

# Lithium

With an atomic number of just three and an atomic weight of 6.941, lithium is the earliest, and lightest, metal to appear on the periodic table of the elements. Only hydrogen and helium precede it. As an alkali metal, lithium demonstrates the highly reactive traits of its family. Pure lithium can react with most constituents of air at room temperature, including water, oxygen, carbon dioxide and nitrogen, but many useful lithium compounds are inert.

The reactivity of the pure element means that it is always found as a compound, rather than as a metal, in nature. The silvery-white metal itself is slightly harder than sodium – which can be cut with a sharp knife – but softer than lead.

Individual lithium atoms are arranged in a cubic lattice in solid metal, making for easy movement of electrons and accounting for lithium's high electrical conductivity. At 0.531 g/cm<sup>3</sup>, lithium's density is about half that of water. The wide range between its melting point of 180°C and boiling point of 1,336°C, combined with its high heat capacity, help to make it a good medium for heat sink or heat transfer applications.

## Application evolution

Lithium was discovered as a compound in the mineral spodumene (LiAlSi<sub>2</sub>O<sub>6</sub>) in 1817 by Swedish scientist Johan August Arfwedson, who named the element after the Greek word for stone. Lithium was first separated as free metal in 1855.

In the first half of the 20th century, lithium compounds were used in ceramics, but the range of the element's applications broadened after its potential was thoroughly investigated during and following World War II. Early additional applications included grease containing lithium stearate, which functions over a very wide range of temperatures, and "pyroceram" – a lithium-containing composition from which the market for heat-resistant glass-ceramic cookware grew.

During the 1950s the US Atomic Energy Commission became a large consumer of lithium, which was needed for lithium hydroxide – a source of the isotope lithium-6 needed then to produce nuclear weapons. But when the commission's contracts expired at the end of that decade, the lithium industry had a spur to develop its nascent commercial markets in aluminium and pharmaceutical industries – in addition to ceramics and lubricants.

Today, major US supplier of lithium metal and compounds FMC Lithium identifies eight major markets for its products: air treatment, construction, energy, fine chemicals, glass and ceramics, greases and lubricants, polymers and pool water treatment. Speciality applications for lithium include aluminium, dyestuffs, industrial sanitation and bleaching.

In metal production, combining lithium with magnesium or with aluminium produces tough, light alloys of value in aerospace. Alcoa, for example, recently won a contract with Nasa to supply aluminium-lithium plate and ingot for early development of the Ares 1 crew launch-vehicle upper stage.

Adding lithium carbonate to aluminium potlines lowers the

melting point of the cryolite bath, allowing a lower operating temperature for the cells. Lithium metal can be used as a scavenger to remove impurities from bronze and copper.

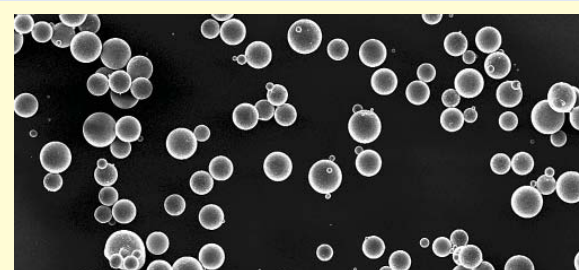
But accounting for around a fifth of global lithium consumption (see *table*), vying with ceramics as the biggest sector for its use, and the application most likely to be recognised by the public, rechargeable lithium-ion batteries are the fastest growing market for the metal. Pharmaceuticals are another market familiar to a sector of the public, where lithium's uses include drugs to treat mental illness.

## Natural sources

Lithium is found in many minerals, some clays and brines. But the dominant commercial sources today are spodumene ore and salars – dry lakebeds where lithium-bearing brines are found just under a layer of crusted salt deposits. The concentration of lithium in such brines is usually 200-2,000 ppm, but solar evaporation produces a stronger concentrate suited for feeding economically viable plants to make lithium carbonate – a generally stable fine white powder and key intermediate product for producing other lithium salts – and lithium chloride. Metal is produced from the chloride by molten salt electrolysis.

In a recent analysis of both hard rock and brine sources of lithium, *Industrial Minerals* magazine (*IM*) identified five active producers from hard rock, and four from brine. Of those, Sons of Gwalia, in Australia, is the biggest producer from hard rock, with an output of around 150,000 tpy of concentrates. Grades vary, but the miner's Greenbushes operation is said to produce spodumene containing 8% lithium oxide.

Several productive salars are located high in the South American Andes and, of the producers from brine, Sociedad Quimica y Minera de Chile (SQM) claims to be the world's



FMC Lithium says it has tamed usually highly reactive lithium metal powder with its SLMP™ (stabilised lithium metal powder) technology, which is said to be safe to handle in a dry room atmosphere and can be transported by air and sea. Stability is achieved through surface passivation of the powder.

Conventional lithium-ion batteries have graphite as the negative electrode and lithium cobalt oxide, a ceramic material, as the positive electrode. Sold as Lectro® Max powder, SLMP can bring lithium into the battery system via alternative anode and cathode compositions.

FMC Lithium's commercial and technical development manager for energy products, and inventor of the technology, Yuan Gao describes SLMP as an "energy enhancement additive". At a pilot stage of development, the powder's potential is being investigated by battery producers.

## Markets for lithium

Sector	Percentage
Ceramics and glass	21%
Batteries	20%
Lubricating greases	17%
Pharmaceuticals and polymers	9%
Air conditioning	7%
Primary aluminium production	5%
Other uses*	21%

\*Including alloys, construction, dyestuffs, industrial bleaching and sanitation, pool chemicals, and speciality inorganics

Source: Sociedad Quimica y Minera de Chile, 2006

largest. It is already producing 27,800 tpy of lithium carbonate, and is currently expanding production.

Other major producers of lithium concentrates are in Argentina, China, Australia, Brazil, Canada, Zimbabwe and the USA.

There is an industry consensus that demand,

particularly from the battery industry, has run ahead of supply, with obvious consequences for prices. IM's sister title *Mineral PriceWatch* has charted a steady rise in the price of lithium carbonate over the past 3-4 years. It has climbed from a stable \$0.9-1.20/lb, during the year from July 2003 to July 2004, to stand at \$3.1-3.30/lb in May 2007, delivered in the USA in bags or drums for large-volume contracts.

FMC Lithium says it has pushed through a global price rise of 12-15% on its complete range of lithium metal and Lectro Max® materials since the beginning of this year. The company cited rising energy, raw material and freight costs as factors contributing to the price increases when they were announced late last year.

While they report price movements, lithium metal producers generally do not make metal price levels public, preferring to

negotiate directly with consumers according to the exact metal grade, contract size and duration, and delivery requirements. Contacted in late August, a spokesman at FMC Lithium told MBM that there had not been further rises since those the firm introduced at the start of the year. But he confirmed the trend for rising lithium prices in the last few years, generated in part by the surging demand for rechargeable lithium-ion batteries widely used in mobile phones, cameras and computers.

In the long term, of course, the supply-demand balance will determine price direction. On the supply side, several existing producers are expanding, while another nine projects are identified as under development by IM. Notably China is on the verge of significant production from brine resources, but industry insiders believe output will ramp up gradually.

On the demand side, lithium battery sales already account for around two-thirds of the value of rechargeable battery sales worldwide, and the seemingly insatiable global demand for portable electronic equipment is showing little sign of subsiding. The growing interest of large automakers in lithium-ion batteries for powering vehicles could be a decisive factor. General Motors is the latest of several large automotive OEMs to declare an interest, recently announcing that it will work with Massachusetts lithium-ion battery supplier A123Systems to develop a battery for its high-profile Chevrolet Volt electric car.

It will be interesting in the next few years to watch which way the supply-demand scales tilt.

■ Sources: FMC Lithium (a division of FMC Corp, USA, [www.fmc lithium.com](http://www.fmc lithium.com)); USGS ([www.usgs.gov](http://www.usgs.gov)); SQM ([www.sqm.com](http://www.sqm.com)); *Industrial Minerals* magazine (June 2007, [www.indmin.com](http://www.indmin.com))

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