Jakob Maarten van Bemmelen

(November 3, 1830 Amelo – March 13, 1911 Leiden)

and the history of the theory of adsorption from solution

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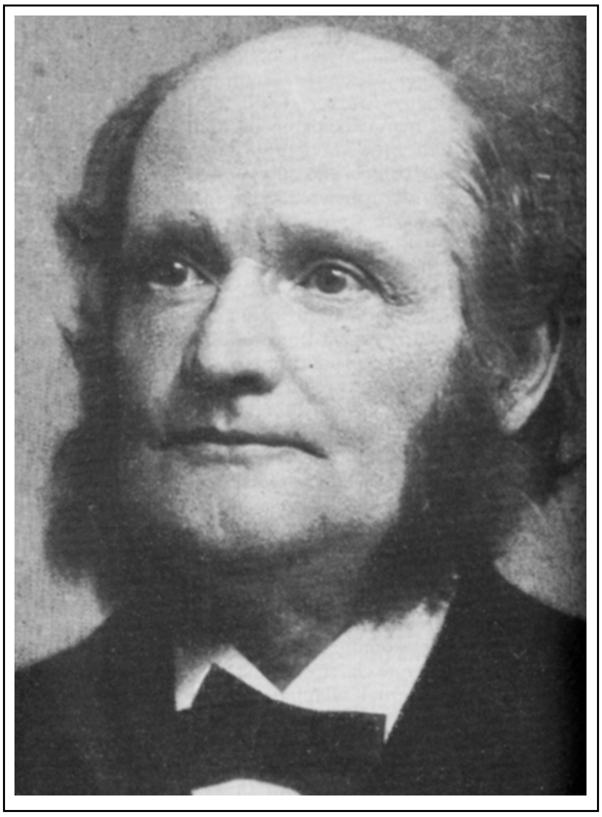

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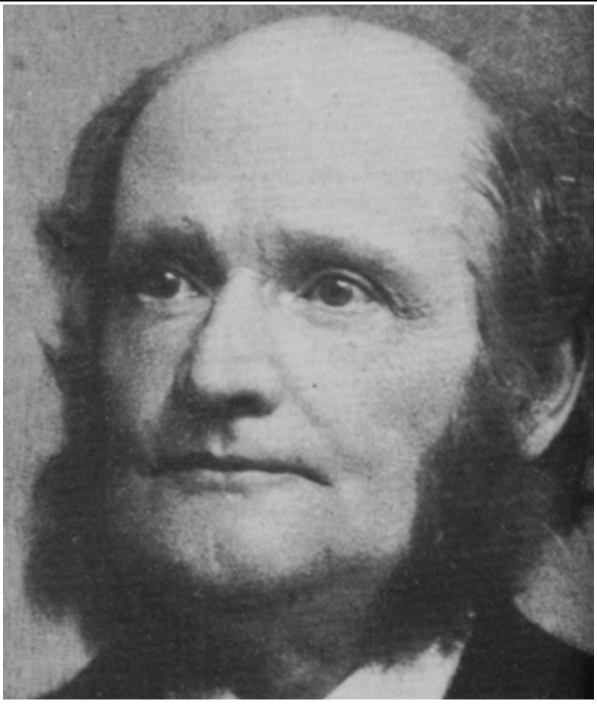
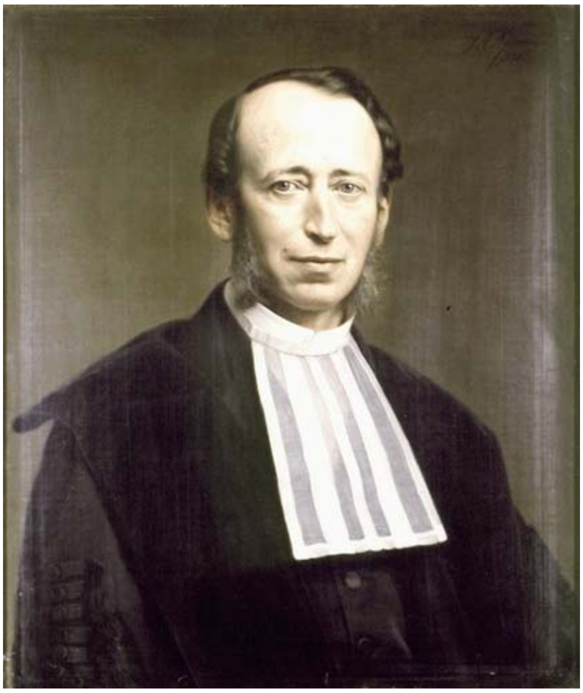


Jakob Maarten van Bemmelen



Petrus Jan van Kerckhoff

Van Bemmelen was descented from a family, many of whose members were distinguished in education, law, and statesmanship. Jakob Maarten van Bemmelen was born on November 3, 1830 in Amelo where his father Jan Frans van Bemmelen was headmaster of the grammar school. His mother was Antoinetta Adriana de Kempenaer. His father died in the same year (December 26, 1830) and his family moved to Leiden. On September 13, 1847 he matricultated there as a student. He studied inorganic- and organic chemistry also pharmacy under Professor Antonius Henrik van der Boon Mesch (15.04.1804 Delft - 12.08.1874 Leiden), who had only a primitive laboratory at his disposal, where van Bemmelen made some quantitative inorganic analysis. Van der Boon Mesch studied fermentation, mineralogy, industrial chemistry, construction of voltaic batteries and boiling points of water/alcohol mixtures.

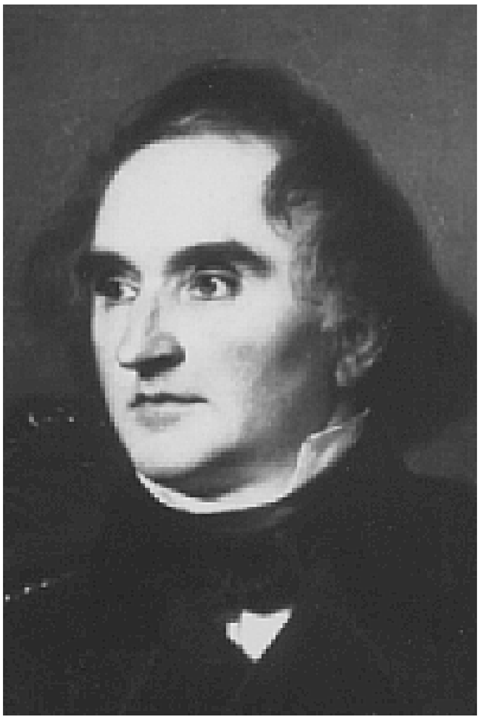
In 1852, van Bemmelen was appointed as an assistent in the laboratory of Professor Petrus Jan van Kerckhoff (1813 - 1876) in Groningen. Van Kerckhoff was head of the chemistry institute since 1851. The houses of the colleges weres just finished, the laboratories conditions in Groningen were exellent for the time. The academic library for students was very well developed. In Groningen van Bemmelen started his research with chemical reactions of acids on glycerine and glucose (BEMMELEN, 1856, 1859). He also carried out an investigation on the composition of infertil types of soil in Groningen province. The thesis which gained him his doctorate at Leiden University in 1854 (October 16, 1854 by A. H. van Boon Mesch with 'summa cum laude') was written in Groningen and summarised his results of investigations on substances which can be extracted by different solvents from the fibres and wood of *Cibutium cumingii*, a Sumatra herb known as a styptic agent (BEMMELEN, 1854).

Two years later (September 1856), J. M. van Bemmelen was appointed lecturer in chemistry and physics at the "Akademie Minerva", an industrial school at Groningen, while remaining an assistent at the University. However, he was soon appointed to the teaching stuff of the agricultural school in Groningen and this brought him into close contact with agriculture. Shortly later he married Miss Maria Boeke (August 31, 1858). They had two sons and three daughters (JORISSEN, 1910, SNELDERS, 1979).

Heike Kamerlingh Onnes

Work done at the request of the committee for Statistics of the Province was published in 1863 as "Contributions to the knowledge of clay soils in Groningen Province" (BEMMELEN, 1863a). In the meantime, he had also acquired a high reputation as a teacher and was appointed headmaster (1864) of the State "Rijkshoogereburgerschool" (a type of reformed secondary school without classical languages) in Groningen, a post he held for five years. One of the pupil at this school was Heike Kamerlingh Onnes (21.09.1853 Groningen - 21.02.1926 Leiden), the Nobel prize winner in Physics 1913.

During this time, van Bemmelen conducted an investigation on exhaustive farming in the Netherlands, following the well-known views of Justus von Liebig (12.05.1803 Darmstadt - 18.04.1873 Munich) (BEMMELEN, 1863b). He also analysed a large number of soil specimens from the Zuider Zee in connexion with the plants to surround the southern part of this basin with dykes with the aim of pumping it dry, a plan which has only been fully implemented in recent years. At this time, he also planned his experiments on the adsorption potential of agricultural soil, the first results he published 1877 (BEMMELEN, 1877a, 1878).

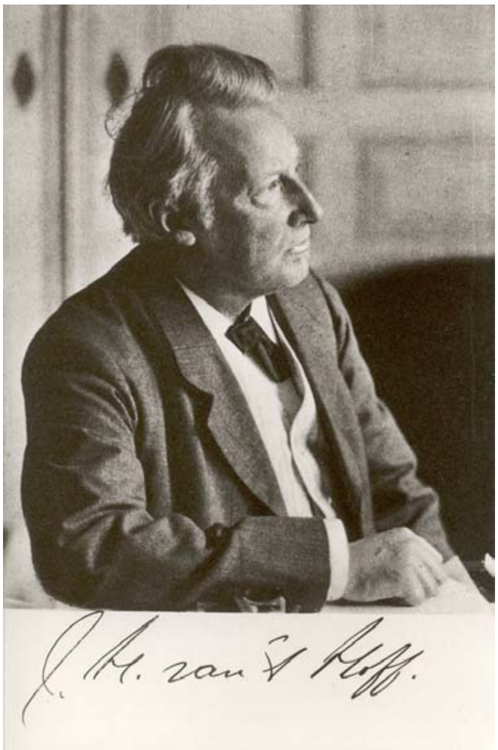


Justus von Liebig

Hendrik Willem Bakhuis Roozeboom

Van Bemmelen was appointed headmaster of the “Hoogereburgerschool“ in Arnhem in 1869 where he remained for nearly five years. Here he devoted much interest to the conditions in the public and private schools in the town (BEMMELEN, 1870, 1871). Here he worked an „change of air“ in schools so that pupils had pure air in schoolrooms (BEMMELEN, 1874).

However, J. M. van Bemmelen´s main work dealt with the analysis of natural waters and the investigation of types of soil. At this time (1873) his brother in law Dr J. D. Boeke, commended 1873 van Bemmelen a pupil of his school (Hoogereburgerschool in Alkmaar) to help van Bemmelen by ground analysis of the Ijpolder (BEMMELEN, 1872, 1873a,b). This man was Hendrik Willem Bakhuis Roozeboom (24.10.1854 Alkmaar - 08.02.1907 Amsterdam). He studied (1874) chemistry in Leiden but had not enough money for a longer study. Bakhuis Roozeboom worked in a food factory, but the factory burnt down in 1878. Then he started his chemistry study new in Leiden and graduated in 1884 under J. M. van Bemmelen. In 1896 Bakhuis Roozeboom became follower of Jacobus Henricus van´t Hoff (30.08.1852 Rotterdam - 01.03.1911 Berlin; Nobel prize winner in chemistry 1901) at the University of Amsterdam. Bakhuis Roozeboom worked about the Gibbs phase rule and the chemical compostion of steel (BAKHUIS ROOZEBOOM, 1900, 1901-1918; BEMMELEN, JORISSEN, RINGER, 1907).

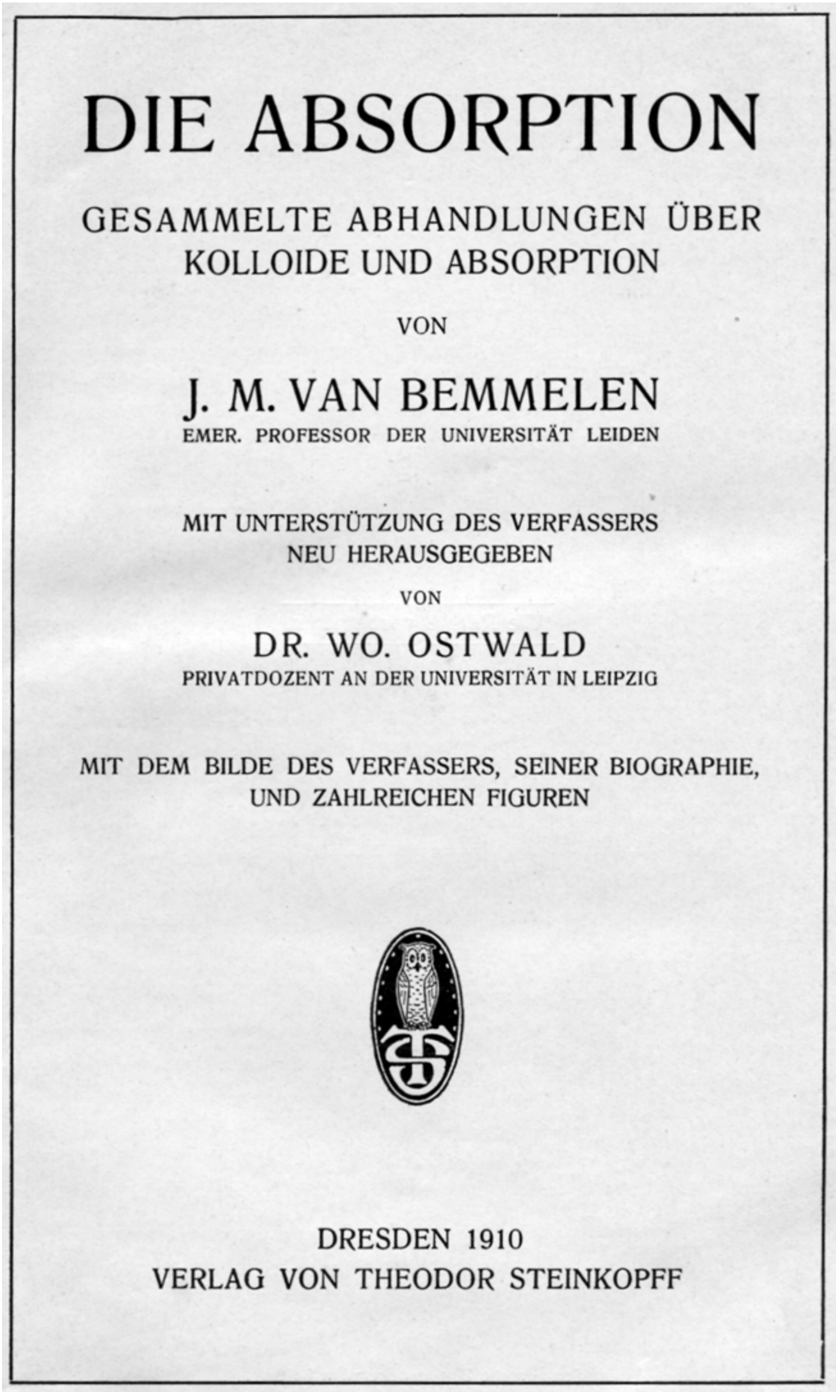

Jacobus Henricus van´t Hoff


Friedrich August Kekulé


Charles Adolphe Wurtz

Van der Boon Mesch had a desease ridden in December 1873 and he must stop his acedemic carreer in Leiden, he died shortly later. In February 1874, van Bemmelen was appointed to the chair of inorganic chemistry in Leiden University, and in his lectures revitalised and brought up to date the teaching in this subject. The first chair of organic chemistry in Leiden occupied with Antoine Paul Nicolas Franchimont (10.05.1844 Leiden - 02.07.1919 Leiden) who had studied at Leiden University and worked under van der Boon Mesch. After his thesis (1871) Franchimont spent a short time as a private assistent to Friedrich August Kekulé (07.09.1829 Darmstadt - 13.07.1896 Bonn) at the University Bonn and to Charles Adolphe Wurtz (26.11.1817 Wolfisheim near Strasbourg -

12.05.1884 Paris) in Paris (1872/73). In 1873/74 he was lecturer in chemistry at the Wageningen Agricultural College. He studied the acylation of sugars and cellulose, nitroamino compounds, urea, urethanes, nitric acid and oxalic acid. He retired in 1914 (JORISSEN, 1910, KERKWIJK, 1934, SNELDERS, 1979).


DIE ABSORPTION

GESAMMELTE ABHANDLUNGEN ÜBER KOLLOIDE UND ABSORPTION

VON

J. M. VAN BEMMELEN
EMER. PROFESSOR DER UNIVERSITÄT LEIDEN

MIT UNTERSTÜTZUNG DES VERFASSERS NEU HERAUSGEGEBEN

VON

DR. WO. OSTWALD
PRIVATDOZENT AN DER UNIVERSITÄT IN LEIPZIG

MIT DEM BILDE DES VERFASSERS, SEINER BIOGRAPHIE, UND ZAHLREICHEN FIGUREN

DRESDEN 1910
VERLAG VON THEODOR STEINKOPFF

In April 25, 1874 J. M. van Bemmelen held his inaugural lecture in Leiden, the title *“Die Scheikunde als leer der stofwisseling“*. His laboratory is now the Kammerlingh Onnes laboratory for low temperature research. He continued his agricultural investigations and initially published several reports on many soil analyses which he carried out at the request of the Government and of some companies. These also dealt with soil specimens collected during drillings in the Zuider Zee and soil types of some dried-off polders (BEMMELEN, 1877b,c 1880, 1886a,b). In addition, in 1877 and 1878 he published two important papers on the adsorption potential of agricultural soil. These investigations led him to conduct a detailed experimental with colloidal systems and to enter the field of research on which his reputation is based. The papers of colloidal science were reprinted in a book *"Die Absorption"* (BEMMELEN, 1910).

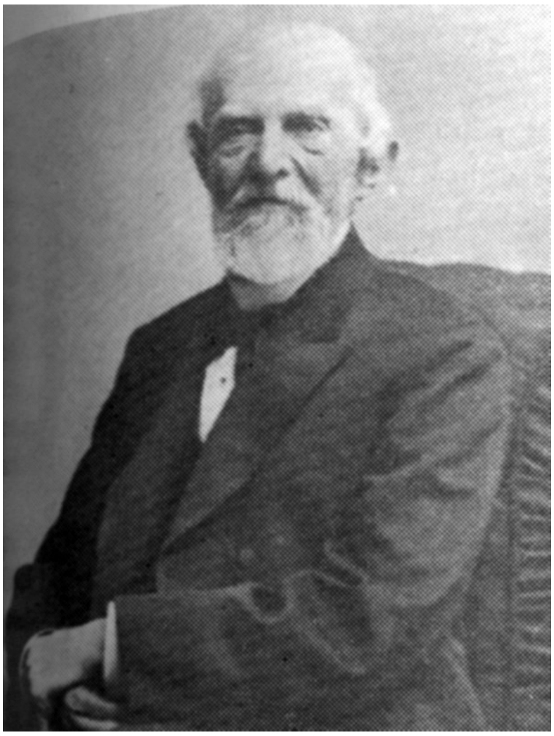
J. M. van Bemmelen was in 1887 appointed a member of the Geological Commitee of the Dutch Royal Academy of Science (Koninklijke Akademie van Wetenschapen), being elected secretary of this commitee five years later. Another of his interests lay in instruction for practical work. Over 31 years he was also active (nine terms as chairman) in the "Society Mathesis Scientiarium Genitrix" established in 1785 for the porpose of intellectual education of the youth from the active classes of the bourgoise, artisans and labourers. Between 1882 and 1891, J. M. van Bemmelen was also chairman of the management of the "Praktische Ambachtschule" and remained an honory member of this body till his death. The last 31 years of his life he was a member of the Municipial School Board, too.


Wolfgang Ostwald

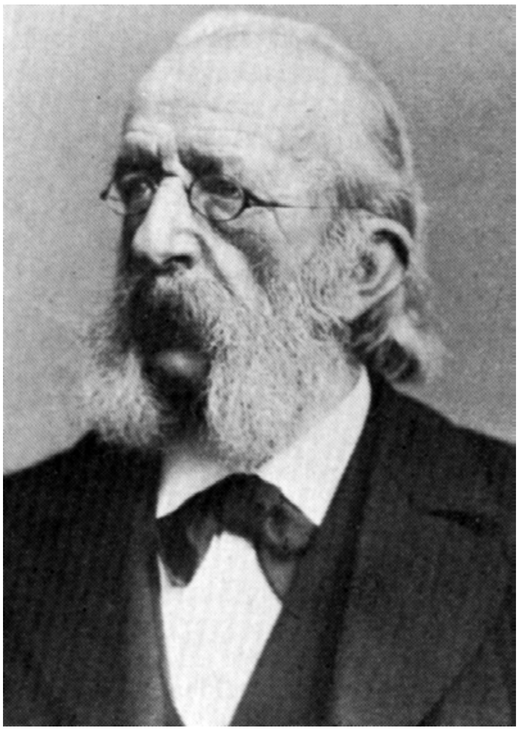
In 1889 van Bemmelen was rector of the University Leiden. In his speech as rector he demanded to raise a fund to have own money for the university. One year later the endowment fund "Leidsch Universiteit-fonds" was founded. This fund supported students and young scientiest with money. On September 16, 1901 Jakob Maarten van Bemmelen became professor emeritus. He was one of the first in Holland to demand that his body be cremated, which necessitated its transport to Bremen in Germany, because there was then no crematorium in Holland. Jakob Maarten van Bemmelen died on March 13, 1911 in Leiden (FORRESTER AND GILES, 1971; FISCHER, 1989)

Carl Wilhelm <u>Wolfgang</u> Ostwald (27.05.1883 Riga - 22.11.1943 Dresden/ Bad Weißer Hirsch) wrote in the foreword of *"Die Absorption"* that Jakob Maarten van

Bemmelen was the founder of the theory of absorption (adsorption) from solution BEMMELEN, 1910). The history of solute-solid adsorption theory can be traced back to



Carl H. D. Boedeker



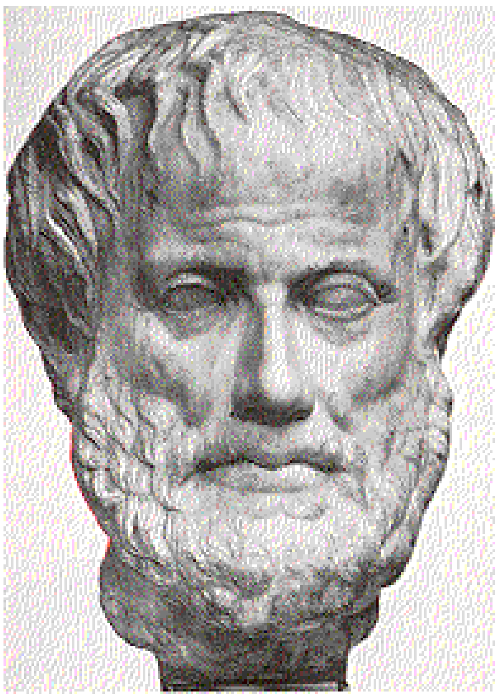
Wilhelm Henneberg

Thomas Graham

Friedrich Wöhler

the time of Carl H. D. Boedeker (1815 - 1895) who has given an equation of the adsorption of soil and shows that its development was entirely due to agricultural chemists (BOEDEKER, 1859). The investigation of the adsorption of both basic and acidic radicals continued to attract the attention of soil chemists.

Similar results are reported by John Thomas Way (1820 Tunbridge Wells, Kent - 1883 Kensington) and Johann Wilhelm Julius Henneberg (10.09.1825 Wasserleben near Wernigerode - 22.09.1890 Göttingen) and Friedrich Carl Adolf Stohmann (25.04.1832 Bremen - 01.11.1897 Leipzig) (WAY, 1850; HENNEBERG AND STOHMANN, 1858). Way and Stohmann were students of Thomas Graham (21.12.1805 Glasgow - 16.09.1869 London), who was founder and first president of the Chemical Society of London, and who first named the term “colloid“. Since 1851 Stohman studied under Friedrich Wöhler (31.07.1800 Eschersheim, now Frankfurt on Main - 23.09.1882 Göttingen) at the University Göttingen, than (1853) at the College of Chemistry in London and shortly later he became assistent of Thomas Graham shortly at the University of London, now University College. A short time he worked in the chemical factory of his father in Neusalzwerk (now Bad Oeynhausen) but with due to economic plight the family must give up the factory and lost their money. He became assistent at the Agriculturchemical Laboratory of the the Royal Agriculture Society (Agriculturchemisches Laboratorium der Königlichen Landwirthschafts-gesellschaft) in Celle. Later he was Professor of Chemical Agriculture in Brunswick, Munich, Halle, and, 26 years until his death, in Leipzig (OSTWALD WI., 1897).

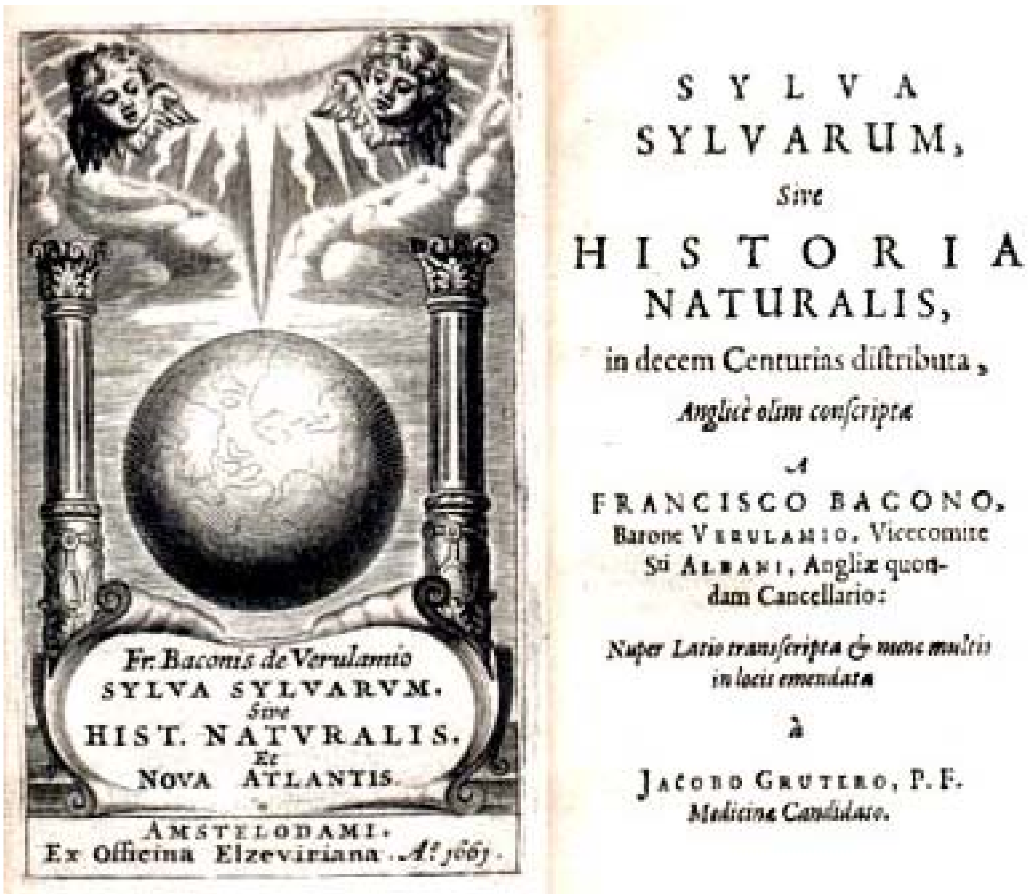


Aristoteles

Francis Bacon (Baron of Verulam)

The filtration of sea water through sand is known from the earliest times. Aristotele (384 B. C. Stagirus, Macedonia/Greece - 322 B. C. Chalcis, Euboea/

Greece) reported that sea water lost some of its taste by filtration through sand. Lord Francis Bacon (Baron of Verulam; 22.01.1561 London - 09.04.1626 Highgate near London) speaks of a method of obtaining fresh water which was practised on the coast of Barbary in his *Sylva Sylvarum*: *“Digge a hole on the sea shore somewhat above high water mark, and as deep as low water mark, which when the tide cometh will be filled with water fresh and potable“.* He also remembers: *“to have read that trial hath been made of salt water pressed through earth through ten vessels, one within another, and yet it hath not lost its saltness as to become potable“*, but when *“drayned through twenty vessels hath become fresh...“* (BACON, 1627; FORRESTER AND GILES, 1971).



Johann Rudolph Glauber (1604 Karlstadt/Franconia - 10.03.1670 Amsterdam, other 16.03.1670 or 10.03.1668 Amsterdam) later an alchemist, applied chemist, and technical chemist, began his education at the Latin school in Karlstadt, but did not finish. Probably he also worked at the Mohren-Apotheke. He did not attend an university. Glauber settled his life through many towns. He visits laboratories in Paris, Basel, Salzburg (1626), and Vienna (1625/26). In 1635 he worked at the court apothecary in Giessen. From 1636 to 1639 he leaved Giessen and went to Frankfurt, and then probably went to work for the Landgraf von Hessen-Darmstadt in Bonn. In

1640 Glauber left Germany and settled in Amsterdam. In 1644 Glauber came back to Giessen as a court apothecary, 1646 he returned to Amsterdam and bought a large house for which he had to pay annual property tax of 1 000 Gulden which seems an enormous amount. He produced and sold drugs. He fled 1651 to Germany because he was bankrupt with 10 000 Gulden debts. He settled in Wertheim and began experiments in wine improvment, probably also continuing other alchemical experiments. In 1652 in Kitzingen he bought a large house with cash. Glauber maintained a medicial practise of sorts, dispending primarily antimony-containig medicines free of charge. He returned 1655 to Amsterdam where he died.

Johann Rudolph Glauber

In the *Glauberus concentratus* or *Kern der Glauberschen Schriften* written from his pupils (1668, and posthum 1715):

"Die beste Präcipitation geschiehet durch einen sonderlichen Sand, den mir nicht beliebt zu offenbaren, welcher alles Saltz, Schleim, Gestanck und Unreinigkeit aus dem Wasser, Mistlachen, die angebohrene Röte im rothen Wein, Bier etc. etc. in wenigen Stunden fället, und aus rotem Wein weißer Wein wird. Wird doch das Meer-Wasser süß, wann es durch gemeinen Sand lauffet, und allda sein Saltz hinter sich lässet: geschieht nun solches natürlich, warum nicht durch die Kunst". ("The best technology is given through an special sand, which I don not reveal. All salts, slime, maladour and uncleaness from water, liquid dung, the red of the red-wine, beer, etc., falling down in several hours, and the red wine will be white wine. When sea-water will be sweetly, when it was filtered through normaly sand and all the salt goes out of the sea-water: happened this naturally, why not by means of artistry") (GLAUBER, 1715, ROBENS, 2000).

Luigi Ferdinando Marsili

Luigi Ferdinando Marsili (20.07.1658 Bologna - 1730 Bologna) in 1725 made quantitative experiments by filtering of sea water through fifteen successive vessels of garden soil; a reduction of the salt content was proved by evaporation and by change in specific gravity (MARSILI, 1725).

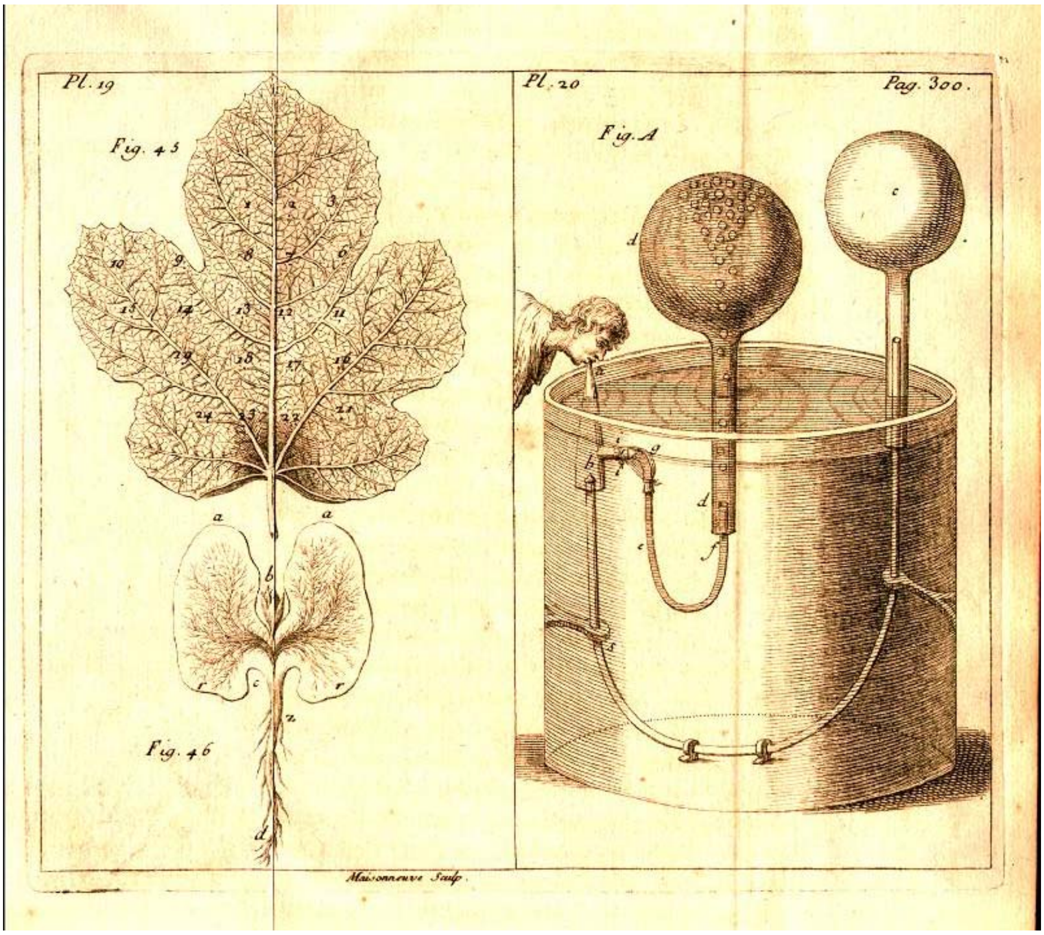
Similar results were obtained with sand. Boyle Godfrey discussed the question of making sea water fit for use on ships and observed that if sea water be put into a stone straining cistern the first pint that runs through will be like pure water, having no taste of salt, but the next pint will be as usual (GODFREY, 1737).

Stephen Hales (17.09.1677 Bekesbourne/Kent - 04.01.1761 Teddington/ Middlesex) worked in plant physiology. His book *Vegetable Statics* (1727) included his most important observations in plant physiology. Hales demonstrated that plant leaves adsorb air and that a portion of air is used for plant nutrition. In *Haemostaticks* (1733) Hales made medical recommendations on therapeutic bleeding and surgey and practical medicinal applications. Hales dealing in *Philosophical experiments* (1739) with the same question as Godfrey, refers to make use of a soft stone as a filtering material, but he points out that this method is of no practical value as only the first portions of the filtrate are free from salt (FORRESTER AND GILES, 1971; BENEKE, 1995a).

Stephen Hales

Jöns Jakob Berzelius

Jöns Jakob Berzelius (20.08.1779 Väversunda - 07.08.1848 Stockholm) reported when solutions of common salt filtered through sand, the first portions that passed are quite free from saline impregnation. Carlo Maria Giovanni Matteucci (21.06.1811 Forli/Romagna - 25.07.1868 Ardenza near Livorno) founded this observation to other salts, and found that the solutions when filtered through sand were diminished in density, thus indicating a retention by the sand of thin quantities of the sand used. Matteucci explains these phenomena on the principle of capillarity. The particles of the sand have a surface section for the water and the salt, but this is greater when the latter, and, therefore, the salt is concentrated and condensed on the sand, while the liquid is proportionally finished in strength and density. When this attraction has been gratified the solution ceases to be affected, and goes through as it went in (FORRESTER AND GILES, 1971).



Stephen Hales: metabolism by plants and animals

F. H. Storer commented in 1887 that, naturally enough, practical men have long observed how readily barnyard liquor and other coloured waters are made clear and odourless when put in contact with fresh loam or clay. Several writers at one time or another have called attention to the fact, and have dealt upon its importance notably Sir Humphry Davy (17.12.1778 Penzance/Cornwall - 29.05.1829 Geneva/Switzerland) in 1813, Giuseppe Gazzeri (1771 Florence - 1847) in 1819 and Lambruschini in 1830. Gazzeri wrote as follows: *“Loam and especially clay take possession of soluble matters which are intrusted to the soil, and retain them in order* *to give them by degrees to plants, comformably with their needs...“*. Lambruschini suggeted that it might perhaps be well to apply the name “incorporation“ to the act of combining dung liquor and soil. We can readily recognise, he said, that fertilising liquids and the constituents of a well prepared soil enter into a peculiar combination, by virtue of a special affinity. This combination is not weak enough to allow any very easy loss of the fertilising constituents, and to permit plants to consume them too rapidily, and yet the combination is not strong, but that the vital action of growing plants can gradually overcome it (GAZZERI, 1919; LAMBRUSCHINI, 1830; STORER, 1887; FORRESTER AND GILES, 1971).

Humphry Davy

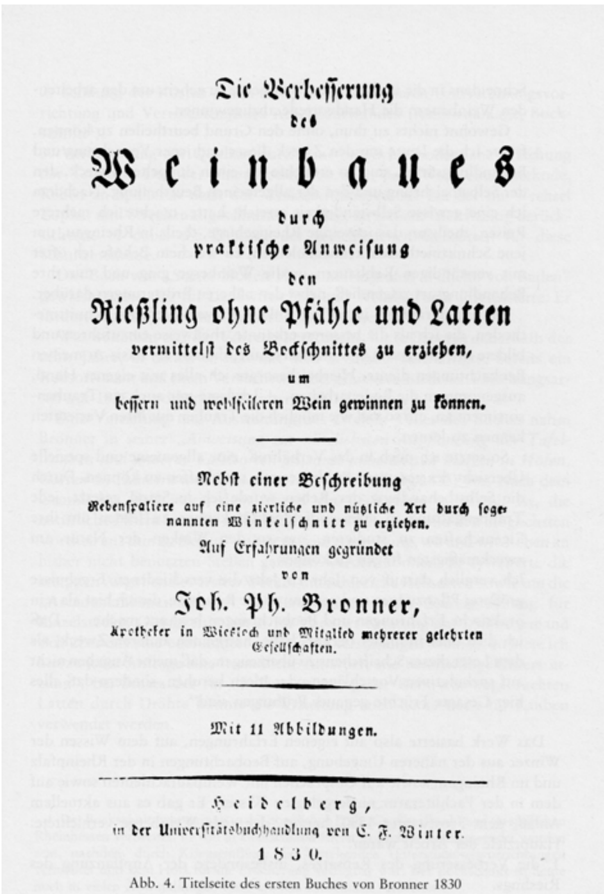
Giuseppe Gazzeri

In 1836 Johann Philipp Bronner (11.02.1792 Neckargemünd, near Heidelberg - 04.12.1864 Wiesloch, near Heidelberg) who lived in Wiesloch (Germany) has written in his book about grape culture the following passages:

“Fill a bottle which has a small hole in its bottom with fine river sand or halfdry sifted garden earth. Pour gradually into the bottle thick and putrefied dung-liquor until its contents are saturated. The liquid that flows out at the lower opening appears almost odourless and colourness, and had entirely lost its original properties“.

After instancing the facts that wells situated near dung-pits are not spoiled by the latter, and that the foul water of the Seine at Paris becomes potable after filtering through porous sandstone, Bronner continues:

Johann Philipp Bronner



Die Verbesserung
des
Weinbaues
durch
praktische Anweisung
den
Rießling ohne Pfähle und Latten
vermittelst des Bockschnittes zu erziehen,
um
bessern und wohlfeileren Wein gewinnen zu können.

Nebst einer Beschreibung
Rebenspaliere auf eine zierliche und nützliche Art durch sogenannten Winkelschnitt zu erziehen.
Auf Erfahrungen gegründet
von
Joh. Ph. Bronner,
Apotheker in Wiesloch und Mitglied mehrerer gelehrten Gesellschaften.

Mit 11 Abbildungen.

Heidelberg,
in der Universitätsbuchhandlung von C. F. Winter.
1830.

Abb. 4. Titelseite des ersten Buches von Bronner 1830

"These examples sufficiently prove that the soil, even sand, possesses the property of attracting and fully absorbing the extractive matters so that the water which subsequentely passes is not able to remove them; even the soluble salts are absorbed, and are only washed out to a small extent by new quantitives of water" (BRONNER, 1836; FORRESTER AND GILES, 1971).

Johann Philipp Bronner was apothecary in Wiesloch (Stadt-apotheke) and in 1820 started practical experiments in his vineyard. Before this time he had traveled through Europe obtaining great experience in winegrowing. J. P. Bronner made a conditioning of vine cuttings, with later 400 breeds. He was a pioneer and one of the resourcefulliest and forward-looking vineculter explorer of the 19th century in Germany. He wrote eight books about oenology (BRONNER, 1833, 1834, 1835, 1836, 1837a,b, 1839, 1842). The pharmacy of Bronner (Stadt-apotheke) became later in August 8, 1888 the first fuel filling station of the world, when Bertha Benz (03.05.1849 Pforzheim - 05.05.1944 Ladenburg near Heidelberg), the woman of Carl Friedrich Benz (25.11.1844 Mühlburg near Karls-ruhe - 05.04.1929 Ladenburg), drived - without the knowledge of her husband - with her sons Eugen and Richard with the first car "Benz Patent Motorwagen" 106 km from Mannheim to Pforzheim, to refuel in the pharmacy in Wiesloch now under apothecary Willi Ockel 3 liters of

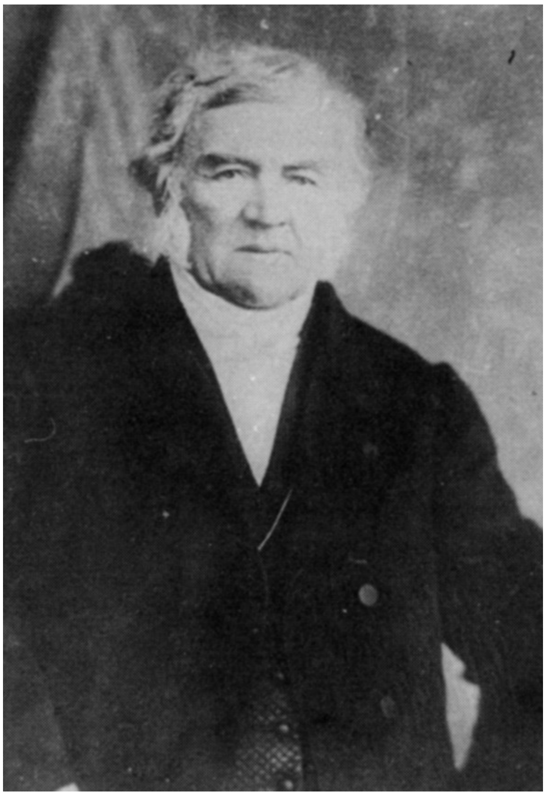
Ligorin. The “Benz Patent Motorwagen” was in January 29th 1886 patented under the German Patent-Number 37 435.

Bertha Benz

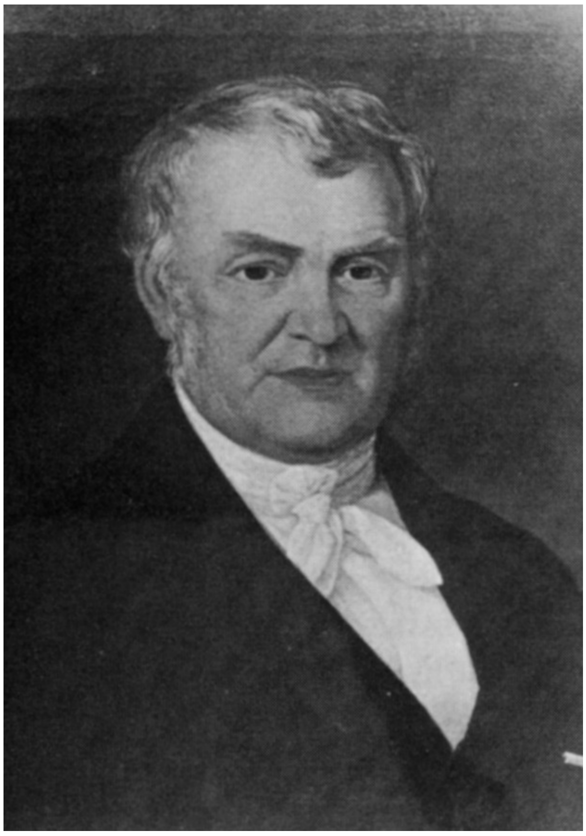
Carl Friedrich Benz

Old pharmacy of Johann Philipp Bronner in Wiesloch (2003)

Memorial tablet for Johann Philipp Bronner in Wiesloch



Johann Philipp Bronner



Johann Philipp Bronner

Memorial for Bertha Benz and her sons with the first car and the fuel filling station in Wiesloch

Harry S. Meysey Thompson

Similar obeservations as made by Bronner were reported by two members of the Royal Agricultural Society of England, the Reverend Canon Anthony Huxtable (30.11.1808 Somerset - 12.12.1883 St. Leonard´s on Sea) (later Archdeacon) who farmed at Sutton Waldron, near Shaftesy on the chalk hills of Dorset and Harry Stephen Thompson (11.08.1809 Moat Hill - 26.03.1874 Kirby Hill) (later Sir Harry S. Meysey Thompson of Kirby Hall), a Yorkshire farmer from Moat Hall, near York. Thompson was a founder member of the Agricultural Society and was very active in the society all his life. From 1855 till his death Harry S. Thompson was the second editior of the Journal, and for 1867 President of the Society.

C. A. Huxtable collected the liquid running from cowhouses, stables and piggeries into a tank and made an experiment in the filtration of the liquid manure in his tanks through a bed of an ordinary loamy soil. After the passage through the filter bed, the urine was found to be deprived of colour and smell. This was a singular and interesting observation, implying, the power of the soil to separate from solution those organic substances which give colour and offensive smell to putrid animal liquids.

Canon Anthony Huxtable

At about this time the practise of dosing tanks and manure heaps with sulphuric acid was widespread to prevent the escape of the useful volatile ammonia, whereby large quantities of ammonium sulphate were formed. Thompson records that he was aware that the soil had a certain power of retaining ammonia but he was anxious to list the extent of this power and to ascertain whether it also extended to the sulphate, as, if not, the use of sulphuric acid as a fixe, through preventing the escape of ammonia in a volatile form, would have been objectionable from its forming a highly soluble salt that would be readily washed down into the subsoil and carried off in the drains.

Harry S. Meysey Thompson made experiments and used cultivated soil from one of his fields, a light sandy loam of good quality and placed it in glass percolaters. He weighted all substances and measured the liquids. Thompson must get the credit for the first quantitative studies on cation exchange. He discovered that the addition of $(NH_4)_2SO_4$ to a column of soil resulted in the appearance of $CaSO_4$ solution after leaching. Before Thompson published his results, he told 1848 a young consulting chemist to the Royal Agricultural Society, John Thomas Way, of his results (THOMPSON, 1850).

John Thomas Way was in 1846 appointed Professor of Chemistry of the Royal Agricultural Society of England. He was a member of the first (1847) and second (1864) Commission on River Pollution. 1864 health began to fail and he did little more scientic work.

Way started his experiments and used a variety of soils, pipe clay, and some home-made alumosilicates. In addition to NH_4^+, he studied the exchange of all cations (and anions) usually found in soils. Way worked four years and his results are summarized briefly as follow:

1) The common cations (Na^+, K^+, NH_4^+) added as salts of strong acids, are retained by the soil, and equivalent quantities of the same salts are replaced, (e.g 2 KCl + Soil $\rightarrow$ $CaCl_2$ + K_2-soil)
2) Hydroxides and carbonates of cations are adsorbed completely with no replacement of Ca^{2+} or anions.
3) The strong acid salts (Cl^-, NO_3^- and SO_4^{2-}) of Ca^{2+} are not adsorbed by soils.
4) Clay is the material responsible for cation adsorption, organic matter and sand are unimportant.
5) Heating or acid treatment tend to destroy the adsorption.
6) The adsorption is very rapid, almost instantaneous.
7) Increasing the concentration of the added salt increases the amount of adsorption.
8) Cation adsorption is irreversible.
9) Phosphate is held by soils.

The conclusion about organic matter was wrong and so was the conclusion about irreversibility, which his own data disproved (WAY, 1852). In other respects, the conclusion were correct, given the Ca-saturation of his original soils. Conclusions 2 and 3 are only apparently correct because the analysis of leachates gave no clue to the actual reactions. Nevertheless the results were revolutionary in their implications that the great agricultural chemist Justus von Liebig commanted: *“These experiments are very remarkable and should be opposed with might and main“* (WIEGNER, 1931, FORRESTER AND GILES, 1971; THOMAS, 1977).

Friedrich Stohmann and Wilhelm Henneberg met end of 1856 in the agricultural chemistry in Celle (Laboratorium der Königlich Hannoverschen Landwirthschaftsgesellschaft Celle, since 1857 Weende, now Göttingen), repeated Way´s observations. They looked carefully at the effect of concentration on the qualitity of ammonium adsorbed by soils, and by doing so became the first to measure a solute-solid adsorption isotherm. They also showed that there were differences in adsorption of ammonium from different salts, in the order $H_2PO_4^- > SO_4^{2-} > Cl^- = NO_3^-$, an observation that took many years to understand. The Table in Henneberg and Stohmann´s paper gives the first quantitative results published on adsorption from solution (HENNEBERG AND STOHMANN, 1858).

Table of Henneberg and Stohmann (1858)

Ammoniakabsorption durch 100 Grm. Gartenerde aus 200 Cubikcentimetern Lösung in Gramm NH_3 ausgedrückt:

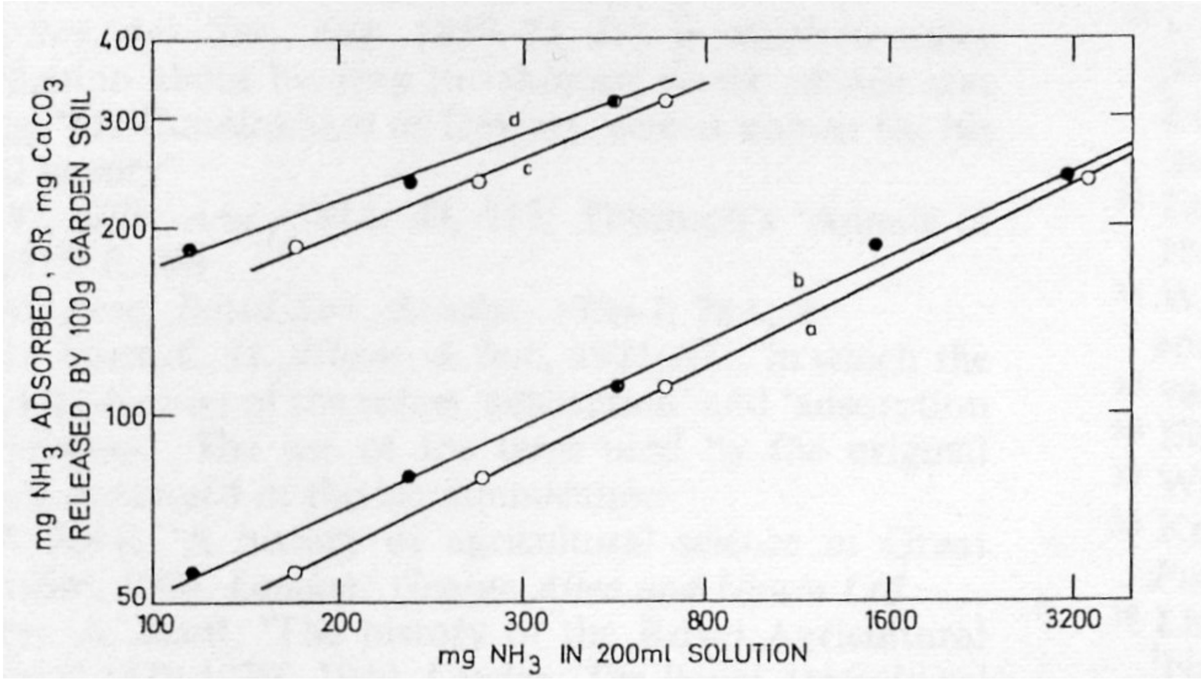
	Dauer der Berührung, Stunden	200 CC. Lösung enthielten NH_3: 0,170 Grm. 0,05 Atom im Liter		0,340 Grm. 0,1 Atom im Liter		0,680 Grm. 0,2 Atom im Liter		1,700 Grm. 0,5 Atom im Liter		3,400 Grm. 1 Atom im Liter	
		Hbg.	St.	Hbg.	St.	Hbg.	St.	Hbg.	St.	Hbg.	St.
1) Aetzammoniak	4	—	0,056	—	0,086	—	0,122	—	—	—	—
	24	—	0,058	—	0,080	—	0,174	—	—	—	—
	168	0,052	0,067	0,095	0,120	—	—	—	—	—	—
	Durchschnitt	0,058		0,095		0,149					
2) Chlorammonium	4	0,056	0,056	0,070	0,070	0,102	0,102	{0,106 0,115	0,122	0,206	0,208
	24	0,058	0,052	—	—	{0,112 0,104 0,112	0,102	0,128	0,102	—	0,238
	168	0,056	0,049	0,072	0,074	{0,110 0,106	0,118	0,136	0,118	{0,136 0,162	0,130
	Durchschnitt	0,0545		0,071		0,107		0,118			
3) Salpetersaures Ammoniak	4	—	0,055	0,083	0,081	0,106	—	0,154	0,188	—	—
	24	0,052	0,056	0,080	0,078	—	0,106	—	0,174	—	—
	168	—	0,053	—	0,079	—	0,105	—	0,157	—	—
	Durchschnitt	0,054		0,080		0,106					
4) Schwefelsaures Ammoniak	4	—	0,057	—	—	—	0,120	—	—	—	—
	24	—	0,057	{0,087 0,086	0,086	0,114	0,120	—	—	—	—
	168	—	0,057	—	0,086	0,116	0,122	—	—	—	—
	Durchschnitt	0,057		0,086		0,118					
5) Mischung von Aetzammoniak und Chlorammonium zu gleichen Atomen	4	—	—	—	—	—	—	—	—	—	—
	24	—	—	0,089	—	0,118	—	—	—	—	—
	168	—	—	—	—	—	—	—	—	—	—
	Durchschnitt	—	—	—	—	—	—	—	—	—	—
6) Phosphorsaures Ammoniak ($2 NH_4O, HO, PO_5$)	4	—	—	0,140	{0,136 0,136 0,136	—	{0,188 0,202 0,208	—	—	—	—
	24	—	—	0,144	{0,150 0,144	0,205	0,205	—	—	—	—
	168	—	—	—	—	0,226	—	—	—	—	—
	Durchschnitt	—	—	0,141		0,206		—	—	—	—
Durchschnitt von 2 bis 4		0,055		0,079		0,110		—	—	—	—

der Ackerkrume gegen Ammoniak u. Ammoniaksalze. 159

Table from Henneberg and Stohman´s paper. The first detailed quantitative results published on adsorption from solution.

Table of Boedeker (1859): Ammonia adsorption and calcium release by soil

Ammonia in 200 cm^3 solution (mg)	Ammonia adsorbed by soil (mg/100 g)	Ammonia adsorbed by soil (mg/100 g)	‘Carbonate of lime’ released from soil (mg/100 g)	‘Carbonate of lime’ released from soil (mg/100 g)
	Calculated	Found	Calculated	Found
170		55	161.8	186
340	77.8	79	227.9	233.5
680	110	110	323.6	312.5
1700	173.9	188 (max.)		
3400	245.9	238 (max.)		



Boedeker´s 1859 data tabulated and plotted on log-log scales. NH_3 adsorbed vs (a) initial, (b) final conc^n; $CaCO_3$ released vs (c) initial, (b) final conc^n

Henneberg and Stohmann made no attempt to express their findings by a law, but a few month later Carl Boedeker, a colleague, then head of the Physiological Institute in Göttingen, published his deductions from their results (BOEDEKER, 1859).

Samuel William Johnson (born 1830 in Kingsborough/New York) studied chemistry at the Yale Scientific School, and at the Universities in Leipzig and Munich, where he was a student of Justus von Liebig. Johnson reviewed the work of Way and corrected his two wrong conclusions. Johnson recognized the adsorption work of Henneberg and Stohmann and showed that nutrients can go into solution after they are adsorbed (exchange is reversible) and thus be taken up by plants. He found that Way was incorrect in starting that organic matter did not adsorb NH_4. He found it hold even more NH_4^+ than clay did, and Johnson coined the term “exchange of bases” for Way´s observation (JOHNSON, 1859). Johnson was later the first director of the first experimental station in Connecticut, elected President of the American Chemical Society (1878) and (1866) received an election to the National Academy of Sciences (FORRESTER AND GILES, 1971; THOMAS, 1977).

Most of the work between the late 1850´s and 1900 was an extension of or elaboration on Way´s original work. Important researchers were H. Eichhorn who showed that crystalline zeolites could be changed easily from one to another merely by replacing the cation present (e.g. Ca^{2+} to Na^{+}) (EICHHORN, 1858); C. Peters who did detailed studies on concentration, anion and cation effects, amplifying Hennebergs and Stohmann´s results (PETERS, 1869); and Jakob Maarten van Bemmelen who showed that cations other than Ca^{2+} could be replaced from soils (Bemmelen, 1877a).

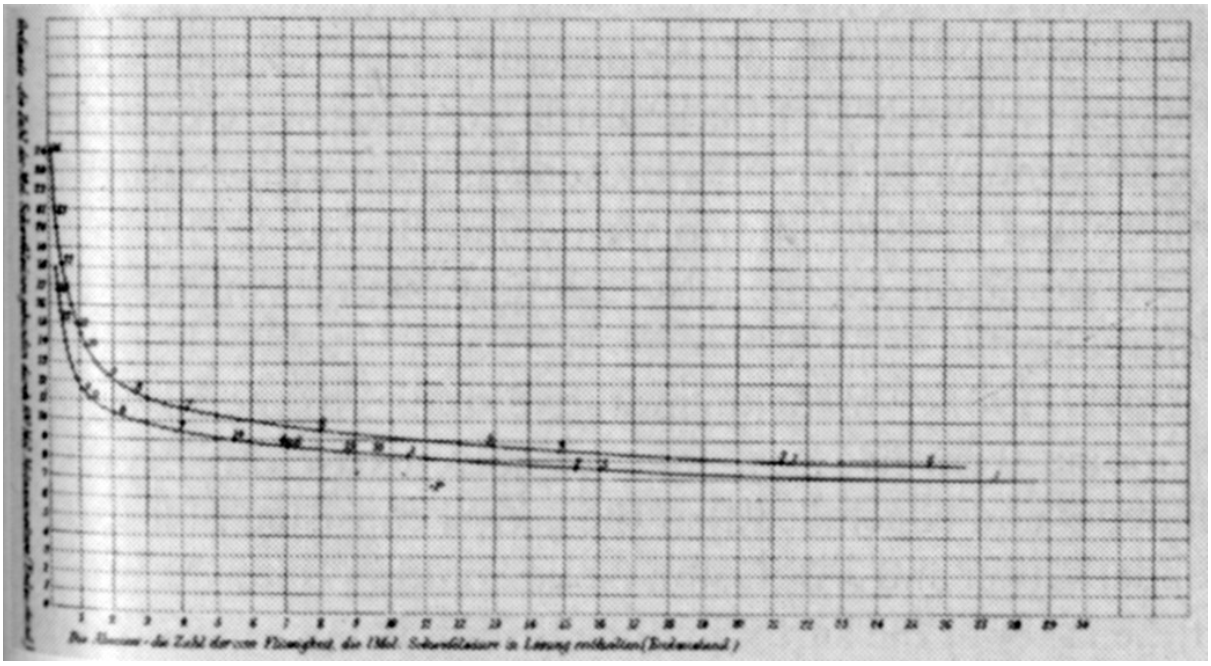


Figure 1 (BEMMELEN, 1881):
The adsorptions isotherms of sulphuric acid by metastannic acid by Jakob Maarten van Bemmelen are probably the first published adsorption isotherms from solution

J. M. van Bemmelen made the greatest contributions. His data show conclusively that cation exchange is not restricted to calciumions in the soil, as Way assumed, but works with other cations as well. He also formulated the first mental picture of cation exchange and the first published adsorption isotherm from solution in the form now used (BEMMELEN, 1888). This paper is a classic one of a long line of publications on adsorption and was often quoted by agricultural and colloid scientiest in the early year of the last century.

The isotherms of Boedeker (BOEDEKER, 1859) were interpreted in 1906/07 from Herbert Max Finlay Freundlich (28.01.1880 Charlottenburg, now Berlin - 31.03.1941 Minneapolis/ Minnesota) (*Freundlich-Isotherm*) (FREUNDLICH, 1906a,b).

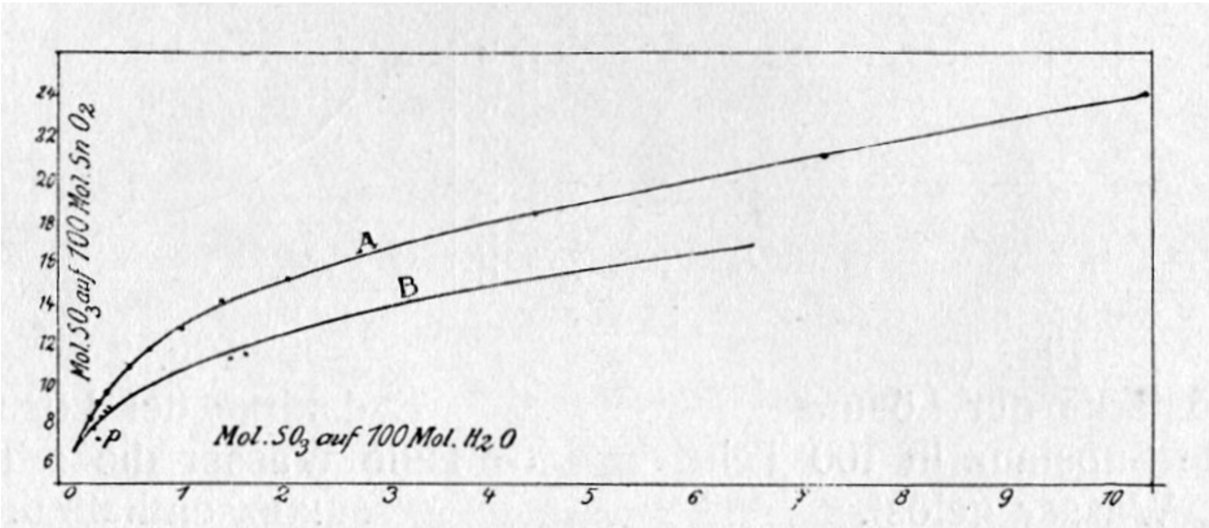


Figure 2 (BEMMELEN, 1881,1910):
The isotherms of sulphuric acid by metastannic acid by Jakob Maarten van Bemmelen from the original data of 1881 (Figure 1), published 1910, are probably the first complete adsorption isotherms

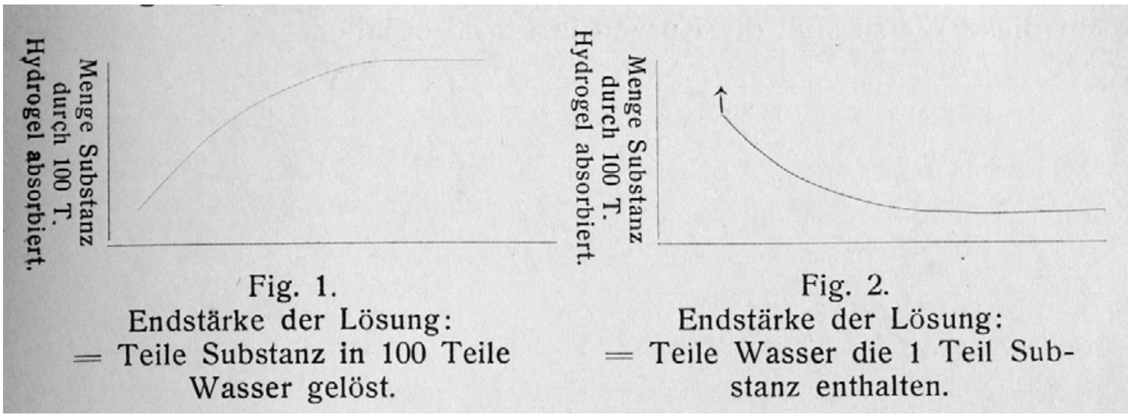
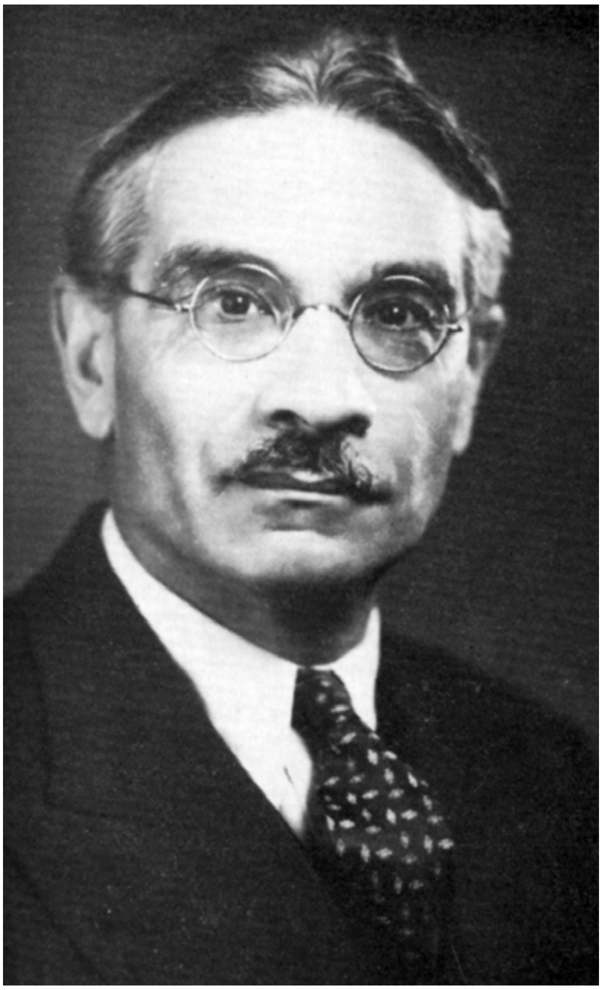


Figure 3 (BEMMELEN, 1888):
The diagram on the left is probably the first published adsorption isotherm in the form now used

The famous *Langmuir-Isotherm* was published by Irving Langmuir (31.01.1881 Brooklyn - 16.08.1957 Falmouth/ Mass.) in 1918 (LANGMUIR, 1918).

In 1938 Stephen Brunauer (12.02.1903 Budapest - 06.07.1986 Potsdam/New York), Paul Hugh Emmett (22.09.1900 Portland/Oregon - 22.04.1985

Corvallis/Oregon) and Edward Teller (15.01.1908 Budapest - 09.09.2003 Stanford/California) published an adsorption isotherm for gases on solids (*BET-equation*) (BRUNAUER, EMMETT, TELLER, 1938).

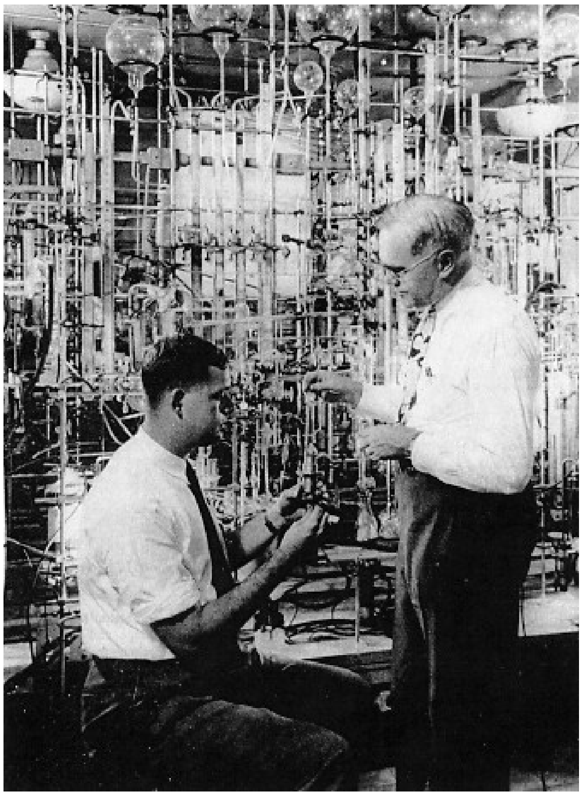


Herbert Max Finlay Freundlich

Irving Langmuir

The term “absorption” was used in the 19th century for all absorption and adsorption problems. Moritz Ludwig Frankenheim (29.06.1801 Brunswick - 14.01.1869 Dresden) in 1835 recognized that absorption in porous systems was different to homogeneous liquids. He elaborated the concepts *adsorption* and *insorption.* Frankenheim understood by adsorption not only the aggregation of gases in porous systems but also the liquid uptakes. Frankenheim called “insorption” what we today call absorption. This classification was not very fortunate because the adsorption of gases and the uptake of liquids are two different operations. The terms were not often used and other authors used further “absorption” (FRANKENHEIM, 1835, BENEKE, 1995b).

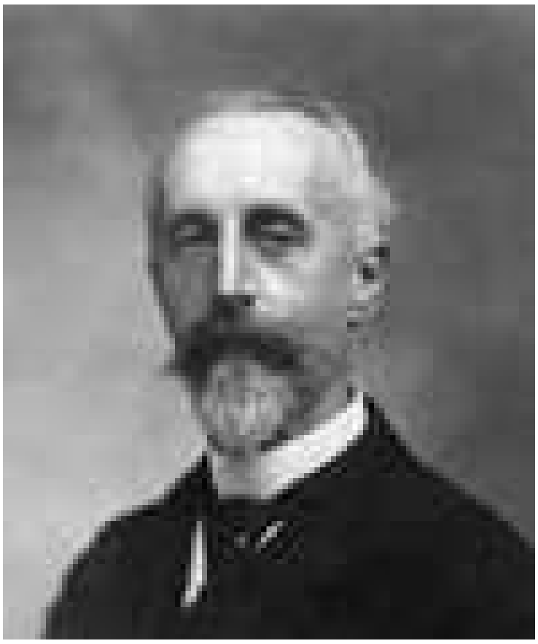
Stephen Brunauer



Paul Hugh Emmett (right) with a coworker in front of a gas adsorption apparatus (1953)

Edward Teller

(Johann) Heinrich Gustav Kayser (16.03.1853 Bingen at Rhine - 14.10.1940 Bonn) in 1881 used the term “adsorption” for the accumulation of gases on surfaces and the adsorption of molecules from solutions through porous substances (KAYSER, 1881a,b). The sorption of gases and the adsorption of solutes in gels were named “adsorption” but Jakob Maarten van Bemmelen avoided this word and spoke his long life from “absorption”. In the adsorption in gels he saw a special process; which was neither an adsorption from solution nor a formation of a chemical compound identic (BEMMELEN, 1888, BENEKE, 1995b).


Heinrich Gustav Kayser

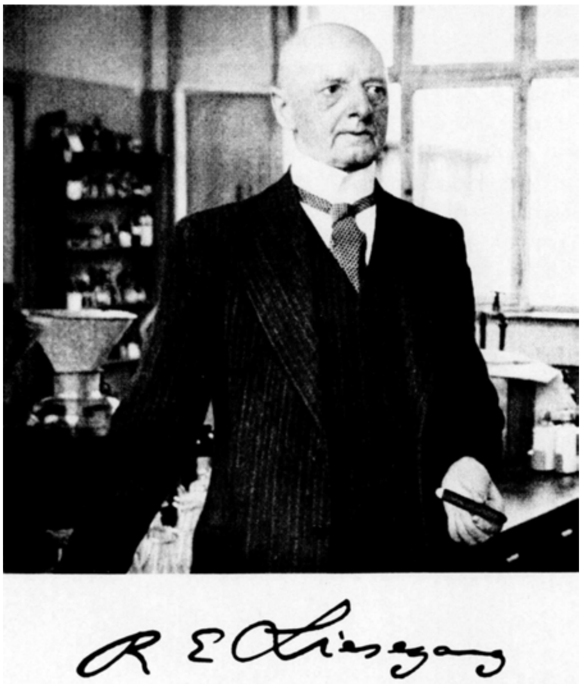
Jakob Maarten van Bemmelen had a very independent mind and an exellent memory, and was small in figure. He held firm opinions, and had a boyish sence of humour. He was much interested in physics and theological research and devoted much time to study the genealogy of his own family. Once, he sketched out the plan of the Zuider Zee on the breakfast table - in treacle to instruct his family. Being admonished by his wife, he replied that they had to learn their geography! At his 80th birthday (1910) his grandson held a speech to congratulate his grandfather. Jakob Maarten van Bemmelen recited the speech in Greek which he had delivered at his own University Matriculation examination (FORRESTER AND GILES, 1971; FISCHER, 1989).


Pierre Maurice Marie Duhem


Henry Louis Le Chatelier

To his 80th birthday friends published a book in honor of Jakob Maarten van Bemmelen. In this book are contributions from Jacobus Henricus van´t Hoff, Pierre Maurice Marie Duhem (10.06.1861 Paris - 14.09.1916 Cabrespine (Aude)), Heike Kammerlingh Onnes, Henry Louis Le Chatelier (08.10.1850 Paris - 17.09.1936

Miribel-les-Échelles (Isère)), Raphael Eduard Julius Liesegang (01.11.1869 Elberfeld, now Wuppertal - 13.11.1947 Bad Homburg vor der Höhe), Hendrik Antoon Lorentz (18.07.1853 Arnheim - 04.02.1928 Haarlem), Wolfgang Ostwald, The(odor) Svedberg (30.08.1884 Valbo near Gävle - 26.02.1971 Kopparberg near Örebro) and others (HARDY, 1911).

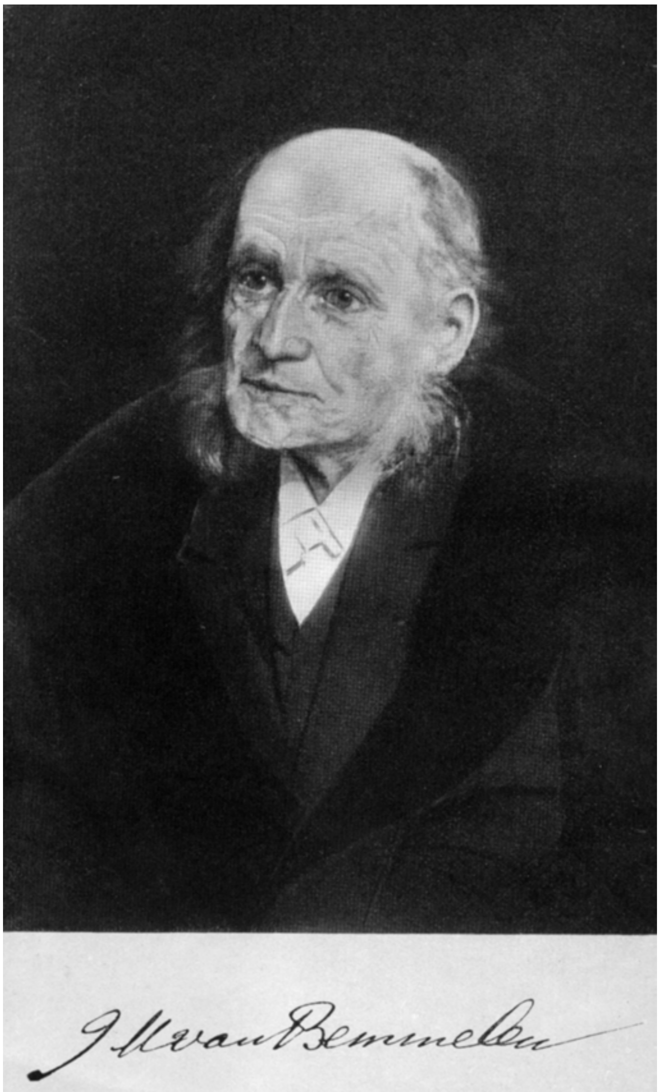


Raphael Eduard Julius Liesegang

Hendrik Antoon Lorentz

Carlo Matteucci

The Svedberg (left) with mechanist



Jakob Maarten van Bemmelen

The eldest son of Jakob Maarten van Bemmelen, Johan Frans van Bemmelen (26.12.1859 Groningen - 06.08.1956 Leiden) married Adriana Jacoba Paulus in July 8, 1897. They had one son and two daughters. J. F. van Bemmelen studied biology and was later (since 1907) Professor of zoology in Groningenand he retired 1930 (VISSER, 2001).

The grandson of Jakob Maarten van Bemmelen and son of Johan Frans van Bemmelen, Jacob Maarten van Bemmelen (20.04. 1898 ´s-Gravenhage - 12.01.1982 Dordrecht) was Professor for criminal law in Leiden. He wrote his thesis 1923 in Groningen *“Van zedelijke Vertreterin tot Reclasseering. Geschiedenis van het nederlandsch Genoot schap tot zedelijke Verbetering der Gevangenen 1823-1923“*: He was married (1. Marriage July 12, 1922) with Clara Adriana Petronella Kluit, they had four sons. Second marriage (May 23, 1966) with Johanna Maria Leendern, no children. Jacob Maarten van Bemmelen was sometimes editior of the journals “Tijdschrift voor Strafrecht“, “Weekblad van het Recht“ and “Nederlands Juristenblad“. Later his interests were soldiery laws. During the second world war he jointed the Netherland Council of War in Den Haag. Later he became editor (1946-1955) of the journal “Militair-Rechtelijk Tijdschrift“ and Vice-president of the Association Internationale de Droit Pénal and the International Society of Criminology (VEEN, 1994).

Table of the chronology of the early experimental age of adsorption science

(ROBENS, 1992, BENEKE 1995c, DĄBROWSI, 2001)

Date	Explorer/Land	Significance
5000 BC	Cyprus	Washing of woollen cloth with fuller´s earth was certainly practised in Cyprus (BENEKE AND LAGALY, 2002).
3750 BC	Egyptians and Sumerians	Use of charcoal for reduction of copper, zinc and tin ores for manufacture of bronze.
1550 BC	Egyptians	Application of charcoal for medicinal purposes to adsorb odorous vapours from putrefactive wounds and from intestine.
460 BC	Hippocrates (at 460 BC Kos-at 370 BC Larissa Pliny the elder (24 Comun - 79 Stabiae)	introduced the use of charcoal to treat a wide range of affections including epilepsy, chlorolysis and anthrax
460 BC	Phoenicians	First recorded application of charcoal filtres for purification of drinking water.
157 AD	Claudius Galen (129 Pergamon - 199 Rom)	introduced the use of carbons of both vegetable and animal origin to treat a wide range of complaints.
17th century		Deposits of fuller´s earth were founded in England. The fuller´s earth was not only used for fulling cloths but also in pharmaceutical and cosmetic applications in form of powders and ointments (BENEKE AND LAGALY, 2002).
1773 1777	Carl Wilhelm Scheele (19.12.1742 Stralsund - 21.05. 1786 Köping) Félice Fontana (15.04.1730 Pomarolo - 10.03.1805 Florence)	reported some experiments of the uptake of gasses by charcoal and clays derived from various sources (SCHEELE, 1777; FONTANA, 1777).
1786, 1788	Johann Tobias Lowitz (25.04.1757 Göttingen- 07.12.1804 St. Peters- burg)	awoded the antiseptic effect in power form charcoal. Used charcoal for decolorization of tartaric acid solutions (LOWITZ, 1786).
1793	D. M. Kehl	disscussed helpfulness of charcoal for removal of odours from gangrenous ulcer and applied carbons of animal orign for removal of colours from sugar (KEHL, 1793).
1794	England	Charcoal was used in the sugar industry in England as a decolorization agent of cane sugar syrups.

1808	France	Charcoal was used in the sugar industry in France as a decolorization agent of beet sugar syrups.
1814	Nicolas Théodore de Saussure (04.10.1767 Geneva - 18.04.1845 Geneva)	started systematic studies of adsorption of various gases by porous substances such as sea-foam, cork, charcoal, and asbestos. He discovered the exothermic character of adsorption processes (DE SAUSSURE 1814, 1815).
Since 1828		New methods were found for reactivation of required charcoal. Other commondities (blood, cereals, tar, turf, waste paper) were found to produce charcoal.
1850	Friedlieb Ferdinand Runge (08.02.1795 Billwärder, now Hamburg - 25.03. 1867 Oranienburg near Berlin)	adsorptive separation of chemicals on filter paper by capillary force (Runge-pictures, later paper-chromatography) (RUNGE, 1850 a, b).
1865	J. Hunter	reported the high sorption capacity of charcoal made from coconuts (HUNTER, 1865).
1871	W. Thomson	reported by the adsorption of gases and vapours in alumina that the adsoprtion will be a factor of the pore volume and pore diameter (THOMSON, 1871).
1881	Heinrich Gustav Kayser (16.03.1853 Bingen - 14.10.1940 Bonn)	introduced the terms 'adsorption', 'isotherm' or 'isotherm curve'. He also developed some theoretical concepts that became basic to monomolecular adsorption theory (KAYSER, 1881a,b).
1879, 1883	P. Chappuis	made the first calorimetric measurements of the heat of wetting of various carbons by liquids (CHAPPUIS, 1879, 1881, 1883).
1878	USA	English fuller´s earth was used for bleaching vegetable oils and became the most important fuller´s earth on the European and American market. Some time before an American traveller in the Middle East had observed that people used clay to lighten olive oil (BENEKE AND LAGALY, 2002).
Since 1890	USA	Great deposits of fuller´s earth were found in Arkansa, Florida, Montana, Wyoming (BENEKE AND LAGALY, 2002).
1901	R. von Ostreyko	set the basis for commercial development of activated carbons through processes that involve the incorporation of metallic chlorides with carbonaceous materials before carbonization and the mild oxidation

		of charred materials with carbon dioxide or steam at increased temperatures (Patented) (VON OSTREYKO, 1901.)
1903	Michail Semjonowitsch Tswett (19.05.1872 Asti - 26.06.1919 Woronesch)	discovered the phenomenon of selective adsorption during separation of chlorophyl and other plant pigments by means of silica materials. He introduced the therm 'column solid-liquid adsorption chromatography'. This discovery was not only the beginning of a new analytical technique, but also the origin of a new field of surface science. TSWETT, 1903, 1906a,b).
1904	Sir James Dewar (20.09.1842 Kincardine on Forth/Scotland - 27.03.1923 London)	found selective adsorption of oxygen from its mixture with nitrogen, during air uptake by charcoal (DEWAR, 1904, a,b).
1906/07	Bavaria	The production of acid activated clays (bleaching earth) started in Bavaria (BENEKE AND LAGALY, 2002).
1909	James William McBain (22.03.1882 Chatham/ New Brunswick - 1953)	proposed the term 'absorption' to determine a much slower uptake of hydrogen by carbon than adsorption. He also proposed the term 'sorption' for both adsorption and absorption (MCBAIN, 1909).
1911	Netherland	The NORIT factory in Amsterdam was founded, and in the beginning produced charcoal from turf. It is now one of the most advanced international manufactures of active carbons
1911	Poland	A wood distillation plant was built in Hanjnówka (East Poland), initally manufacturing active carbons solely from wood materials.
1914		World War I introduced the problem of protecting humans respiratory tracts from toxic warefare agents.
1915	Nikolai Dimitrievic Zelinsky (06.02.1861 Tiraspol - 31.07.1953 Moscow)	the first who suggested and applied the use of active carbons as the adsorption medium in gas masks.
1941	Archer John Porter Martin (01.03.1910 London) Richard L. M. Synge (28.10.1914 Liverpool - 18.08.1994 Norwich)	introduced into laboratory practice the solid-liquid partion chromatography, both in column and planar form (Nobel-Prize of chemistry in 1952).
1956	Richard Maling Barrer (16.10.1910 New Zealand - 12.09.1996 Chisle-hurst/Kent)	invented methods of zeolite synthesis. In this year the North-American Linde Company started production of synthetic zeolites at a commercial scale.

Acknowledgement

We thank Marjo C. Mittelmeijer-Hazeleger, Van ‘t Hoff Institute for Molecular Sciences, Nieuwe Achtergracht 166, 1018 WV Amsterdam, The Netherlands for later corrections of the literature list.

Literature

BACON F (1627) New Atlantis, a work unfinished. Added to Sylva sylvarium or a naturall historie. In ten centuries. Printed by John Haviland and Augustine Mathewes for William Lee, London

BAKHUIS ROOZEBOOM H W (1900) Eisen und Stahl vom Standpunkte der Phasenlehre. Zeitschrift für Physikalische Chemie 34: 437

BAKHUIS ROOZEBOOM H W (1901-1918) Die heterogenen Gleichgewichte vom Standpunkte der Phasenlehre. Band 1-3. Friedrich Vieweg und Sohn, Braaunschweig

BEMMELEN J M VAN (1854) Dissertatio chymica inauguralis de Ciibotio Cumingii. Leiden

BEMMELEN J M VAN (1856) Über die Einwirkung der Bernsteinsäure und Citronensäure auf Glycerin. Journal für Praktische Chemie 69: 84

BEMMELEN J M VAN (1859) Over de verhouding van glycerine, mannitane en glucose tegenover twee- en driebasische zuren. G. J. Mulder, Scheik Verhand en Onderz II: 1

BEMMELEN J M VAN (1863a) Bouwstoffen tot de kennis van de kleigronden in de provinci Groningen. G. J. Mulder, Scheik Verhandl en Onderz III, 2: 1

BEMMELEN J M VAN (1863b) Eenige hoofdstukken de nieuwe scheikunde geschetst naar aanleiding van de scheikundige brieven van Justus von Liebig. I. Ozon. II. Gisting, rotting, vertering. III. Bereiding van organische stoffen uit de grondstoffen. IV. Generatio spontanea. V. Constitutie der organische verbindungen. VI. Voeding en ademhaling. Zugefügt an seine holländische Übersetzung von Liebigs Chemische Briefe. J. Oomkens, Groningen, 315 s

BEMMELEN J M VAN (1870) Toestand der openbare en bijzondere scholen in Arnhem. G. W. van den Wiel & Co.

BEMMELEN J M VAN (1871) Luchtverversching in schoolgebouwen. De Schoolbode: 385; 465

BEMMELEN J M VAN (1872) Bestimmungen der im Brunnenwasser vorhandenen Salpetersäure durch Indigo. Zeitschrift für Analytische Chemie 11: 136; Maandblad v Natuurwetensch (1872): 1

BEMMELEN J M VAN (1873a) Bepaling van koolzuur in welwaters. Maandblad v Natuurwetensch 3: 97

BEMMELEN J M VAN (1873b) Bepaling van ammonia in drinkwaters in verband met de vraag, of bij destillatie van water in aanraking met de lucht ammonia wordt gevormd. Maandblad v Natuurwetensch 3: 111

BEMMELEN J M VAN (1874) Uitkomsten van de toestellen ter luchtverversching der openbare scholen te Amsterdam en Enschede. Schoolbode

BEMMELEN J M VAN (1877a) Das Absorptionsvermögen der Ackererde. Landw Versuchstat 21: 135-191, Kon Akad v Wetensch 24. Febr. 1877

BEMMELEN J M VAN (1877b) Landbouwkundig onderzoek naar de samenstelling der monsters aarde, verzameld bij de boringen in de Zuiderzee (1875) door den ingenieur P. Havelaar op last van den Minister van Binnenlandsche Zaken, en over de grondlagen in de Zuiderzee (zuidelijk gedeelte); Beilage V zum Gesetzentwurf „Bedijking en droogmaking van het zuidelijk gedeelte der Zuiderzee“, eingereicht an die „Tweede Kamer der Staten-Generaal“ vom Minister Heemskerk in der Sitzung 1876-1877. Also: Archiv Geol Comm Kon Akad v Wetensch

BEMMELEN J M VAN (1877c) Landbouwscheikundig onderzoek van den droogemalen Legmeerpolder. Bericht aan de „Maatschappij tot droogmaking der Legmeerplassen“. Ellemann, Harms & Cie, Amsterdam

BEMMELEN J M VAN (1878) Das Absorptionsvermögen der Ackererde. Ber Dtsch Chem Ges 11: 2228; Landw Versuchstat 23: 265

BEMMELEN J M VAN (1880) Landbouwscheikundig onderzoek van de aardmonsters uit het Wieringermeer door boring verkregen. Bericht aan de „Commissie uit de Waterschappen ter voorbereiding van de indijking“. E. J. Brill, Leiden. Also: Arch Geol Comm Kon Akad v. Wetensch

BEMMELEN J M VAN (1881) Die Verbindungen einiger festen Dioxydhydrate mit Säuren, Salzen und Alkalien. Journal für Praktische Chemie (2) 23: 324, 379; Archives Néerlandaises 15 (1880) 407; Kon Akad v Wetensch 28 Juni 1879, 29. Mai 1880

BEMMELEN J M VAN (1886a) De vermoedelijke vruchtbaarheid van den Vinkeveen-Proosty-Polder na de ontvening en droogmaking (met analysen van het veen) Provincie Verslag der Gedeputeerde Staten van Utrecht

BEMMELEN J M VAN (1886b) Bijdragen tot de kennis van den alluvialen bodem in Nederland. I: De bodem van het voormalige IJ. II. De samenstelling van de nieuwe zeeklei in het I J en de Zuiderzee. III. De samenstelling en vorming van de zure grondenin het Nederlandsch alluvium. Verhandl Kon Akad v Wetensch (1886): 25; Rec Trav Chim Pays Bas 5: 199

BEMMELEN J M VAN (1888) Über die Absorptionsverbindungen und das Absorptionsvermögen der Ackererde. Landwirtsch Versuchsstat 35: 69-136

BEMMELEN J M VAN, JORISSEN W P, RINGER W E (1907) H. W. Bakhuis Roozeboom. Nachruf. Berichte der Deutschen Chemischen Gesellschaft 40: 5141-5170

BEMMELEN J M VAN (1910) Die Absorption. Gesammelte Abhandlungen über Kolloide und Absorption. Mit Unterstützung des Verfassers neu herausgegeben von Dr. Wolfgang Ostwald. Verlag von Theodor Steinkopff, Dresden, 548 Seiten. [Collected papers of J. M. van Bemmelen on colloids and absorption (adsorption) , ed. Wolfgang Ostwald]

BENEKE K (1995a) Kapillarität und Blutkreislauf. In: Zur Geschichte der Grenzflächenerscheinungen - mit ausgesuchten Beispielen. Beiträge zur Geschichte der Kolloidwissenschaften. Mitteilungen der Kolloid-Gesellschaft, 1995. Verlag Reinhard Knof, Kiel: 5-25

BENEKE K (1995b) Benetzung und Adsorption. In: Zur Geschichte der Grenzflächenerscheinungen - mit ausgesuchten Beispielen. Beiträge zur Geschichte der Kolloidwissenschaften. Mitteilungen der Kolloid-Gesellschaft, 1995. Verlag Reinhard Knof, Kiel: 43-46

BENEKE K (1995c) Zur Geschichte der Grenzflächenerscheinungen - mit ausgesuchten Beispielen. Beiträge zur Geschichte der Kolloidwissenschaften. Mitteilungen der Kolloid-Gesellschaft, 1995. Verlag Reinhard Knof, Kiel 141pp

BENEKE K, LAGALY G (2002) From Fullers Earth to Bleaching Earth. A historical note. ECGA Newsletter, No. 5, July 2002: 57-78
URL: http://www.uni-kiel.de/anorg/lagaly/group/klausSchiver/bleachingearth.pdf (22.11.2004)

BOEDEKER C H D (1859) Journal für Landwirtschaft 7: 48 (Untertitel Landwirthschaftliches Centralblatt für das Königreich Hannover. Redigiert von Wilhelm Henneberg. Erschien von 1853 bis 1876 in Celle, später Göttingen)

BRONNER J P (1833) Der Weinbau in Sued-Deutschland. Teil 1. Der Weinbau am Haardtgebirge von Landau bis Worms. C. F. Winter, Heidelberg, 164 pp (Nachdruck: Schwäbische Verlags Gesellschaft Brenner, Tübingen, 1986)

BRONNER J P (1834) Der Weinbau in Sued-Deutschland. Teil 2. Der Weinbau in der Provinz Rheinhessen, im Nahethal und Moselthal. C. F. Winter, Heidelberg, 188 pp (Nachdruck: Schwäbische Verlags Gesellschaft Brenner, Tübingen, 1986)

BRONNER J P (1835) Anweisung zur nützlichen Anpflanzung der Tafeltrauben und anderer Traubensorten an sonst unbenutzten Plätzen in Höfen, Gärten an Häusern und Mauern u. s. w. C. F. Winter, Heidelberg, 1835

BRONNER J P (1836) Der Weinbau in Sued-Deutschland. Teil 3. Der Weinbau im Rheingaue, von Hochheim bis Coblenz, vollständig dargestellt. C. F. Winter, Heidelberg, 182 pp (Nachdruck: Schwäbische Verlags Gesellschaft Brenner, Tübingen, 1986)

BRONNER J P (1837a) Der Weinbau in Sued-Deutschland. Teil 4. Der Weinbau im Koenigreich Wuertemberg. Abth. 1. C. F. Winter, Heidelberg (Nachdruck: Schwäbische Verlags Gesellschaft Brenner, Tübingen, 1986)

BRONNER J P (1837b) Der Weinbau in Sued-Deutschland. Teil 5. Der Weinbau im Koenigreich Wuertemberg. Abth. 2. C. F. Winter, Heidelberg (Nachdruck: Schwäbische Verlags Gesellschaft Brenner, Tübingen, 1986)

BRONNER J P (1839) Der Weinbau in Sued-Deutschland. Teil 6. Der Weinbau des Main- und Taubergrundes und der Wuerzburger Gegend. C. F. Winter, Heidelberg (Nachdruck: Schwäbische Verlags Gesellschaft Brenner, Tübingen, 1986)

BRONNER J P (1842) Der Weinbau in Sued-Deutschland. Teil 7. Der Weinbau und die Weinbereitung an der Bergstrasse. C. F. Winter, Heidelberg (Nachdruck: Schwäbische Verlags Gesellschaft Brenner, Tübingen, 1986)

BRUNAUER S, EMMETT P H, AND TELLER E (1938) Adsorption of gases in multimolecular layers. Journal ot the American Chemical Society 60: 309-319

CHAPPUIS P (1879) Annalen der Physik und Chemie N. F. (Wiedemanns Annalen) 8: 1
CHAPPUIS P (1881) Annalen der Physik und Chemie N. F. (Wiedemanns Annalen) 12: 161
CHAPPUIS P (1883) Annalen der Physik und Chemie N. F. (Wiedemanns Annalen) 19: 21
DĄBROWSKI A (2001) Adsorption - from theory to practise. Advances in Colloid and Interface Science 93: 135-224
DE SAUSSURE T (1814) Annalen der Physik N. F. (Gilberts Annalen) 74: 113
DE SAUSSURE T (1815) Ann Phil 6: 241
DEWAR J (1904a) Proceedings of the Royal Society [London] 74: 122
DEWAR J (1904b) Proceedings of the Royal Society [London] 74: 127
EICHHORN H (1858) Ueber die Einwirkung verdünnter Salzlösungen auf Silicate. Annalen der Physik und Chemie 2. Folge (Poggendorffs Annalen) 105: 126-133
FISCHER A (1989) Bemmelen, Jakob Maarten von geb. 03.11.1830 in Almelo, gest. 13.03.1911 in Leiden. In: Pötsch W. R, Fischer A, Müller W. (Hrsg), Lexikon bedeutender Chemiker. Verlag Harri Deutsch, Thun, Frankfurt a. M. (1989) 38
FONTANA F (1777) Mem. Matemat. Fisica Societa Italiana 1: 679.
FORRESTER S D, GILES C H (1971) From manure heaps to monolayers. The earliest development of solute-solid adsorption studies. Chemistry and Industry 13th November 1971: 1314-3121
FORRESTER S D, GILES C H (1972) From manure heaps to monolayers. One hundred years of solute - solvent adsorption isotherm studies. Chemistry and Industry 15th April 1972: 318-325
FRANKENHEIM M L (1835) Die Lehre von der Cohäsion, umfassend die Elasticität der Gase, die Elasticität und Cohärenz der flüssigen und festen Körper und die Krystallkunde, nebst neuen Tabellen über alle Theile der Cohäsionslehre, insbesondere über die Elasticität und die Festigkeit. 502 Seiten. A. Schulz und Comp., Breslau
FREUNDLICH H (1906a) Über die Adsorption in Lösungen. Habilitationsschrift, Berlin
FREUNDLICH H (1906b) Über die Adsorption in Lösungen. Zeitschrift für Physikalische Chemie A 57: 385-470
GAZZERI, G (1819) Textbook of manuring, 1819. Quoted by A. Orth Landwirtsch Versuchsstat 16 (1873) 56
GLAUBER J R (1715 posthum) Glauberus Contractus oder Kern der Glauberschen Schriften, Leipzig und Breslau, 1715
GODFREY B (1737) Miscellaneous experiments and observations.
HARDY W B (1911) Book review. Gedenkboek aangeboden an J. M. van Bemmelen, 1830-1910. Festschrift zum 80. Geburtstag. Mit Beiträgen von Jacobus Henricus van´t Hoff, Pierre Maurice Marie Duhem, Heike Kammerlingh Onnes, Henry Le

Chatelier, Raphael Eduard Liesegang, Hendrik Antoon Lorentz, Wolfgang Ostwald, Theodor Svedberg u. a. C. de Boer, Helder, 1910, 461pp. Nature 88: 238-239

HENNEBERG W, STOHMANN F (1858) Ueber das Verhalten der Ackerkrume gegen Ammoniak und Ammoniaksalze. Annalen der Chemie und Pharmacie 107: 152-174

HUNTER J (1865) Journal of the Chemical Society [London] 18: 285.

KAYSER H (1881a) Ueber die Verdichtung von Gases an Oberflächen in ihrer Abhängigkeit von Druck und Temperatur. Teil I. Annalen der Physik 3. Folge 12: 526

KAYSER H (1881b) Ueber die Verdichtung von Gases an Oberflächen in ihrer Abhängigkeit von Druck und Temperatur. Teil II. Annalen der Physik 3. Folge 14: 450

KEHL D M (1793) Observations et Journal sur la Physique, de chemie et d'Historie Naturelle et des arts, Paris, Tome XLII: 250

KERKWIJK C P VAN (1934) Antoine Paul Nicolas Franchimont 1844-1919. Leiden, 1934, 169 p

JOHNSON S W (1859) On some points of agricultural science. American Journal of Science and Arts Ser 2. 28: 71-85

JORISSEN W P (1910) Jakob Maarten van Bemmelen (3. Nov. 1830 bis 3. Nov. 1910) [bis 13. 03.1911]. In: Die Absorption von J. M. van Bemmelen. Emer. Professor der Universität Leiden. Gesammelte Abhandlungen über Kolloide und Absorption. Mit Unterstützung des Verfassers neu herausgegeben von Dr. Wolfgang Ostwald. Verlag von Theodor Steinkopff, Dresden (1910): 1-12

LAMBRUSCHINI (1830) Atti die Georgofili di Firenze 9: 330. Quoted by F. Sestini Landwirtsch Versuchsstat 16 (1873) 409

LANGMUIR I (1917) The constitution and fundamental properties of solids and liquids. Part II. Liquids Journal of the American Chemical Society 39: 1848

LANGMUIR I (1918) The adsorption of gases on plane surfaces of glass, mica and platinium. Journal of the American Chemical Society 40: 1361-1402

LOWITZ J T(1786) Crell's Chemische Annalen 1: 679

MARSILI L F (1725) Histoire physique de la mer. Amsterdam, 1725

McBain J W (1909) Philosophical Magazine 18: 916.

OSTWALD WI (1897) Friedrich Stohmann (1832 - 1897). Berichte der Deutschen Chemischen Gesellschaft 30: 3214-3226

PETERS C (1860) Ueber die Absorption von Kali durch Ackererde. Landw Versuchstat 2: 131-151

ROBENS E (1992) Glosse zur Geschichte der Adsorption. Vortrag zum VI: FISONS-Workshop, 03.11.1992, Aukamm-Hotel, Wiesbaden

ROBENS E (2000) Kuriositäten aus der Geschichte der Adsorption. Lesson on the X. Workshop on the charactereisation of finely divided and porous materials on November 15th and 16th 2000 in Bad Soden/Ts.

RUNGE F F (1850a) Zur Farben-Chemie. Musterbilder für Freunde des Schönen und zum Gebrauch für Zeichner, Maler, Verzierer und Zeugdrucker. 1. Lieferung. Dargestellt durch chemische Wechselwirkung. Verlag E. S. Mittler & Sohn, Berlin

RUNGE F F (1850b) Der Bildungstrieb der Stoffe, veranschaulicht in selbstständig gewachsenen Bildern (Fortsetzung der Musterbilder). Selbstverlag, Oranienburg, 1855. Zu haben in Mittler´s Sortiments-Buchhandlung in Berlin

SCHEELE C W (1777) Chemische Abhandlungen von der Luft und dem Feuer. In: Ostwald´s Klassiker der exakten Wissenschaften Nr. 58, Willhelm Ostwald (Hrsg.), Engelmann, Leipig 1894, S. 100.

SNELDERS H A M (1979) Bemmelen, Jakob Maarten van (1830-1911). Biografisch Woordenboek van Nederland 1, Den Haag (1979)
URL: http://www.inghist.nl/Onderzoek/Projecten/BWN/lemmata/bwn1/bemmelen (21.06.2002)

SNELDERS H A M (1979) Bakhuys Roozeboom, Hendrik Willem (1854-1907). Biografisch Woordenboek van Nederland 1, Den Haag (1979)
URL: http://www.inghist.nl/Onderzoek/Projecten/BWN/lemmata/bwn1/bakhuys (27. 06.2002)

STORER F H (1887) Agriculture in some of its relation with chemisty. 2 Vols. Sampson Law, Marston, Searle and Rivington, London, 1887

THOMAS G W (1977) Historical developments in soil chemistry: Ion exchange. Soil Science Society American Journal 41: 230-238

THOMPSON H S (1850) On the adsorbent power of soils. Journal of the Royal Agricultural Society of England 11: 68-74

THOMSON W (1871) Philosophical Magazine 42: 448 (Cited from: Krczil F (1938) Aktive Tonerde ihre Herstellung und Anwendung. Verlag von Ferdinand Enke, Stuttgart p. 101)

TSWETT M (1903) O novoy kategori adsorbtsionnykh yavleny i o primenenii ikh k biokkhimicheskomu analizu. Title translation in english: [On a new category of adsorption phenomena and on its aoolication to biochemical analysis.] Title translation in german: [Eine neue Kategorie von Adsorptionsphenomenen und deren Anwendung für die biochemische Analyse]. Trudy Varhavskago Obshchestva estevoispytatelei Otd Biol (Tr Warsawsk Obst Jestesv Otd Biol)14: 20-39

TSWETT M (1906a) Physikalisch-chemische Studien über das Chlorophyll. Die Adsorptionen. Berichte der Deutschen Botanischen Gesellschaft 24: 316-323

TSWETT M (1906b) Adsorptionsanalyse und chromatographische Methode. Anwendung auf die Chemie des Chlorophylls. Berichte der Deutschen Botanischen Gesellschaft 24: 384-393

VEEN TH W VAN (1994) Bemmelen, Jacob Maarten van (1898-1982). Biografisch Woordenboek van Nederland 4, Den Haag (1994)
URL: http://www.inghist.nl/Onderzoek/Projecten/BWN/lemmata/bwn4/bemmele (02. 07.2002)

VISSER R P W (2001) Bemmelen, Johan Frans van (1859-1956). Biografisch Woordenboek van Nederland 5, Den Haag (2001)
URL: http://www.inghist.nl/Onderzoek/Projecten/BWN/lemmata/bwn5/bemmelen (02. 07.2002)

von Ostreyko R (1901) German Patent 136 792 1901

WAY J T (1850) On the power of soils to absorp manure. Journal of the Royal Agricultural Society of England 11: 313-379

WAY J T (1852) On the power of soils to absorp manure. Journal of the Royal Agricultural Society of England 13: 123-143

WIEGNER G (1931) Some physico-chemical properties of clays. I. Base exchange or ionic exchange. Journal of the Society of Chemistry and Industry 50: 65-71

Complete list of publications of Jakob Maarten van Bemmelen -

BEMMELEN J M VAN (1854) Dissertatio chymica inauguralis de Ciibotio Cumingii. Leiden

BEMMELEN J M VAN (1856) Ueber die Einwirkung der Bernsteinsäure und Citronensäure auf Glycerin. J Prakt Chem 69: 84

BEMMELEN J M VAN, ANKUM C H VAN (1856) Onderzoek naar eene arsenikvergiftiging. Haaxman´s Tijdschr v Wetensch Pharm 3: 289

BEMMELEN J M VAN (1859) Over de verhouding van glycerine, mannitane en glucose tegenover twee- en driebasische zuren. G. J. Mulder, Scheik Verhand en Onderz II: 1

BEMMELEN J M VAN, BOEKE J (1859) De verbetering der zure gronden in den Haarlemmermeer. De Boerengoudmijn: 4

BEMMELEN J M VAN (1863) Eenige hoofdstukken de nieuwe scheikunde geschetst naar aanleiding van de scheikundige brieven van Justus von Liebig. I. Ozon. II. Gisting, rotting, vertering. III. Bereiding van organische stoffen uit de grondstoffen. IV. Generatio spontanea. V. Constitutie der organische verbindungen. VI. Voeding en ademhaling. Zugefügt an seine holländische Übersetzung von Liebigs Chemische Briefe. J. Oomkens, Groningen, 315 S

BEMMELEN J M VAN (1863) Bouwstoffen tot de kennis van de kleigronden in de provincie Groningen. G. J. Mulder, Scheik Verhandl en Onderz III, 2: 1

BEMMELEN J M VAN (1864) Over de samenstelling en de aard der grondsoorten, die voor de meekrapcultuur geschikt zijn. Tijdschrift van Nijverheid 5: 195

BEMMELEN J M VAN (1864) Beoordeeling van [Besprechen von] Th. Fletcher´s „Wenken aan landbouwers en veehoudersgrond op wetenschap en ervaring“. Nieiwe Boerengoudmijn 1 No. 8

BEMMELEN J M VAN (1864) Analyse van een kalksteen uit Oding en uit Winterswijk. G. J. Mulder, Scheik Verhandl en Onderz III, 174

BEMMELEN J M VAN (1865) Roofbouw in Nederland. Tijdschr v Volksvlijt 2: 1

BEMMELEN J M VAN (1866) Bodenuntersuchungen in den Niederlanden. Landwirtsch Versuchstat 8: 255

BEMMELEN J M VAN (1867) Scheikundig onderzoek der monsters aarde uit de Zuiderzee, verzameld door Stieltjes en Beyerinck. Verslag aan de Ned. Maatsch. v. Grondcrediet; geplaatst in de verz. v. offic. Bescheiden betr. De droogmaking van het Z. gedeelte der Zuiderzee [Bericht aan de „Ned. Maatsch. van Grondcrediet“, aufgenommen in die sammlung von offiziellen Akten betreffend des Auspumpens des südlichen Teils der „Zuiderzee“, Seite 251-265

BEMMELEN J M VAN (1868) Scheikundig onderzoek van terpaarde. Verslag XXII^{e} Landhuishoudk. Congres Roermond 1868 (uitgeg. 1869), 1; nieuwe Boerengoudmijn 6, No. 19

BEMMELEN J M VAN (1868) Afvoer van faecale stoffen volgens het stelsel van Liernur. De Economist 1868

BEMMELEN J M VAN (1869) Landbouwonderwijs; een antwoord aan den Heer Geertsema. Landbouwsecourant, 9 en 23 Dec. 1869

BEMMELEN J M VAN (1870) Toestand der openbare en bijzondere scholen in Arnhem. G. W. van den Wiel & Co.

BEMMELEN J M VAN (1871) Luchtverversching in schoolgebouwden. De Schoolbode: 385; 465

BEMMELEN J M VAN (1871) De hoogeveenen en het veenbranden. De Gids II: 281

BEMMELEN J M VAN (1872) Proefstations. Verslag XXVI^{e} Landhuishoudkundig Congres Utrecht 1872

BEMMELEN J M VAN (1872) Beoordeeling van Cahours-Riche, Scheikunde voor dames, ten dienste van H. B. Scholen voor meisjes (vert. Ddoor Menalda van Schouwenburg [übersetzt von Menalda van Schouwenburg]). Isis I, No. 24

BEMMELEN J M VAN (1872) Bestimmungen der im Brunnenwasser vorhandenen Salpetersäure durch Indigo. Z f Analyt Chem 11: 136; Maand v Natuurwetensch (1872): 1

BEMMELEN J M VAN (1873) Bepaling van koolzuur in welwaters. Maandblad v Natuurwetensch 3: 97

BEMMELEN J M VAN (1873) Bepaling van ammonia in drinkwaters in verband met de vraag, of bij destillatie van water in aanraking met de lucht ammonia wordt gevormd. Maandblad v Natuurwetensch 3: 111

BEMMELEN J M VAN (1874) Oorzaken der nadeelige gevolgen van eene overstrooming van bouw- en weilanden door slootwater. Bijlage in het werk van J. P. Koster, „de provincie Groningen en hare defensie in de laatste twee eeuwen“. Hoitsema, Groningen

BEMMELEN J M VAN (1874) Bouwstoffen tot de kennis van het welwater en van de aardlagen in de gemeente Arnhem; uitgegeven door het Geneesk. Staatsoezicht van Gelderland en Utrecht

BEMMELEN J M VAN (1874) Uitkomsten van de toestellen ter luchtverversching der openbare scholen te Amsterdam en Enschede. Schoolbode

BEMMELEN J M VAN (1874) De scheikunde als leer der stofwisseling. Redevoering ter aanvaarding van het hoogleeraarsambt in de faculteit der wis- en natuurkunde aan de Hoogeschool te Leiden (25 April 1874)

BEMMELEN J M VAN (1877) Landbouwkundig onderzoek naar de samenstelling der monsters aarde, verzameld bij de boringen in de Zuiderzee (1875) door den ingenieur P. Havelaar op last van den Mnister van Binnenlandsche Zaken, en over de grondlagen in de Zuiderzee (zuidelijk gedeelte); Beilage V zum Gesetzentwurf „Bedijking en droogmaking van het zuidelijk gedeelte der Zuiderzee“, eingereicht an die „Tweede Kamer der Staten-Generaal“ van de Minister Heemskerk in der Sitzung 1876-1877. Also: Archiv Geol Comm Kon Akad v Wetensch

BEMMELEN J M VAN (1877) Das Absorptionsvermögen der Ackererde. Landw Versuchstat 21: 135-191, Kon Akad v Wetensch 24. Febr. 1877

BEMMELEN J M VAN (1877) Verslag betreffende den toestand der inrichtingen tot luchtverversching in lagere scholen te Leiden. Ellemann, Harms & Cie, Amsterdam
BEMMELEN J M VAN (1877) Landbouwscheikundig onderzoek van den droogemalen Legmeerpolder. Bericht an de „Maatschappij tot droogmaking der Legmeerplassen". Ellemann, Harms & Cie, Amsterdam
BEMMELEN J M VAN (1877) De genezing der oversroomde landen in de Provincie Groningen. Landbouwcourant 7 Juli 1877
BEMMELEN J M VAN (1878) Das Absorptionsvermögen der Ackererde. Ber Dtsch Chem Ges 11: 2228; Landw Versuchstat 23: 265; Kon Akad v Wetensch 24 Febr. 1877
BEMMELEN J M VAN (1878) Landbouwscheikundig onderzoek der drooggemalen IJpolders (1873-1878). Acht verslagen uitgebracht aan het Bestuur der Amsterdamsche Kanaalmaatschappij, met analysen, profielen en kaarten; gedrukt bij B. van der Land. Also: Arch Geol Comm Kon Akad v Wetensch [Acht Abhandlungen eingereicht an das „Bestuur der Amsterdamsche Kanalmaatschappij", mit Analysen, Profilen und Karten gedruckt bei B. van der Land. Siehe auch das Arch Geol Comm Kon Akad v Wetensch]
BEMMELEN J M VAN (1878) Het vloeibaar maken van lucht en van de permanente gassen. Tijdspiegel: 275
BEMMELEN J M VAN (1879) Ueber den Zustand der Alkaliphosphate in wässriger Lösung. Ber Dtsch Chem Ges 12: 1675
BEMMELEN J M VAN, INGENHOES P H B (1879) Ueber das Bestehen von Doppelsalzen in Lösungen (Bariumacetonitrat, Calciumacetochlorür und Bariumfornionitrat). Ber Dtsch Chem Ges 12: 1678
BEMMELEN J M VAN (1879) Levensbericht van P. J. van Kerckhoff. Jaarb Kon Akad v Wetensch
BEMMELEN J M VAN (1880) La composition des hydrates des dioxydes du silicium, de l´étain et du manganàse. Archives Néerlandaises 15: 321; Ber Dtsch Chem Ges 13: 1466
BEMMELEN J M VAN (1880) Nieuwe mededeeling omtrent luchtverversching op scholen. Schoolbode 1880
BEMMELEN J M VAN (1880) Landbouwscheikundig onderzoek van de aardmonsters uit het Wieringermeer door boring verkregen. Bericht an de „Commissie uit de Waterschappen ter voorbereiding van de indijking". E. J. Brill, Leiden. Also: Arch Geol Comm Kon Akad v. Wetensch
BEMMELEN J M VAN (1881) Die Verbindungen einiger festen Dioxydhydrate mit Säuren, Salzen und Alkalien. J Prakt Chem (2) 23: 324, 379; Archives Néerlandaises 15 (1880) 407; Kon Akad v Wetensch 28 Juni 1879, 29. Mai 1880
BEMMELEN J M VAN, POSTHUMUS N W (1881) Geol. Atlas van Nederland. C. L. Brinkman, Amsterdam

BEMMELEN J M VAN (1882) Das Hydrogel und das Hydrat des Berylloxyds und des Magnesiumoxyds. J Prakt Chem 26: 227; Kon Akad v Wetensch 24 Sept. 1881
BEMMELEN J M VAN (1882) Verslag aan de Kon. Akad. van Wetenschappen in zake de lijkverbranding (van de minderheid der Commissie). Versl en meded Kon Akad v Wetensch (2) 18: 212
BEMMELEN J M VAN (1882) Redevoering op de alg. Verg. Van het Genootenschap „Mathesis Scientiarum Genitrix“ te Leiden.
BEMMELEN J M VAN (1883) Eisengehalt der Leber in einem Falle von Leukaemie. Z Physiol Chem 7: 479
BEMMELEN J M VAN (1883) Het bezinken van klei in zoutwater. Kon Akad v Wetensch 24 Nov. 1883
BEMMELEN J M VAN (1883) Toespraak bij de inwijding der praktische ambachtsschool te Leiden (2. Juli 1883), gedruckt bij J. J. Groen, Leiden
BEMMELEN J M VAN (1885) De opleiding der aanstaande studenten in de Geneeskunde aan de Gymnasien en Hoogere Burgerscholen. Ber en meded van de Ver v. leeraren aan Inrichtingen van M. O., Leeuwarden
BEMMELEN J M VAN (1886) Bijdragen tot de kennis van den alluvialen bodem in Nederland. I. De bodem van het voormalige IJ. II. De samenstelling van de nieuwe zeeklei in het IJ en de Zuiderzee. III. De samenstelling en vorming van de zure gronden in het Nederlandsch alluvium. Verhand Kon Akad v Wetensch 25; Rec Trav Chim Pays-Bas 5: 199
BEMMELEN J M VAN (1886) De vermoedelijke vruchtbaarheid van den Vinkeveen-Proosty-Polder na de ontvening en droogmaking (met analysen van het veen) Province Verslag der Gedeputeerde Staten van Utrecht
BEMMELEN J M VAN (1887) Notice sur l´oxyde de Germanium. Rec Trav Chim Pays-Bas 6: 205; Kon Akad v Wetensch 29 April 1887
BEMMELEN J M VAN (1887) De droogmaking der Zuiderzee. Tijdschr v nijverheid 11: 325
BEMMELEN J M VAN (1887) Explosion d´un tube contenant des cristeaux de sulfate de protoxyde de chrome. Rec Trav Chim Pays-Bas 6: 202
BEMMELEN J M VAN (1888) Über die Absorptionsverbindungen und das Absorptionsvermögen der Ackererde. Landwirtsch Versuchsstat 35: 69-136
BEMMELEN J M VAN (1888) Sur la nature des colloïdes et leur teneur en eau. Rec Trav Chim Pays-Bas 7: 37
BEMMELEN J M VAN (1888) L´hydrogel de l´acide silicique. Rec Trav Chim Pays-Bas 7: 69
BEMMELEN J M VAN (1888) Le colloïde d´alumine et l´hydrate d´alumine. Rec Trav Chim Pays-Bas 7: 75
BEMMELEN J M VAN (1888) Les colloïdes de l´oxyde stannique. Rec Trav Chim Pays-Bas 7: 87

BEMMELEN J M VAN (1888) Sur le colloïde de l´oxyde ferrique. Rec Trav Chim Pays-Bas 7: 106
BEMMELEN J M VAN (1888) Sur le colloïde de l´oxyde chromique. Rec Trav Chim Pays-Bas 7: 114
BEMMELEN J M VAN (1889) De nieuwe richting in de Anorganische Chemie. Redevoering uitgesproken op den 314den verjaardag der Universiteit te Leiden.
BEMMELEN J M VAN (1889) Verslag van de lotgevallen der Universiteit in het afgeloopen jaar, uitgebracht den 17den September 1889 bij het overdragen der waardigheid van Rector Magnificus.
BEMMELEN J M VAN (1890) Die Zusammensetzung des Meeresschlicks in den neuen Alluvien des Zuiderzee (Niederlande). Landwirtsch Versuchsstat 37: 239
BEMMELEN J M VAN (1890) Die Zusammensetzung des vulkanischen Bodens in Deli (Sumatra) und in Malang (Java), und des Fluss-Thonbodens in Rembang (Java), welche für die Tabakskultur benutzt werden. Landwirtsch Versuchsstat 37: 257; Kon Akad v Wetensch 25 Jan. 1890
BEMMELEN J M VAN (1890) Ueber die Bestimmung des Wassers, des Humus, des Schwefels, der in den kolloidalen Silikaten gebundenen Kieselsäure, und des Mangans, im Ackerboden. Landwirtsch Versuchsstat 37: 277
BEMMELEN J M VAN (1890) Die Zusammensetzung der Ackererde, nach Anleitung der in den vorigen Abhandlungen mitgetheilten Analysen von gewöhnlichen und vulkanischen Thonböden. Landwirtsch Versuchsstat 37: 347
BEMMELEN J M VAN (1890) Ueber die Ursachen der Fruchtbarkeit des Urwaldbodens in Deli (Sumatra) und Java für die Tabakscultur, und der Abnahme dieser Fruchtbarkeit. Landwirtsch Versuchsstat 37: 374
BEMMELEN J M VAN (1890) Ueber die Zusammensetzung der Asche der Tabaksblätter in Beziehung zu ihrer guten und schlechten Qualität, insbesondere ihrer Brennbarkeit. Landwirtsch Versuchsstat 37: 409
BEMMELEN J M VAN, GUNNING J W, TJADEN MODDERMAN R S (1890) Beoordeeling van antwoorden op een prijsvraag van het Genootschap tot bevordering van natuur-, genees- en heelkunde [Beurteilung von Antworten auf eine Preisfrage des „Genootschap tot bevordering van natuur-, genees- en heelkunde“]. Handelingen 1890
BEMMELEN J M VAN, KLOBBE E A (1892) Über das amorphe wasserhaltige Eisenoxyd, das kristallinische Eisenoxydhydrat, das Kaliumferrit und das Natriumferrit. J Prakt Chem 46: 497; Archives Néerlandaises 29 (1896) 413; Versl Kon Akad v Wetensch 27 Febr. en 24 Sept. 1892
BEMMELEN J M VAN (1894) Das Hydrogel und das kristallinische Hydrat des Kupferoxyds. Z Anorg Chem 5: 466; Archives Néerlandaises 30 (1897) 1; Versl Kon Akad v Wetensch 28 Jan. 1893
BEMMELEN J M VAN (1895) Der Teilungskoëfficient bei Absorptionen aus Lösungen durch feste Stoffe. Z Physikal Chem 18: 331; Versl Kon Akad v Wetensch 27 Juni

1896
BEMMELEN J M VAN (1896) Over de samenstelling , het voorkomen, en de vorming van Sideroze (witte kleien) en van Vivianiet in de onderste aardlaag der hoogvenen van Zuidoost Drenthe. Verhand Kon Akad van Wetensch 1e sectie, III, No. 1; Archives Néerlandaises 30 (1897)25
BEMMELEN J M VAN (1897) Die Absorption I: Das Wasser in den Kolloiden, besonders in dem Gel der Kieselsäure. Z Anorg Chem 13: 233; Versl Kon Akad v Wetensch 26. Nov. 1892, 29. Juni 1895
BEMMELEN J M VAN (1897) Der Gehalt an Fluorcalcium eines fossilen Elefantenknochens aus der Tertiärzeit. Z Anorg Chem 15: 84; Versl Kon Akad v Wetensch 27 Juni 1896; Archives Néerlandaises (2) 3 (1900) 230
BEMMELEN J M VAN (1897) Die Absorption. Anhäufung von Fluorcalcium, Kalk, phosphaten in fossilen Knochen. Z Anorg Chem 15: 90; Versl Kon Akad v Wetensch 5: 335; Archives Néerlandaises (2) 3 (1900) 236
BEMMELEN J M VAN (1898) Die Absorption. II. Die Bildung des Gels und ihre Structur. Z Anorg Chem 18: 14
BEMMELEN J M VAN (1898) Die Absorption. III. A. Die Hohlräume, die bei der Entwässerung des Hydrogels von SiO_2 entstehen. B. Der Verlust des Absorptionsvermögens der Kolloide. C. Die Umsetzung von kristallinen Hydraten in amorphen Substanzen (Absorptionsverbindungen). Z Anorg Chem 18: 98
BEMMELEN J M VAN (1898) Toespraak op de algemeene vergadering der Electrotechnische Vereeniging op 5 April 1898, in het Physisch Laboratorium der universiteit te Leiden, over de historie van het onderwijs aan „Mathesis Scientiarium Genitrix“.
BEMMELEN J M VAN (1899) Die Absorption. IV. Die Isotherme des kolloiden Eisenoxydes bei 15 °. Z Anorg Chem 20: 185; Versl Kon Akad v Wetensch 26 Jan. 1899
BEMMELEN J M VAN, HOITSEMA C, KLOBBIE E A (1900) Ueber das Vorkommen, die Zusammensetzung und die Bildung von Eisenanhäufungen in und unter Mooren. Z Anorg Chem 22: 313; Archives Néerlandaises (2) 4 (1901) 19
BEMMELEN J M VAN, KLOBBIE E A (1900) Die Absorption. V. Die Absorption von HCl und KCl aus wässriger Lösung durch kolloides Zinnoxyd. Z Anorg Chem 23: 111
BEMMELEN J M VAN (1900) Die Absorption. VI. Die Absorption von Stoffen aus Lösungen. Z Anorg Chem 32: 321
De chemische samenstelling van 2 monsters Loess. Verhandl Kon Akad v Wetensch 2e sectie, VII, No. 3
BEMMELEN J M VAN (1901) Bijdrage tot de wetenschappelijke Biographie van G. J. Mulder. Historisch kritische beschouwing van zijn werk: „Scheikunde der bouwbare aarde“. Verhandl Kon Akad v Wetensch 7 sectie 1, No. 7; Landbouwk Tijdschr (1901): 393
BEMMELEN J M VAN, REINDERS G (1901) Twee nieuwe vindplaatsen van

moerasijzersteen in en onder veen. Versl Kon Akad v Wetensch 9: 406
BEMMELEN J M VAN (1902) Die Absorption. VII. Die Einwirkung von höheren Temperaturen auf das Gewebe des Hydrogels der Kieselsäure. Z Anorg Chem 30: 265; Archives Néerlandaises (2) 6 (1901) 607
BEMMELEN J M VAN (1903) Die Absorption. VIII. Absorptionsverbindungen von Hydrogelen, falls auch chemische Verbindungen oder Lösungen stattfinden können. Z Anorg Chem 36: 380; Versl Kon Akad v Wetensch 27 Juni 1903
BEMMELEN J M VAN (1903) Levensschets van Dr. J. D. Boeke [Lebensbericht von Dr. J. D. Boeke], Directeur der Rijks Hoogere Burgerschool te Alkmaar. Tijdschri v toegep scheik en hyg VI: 289
BEMMELEN J M VAN (1903) Untersuchung des Wassers von Ajer Panas auf Saparoea und von Gassit auf Buru. In: Over de Molukken van K. Martin
BEMMELEN J M VAN (1903) Onderzoek van eenige grondsoorten uit Suriname. Alluviale klei en Lateriet. Landbouw k Tijdschr 1903: 315
BEMMELEN J M VAN, MEERBUERG P A, HUBER NOODT U (1903) Das System $SbCl_3$-HCl-H_2O. Z Anorg Chem 33: 272
BEMMELEN J M VAN (1904) Beiträge zur Kenntnis der Verwitterungsprodukte der Silikate in Ton-, vulkanischen und Lateritböden. Z Anorg Chem 42: 265; Versl Kon Akad v Wetensch 13: 351; Archives Néerlandaises (2) 10 (1905) 207
BEMMELEN J M VAN (1904) Die Absorption von Wasser durch Ton. Z Anorg Chem 42: 314; Archives Néerlandaises (2) 10 (1905) 266
BEMMELEN J M VAN (1905) Die Metazinnsäure und Metazirkonsäure. Z Anorg Chem 45: 83
BEMMELEN J M VAN (1905) Herinneringen uit den tijd van mijn Directeurschap van de Rijkshoogere Burgerschool in de jaren 1864-1869. In het Gedenkboek der School. Tweede reunie der oud-leerlingen Juli 1904. G. A. Evers, Groningen
BEMMELEN J M VAN (1906) Die Absorption. IX. Ueber den Unterschied zwischen Hydraten und Hydrogelen und die Modifikationen der Hydrogele (Zirkonsäure und Metazirkonsäure). Z Anorg Chem 49: 125
BEMMELEN J M VAN (1906) Buchbesprechchung von Richard Zsigmondy: Zur Erkenntnisse der Kolloide. Chem Weekblad 3: 209
BEMMELEN J M VAN (1906) Leblanc en Dizé. Chem Weekblad 3: 209
BEMMELEN J M VAN (1907) Beschouwingen over het tegenwoordig standpunt onzer kennis van de terpen. Ed. Ydo, Leiden
BEMMELEN J M VAN (1907) Leblanc en Dizé. Chem Weekblad 4: 133
BEMMELEN J M VAN (1907) Het leven en de werken van H. W. Bakhuis Roozeboom in zijnen Leidschen tijd. Chem Weekblad 4: 299
BEMMELEN J M VAN, JORISSEN W P, RINGER W E (1907) H. W. Bakhuis Roozeboom. Nachruf. Ber Dtsch Chem Ges 40: 5141-5170
BEMMELEN J M VAN (1908) Nähere Betrachtungen über die von G. Tschermak angenommenen Kieselsäuren. Z Anorg Chem 59: 225; Chem Weekblad 5: 567;

Archives Néerlandaises (2) 14 (1909) 222

BEMMELEN J M VAN (1909) Die Absorption. X. Beitrag zur Kenntnis der Eigenschaften der Hydrogele bei ihrer Entwässerung und Wiederwässerung. Z Anorg Chem 62: 1; Chem Weekblad 6: 199, 254

BEMMELEN J M VAN (1909) Die Verwitterung der Tonböden. Zweite Abhandlung. Z Anorg Chem 62: 221-236

BEMMELEN J M VAN (1909) Eenige bladzijden. In: W. P. Jorissen, Het Chemisch (thans anorganisch-chemisch) Laboratorium der Universiteit te Leiden van 1859 tot 1909 en de chemische laboratoria dier Universiteit vóór dat tijdvak en zij, die er in doceerden. A. W. Sythoff´s Uitgeversmaatsch., Leiden

BEMMELEN J M VAN (1909) Aanteekening omtrent de daling van den Nederl bodem Versl Kon Akad v Wetensch 18: 407

BEMMELEN J M VAN (1910) Die verschiedenen Arten der Verwitterung von Silikatgesteinen in der Erdrinde. Z Anorg Chem 66: 322; Chem Weekblad 6 (1909) 947, 7 (1910) 326

BEMMELEN J M VAN (1910) Over de plasticiteit der kleigronden [Über die Plastizität der Tonböden]. Chem Weekblad 7: 793

BEMMELEN J M VAN (1910) Die Absorption. Gesammelte Abhandlungen über Kolloide und Absorption. Mit Unterstützung des Verfassers neu herausgegeben von Dr. Wolfgang Ostwald. Verlag von Theodor Steinkopff, Dresden, 548 Seiten. [Collected papers of J. M. van Bemmelen on colloids and absorption (adsorption) , ed. Wolfgang Ostwald]

Gedenkboek aangeboden aan Jakob Maarten van Bemmelen (1830-1910). Uitgegeben bij C. de Boer jr. Te Helder (1910)

Vorwort: Aan Jakob Maarten van Bemmelen den scherpzinnigen en onvermoeiden onderzoeker, den Nestor der Nederlandsche Scheikundigen, wordt dit Gedenkboek op zijn tachtigsten Verjaardag aangeboden door zijne Vrienden.