Niobium
Factsheet

Ferroniobium

Niobium was discovered by Charles Hatchett in 1801. It is named after Niobe, the daughter of Tantalus in Greek mythology, reflecting its similarities to tantalum. Niobium is found in minerals such as **pyrochlore** and **columbite**. Major producers include **Brazil** (91%) and **Canada** (8%), with worldwide production in 2023 at **83,000 tonnes**, with reserves estimated at >17,000,000 tonnes. The abundance of niobium in the continental crust is approximately **8 ppm**. Niobium has **high economic importance** as a key enabler for **green technology** and acts in many ways to provide functionality to many materials critical to the sustainability agenda.

Basic Properties	
Symbol	Nb
Atomic Number	41
Atomic Weight	92.90637
Group/Period	Group 5, Period 5 of the periodic table
Category	Transition metal
Physical Properties	
Colour/Appearance	Shiny, white, metallic
Melting Point	About 2,468°C (4,474°F)
Boiling Point	About 4,927°C (8,901°F)
Density	8.57 g/cm³ at 20°C
State at Room Temperature	Solid
Chemical Properties	
Oxidation States	Most common +5, but also shows +3 and +4
Electronegativity	1.6 (Pauling scale)
Atomic Radius	Approximately 146 pm
Ionization Energies	First: 652.1 kJ/mol

Safety and Handling of Ferroniobium and Niobium Oxides

Handling: Niobium compounds are generally benign in character and require no special measures in handling.
Reactivity: Niobium is not reactive under normal ambient conditions.
Chemical stability: Niobium is stable under normal ambient and anticipated storage and handling conditions of temperature and pressure.
Flammability: Niobium in powder or dust form is flammable.
Note: users should always refer to their supplier for specific guidance on safety and handling requirements. Further general information can be found via the European Chemicals Agency (link overleaf).

Main Applications of Niobium

Batteries: Anode, cathode and solid-state materials including niobium titanium oxides (NTO), lithium niobates and lithium tungsten oxides.

Fuel Cells: Two-dimensional transition metal dichalcogenides. (TMDs).

Catalysts: Metallic 2D Materials for Electrocatalytic Reduction of CO_2 and N_2.

Photovoltaics: Stabilisation of CsPbI2Br perovskite through incorporation of niobium (Nb5+) ions.

Magnets: Niobium-tin and niobium-titanium superconducting materials.

Metallurgical Additives: Niobium aluminide (NbAl3) grain refiner in aluminium; niobium micro-alloy in HSLA steels.

Material Facts

Paramagnetic: Niobium is weakly attracted by the poles of a magnet but does not retain permanent magnetism.

Alloy Constituent: Niobium enhances strength and toughness in steels. It also acts as a grain refiner in aluminium alloys.

Superconducting: Wires based on superconducting alloys of niobium-titanium or niobium-tin are widely used in the magnets of MRI scanners.

Catalyst: Niobium plays a role in many catalysts which are critical in enhancing reaction efficiencies in industrial chemical processes.

Dopant: Enhancing the dielectric properties of ceramics, doping with niobium is crucial for capacitors and other electronic components.

Optical Properties: Niobium increases the refractive index of glass allowing thinner lenses to be used in glasses.

Hypoallergenic: Niobium and some of its alloys are hypoallergenic and used in jewellery, pacemakers and prosthetics.

Piezoelectric Effect: Niobium can enhance the conductivity of semiconductor oxides, making them more effective in their application as piezoelectric sensors and actuators.

Environmental Impact

Primary niobium is predominantly sourced from abundant but non-renewable geological sources.

The largest use of niobium is as an alloy addition in steel.

Steel is the most recycled material in the world. Scrap containing niobium is collected and reused in the steelmaking process where the functional role of niobium can be restored with further additions of primary material to compensate for dilution in the scrap recovery process.

The recovery of niobium compounds is feasible where it is used in significant concentrations for example in batteries, superconducting wires and super alloys.

Used MRI scanners with niobium containing superconductors are often reconditioned with the superconducting coils being re-used in refurbished machines.

Techniques are available for recycling niobium including hydrometallurgy and pyrometallurgy. Hydrometallurgy is the most likely process to extract niobium in a profitable way and with the least environmental impact.

Scaled up recycling needs to be trialled.

The development of a circular economy for niobium is strategically important to diversify the supply chain, reduce environmental burden and increase market acceptance.

Useful Links:
[Circular Niobium]
[Royal Society of Chemistry]
[Niobium Technology & Applications]
[European Chemicals Agency]

Circular Niobium
Knowledge and Innovation Centre