What is zirconium?

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Abstract People have adorned themselves with diamonds for centuries. Historically, diamonds were worn by kings and queens, but they are worn today by ordinary people in their rings, watches and other accessories. Diamonds are often replaced by glass, crystal or moissanite, but only zirconium oxide is so similar to a natural diamond that they can be mistaken for each other. In this article we describe the wonderful chemical element zirconium and the zircon mineral.

Many people can't distinguish between the two terms zircon and zirconium; they are often thought to be the same. But what is the difference between them? The term zircon refers to precious mineral gemstones, whereas zirconium is the name of a metal. There is also the artificially grown analogue of a diamond – cubic zirconia (ZrO_2).

Zirconium is element 40 in the periodic table. Despite the fact that zirconium is a trace element, there are about 40 minerals in which zirconium is present as an oxide or salt. Zircon (a mineral of the subclass of insular silicates, zirconium orthosilicate, $ZrSiO_4$) is the most common zirconium mineral. It is found in many types of rock, but mainly in granites and syenites (Figure 1).

Zircon is one of the most ancient minerals on the Earth; it is almost as old as our planet. Scientists have determined that this mineral is 3–4 billion years old.

The mineral zircon often contains impurities of other elements such as iron, copper, calcium, titanium or zinc. It is mostly found as pyramidal or prismatic crystals. With intense heating, zircon changes its colour and can become dark brown, bright turquoise or many other shades (Figure 2). However, in time the shades that were obtained by thermal treatment lose their colour. It is not malleable and begins to oxidise at 200–400 °C.

The main criterion for identification of zircon is the large number of colours that the stone can have:

- Starlit is a transparent stone. It is rarely found in nature in a pure blue shade. This colour is obtained by roasting red–brown samples.
- Hyacinth is also a transparent stone, but it is red, orange or brownish.
- Malecon is dark brown and it emits low levels of radiation.
- Jargon stone has a yellow, straw or golden colour.
- Matarskiy diamond is a colourless stone.

Figure 1 A crystal of zircon on a matrix of calcite from Pakistan; Rob Lavinsky, iRocks.com – CC-BY-SA-3.0

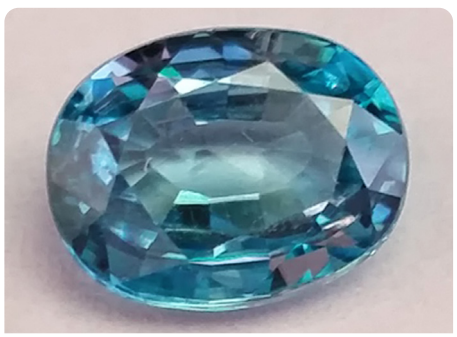

Figure 2 A pale blue zircon gemstone

The colours of these minerals are due to small quantities of other metals in them. The origin of the names 'zircon' and 'zirconium' is not clear, but there are some suggestions that they come from the Arabic 'zarkun' (cinnabar) or from the Persian 'zargun' (golden colour).

Zirconium was first identified in 1789 by the German chemist M. G. Klaproth in the form of dioxide from the ore zircon. The Swedish chemist Berzelius produced it as a powder for the first time in 1824. Zirconium as a metal was obtained only 100 years later by the Dutch scientists A. van Arkel and I. de Boer during the thermal dissociation of zirconium iodides.

Physical and chemical properties

Zirconium has high ductility and is resistant to corrosion. The metal has a chemical resistance – that is, it does not dissolve in acids or alkalis, and it is not susceptible to corrosion. It melts at 1855 °C (3371 °F) and the boiling point is 4371 °C (7900 °F). Its density is 6.45 g cm^{-3}.

Zirconium has a silvery-grey colour, but can look transparent because the colour is unsaturated (Figure 3). The colour of zircon varies depending on the impurities in it – from brownish-yellow to brown, grey, red, pink and even sometimes transparent.

Not everyone can afford the high prices of jewellery containing desirable precious stones. This is why people began to use synthetic substitutes for precious stones. Jewellery with these substitutes looks exquisite too, and the prices can be significantly

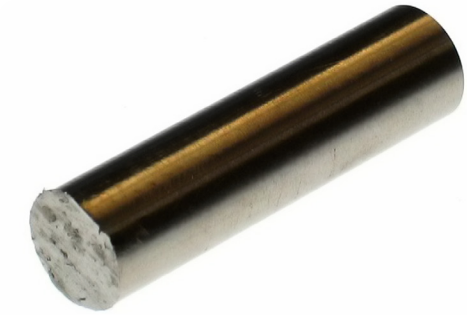

Figure 3 A rod of zirconium; https://commons.wikimedia.org/wiki/File:Zirconium_rod.jpg – GNU Free Documentation License

cheaper. One substitute used in jewellery is zirconium oxide (cubic zirconia). Zirconium oxide has a similar appearance to a diamond, and is used as a cheaper alternative in the manufacture of jewellery.

Nowadays there are several varieties of zirconium. Zirconium metal is very plastic (softer and more flexible than is usual for metals), and it has a silvery-grey shade. A characteristic feature of the powdered metal, which has a dark blue shade, is the presence of small granules. In this form, zirconium is used in medicine and in industry.

Zirconium in our lives

Zirconium is one of the most chemically inert metals. Until recently, it wasn't thought to have any effect on the human body. But drawing upon recent research findings (https://web.snauka.ru/issues/2013/10/28160), the metal in the form of microparticles turns out to have some effect on our bodies. There are uses of zirconium in our lives, and especially in medicine. Medical instruments, prostheses, and so on, are produced from it. All this is due to its low involvement in biological activity. This provides a high resistance to chemical attacks and oxidation processes. Zirconium as part of zircon is also used in dental medicine for the production of tooth crowns. It minimises the risk of such conditions as gum diseases and prevents the development of a large number of infectious diseases of an oral cavity. There is typically 1 mg of zirconium in the human body. It regulates the work of the pancreas, so if there is insufficient zirconium, diseases of the digestive organs can occur.

But despite this fact, many scientists still deny the biological importance of zirconium for the human body, and mostly they are right. Low levels of this metal occur very rarely; only people who have certain features of the body suffer from consequences. As zirconium is directly connected with the pancreas, low levels can cause the following problems: disorder of the intestines; dehydration; bile outflow deterioration; tachycardia (rapid heart rate); nausea and vomiting. Constant low levels of zirconium may lead to such diseases as chronic pancreatitis and diabetes mellitus.

Application

Zirconium (as zirconium oxide) is mostly used in jewellery, but it is also used in other fields. Various kinds of alloys are produced using this element, which are used in the following branches of industry: production of construction materials, nuclear reactors (as the main construction material), parts of aircrafts as well as parts of a ceramic matrix of the heat-resistant thermal protection system of the surface of hypersonic aircrafts and recoverable spacecrafts and other components. It can also be used when producing superconducting magnets, and zirconium powder is used in making fireworks. Zirconium oxide is also used to produce glass where additional strength is needed; for example in a spacecraft where huge temperature fluctuations may occur, and normal glass would not last long under such conditions.

'Magic' properties

In ancient times, zirconium was considered to have the capacity to bring wealth and success to its owner. It was an asset of wise men; with its help they were thought to gain knowledge of the future and the gift of wisdom. Amulets decorated with zircon stones were used to protect against liars.

Resources

You can find out more about the chemical element zirconium and its place in the periodic table at:
www.webelements.com/zirconium/
https://en.wikipedia.org/wiki/Zirconium
https://en.wikipedia.org/wiki/Zircon
https://art-posh.ru/yuvelir-info/cirkonij-metall-svojstva.html
https://sovets.net/16880-cirkonij-chto-eto-takoe.html
https://leg.co.ua/arhiv/generaciya/materialy-yadernyh-energeticheskih-ustanovok-55.html

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