

# Irreplaceable Inorganics

These bulk chemicals are essential for the manufacturing sector.

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Fundamentally, the inorganic chemical industry involves the mass production of bulk quantities (often measured in tons) of compounds of varying grades, used largely by the manufacturing sector to develop various end products. Thus, it is distinguished from the fine chemicals market, which typically involves small volumes and ultrahigh purity. More specifically, the key components of the inorganic chemicals market include bulk salts such as phosphates and silicates, acids and alkalis such as hydrochloric acid and soda ash, and gases such as carbon dioxide and argon.

## Creating Chemicals

For the most part, manufacturers generate or extract inorganic chemicals from brines or mineral ores; other inorganic chemicals are pulled from atmospheric gases or are by-products of other processes such as petroleum or steel manufacture. The roots of many of today's chemical companies extend to the 19th century, from companies formed with the sole purpose of making and/or selling inorganic chemicals. In 1802, DuPont began as a producer of explosives. It has now become one of the largest U.S. chemical companies. Union Carbide Corp. (now a subsidiary of Dow Chemical Corp.) is another of the largest chemical companies in the United States. The company began in 1917 as the Union Carbide & Carbon Corp. by acquiring the stock of Linde Air Products Co., National Carbon Co., Prest-O-Lite Co., and the originally named Union Carbide Co. formed in 1898 to make calcium carbide.

Among smaller chemical companies, Pennwalt Corp. started out as Pennsylvania Salt Manufacturing Co. in 1850, manufacturing lye and alkaline salts. Philadelphia Quartz Co. (today known as PQ Corp.) was formed in 1864 as the successor to a business that was organized in 1831 to make candles and soap. This particular company began adding sodium silicate to its soap in 1861 and also began making silicates in 1864. Foote Mineral Co. was incorporated in 1916, but it started with a



business founded 40 years earlier by A. E. Foote, a professor of chemistry and mineralogy in the Midwest who exhibited his extensive mineral collection at the country's centennial celebration in Philadelphia in 1876. A world leader in lithium production by the 1990s, the company was acquired by Dynamit Nobel in 1998.

Victor Chemical Works was once a medium-sized chemical company, but it was taken over by Stauffer Chemical Co. in 1960. Victor Chemical dates from 1902 when its founder, August Kochs, acquired Peterson and Mansar, which was a flour company. Kochs improved the process for making monocalcium phosphate for use in baking. Stauffer began in California in 1885 as the partnership Stauffer & Co., which was formed to recover chalk ballast dumped by ships in San Francisco Bay and sold by Stauffer mainly as a whitening agent. Stauffer itself was purchased by ICI in 1987.

In 1928, G. Frederick Smith, professor of analytical chemistry at the University of Illinois, founded GFS Chemicals to produce both inorganic and organic compounds for use in analytical methods, specializing in compounds such as perchlorates. Over the years, Smith and his company have had a profound effect on the development of these methods.

## Selling Salts

Commercial manufacturing of elemental phosphorus began in the United States in 1870 using bone char technology, which was imported from England. The first electric arc furnace began operating in 1887 at the plant of Oldbury Electrochemical Co. (later acquired by Hooker Electrochemical Co. in 1956). Hooker became part of Occidental Petroleum in 1968, was renamed the Occidental Chemical Corp. in 1983, and is today known as OxyChem—in a story typical of the convoluted



**Top:** World War II chlorine ad, Solvay Sales Corp., 1942, *Chemical & Engineering News*

**Center:** Sulfur mine, Texas Gulf Sulphur Co. ad, 1950, *Chemical & Engineering News*



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history of these early chemical pioneers.

Other manufacturers joined the pioneers in the early 1900s, but it was not until the 1930s and later that elemental phosphorus began to become a chemical of any industrial significance. Many organizations have contributed to the evolution of electric arc smelting technology in the United States, including Swann Chemical (best known for its development of PCBs, and subsequently acquired by Monsanto), Virginia Carolina Chemical (which became part of Mobil Oil in 1964), and Victor Chemical Works (mentioned above). Probably more than any other organization, however, the Tennessee Valley Authority (TVA) was responsible for much of the smelting technology used today and especially that used for the large

### BRIGHT LIGHTS, BIG ACHIEVEMENTS

In 1902, world-class gas company Air Liquide was founded with the goal of cheaper acetylene production methods, relying on techniques developed by a young French engineer, Georges Claude. Born in Paris in 1870 and trained at the Ecole de Physique et de Chemie, Claude and colleague Albert Hess determined that acetylene could be safely transported when dissolved in acetone and bound in a ceramic matrix. Naturally intrigued by scientific and engineering problems, Claude later developed a method for injecting inert gases into colored tubes and with his nephew André determined how to purify neon for use in lighting applications, developing the neon lights that are so ubiquitous today. He later extended these efforts at Air Liquide into the production of other gases for lighting purposes, eventually determining how to isolate other noble gases for use in the argon, krypton, and xenon gas lamps that generate much brighter white light than is possible with normal incandescent bulbs.

The advent of World War I saw Claude change his focus somewhat from lighting issues to warfare and human welfare. Among his military achievements were the development of the cryogenic aerial bomb using liquid oxygen, a method for detecting enemy location using sound, and the production of gas masks. Likewise, witnessing the rampant nitrogen shortages brought on by the conflict, Claude recommended that Air Liquide do research to make France self-sufficient in nitrogen compounds, and he developed a high-pressure ammonia process that offered higher yields than the Haber process. Claude died in 1960 while working on geothermal energy and methods to extract gold from seawater.

expansions in capacity that manufacturers undertook in the 1940s and 1950s under the momentum of a rapidly growing market in the soap and detergent industry. TVA's interest centered largely on developing phosphorus technology for fertilizer production, but its findings made possible a rapid expansion of phosphorus production for other industrial uses.

The modern phosphatizing industry dates from 1906 with the issuance of a patent in England. Many improvements had been recorded by World War II and were highly used commercially in Great Britain and the United States. Phosphatizing was found useful for iron, steel, and coating metals based on aluminum, cadmium, magnesium, and zinc. Refrigerators, washing machines, and other electrical appliances as well as a wide range of other products are all phosphatized today before they are painted or enameled. Another phosphatizing process serves for surfaces that are not subsequently painted. One such process is Parkerizing, which Parker Rustproofing Co. developed in 1918. In it, a manganese salt in phosphoric acid produces a heavy and absorbent manganese phosphate coating. It provides good resistance to corrosion, especially after a thin film of oil or wax is applied. The black and slightly oily surface on nuts, bolts, screws, tools, and ordnance parts results from such treatment.

The United States is a large exporter of borates, with slightly more than 50% of its production being marketed abroad. U.S. producers recover all

borates in the desert areas of California. The largest single producer, U.S. Borax & Chemical Corp. (which became Rio Tinto Borax) recovers borates principally as sodium tetraborate decahydrate (tincal or borax) in an open pit mining operation. Another longtime major producer, American Potash and Chemical Corp. (which became part of Kerr-McGee Corp.) recovers sodium borates from complex lake brines. These were joined by Tenneco, which

made its first shipments of calcium borate (colemanite) in 1971, and then by Occidental Petroleum, which started producing sodium borate from lake brines in 1973.

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### Acids and Alkalis

Although it has been produced since time immemorial, the demand for sulfuric acid didn't really begin to peak until the 1700s, when it was used to prepare nitric and hydrochloric acids as well as to assay nonferrous metals. Perhaps the greatest demand for sulfuric acid, however, came with the development of the Leblanc method for producing soda ash (sodium carbonate).

Various methods were developed over the next two centuries to produce the acid, but in the late 1800s, a new technique based on metal catalysis was developed and revolutionized the industry. The first U.S. plant using this method was established in 1899 in Mineral Point, WI, but others quickly followed, and by the start of the World War I, the U.S. output of sulfuric acid approached 4 million tons. Over the intervening century, the new method of sulfuric acid production has replaced the earlier lead-chamber method.

In the early 1860s, Ernest and Alfred Solvay introduced a new method for preparing soda ash that revolutionized the industry. By 1890, most of the British soda firms using the earlier-developed Leblanc process combined to form the United Alkali Co. When Imperial Chemical Industries (ICI) was founded in 1926, it became home to the United Alkali Co. as well as Brunner, Mond & Co., which relied on the Solvay process.

Meanwhile, in the United States, the Solvay Process Co. was founded in 1884 to offer the burgeoning American industries a source of alkali that was more reliable than the European imports or potash leachates. Operations at the Solvay Process Co. quickly expanded, and in 1920, it became part of the Allied Chemical & Dye Corp. In 1938, however, extensive soda ash-rich deposits were identified in the Green River area of Wyoming. Soda ash quickly became easier to extract than to make using the Solvay process, and it wasn't long before most plants using this method ceased operations or switched to manufacturing other chemicals.

### Neoclassical Gas

Industrial gases have been critical to the development and mass production of several other industries, peaking in importance through the late 19th and early 20th centuries. Oxygen, for example, has found limitless opportunities in the medical arena as well as in feeding the war machine, and in combination with hydrogen, it has propelled humans into space. Thus, gases and the companies that produce them have been instrumental in shaping human society for the past century or so.

Liquid Carbonic was founded in 1888 in Terre Haute, IN, by Jacob Baur, a local chemist, and several friends and relatives. As its name would indicate, the company's early focus was on the production of carbon dioxide, which it supplied to the soda fountain and soft drink industries. With the acquisition of Wall Chemicals in 1939, Liquid Carbonic moved into the industrial and medical gases business, manufacturing oxygen, acetylene, and other compressed gases. In 1965, the company began to test market a new food-saving process that was based on flash-freezing using liquid nitrogen, and later introduced a version that incorporated liquid carbon dioxide. Through a series of mergers and acquisitions, Liquid Carbonic was eventually taken over by another gas-producing company, Praxair.

Also founded in the late 1800s was Linde AG, which set up operations in Wiesbaden, Germany. This company was also instrumental in developing new gas production methods, such as the isolation of oxygen from nitrogen using rectification, a process that became important in construction and Germany's military efforts. In 1910, the company opened its first acetylene production facility in Dusseldorf, and eventually moved into the manu-

facture of rare gases such as argon.

As Linde was developing its company in Germany, Carl von Linde was also talking to investors in the United States and in 1907 established the Linde Air Products Co. in Cleveland. Unfortunately, although oxyacetylene welding and cutting tools were popular in Europe at the time, the methods were largely unheard of in the United States. Thus, to ensure a market for his product, Linde had to introduce the process in the new world. This process caught the eye of the Union Carbide Co., which was the main producer of acetylene in the United States, and in 1911, Union Carbide acquired part of the American Linde subsidiary. Because liquid oxygen was difficult and dangerous to distribute, in 1935, Linde Air Products introduced the Cascade oxygen system, which made oxygen use affordable for smaller customers. By 1957, the company dropped Air Products from its name, becoming the Linde Division of Union Carbide, which, in 1992, split off from Union Carbide to become Praxair.

Brin's Oxygen Co. (BOC), which was later renamed British Oxygen Co., was founded in England in 1886 to provide oxygen for lighting and medical uses. BOC moved into the production of liquefied hydrogen in the early 1900s and gained the British rights to numerous Linde patents in exchange for BOC shares. The Linde relationship, however, ceased in 1914 with the onset of World War I. Over the first half of the 20th century, BOC expanded its efforts overseas and practically monopolized the industrial gas industry throughout the British Commonwealth. After World War II, the company continued to incorporate new production methods into its business, eventually moving into other products such as liquid helium.

Over the past 100 years or so, several other gas-production companies have been founded, merged, and acquired around the world. In Japan, Nippon Sanso was founded in 1910 to produce industrial oxygen, and in 1983, it expanded its American operations with the acquisition of Matheson Gas Products. In 1940, Air Products was founded in Detroit to build and lease oxygen generators at client facilities to reduce or remove the need to ship gas containers across the country. And in 1982, the Connecticut Oxygen Corp. became U.S. Airgas, which today, as Airgas, is the largest U.S. distributor of industrial, medical, and specialty gases.

### The Bottom Line

Thus, although it can be hard to define precisely what compounds and processes constitute the inorganic chemicals industry, there is no denying its central importance to society in general and to the manufacturing sector in particular. This market has helped cure disease, facilitated war and peace, and allowed humankind to voyage into inner and outer space. Without a doubt, as extraction and purification techniques continue to develop, the inorganic chemical industry can only continue to grow. ♦



Above: World War II support, Michigan Alkali Co. ad, 1942, *Chemical & Engineering News*