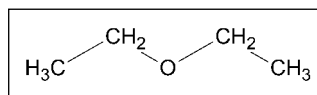


## 37. Ether

**CHEMICAL NAME** = ethoxyethane  
**CAS NUMBER** = 60-29-7  
**MOLECULAR FORMULA** =  $C_2H_5OC_2H_5$   
**MOLAR MASS** = 74.1 g/mol  
**COMPOSITION** = C(64.8%) H(13.6%) O(21.6%)  
**MELTING POINT** =  $-116.3^{\circ}C$   
**BOILING POINT** =  $34.5^{\circ}C$   
**DENSITY** =  $0.71 \text{ g/cm}^3$



Ether is a volatile, flammable, colorless liquid with a distinctive odor. Ether is the common name for diethyl ether, which belongs to the large group of organic compounds called ethers. The names ether, diethyl ether, and ethyl ether are all used for the ether given by the formula  $C_2H_5OC_2H_5$ . In this entry, ether is considered the compound  $C_2H_5OC_2H_5$ . Ethers are characterized by an oxygen atom singly bonded to two carbon atoms; they have the general formula R-O-R'. Ethers are commonly named by naming the groups attached to the oxygen followed by the word ether. Diethyl ether is the most common ether and was historically used as an anesthetic. Petroleum ether is not an ether but a mixture of hydrocarbons, which are typically alkanes such as pentane and hexane.

Ether was supposedly discovered by Raymundus Lullus (1232-1315) around 1275, although there is no extant evidence of this in his writings. The discoverer of ether is often credited to the German physician and botanist Valerius Cordus (1515-1554), who gave the first description of the preparation of ether in the mid-16th century. Cordus called the substance *oleum vitrioli dulce*, which is translated as sweet oil of vitriol. Cordus used sulfuric acid (oil of vitriol) to catalyze the conversion of alcohol to ether. At approximately the same time Paracelsus (1493-1541), a Swiss physician who is also cited as a discoverer of ether, observed that chickens were safely put to sleep by breathing vapors from sweet oil of vitriol. In 1730, August Siegmund Frobenius changed the name of sweet vitriol to ether.

Ether was applied topically, inhaled, and consumed for medical purposes well before it was used as an anesthetic. As early as the late 18th century and during the 19th century, ether

was used recreationally to induce drunklike, stupor-state conditions in those who inhaled it. Ether (and nitrous oxide) was inhaled during parties called ether frolics in which the partygoers were entertained by the behavior of those under the influence of ether. Crawford Williamson Long (1815–1878) was the first physician known to use ether as an anesthetic in medicine. Long removed a tumor from a patient anaesthetized with ether on March 20, 1842; he subsequently used ether for other surgeries and in childbirth. Long did not publish an article on his use of ether until 1848, several years after William Thomas Green Morton (1819–1868) had publicly demonstrated its use in dental surgery and received credit for its discovery as an anesthetic.

Morton's demonstration on the use of ether started a 20-year feud between Morton, Long, and two colleagues: Charles T. Jackson (1805–1880), Morton's mentor at Harvard medical school, and Horace Wells (1815–1848), a dentist who used nitrous oxide as an anesthetic in his dental practice. Morton was a former partner of Wells, and Wells had taught Morton dental techniques. Jackson had consulted Wells about his use of nitrous oxide on patients and conducted his own experiments with ether on animals. Morton successfully used ether on a patient in his office in September of 1846 and then gave a public demonstration the next month at Massachusetts General Hospital. Morton applied for a patent for an ether-based substance called Letheon and included Jackson's name on the application. Letheon contained aromatic oils and opium in addition to ether. The patent was granted in November 1846. Meanwhile, Wells claimed that he should share in any financial rewards from the patent. Wells, who used anesthetics recreationally, committed suicide at age 33 while in prison in 1868. There is some indication that Long had filed an earlier claim on ether. Morton fought for priority and sole possession of its use, and Jackson sought credit and any subsequent monetary rewards from the patent. As it became known that ether was the active ingredient in Letheon, it was widely adopted as a general anesthetic. Furthermore, ether had already been used for centuries in medical applications, making a patent priority impossible to enforce. Morton continued his battle for monetary reimbursement for its use, appealing to Congress for compensation, which he never received. He died in poverty at age 49. Jackson died in an asylum at age 75.

Ether and chloroform (see Chloroform) transformed surgery in the middle of the 19th century. Before these substances were available, surgery was a dreaded last alternative. To mitigate the pain during these procedures patients were sedated with opium, alcohol, and herbal mixtures; in some cases hypnotism was used. Ether and chloroform increased surgical procedures and alleviated much of the associated suffering. Ether became the principal anesthetic used in the United States until the middle of the 20th century, although it had side effects such as nausea and prolonged recovery, and it was highly flammable. As new anesthetics began to be developed starting in the 1930s, use of ether decreased. Today ether is not used as an anesthetic in developed countries, but it is still used in developing countries.

Ether is only slightly soluble in water (6.9%), but it is a good solvent for nonpolar organic compounds. Approximately 65% of ether production is used as a solvent for waxes, fats, oils, gums, resins, nitrocellulose, natural rubber, and other organics. As a solvent, it is used as an extracting agent for plant and animal compounds in the production of pharmaceuticals and cosmetics. Another 25% of total ether production is used in chemical synthesis. It is an intermediate used in the production of monoethanolamine (MEA,  $C_2H_7NO$ ). Ether is used in the production of Grignard reagents. A Grignard reagent has the general form  $RMgX$ , where R

is an alkyl or aryl group and X is a halogen. Grignard reagents are widely used in industrial organic synthesis. A Grignard reagent is typically made by reacting a haloalkane with magnesium in an ether solution, for example,  $\text{CH}_3\text{I} + \text{Mg} \xrightarrow{\text{ether}} \text{CH}_3\text{MgI}$ . Ether is a common starting fluid, especially for diesel engines.

Ether is produced by the dehydration of ethanol using sulfuric acid:  $2\text{CH}_3\text{CH}_2\text{OH} + \text{H}_2\text{SO}_4 \xrightarrow{\Delta} (\text{CH}_3\text{CH}_2)_2\text{O} + \text{H}_2\text{SO}_4 + \text{H}_2\text{O}$ . The temperature of the reaction is carried out at about  $140^\circ\text{C}$  to control for unwanted products. The volatile ether is distilled from the mixture. Ether can also be prepared by Williamson synthesis. In this reaction, ethanol reacts with sodium to form sodium ethanolate ( $\text{Na}^+\text{C}_2\text{H}_5\text{O}^-$ ). Sodium ethanolate then reacts with chloroethane to form ether and sodium chloride:  $\text{Na}^+\text{C}_2\text{H}_5\text{O}^- + \text{C}_2\text{H}_5\text{Cl} \rightarrow \text{C}_2\text{H}_5\text{OC}_2\text{H}_5 + \text{NaCl}$ . Ether is also produced as a by-product in the production of ethanol.