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Seth C. Rasmussen

The Quest for Aqua Vitae

The History and Chemistry of Alcohol from Antiquity to the Middle Ages

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The History and Chemistry of Alcohol from Antiquity to the Middle Ages

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The historical work included in the current volume began as an offshoot of my interest in the early introduction and development of chemical glassware in the thirteenth century, including its application to new forms of distillation apparatus. As I had previously undertaken research on the isolation of alcohol via the distillation of wine, I agreed to present an overview of the early history of alcohol as a HIST Tutorial at the 244th National Meeting of the American Chemical Society (ACS) in 2013 as part of programming for the Division of the History of Chemistry (HIST). In the preparation for that presentation, I quickly came to realize that this was historically a pretty murky topic with a number of different viewpoints and biases and few publications that attempted to give a clear view of the big picture of the historical progression over the large timespan involved. As a result, the presentation ultimately given at the 244th ACS Meeting felt like a good start, but a less complete picture of the history involved, which then led to additional research and preparation of the current SpringerBrief volume.

As part of the preparation of this volume, I would like to thank Dr. Valarie Steele of the British Museum for helpful discussions on the chemical analysis of organic residues and biomarkers for the detection of beer and wine, as well as Dr. Stuart Haring of North Dakota State University (NDSU) for discussions on yeast biochemistry and Dr. Erika Offerdahl of NDSU for discussions of general sugar biochemistry and fermentation. In addition, I would like to acknowledge the Interlibrary Loan Department of NDSU, which went out of its way to track down many elusive and somewhat obscure sources. Lastly, I would like to thank the following current and former members of my materials research group at NDSU for reading various drafts of this manuscript and providing critical feedback: Dr. Christopher Heth, Dr. Michael Mulholland, Kristine Konkol, Casey McCausland, Eric Uzelac, Ryan Schwiderski, and Trent Anderson.

Finally, and perhaps most importantly, I must express my continued thanks to Elizabeth Hawkins at Springer, without whom this growing series of historical volumes would not have become a reality.

Contents

Chapter 1
Introduction

Ethyl alcohol, or ethanol, is one of the most ubiquitous chemical compounds in the history of the chemical sciences. Its most common use is as a quite versatile solvent, where it represents one of the very first nonaqueous solvents and most certainly the first polar solvent in this class. Not only is it miscible with both water and wide variety of other organic solvents, but it can solubilize a broad range of analytes. This includes most salts and other water-soluble substances, as well as a great many organic materials not soluble in water, such as fats, resins, and essential oils. As such, it still remains one of the most common chemical media for a wide range of solution-based chemical processes. Beyond its ability to dissolve a large number of chemical species, the antibacterial and antifungal properties of ethanol provide a medium for the preservation of organic matter, as well as an effective disinfectant in medical applications.

Of course, the presence and uses of ethanol go far beyond chemical and medical applications, and as the psychoactive component of fermented beverages it plays a central role in the history of society in general. In fact, ethanol via such fermented beverages is one of the oldest recreational drugs known, and is still the most widely accepted of such drugs in most cultures.

More recently, the flammable nature of ethanol has resulted in its application as a fuel. While such early uses were limited to sources of heating and lighting, ethanol has now become a common fuel or fuel additive for the combustion engine. In this latter application, the ability to produce ethanol from the fermentation of biomass provides the attractive promise of renewable alternatives to petroleum fuels.

Due to its importance and widespread use, the documentation of its history has considerable merit. Not only does this allow us to better understand the sequence of events that led to its initial production via fermentation, but also the confluence of events that ultimately resulted in its successful isolation by distillation. In turn, the history and application of this important chemical species provides critical insight into its overall impact on the progress of chemical practices.

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1.1 Origin of the Term Alcohol

Alcohols, along with ethers, may be regarded as derivatives of water, in which one or both of the hydrogen atoms have been replaced by carbon. During the initial classification of organic compounds in the 1800s, these species were classified as belonging to the '*water type*' (Fig. 1.1), as established in 1850 by Alexander Williamson (1824–1904)[1] (Fig. 1.2) [1–4]. As a chemical class, alcohols are abundant in nature and simple alcohols are important chemical species for applications as solvents, fuels, and synthetic intermediates.

Prior to the 1830s, however, the term alcohol referred not to a class of organic compounds, but simply to ethyl alcohol (CH_3CH_2OH). In fact, in 1810, John Dalton gave a symbol representing alcohol as a single compound in his *New System of Chemical Philosophy* (Fig. 1.3) [5]. The use and meaning of the term alcohol then changed in 1834 with the discovery of methyl alcohol (CH_3OH) by Jean Baptiste Dumas (1800–1884)[2] and Eugène Peligot (1811–1890)[3] (Fig. 1.4)

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[1] Alexander William Williamson (1824–1904) was born to Scottish parents in the London borough of Wandsworth, England [2–4]. He entered the University of Heidelberg in 1841 to fulfill his father's wish that he study medicine [3], but soon gave up medical studies to pursue chemistry under Leopold Gmelin (1788–1853) [2–4]. He moved to Giessen in 1844 to complete his chemical education under Justus Liebig (1803–1873) [2–4] before finally moving to Paris in 1846 where he studied mathematics under Augusta Comte (1798–1857) at the École Polytechnique [3, 4]. On the basis of important research on hypochlorous acid and on Prussian blue, he then succeeded George Fownes (1815–1849) as the professor of analytical chemistry at University College, London in 1849 [2, 4]. He became a Fellow of the Royal Society in 1855 [2] and succeeded Thomas Graham (1805–1869) as professor of general chemistry [2, 4], which was combined with his former post. His best and most well known work was on the constitution of alcohol and ether [2–4], especially the Williamson ether synthesis that carries his name [8]. He resigned his position in 1887 and died in the village of Hindhead in Surrey, England in 1904 [2].

[2] Jean Baptiste André Dumas (1800–1884) was born in Alais, in southern France, where he received a classical education before being apprenticed to an apothecary at age 15 [9, 10]. In 1816, he moved to Geneva and entered the pharmaceutical laboratory of Le Royer [9]. He also studied chemistry and attracted the attention of Charles Gaspard de la Rive (1770–1834), who was professor of chemistry at Geneva [9, 10]. During this time, he also met Alexander von Humboldt (1769–1859), who encouraged him to go to Paris to complete his studies. As a result, he became a lecture assistant of Louis Thenard (1777–1857) at the École Polytechnique in 1823 [9, 10]. In 1829, he became one of the founders of the École Centrale des Arts et Manufactures, while also teaching at the École Polytechnique, succeeding Thenard as professor in 1835. He became a member of the Academy of Sciences in 1832 and succeeded Joseph Louis Gay-Lussac (1778–1850) at the Sorbonne as assistant professor, becoming professor in 1841 [9]. Dumas was the first chemist in France to give practical laboratory instruction to students and was considered the most outstanding French chemist of his time [9, 10].

[3] Eugène Melchior Peligot (1811–1890) was an assayer in the Paris Mint, before becoming professor of applied chemistry in the Conservatoire des Arts et Métiers. Besides various collaborations in organic chemistry with Dumas, he discovered potassium chlorochromate (Peligot's salt) and was the first to prepare metallic uranium [11].

Fig. 1.1 Organic compounds of the water type

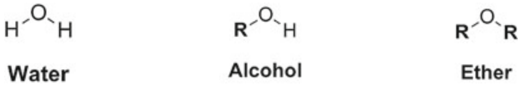

Fig. 1.2 Alexander William Williamson (1824–1904) (Edgar Fahs Smith Collection, University of Pennsylvania Libraries)

[6, 7]. As a result, Jöns Jacob Berzelius (1779–1848)[4] (Fig. 1.5) proposed the general name alcohol for these compounds. Thus ethanol was referred to as wine alcohol (*weinalkohol*) and methanol as wood alcohol (*holzalkohol*) [6]. Shortly thereafter, Dumas and Peligot showed that a compound previously discovered by Michel Chevreul (1746–1889) was cetyl alcohol ($C_{16}H_{33}OH$) [6, 7] and the fact that the family now contained three known examples suggested that a series of such alcohols would be subsequently discovered.

To make its history even more interesting, the origin of the word alcohol does not refer to the substance ethanol, nor does it even derive from any organic species. The word alcohol can ultimately be traced back to the word *kohl* (or *kuhl*),

[4] Jöns Jacob Berzelius (1779–1848) was born in a small Swedish town in East Gothland. Both of his parents died when he was young and he was raised by his stepfather Anders Ekmarck. In 1796 he left school after which he entered the University of Uppsala as a medical student. He was forced to leave due to lack of means and became a private tutor. In 1798, however, he won a small scholarship and reentered the University, finally graduating with a dissertation on mineral water [12]. He completed his M.D. in 1802 with a thesis on the medical applications of galvanism and was appointed reader in chemistry at the Carlberg Military Academy in 1806. The following year he was appointed professor of medicine and pharmacy in the School of Surgery in Stockholm, where he had a modest laboratory and funding for apparatus and materials [12]. In 1808 he was elected a member of the Swedish Academy of Sciences and became a joint secretary in 1818 [12]. He resigned his professorship in 1832, but continued to be active in chemical discussions until his death in 1848 [12].

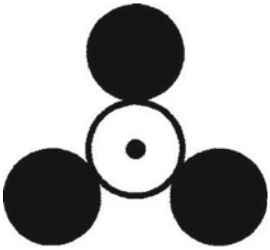

Fig. 1.3 John Dalton's symbol for alcohol from his *New System of Chemical Philosophy* in 1810

Fig. 1.4 Jean Baptiste André Dumas (1800–1884) and Eugène Melchior Peligot (1811–1890) (Edgar Fahs Smith Collection, University of Pennsylvania Libraries)

which referred to a finely powdered form of the mineral stibnite, or antimony trisulphide (Sb_2S_3, Fig. 1.6)[5] [13–17]. Kohl is dark-grey to black and was used as a cosmetic in antiquity, particularly as eye makeup in Egypt. Textual records document its use dating back to at least the 15th century BCE [17].

As Greek and Roman knowledge was eventually transmitted to the Islamic Empire, kohl was modified with the Arabic prefix *al*- to become *al-kohl* (or *al-kuhl*) [13–15, 17, 18]. Over time, the word first came to be used to refer to any very fine powder [13, 15, 17–19] and then further extended to mean the most fine

[5] It should be noted that some forms of kohl were comprised of lead sulfide (PbS) [17].

Fig. 1.5 Jöns Jacob Berzelius (1779–1848) (Edgar Fahs Smith Collection, University of Pennsylvania Libraries)

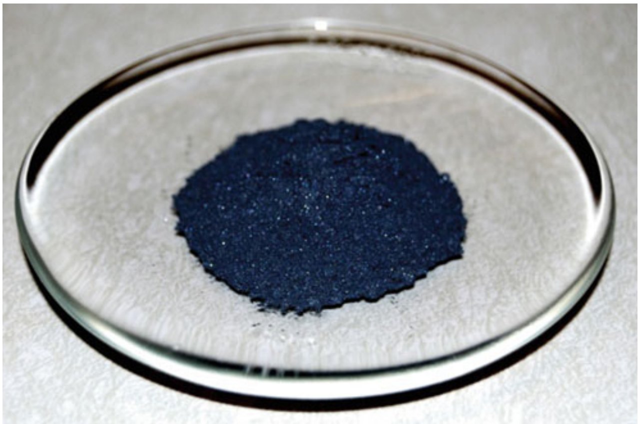

Fig. 1.6 Powdered antimony trisulfide (Sb_2S_3), which was known to the ancients as *kohl*

or subtle part of something [14–16]. As a result, *al-kohl* or *al-kohol* was then generally used for any substance attenuated by pulverization, distillation, or sublimation [20]. By the 16th century, Paracelsus[6] (Fig. 1.7) in his *Von Offenen*

[6] Paracelsus (1493–1541) was a noted alchemist and medical practitioner whose real name was Philippus Aureolus Theophrastus Bombastus von Hohenheim [21]. Bombastus referred to the