

A review on

Muslim Contribution to Chemistry

Author: Salah Zaimeche BA, MA, PhD
Chief Editor: Professor Salim Al-Hassani
Production: Ahmed Salem BSc

Release Date: December 2001
Publication ID: 4017

Copyright: © FSTC Limited 2001, 2002

IMPORTANT NOTICE:

All rights, including copyright, in the content of this document are owned or controlled for these purposes by FSTC Limited. In accessing these web pages, you agree that you may only download the content for your own personal non-commercial use. You are not permitted to copy, broadcast, download, store (in any medium), transmit, show or play in public, adapt or change in any way the content of this document for any other purpose whatsoever without the prior written permission of FSTC Limited.

Material may not be copied, reproduced, republished, downloaded, posted, broadcast or transmitted in any way except for your own personal non-commercial home use. Any other use requires the prior written permission of FSTC Limited. You agree not to adapt, alter or create a derivative work from any of the material contained in this document or use it for any other purpose other than for your personal non-commercial use.

FSTC Limited has taken all reasonable care to ensure that pages published in this document and on the MuslimHeritage.com Web Site were accurate at the time of publication or last modification. Web sites are by nature experimental or constantly changing. Hence information published may be for test purposes only, may be out of date, or may be the personal opinion of the author. Readers should always verify information with the appropriate references before relying on it. The views of the authors of this document do not necessarily reflect the views of FSTC Limited.

FSTC Limited takes no responsibility for the consequences of error or for any loss or damage suffered by readers of any of the information published on any pages in this document, and such information does not form any basis of a contract with readers or users of it.

FSTC Limited

9 Conyngham Road, Victoria Park, Manchester, M14 5DX, United Kingdom

Web: <http://www.fstc.co.uk> Email: info@fstc.co.uk

A REVIEW ON MUSLIM CONTRIBUTION TO CHEMISTRY

First, it is worth pointing out the excellent web page on the history of chemistry by Prof. H.A. Ead of the Cairo Science Heritage Centre, at: <http://www.frcu.eun.eg/www/universities/html/shc/index.htm>. Some reliance will be made upon his material in the work below; and our audiences are advised to consult and make good use of his site.

There is also an excellent page on the subject, but in French, this time, at:
<http://kdolma.phidji.com/sciences/sciences.asp>

For the rest, the web betrays the usual bareness when it comes to this science, although some Islamic sites, A Zahoor's in particular, at: <http://users.erols.com/zenithco/index.html> have touched on the subject, and above all on the scholars who dealt with it. Thus no need in the work below to go on about the lives of Islamic scholars involved the science, Zahoor's site amply fulfilling the task. Non Islamic sites, as per usual, have completely ignored the matter.

ALCHEMY OR CHEMISTRY?

Before addressing the subject of Muslim chemistry, however, one crucial matter needs to be raised. It concerns the use of the word Alchemy instead of chemistry. This is another instance of historical corruption fooling so many who have no perception of the depths some scholarship can descend to in order to convey distorted images of aspects of history, such as that of Islamic science. Alchemy, indeed, is a corrupt translation of the Arabic word Chemia (chemistry,) preceded by the article Al (which means: the), and which the Arabs always use (like the French and others for that matter) in front of their subject such as Al-Tib (medicine) al-Riyadiyat (mathematics) etc... If this was applied to other subjects, it would become al-medicine; al-mathematics, al-geography and so on... Only Baron Carra de Vaux had had the presence of mind to pointing to this, however briefly.¹ Somehow al-Chemistry should be translated literally The Chemistry and not Alchemy in English; and La Chimie and not l'alchimie in French. The fact that only Westerners translated or dealt with the subject, followed by rather very respectful or shy Muslim scholars means that this corrupt word of al-chemistry has remained, and has become the norm.

The reason why alchemy is used instead of chemistry might have another motive behind it. Chemistry means a modern science; alchemy means the amateur, the occult, the second or third rate. Alchemy belongs to the Muslims; chemistry, of course, does not; instead is the realm of the good. This notion conveyed by some Western historian, that alchemy ended with the Muslims and chemistry began with the Westerners has no historical ground. The reason is simple: all sciences began in some part of the world, most likely China or the Ancient Middle East, or India, at level: 1, the most basic, and then graduated to levels 2, 3, 4, and higher, through the centuries, until they reached us at the level they are, and will evolve in different places in the future. This is the story of every science, and of every sign of our modern world. Thus, it was not that we had alchemy at one point, and then, with the Europeans it became chemistry. This is a crass notion like much else coming from those holding such a view. Chemistry began under one form, associated with occult and similar practices, and then evolved, gradually becoming more refined through the centuries until it took our modern forms and rules. Many elements concur to support this point. Here they follow.

INDUSTRIAL CHEMISTRY

First and foremost many of the products or discoveries made by the Muslims have become part of our modern chemical world; in fact were revolutions in the advance of the science. Mathe summarises the legacy of Muslim chemists,² which include the discovery of alcohol, nitric and sulphuric acids, silver nitrate and potassium, the determination of the weight of many bodies, the mastery of techniques of sublimation, crystallization and distillation. Muslim chemistry also took many industrial uses including: tinctures and their applications in tanning and textiles; distillation of plants, of flowers, the making of perfumes and therapeutic pharmacy. More specifically, some such advances that have revolutionised our world are expertly raised by Multhauf.³ Thus in the *De aluminibus*,⁴ composed in Muslim Spain, (whose author Multhauf does not recognise) but could be Al-Majriti, are described experiments to obtain the chloride of mercury, corrosive sublimate (Hg Cl_2), process and outcome which mark the beginning of synthetic chemistry. Multhauf notes indeed that the chloride of mercury obtained did not just become part of the chemist's repertoire but also inspired the discovery of other synthetic substances. Corrosive sublimate is capable of chlorinating other materials, and this, Multhauf, again, notes, marks the beginning of mineral acids.⁵ In the field of industrial chemistry and heavy chemicals, Multhauf notes again that one of the greatest advances of the medieval times was the manufacture of alum from 'aluminous' rocks, through artificial weathering of alunite, which he describes. And in the same context the Muslims managed to perform the crystallisation of 'ammonia alum' (ammonium aluminium sulphate).⁶ Multhauf, however, falls in the same trap as many of his colleagues, asserting in his conclusion⁷ that it was European Renaissance which gave chemistry a secure and significant place in science, and that with the Muslims all that was, was 'alchemy;' and Multhauf states this in full contradiction of what he had just described, and so expertly, and he had himself classified under modern chemistry.

HOLMYARD'S CONTRIBUTION

One whom from the initial point gave Islamic chemistry its due, and hardly failed to call it so, was Holmyard.⁸ Holmyard, indeed, has the right qualifications to discuss Islamic chemistry, and more than any other, with the exception of Ruska, and also Levey. Holmyard is indeed both a chemist with great reknown, and also an Arabist in training, rightly qualified to look at the science from the expert angles, unlike others, who are either Arabists and so understand little in chemistry, or are experts in chemistry and understand nothing in Arabic. Holmyard notes that the rise and progress of Islamic chemistry is given very little space, and whatever information exists is erroneous and misleading, a fact due partly to Kopp's unfavourable opinion of Islamic chemistry, and the hasty conclusions drawn by Berthelot from his superficial studies of Islamic material.⁹ And neither Kopp, nor Berthelot were Arabists, which, as Holmyard notes, makes their conclusions on Muslim chemistry unable to stand the test of criticism as more information is available.¹⁰ Of course, today's historians can always ignore evidence that has come out since Kopp and Berthelot, and still stick with their misinformation, errors, or distorted statements, and blame such on either one of them. This tactic is in fact very common amongst those writing in any field of history, who shape and reshape events at will and have all the necessary sources and references to justify their writing. Some historians even go as far as blaming the material in the library of their university, stating in their preface or conclusion that any shortcoming in their work was the result of their access to such limited material.

To return to Holmyard, in his *Makers of Chemistry*, tracing the evolution of the science from the very early times until our century, and even if not having at his disposal the vast amount of information that many

have today, he produced an excellent and encompassing, thorough work. It includes none of the usual gaps of centuries one finds with other historians; nor does it include the discrepancies caused by 'sudden', 'enlightened' 'miraculous' breakthroughs out of nothing.

THE ADVENT OF EXPERIMENTAL CHEMISTRY

One of the points raised by Holmyard, which was fundamental to chemistry, and to the development of science in general, is the development of its practical side, that is experiment. This, in fact, is one of the most sticking points in the history of science, a fact that has suffered much from the distortions of scholarship dealing with the history of science. Experiment is what differentiates Muslim science from Greek speculation (called science). Experiment also began with the Muslims, centuries before the likes of Grosseteste, whom scores of scholars,¹¹ in their usual short-sightedness, behind which lurks dishonesty, or incompetence, or both at once, keep attributing to. Indeed, Holmyard notes how Jabir Ibn Hayyan (722-815), one of the earliest Muslim scientists, and the promoter of chemistry (not to use that silly word many of our scholars tend to use: father; as if a science has a father and a son) was acquainted with chemical operations of crystallization, calcination, solution, sublimation, reduction, etc, and, above all, that he describes them. Of greater interest even, as Holmyard notes, Jabir seeks to understand the changes that take place during the process, besides giving opinions to their aims; for instance, explaining how the aim of calcination is to remove impurities from metals, and how metals are calcinated in different ways.¹² Jabir also describes processes for the preparation of steel, the refinement of other metals, for dyeing cloth and leather, for marking varnishes to waterproof cloth, for the preparation of hair-dyes, etc.. He also gives recipes for making a cheap illuminating ink for manuscripts, and mentions the use of manganese dioxide in glass making. He was also acquainted with citric acid and other organic substances, and so on.¹³ On the crucial role of experiment, Jabir had this to say:¹⁴

'The first essential in chemistry is that thou shouldest perform practical work and conduct experiments, for he who performs not practical work nor makes experiments will never attain to the least degree of mastery. But thou, O my son, do thou experiment so that thou mayest acquire knowledge. Scientists delight not in abundance of material; they rejoice only in the excellence of their experimental methods.'

Jabir's overall achievements are elsewhere summarised by Al-Faruqi.¹⁵ Some of his writing includes *Al-Khawass al-kabir* (the Great Book of Chemical properties), *al-Mawazin* (Weights and measures), *Al-Mizaj* (Chemical combination, and *Al-Asbagh* (Dyes). On top of that, he built a precise scale that weighed items 6, 480 times smaller than the ratl (approx 1 kg.) Before John Dalton by ten centuries, he defined chemical combinations as a union of the elements together, in too small particles for the naked eye to see, without loss of character. And he invented a kind of paper that resisted fire. Jabir's other achievements¹⁶ include his perfecting of chemical processes already cited of sublimation, liquefaction, purification, amalgamation, oxidation, crystallization, distillation, evaporation, and filtration. He also identified many new products, including alkalines, acids, salts, paints and greases. He prepared sulphuric acid, nitro-hydrochloric acid (used to dissolve some metals), caustic soda and a multitude of salts such as sulphates, nitrates and potassium and sodium carbonates. Jabir's works with metals and salts subsequently helped develop foundry techniques and glazing processes for tiles and other ceramics.¹⁷ Thus are illustrated Jabir's achievements in the science. However, instead of focusing on his pure scientific contribution to chemistry, many non Muslims dealing with 'Alchemy',¹⁸ prefer to dwell on the rather tedious, obscure, and un-scientific aspects

of his work of the fanciful and folkloric sort of Greek and ancient origins (aspects which both Ibn Sina and Ibn Khaldoun instead denounce very much).

AL-RAZI AND AL-MAJRITI

Nearly a century had elapsed after Jabir before flourished another Muslim maker of modern chemistry: al-Razi (b. 866). Al-Razi maintained the excellence began by Jabir, and gave chemistry foundations it kept up to our day. In his work *Secret of Secrets*,¹⁹ he made the very useful classification of natural substances, dividing them into earthly, vegetable and animal substances, to which he also added a number of artificially obtained ones such as lead oxide, caustic soda, and various alloys. He went further in the cataloguing and description of his experiments, describing first the materials he used, then the apparatus, and methods and conditions of his experiments.²⁰ Al-Razi also set up the laboratory in the modern sense, designing, describing and using more than twenty instruments. Both Anawati and Hill provide a good account of such laboratory,²¹ the precursor of the modern laboratory, of which many parts are still in use today (to which Hill points out, whilst Anawati does not.)²² Al-Razi does not just list the instruments used in chemistry, he also gives details of making composite pieces of apparatus, and provides the same sort of information as can be found today in manuals of laboratory art.²³ Also his systematic classification of carefully observed and verified facts regarding chemical substances, reactions and apparatus, all in very clear language, further contribute to make Al-Razi of 'exceptional importance in the history of chemistry,' according to Holmyard.²⁴ These are, indeed, symbols of modern science; hence, the obvious conclusion that modern science, in practice and methodology, and not just chemistry, found roots in the works of Muslim scientists; Muslim chemistry itself proving to be no occult practice that ended with the European Renaissance.

Al-Majriti (950-1007), from Madrid, hence his name, and already cited briefly, was particularly noted for his work *Rutbat Al-Hakim* (The Rank of the Wise), which amongst other things gives formulae and instructions for the purification of precious metals. This was collected and put together in the year 1009, two years after his death. In this work, Al-Majriti was also the first to prove the principle of conservation of mass, credited eight centuries later to the French Lavoisier,²⁵ the so called father of chemistry.

PHARMACOLOGY IN THE MAKING

Advances in Islamic chemistry led to the development of Islamic pharmacology, Al-Razi, for instance, acting to promote the medical uses of chemical compounds.²⁶ Sabur Ibn Sahl (d 869), it was, however, who was the first physician to initiate pharmacopoeia, describing a large variety of drugs and remedies for ailments. Al-Biruni (d 1051) wrote one of the most valuable Islamic works on pharmacology entitled *Kitab al-Saydalah* (The Book of Drugs), where he gave detailed knowledge of the properties of drugs and outlined the role of pharmacy and the functions and duties of the pharmacist. Ibn Sina, too, described no less than 700 preparations, their properties, mode of action and their indications. He devoted in fact a whole volume to simple drugs in his *Canon*.²⁷ Of great impact were also the works by Massawayh al-Maridini of Baghdad and Cairo, and Ibn al-Wafid of Spain, both of which were printed in Latin more than fifty times, appearing as *De Medicinis universalibus et particularibus* by 'Mesue' the younger, and *the Medicamentis simplicibus* by 'Abenguefit'.²⁸ Peter of Abano (1250-1316) translated and added a supplement to the work of al-Maridini under the title *De Veneris*. In this area, however, it was al-Zahrawi (of Spain) who played a determining role, pioneering in the preparation of medicines by sublimation and distillation. His *Liber servitoris* is of particular interest, Sherwood Taylor explains,²⁹ because its purpose is to tell the reader how to prepare the

'simples' from which were compounded the complex drugs then generally used. Al-Zahrawi also gives methods of preparing litharge, white lead, lead sulphide (burnt lead), burnt copper, cadmia, marcaside, yellow arsenic and lime, the various vitriols, salts, natron etc. He also gives a considerable number of recipes for distilled products, though not alcoholic ones, the beginning of distillation as a means of preparing drugs, perhaps the most significant feature of all according to Sherwood Taylor.³⁰ Abu al-Mansur al-Muwaffaq's contributions in the field are also pioneering. Living in the tenth century, he wrote *The foundations of the true properties of Remedies*, amongst others describing arsenious oxide, and being acquainted with silicic acid. He made clear distinction between sodium carbonate and potassium carbonate, and drew attention to the poisonous nature of copper compounds, especially copper vitriol, and also lead compounds. For the story, he also mentions the distillation of sea-water for drinking.³¹

It is to Levey that credit goes for reviving this (medical) aspect of Islamic chemistry in his comprehensive *Early Arabic Pharmacology*.³² According to Levey, the Muslims were expert organisers of knowledge; their pharmacological texts directed carefully along lines that were useful to the apothecary and medical practitioner. These treatises as a result generally are more or less within well-delineated groups. Some of the major types of Muslim pharmacological he list go as follows:³³

- 1) Medical formularies which include many kinds of compound drugs, pills, pastilles, powders, syrups, oils, lotions, toothpastes...
- 2) Books on poisons.
- 3) Synonymatic: treatises, in which are found lists of simples usually in alphabetical order to help the reader to identify the drug in other languages.
- 4) Tabular, synoptic texts, whereby long texts are turned into tabular work for quick usage, and abstracts made of some treatises for the same purpose.
- 5) Lists of materia medica which include therapeutic considerations and opinions of various writers on the subject, preparations of the drugs and descriptions...
- 6) Substitute drugs in case one drug for whatever reason was not available, a substitute was provided.
- 7) Works on medical specialities available either as separate treatises or as sections of large encyclopaedias of medicine.

CHEMICAL TECHNOLOGY

Levey's contribution was also instructive in other branches of Islamic chemistry. A good series of articles of his, unfortunately not gathered in a sort of varorium, can be found scattered in various medical journals. But the best revue to acquaint us with Levey's work is *Chymia*,³⁴ edited by H.M. Leicester. In Volume 7 (1961) of this review, Levey deals with inks, glues, and erasure fluids, making a preliminary survey of Islamic chemical technology (pp 57-72). Levey brings to knowledge the pioneering works of the Tunisian scientist Ibn Badis (1007-1061), who in *his Umdat al-Kuttab* (Staff of the Scribes) in twelve chapters, writes amongst others on: the excellence of the pen, the preparation of types of inks, the preparation of colored inks, the coloring of dyes and mixtures, secret writing, the making of paper, and so on...a remarkable list indeed. In the same issue Levey also looks at the development of the Islamic atomic theory (pp.40-56). In volume eight, he considers Al-Kindi's views of Aqrabadhins (pharmacists) (pp 11-20), whilst in volume nine, he considers the crucial matters of chemical technology and commercial law in Early Islam (pp 19-25). In the latter, Levey looks at the office of the Muhtassib (censor of customs), where the practice of the law comes into contact with the commercial chemical applications; the muhtassib enforcing what was legally

right, and preventing what was illegal; and checking weights and measures, inspecting apothecaries, demanding the purity in the manufacture of goods, preventing the use of inferior dyes, and so on. Finally, in volume 11 of the same revue (pp 37-44), Levey looks at the chemical formulary of a scientist not considered in this paper, but so deserving it: al-Samarquandi.

TRANSMISSION OF CHEMISTRY TO EUROPE

Of course Muslim chemistry, like other sciences was heavily translated into Latin, and also into local languages, which explains its spread to Europe (more on this in the chapter on the transfer of Muslim science to Europe). Many of the manuscripts translated have anonymous authors. Of the known ones, Robert of Chester (12th Century), translated *Liber de compositione alchemise*. At about the same time, Hugh of Santalla made the earliest Latin translation of *lawh azzabarjad* (the Emerald table). Alfred of Sareshel translated the part of Ibn Sinna's *Kitab al-Shiffa* (the Book of Healing) that deals with chemistry. It is, however, as per usual, the Italian, Gerard of Cremona, who made the more valuable translations of Al-Razi's study and classification of salts and alums (sulphates) and the related operations the *De aluminibus et salibus*, whose Arabic original is preserved.³⁵ The many versions of this work had a decisive influence on subsequent operations in the West, more generally on mineralogy;³⁶ as did others in the formation of the foundations of such science. In fairly recent times, Holmyard, Kraus, and above all Ruska, have devoted considerable focus to Muslim chemistry, much of which, unfortunately, is not accessible to non German speakers,³⁷ who thus will be deprived from forming a truest picture of Islamic chemistry.

CONCLUSION

After such an expose, however brief, should we still consider Muslim chemistry as an occult practice called alchemia? Are not many aspects of such science exactly what we have in our modern chemistry? And if this is not enough, here is what Muslims thought of the occult alchemia. Both Ibn Sina and Ibn Khaldoun attacked the experimentalists who sought to turn ordinary metals into precious ones, gold in particular. Ibn Sina, for instance, in *The Book of Minerals*, denounces the artisans who dye metals in order to give them the outside resemblance of silver and gold. He asserts that fabrication of silver and gold from other metals is 'practically impossible and unsustainable from a scientific and philosophical point of view.'³⁸ Ibn Khaldoun, for his part,³⁹ denounces the frauds who apply on top of silver jewelry a thin layer of gold, and make other manipulations of metals. To Ibn Khaldoun, the Divine wisdom wanted gold and silver to be rare metals to guarantee profits and wealth. Their disproportionate growth would make transactions useless and would 'run contrary to such wisdom.'⁴⁰

It is, thus, time to give Muslim chemistry its due place in history. For that to happen, the concentrated effort of Arabic speaking, able scholars, with some honesty, ought to get on with the task of writing truest accounts of Islamic chemistry in history, do for this science what Rashed, Djebbar and Yuskevitch did for Islamic mathematics, or what al-Hasan and Hill did for Islamic engineering, and what King, Saliba, Kennedy and Samsó seek to do for Islamic astronomy, bringing Islamic chemistry out of the slumber others have dug in for it.

References

- ¹ Baron Carra de Vaux: *Les Penseurs de l'Islam*, (5 vols), Geuthner, Paris, vol 2, at p. 374.
- ² Jean Mathe: *The Civilisation of Islam*, tr. by David Macrae, Crescent Books, New York.
- ³ R.P. Multhauf: *The Origins of chemistry*; Gordon and Breach Science Publishers; London, 1993.
- ⁴ *De aluminibus* was translated into Latin by Gerard of Cremona in Toledo, Spain, in the 12th century.
- ⁵ R.Multhauf: *The Origins*, op cit, at pp 160-3;
- ⁶ *Ibid*, p 339.
- ⁷ At p. 351.
- ⁸ E.J. Holmyard: *Makers of Chemistry*; Oxford at the Clarendon Press, 1931.
- ⁹ E.J. Holmyard: *Chemistry in Islam*; in R. M. Palter edition: *Toward Modern Science*; Noonday Press, New York, 1961; in Vol 1, at pp. 160-70. At pp 160-1.
- ¹⁰ *Ibid*.
- ¹¹ That include that so 'illustrious' Crombie, whose book: '*Robert Grosseteste and the origins of experimental sciences*,' 1953, conveys this sort of (and other) distortions.
- ¹² E.J. Holmyard: *Makers*, op cit; p. 59.
- ¹³ *Ibid* at pp 59-60;
- ¹⁴ *Ibid*, p. 60.
- ¹⁵ I, and L. Al-Faruqi: *The Cultural Atlas of Islam*; Mc Millan Publishing; New York; 1986; at p. 328.
- ¹⁶ Most particularly from A. M. Kettani: *Science and Technology in Islam*; in Z. Sardar ed: *The Touch of Midas*; Manchester University Press; 1984; pp 66-90; at 78, and Carra de Vaux: *Les Penseurs de l'Islam*, op cit.
- ¹⁷ G.M. Wickens: *The Middle East as a world centre of science and medicine*, in *Introduction to Islamic Civilisation*, edited by R.M. Savory; Cambridge University press; Cambridge; 1976; pp. 111-18, at p. 113.
- ¹⁸ For instance: Georges Anawati, *Arabic alchemy*, in *Encyclopaedia of the History of Arabic Science*; Edited by R. Rashed, 3 vol; at pp. 865-7; and C. Ronan: *The Arabian science*, in *The Cambridge Illustrated History of the World's Science*; Cambridge University Press, pp 201-244, at p.p 237-8.
- ¹⁹ Translated by Gerard of Cremona.
- ²⁰ M. Ali Kettani: *Science*, op cit, p. 79.
- ²¹ G. Anawati: *Arabic*, op cit, at p. 868; D.R. Hill: *Islamic Science and Engineering*; Edimburgh University Press; 1993; at p. 84.
- ²² This fact is highly important as it demonstrates how Muslim science is still valid in many respects today.
- ²³ E.J. Holmyard: *Makers*, op cit, at p. 66.
- ²⁴ *Ibid*; p. 64.
- ²⁵ M. Ali Kettani: *Science*, op cit, p. 79.
- ²⁶ C. A. Ronan: *The Arabian*, op cit, p. 239.
- ²⁷ Volume ii includes the names of simple drugs arranged in alphabetical order.
- ²⁸ Max Meyerhof: *Science and medicine*, in *The Legacy of Islam*, edited by Sir T. Arnold and A. Guillaume; first edition, Oxford University Press, 1931; pp 311-55; at pp 331-2. (Worth mentioning here that the second edition of the *Legacy of Islam* is abysmal in comparison with the first).
- ²⁹ F.Sherwood Taylor: *A History of Industrial chemistry*. Heinmann, London, 1957; pp 140-1. Sherwood Taylor's writing is however very dismissive of Islamic chemistry; generally tending to refer to any Islamic breakthrough in the shortest wording possible permitted by the English language.
- ³⁰ *Ibid*, p. 141.

³¹ In Holmyard: *Makers*, op cit, at p.68.

³² Leiden, 1973.

³³ M. Levey: *Early Arabic Pharmacology*; E. J. Brill; Leiden, 1973; at 68-70.

³⁴ University of Pennsylvania Press, Philadelphia.

³⁵ J. Ruska: *Das Buch der Alaune und Salze*, Berlin, 1935, mentioned in R. Halleux: *The Reception of Arabic Alchemy in the West*, in the *Encyclopedia of the History of Science*, op cit, pp 886-902, at p. 892.

³⁶ R. Halleux: *The Reception*, op cit, p. 892.

³⁷ See for instance:

-P. Kraus: *Jabir Ibn Hayyan*. Textes choisis, Paris, Cairo, 1935.

-J. Ruska: 'Al-Rasi (Rhases) als Chemiker', *Zeitschrift für Angewandte Chemie* 35, 1912, pp 719-24.

-J. Ruska: 'Die Alchemie des Avicenna', *Isis* 21, 1933: 14-51.

-J. Ruska: 'Die Alchemie ar-Razi's', *Der Islam* 22, 1935, 281-319.

-J. Ruska: *Das Buch der Alaune und Salze*, Berlin, 1935.

³⁸ Georges Anawati: *Arabic Alchemy*, op cit, p.877. One has to be careful of Anawati's article, though. Whilst Ibn Sinna and Ibn Khaldoun never attacked the science of chemistry and true scientists, but just the crooked versions of it, Anawati, like others, eagerly generalises and accuses them of attacking the science itself. There is absolutely in neither Ibn Sinna's work, who was himself a chemist to large extent, or in Ibn Khaldoun's, one single instance of an attack on the science itself.

³⁹ For greater detail on Ibn Khaldun's view of alchemy, see Prof Ead's site referred to above.

⁴⁰ G. Anawati: *Arabic*, op cit, p. 881.

Bibliography

-Georges Anawati, *Arabic alchemy*, in *Encyclopaedia of the History of Arabic Science*, Edited by R. Rashed, 3 vol; Routledge, London, 1996 at pp. 865-7.

-*Chymia*, Quarterly review devoted to the history of chemistry; edited by H.M. Leicester. University of Pennsylvania Press, Philadelphia.

-A.C Crombie, whose book: '*Robert Grosseteste and the origins of experimental sciences*,' Oxford, 1953.

-*De aluminibus* was translated into Latin by Gerard of Cremona in Toledo, Spain, in the 12th century.

-Baron Carra De Vaux: *Les Penseurs de l'Islam*, (5 vols), Geuthner, Paris, vol 2.

-I, and L. Al-Faruqi: *The Cultural Atlas of Islam*; Mc Millan Publishing; New York; 1986.

-R. Halleux: *The Reception of Arabic Alchemy in the West*, in the *Encyclopedia of the History of Arabic Science*. pp 886-902.

-D.R. Hill: *Islamic Science and Engineering*; Edimburgh University Press; 1993.

-E.J. Holmyard: *Makers of Chemistry*; Oxford at the Clarendon Press, 1931.

-E.J. Holmyard: *Chemistry in Islam*; in R. M. Palter edition: *Toward Modern Science*; Noonday Press, New York, 1961; in Vol 1, at pp. 160-70.

-A. M. Kettani: *Science and Technology in Islam*; in Z. Sardar ed: *The Touch of Midas*; Manchester University Press; 1984; pp 66-90.

-P. Kraus: *Jabir Ibn Hayyan*. Textes choisis, Paris, Cairo, 1935.

-M. Levey: *Early Arabic Pharmacology*; E. J. Brill; Leiden, 1973.

-Jean Mathe: *The Civilisation of Islam*, tr. by David Macrae, Crescent Books, New York.

-
- M. Meyerhof: Science and medicine, in *The Legacy of Islam*, edited by Sir T. Arnold and A. Guillaume; first edition, Oxford University Press, 1931; pp 311-55.
- R.P. Multhauf: *The Origins of chemistry*; Gordon and Breach Science Publishers; London, 1993.
- C. Ronan: The Arabian science, in *The Cambridge Illustrated History of the World's Science*; Cambridge University Press, 1983; pp 201-44.
- J. Ruska: *Das Buch der Alaune and salze*, Berlin, 1935.
- J.Ruska: 'Al-Rasi (Rhas) als Chemiker', *Zeitschrift fur Angewandte Chemie* 35, 1912, pp 719-24.
- J. Ruska: 'Die Alchemie des Avicenna', *Isis* 21, 1933: 14-51.
- J.Ruska: 'Die Alchemie ar-Razi's', *Der Islam* 22, 1935, 281-319.
- J.Ruska: *Das Buch der Alaune und Salze*, Berlin, 1935.
- G.M. Wickens: 'The Middle East as a world centre of science and medicine,' in *Introduction to Islamic Civilisation*, edited by R.M. Savory; Cambridge University Press; Cambridge; 1976; pp. 111-18.

<http://www.frcu.eun.eg/www/universities/html/shc/index.htm>

<http://kdolma.phidji.com/sciences/sciences.asp>

<http://users.erols.com/zenithco/index.html>