frisch, teacher and scientist in Berlin, who in 1710 published the first article on Prussian Blue in the* Miscellanea Berolinensia. *Engraving by his son Philipp Jacob Frisch, 1741 (© Leopoldina, Halle, Germany).*

Some Comments on the Translation

It is remarkable that the name of the color is mentioned only once in the article, i.e., in the title. The book dealer of the Society of Sciences was Johann Christoph Papen (22), a publisher and book dealer who had a shop in Berlin between 1700 and 1723, when he was forced to sell his business. He was also the publisher of the first *Miscellanea* volume of 1710 and of the second one of 1723. Over a longer time, he was factor (i.e., mercantile agent) of the Royal Prussian Society of Sciences. Obviously, he also sold Prussian Blue for Frisch and Diesbach.

Who was Johann Leonhard Frisch?

Biographical information on Frisch, the author of the "Notitia Coerulei Berolinensis," can be found in several sources (e.g., Refs. 23, 24, 25). A short summary of this information is given here, together with some comments on his scientific career and his chemical studies.

Johann Leonhard Frisch was born on March 19, 1666, in Sulzbach in the German region of the Upper Palatinate, which is today part of the German state of Bavaria. At that time, the small town of Sulzbach, lying about 50 km east of Nürnberg, was the capital of the German state Palatinate-Sulzbach, a duchy of the Holy Roman Empire of the German Nation.

Johann Leonhard's father, Johann Christoph Frisch (1631–1679), was a lawyer employed as a secret *Secretarius* of the government of Palatinate-Sulzbach. His mother Sabina was the daughter of the goldsmith Fecher from Strassburg (present-day Strasbourg). The family moved from Sulzbach to Nürnberg in Franconia because Johann Christoph Frisch became registrar of the government of that city. From 1670, beginning at the age of only four years, Johann Leonhard attended the Lorenz school in Nürnberg and was instructed in Greek by his grandfather (also named Johann Leonhard Frisch, 1604–1673), a clergyman in Nürnberg. Then for some years, Johann Leonhard's father was inspector in Schnabelwaid in the Margraviate of Brandenburg-Bayreuth, also located in the region of Franconia. In this very small town, Johann Leonhard received only private teaching. From 1680 he studied at the gymnasium in Nürnberg and started his university studies in theology in Altdorf near Nürnberg in 1683.

Around 1686 he began his travels through Europe. First he moved to Jena in the German region of Thuringia to continue his studies, which he completed in Strasbourg (by this time annexed by France) in Alsace in 1688. After traveling through France and Switzerland, he returned to Nürnberg. There he received a candidate degree in theology. From 1691 on he traveled again, this time first via Vienna to Hungary. He stayed for a short time as a preacher in Banská Bystrica in Upper Hungary in a region which is now roughly Slovakia. After leaving this area, he moved south to the border region between Hungary and Turkey and served as a translator for the imperial army during the War of the Holy League (1683–1698), a part of the Great Turkish War. By way of Italy, he made his way back to his home region in 1693.

In the following years, he was manager of several agricultural enterprises in Germany and a private teacher of young noblemen. By 1696 Frisch was similarly employed in the town of Blankenburg in the Harz Mountains. His last brief travel period led him in 1698 to the Netherlands. Finally, in the same year, Frisch came via Hamburg to Berlin were he stayed for the remaining 45

years of his life. Shortly after his arrival in Berlin, he became employed as a teacher in the Berlin gymnasium located in the former Grey Monastery of the Franciscans. Soon afterwards, in 1699, he married Sophie Elisabeth Darnmann, daughter of a pastor from Blankenburg. Frisch now had a steady career at the gymnasium, a job that allowed him enough time to follow his scientific interests. From 1725 on, he was rector of the school.

In December 1706 he became a member of the Royal Prussian Society of Sciences. For the next six years or so, he was responsible for the silk production efforts of the Society, with mixed success. In his early years in Berlin, he was also interested in alchemy and chemistry and performed some experimental work of his own, as can be deduced from some of his letters to Leibniz (11) from the years 1708 to 1712. This experimental work addressed, for example, the alchemical production of gold and the production of different colored pigments or dyes. The alchemical experiments were directed mainly on the testing of processes and "powders" of alchemical gold makers, who were active in Berlin at that time, and on the extraction of gold from copper.

His other chemical experiments focused on the preparation of new colors. In addition to his work on the improvement of Prussian Blue (3), Frisch also mentioned a dark red lake color, a blood-red iron solution, and a green copper solution. He tried to use this last one for producing a green-colored paper. At least some of this experimental work was performed together with Diesbach. Frisch also tried to convince the Prussian Society of Sciences to perform "chymical work," but with no real success. However, after 1712 there is no longer mention of chemical experiments in Frisch's letters to Leibniz. He only mentions his Prussian Blue from time to time in a business context. There is also only one further scientific article from Frisch with a chemistry focus after the *Miscellanea* article of 1710. This short article in the third *Miscellanea* volume of 1727 (26) gives a different solution to one of Leibniz's alchemical riddles from the first *Miscellanea* volume (16).

Frisch concentrated his scientific efforts on other fields in which he excelled. These fields included linguistic studies, culminating in several dictionaries, and the study of insects and birds. These latter studies resulted in two encyclopedic books published in several volumes. His work on insects in 13 volumes was completed in 1738, and his voluminous work with illustrations of German birds in 12 volumes was completed in 1763 by three of his sons and a grandson, 20 years after his death. In further volumes of the *Miscellanea Berolinensia*, after his two contributions to the first volume from 1710, Frisch authored as many as 49 articles in which he made, among other things, important early contributions in parasitology. In May 1725 Frisch was elected as the 380th member of the German Leopoldina science academy with the surname (cognomen) Vegetius.

Frisch, who died March 21, 1743, at the age of 77, had three daughters and five sons. Among them were two engravers, Philipp Jacob (1704–1753) and Ferdinand Helfreich (1707–1758), and the preacher and scientist Jodocus Leopold (1714–1787). A well-known grandson was Johann Christoph Frisch (1738–1815), son of Ferdinand Helfreich. Johann Christoph was a famous painter and member of the Academy of Arts in Berlin. From 1805 to 1815, he was director of that academy.

Even in historical sources, Frisch is only very seldom mentioned in connection with Prussian Blue. In a book with his biography and several memorial poems (23), a connection between Frisch and Prussian Blue occurs in only one instance. A translation of the corresponding verse ends this biography of Frisch:

"Who was it who enhanced the colors bright
By such a heavenly blue?
Who could show by his own might
In silk production great samples, too?
Who was it who could show creature
To God's honor after death as if alive
It was Frisch! If I would be silent, nature would not."

Conclusions

In this paper, we have provided an English translation of the first article on Prussian Blue, together with a short history of the founding of the corresponding journal and a biography of the author Johann Leonhard Frisch.

An enormous number of scientific articles on Prussian Blue have been published in the scientific literature in the last 300 years. According to *Chemical Abstracts* (27) and the author's bibliography of earlier papers, this aggregate amounts to more than 5,500 publications up to 2009. Indeed Prussian Blue remains an interesting and still modern research subject.

ACKNOWLEDGMENTS

I thank Dr. Norbert Kummer from Chemical Abstracts Service and Stephan Fölske from the archive of the Berlin-Brandenburg Academy of Sciences (successor

to the Royal Prussian Society of Sciences) for their help in sourcing information. I also thank my father Manfred Kraft for his assistance in literature searches and access, translations of several Latin texts into German, and many discussions on the subject of the history of Prussian Blue.

REFERENCES AND NOTES

1. Johann Jacob Diesbach was a Swiss pigment and dye producer living in Berlin at least between 1701 and 1716. Further information on him has yet to be discovered.
2. Johann Konrad Dippel (1673-1734) was a German pietist theologian, physician, and alchemist. Between 1704 and 1707 he lived in Berlin and between 1707 and 1714 in Maarsen, Netherlands.
3. A. Kraft, "On the Discovery and History of Prussian Blue," *Bull. Hist. Chem.*, **2008**, *33*, 61-67.
4. J. L. Frisch, "Notitia Coerulei Berolinensis nuper inventi," *Miscellanea Berolinensia ad incrementum scientiarum*, **1710**, *1*, 377-378.
5. Daniel Ernst Jablonski (1660-1741), court preacher in Berlin from 1693, one of the initiators of the foundation of the Royal Prussian Society of the Sciences and from 1733 until his death president of the Society. His scientific interests focused on theology and oriental languages.
6. Johann Jacob Chuno (1661-1715), of French Huguenot origin (his name was also written as Cuneau), Royal Court Councilor and first *Archivarius* of the secret states archive in Berlin. He was one of the initiators of the founding of the Royal Prussian Society of the Sciences. His scientific interest focused on mathematics.
7. Sophie Charlotte von Braunschweig-Lüneburg (1668-1705), married in 1684 to Friedrich von Hohenzollern (1657-1713), Electress of Brandenburg from 1688, first Queen in Prussia from 1701. Her friendship with Leibniz and her involvement in the foundation of the Royal Prussian Society of the Sciences are remarkable.
8. A. Harnack, *Geschichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin*, Reichsdruckerei, Berlin, 1900, 129.
9. Ref. 8, p 145.
10. Ref. 8, p 157.
11. L. H. Fischer, Ed., *Joh. Leonh. Frisch's Briefwechsel mit G. W. Leibniz*, Georg Olms Verlag, Hildesheim, New York, 1976 (reprint of the book from 1896).
12. Johann Theodor Jablonski (1654-1731), brother of D. E. Jablonski (5), lived in Berlin from 1700 and was secretary of the Society of Sciences and taught a Prussian prince. He published a French-German dictionary and an encyclopedic dictionary.
13. A. Harnack, Ed., *Berichte des Secretärs der Brandenburgischen Societät der Wissenschaften J. Th. Jablonski an den Präsidenten G. W. Leibniz (1700-1715), nebst einigen Antworten von Leibniz,* Verl. d. König. Akad. D. Wiss., Berlin, 1897.
14. Joseph Werner (1637-1710), a Swiss painter, lived in Berlin from 1696. He was the first director of the Berlin Academy of Arts. In several biographies it is mentioned that he returned to Switzerland in 1706 or 1707. However, letters of J. T. Jablonski to Leibniz (13) prove that he still lived in Berlin in January 1710.
15. Christoph Joseph Werner (1670-1750), son of Joseph Werner. He came to Berlin with his father in 1696. After 1713 he was court painter in Dresden, the capital of the German State of Saxony.
16. G. W. Leibniz, "Oedipus Chymicus aenigmatis Graeci & Germanici," *Miscellanea Berolinensia ad incrementum scientiarum*, **1710**, *1*, 16-22.
17. G. W. Leibniz, "Historia inventionis Phosphori," *Miscellanea Berolinensia ad incrementum scientiarum*, **1710**, *1*, 91-98.
18. J. L. Frisch, "Origo quorundam vocabulorum Germanicorum et cum aliis linguis affinitas," *Miscellanea Berolinensia ad incrementum scientiarum*, **1710**, *1*, 60-83.
19. Johann Ludwig Conrad Mümler (1753-1787), a physician in Wolfenbüttel, translated several scientific publications from books and journals into German from Latin or French.
20. J. L. C. Mümler, Ed., "Nachricht von dem vor kurzem erfundenen Berlinerblau," *Physicalische und medicinische Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin*, **1781**, *1*, 95-97.
21. Manfred Kraft (born 1936) is a retired chemist living in Leipzig and father of the author. He worked as a research chemist at the precursor companies of today's KataLeuna GmbH for more than 30 years. He is interested in the history of chemistry and among other works translated several 18th-century chemical texts from Latin into German.
22. Johann Christoph Papen (?-?), book dealer and publisher in Berlin between 1700 and 1723. In 1723 he was forced to sell his business to Ambrosius Haude (1690-1748) because of economic difficulties. Later this business would become the important Haude & Spener Publishing Company. Between 1702 and 1722 Papen was also factor (i.e., mercantile agent) of the Royal Prussian Society of Sciences.
23. J. J. Wippel, *Das Leben des Weiland berühmten Rectors an dem Gymnasio zum grauen Kloster in Berlin, Johann Leonhard Frisch: nebst beygefügten Stand- und Lob-Reden, auch einigen Trauer-Gedichten*, Nicolai, Berlin, 1744.
24. "Johann Leonhard Frisch," *Allgemeine Deutsche Biographie*, **1878**, *8*, 93-95.
25. "Johann Leonhard Frisch," *Neue Deutsche Biographie*, **1961**, *5*, 616.
26. J. L. Frisch, "Alia ratio solvendi quatuor posteriores versus aenigmatis Basilii Valentini, cujus Tomo I. Miscell. Berol. p. 21, mentio facta est," *Miscellanea Berolinensia ad incrementum scientiarum*, **1727**, *3*, 25-26.
27. CAplus with SciFinder (Chemical Abstracts Service of the American Chemical Society).

ABOUT THE AUTHOR

Alexander Kraft, Ph.D. in Physical Chemistry (semiconductor electrochemistry) from Humboldt University in Berlin, 1994, is co-founder and one of the managing directors of Gesimat GmbH, Berlin, Germany, a company that developed a smart switchable glazing incorporating a thin electrochromic Prussian Blue film. Before starting with Gesimat in 1998, he developed electrochemical water-treatment technologies and devices. He continued working in this field as a scientific adviser until 2006.

8th International Conference on History of Chemistry "Pathways of Knowledge"

September 14 - 16, 2011 in Rostock, Germany

The Working Party (WP) on History of Chemistry of the European Association for Chemical and Molecular Sciences (EuCheMS) will hold its bi-annual International Conference on History of Chemistry (8th ICHC) in Rostock, Germany, from 14 to 16 September 2011.

From 12 to 14 September 2011 the National Conference of the Working division on History of Chemistry of the German Chemical Society will be held in Rostock, too. At this conference historians of science and technology and chemists will meet around several themes in history of chemistry. Everybody has the interesting option of visiting both events in Rostock.

The 8th ICHC will focus on the theme "Pathways of Knowledge".

This theme is in direct connection to the general aim of the conferences organised by the WP, namely to facilitate communication between historically interested chemists and historians of chemistry from all over Europe. Previous conferences organised by the WP were held in Lisbon 2005 (Chemistry, Technology and Society), Leuven 2007 (Neighbours and Territories: The Evolving Identity in Chemistry) and Sopron 2009 (Consumers and Experts: The Use of Chemistry and Alchemy).

http://www.gdch.de/vas/tagungen/tg/5511__e.htm