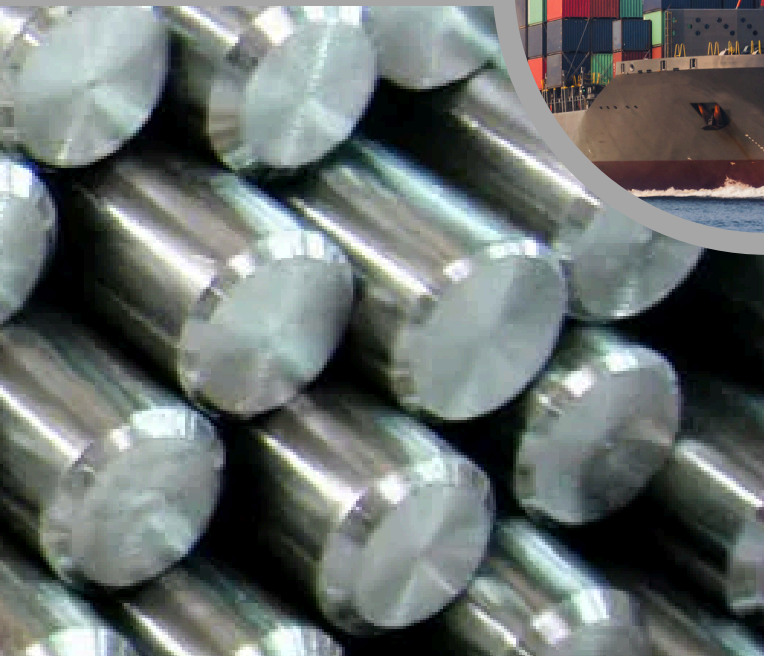


MEDSTERN CANADA LLP



RELIABLE. AUTHENTIC.

EDITION
SUMMER 2025



Power Plants: Titanium (Ti) for piping systems, condensers, heat exchangers, steam turbines, desulfurization stages.

RELIABLE TITANIUM

Energy Generation

Titanium is a most sophisticated material, primarily used as an alloy due to its high temperature and corrosion resistance. Significant amounts are consumed by industry each year. It is often a first choice for system-critical components in large-scale power plants. It can also be used for desalination plants or turbines.

RENEWABLES

Hydrogen Economy, Wind Power



Ti also performs as a catalyst in the production of green hydrogen using electrolyzers, in electrodes (MMO), mesh material for hydrogen storage tanks, or components of fuel cells, e.g., bipolar plates. Titanium alloys are used in wind turbine shafts, fasteners, and other critical components, particularly in offshore turbines.

TRANSPORTATION

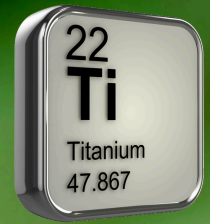
High-Performance Machinery, Trains



For the automotive and aviation industries, Ti offers enhanced performance and durability due to its high strength-to-weight ratio. Titanium alloys can also reduce the weight of railcars or be used in coiling springs, brake discs of train wagons. Trucks utilize Titanium-made components, e.g., axles, kingpins, hangers, baseplates, and fuel tanks.

INVESTMENT OPPORTUNITIES

Sustainable Mining, Metals, and Galvanic Industries



Canada boasts a diverse range of minerals, including traditional commodities like base metals, as well as critical minerals. The country is home to a large number of mining companies and is a leading destination for international mining finance. Foreign direct investment (FDI) in the Canadian mining sector was \$65.1 billion in 2022.

Status 2024/2025

ACCESS RESOURCES, GROW SUPPLY BASE

**MINES, MINERAL
DEPOSITS**

**METAL, GALVANIC
INDUSTRIES**

**LOGISTIC
INFRASTRUCTURE**

Including extraction, services, primary and downstream manufacturing, the Canadian Mining and Metals Sector contributed a total of \$108.5 billion to GDP in 2022. Canada has a well-established mining sector with a supportive regulatory framework, including established stock exchanges. Investors who can guarantee offtake agreements contribute significantly to the economy. Reliable and robust technologies are the key to leaving behind only clean water, healthy landscapes, and achieving greater competitive strength through value-added mining and metal commodities.

AUTHENTIC TITANIUM

Physical and Chemical Properties

47.867 22
[Ar]3d²4s²

Ti

Transition Metal
TITANIUM

Atomic Structure, Titanium, Ti

Electron Affinity	7.62 kJ/mol	Electronegativity (Pauling)	1.54
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Periodic Table of the Elements

Titanium, Ti

Period 4

Group 4

Physical Properties, Titanium, Ti

Density at 20 °C 4507 kg/ m³

Spec. Heat Capacity 520 J/ (kg * K)

Melting point 1941 K, 1668 °C

Boiling point 3560 K, 3287 °C

Isotopes, Titanium, Ti

⁴⁶Ti

⁴⁷Ti

⁴⁸Ti

⁴⁹Ti

⁵⁰Ti

45.9526 u

46.9517 u

47.9479 u

48.9479 u

49.9448 u

PHYSICAL



Appearance: Silvery-white metal, light reflecting

Crystal Structure: HCP (α) phase, BCC (β) phase

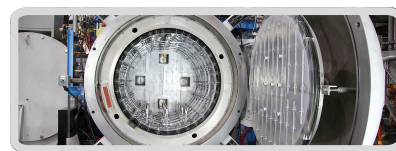
Hardness: 6.0 Mohs Scale, depending on purity

Malleability: Can be shaped at high temperatures

Conductivity: low conductivity, high resistance

Young's Modulus: 116 GPa

CHEMICAL



Corrosion Resistance: excellent resistance to corrosion in various environments, e.g., seawater

Thermal Expansion (25°C): 8.6 μm (m⁻¹ · K⁻¹)

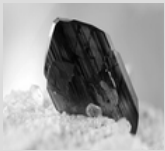
Common Oxidation States: +4, also +2, +3

Titanium Compounds: e.g., Titanium Dioxide (TiO₂), Titanium Tetrachloride (TiCl₄)

TITANIUM MINERALS

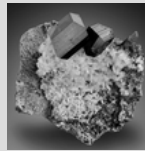
Mining Industry, Raw Materials

Brookite (TiO₂)



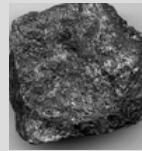
Titanium-Dioxide
Strunz:
4.DD.10

Anatase (TiO₂)



Titanium-Dioxide
Strunz:
4.DD.05

Ilmenite (FeTiO₃)



Iron-Titanium Oxide
Strunz:
4.CB.05

Rutile (TiO₂)



Titanium-Dioxide
Strunz:
4.DB.05

FROTH FLOTATION

Ore Preparation Phase: From Gangue Material to Ilmenite ore concentrate

Crushing

Grinding

Classification

Beneficiation

- ☐ Jaw-, cone crusher, rod and ball mills
- ☐ Hydrocyclones, screens
- ☐ Gravity spiral concentrators, magnetic fields
- ☐ Froth flotation for ore concentration
- ☐ Smaller rock chunks, fine crushing
- ☐ Ilmenite ore FeTiO₃ : < 10% TiO₂ content, often mixed with iron-bearing minerals
- ☐ Fineness particles < 0.074 mm

Froth Flotation Process

- ☐ Slurry conditioning
- ☐ Making Titanium-containing particles hydrophobic
- ☐ Flotation cell, air injection, mechanical agitation
- ☐ Foam layer skimming, dewatering, drying
- ☐ Addition of water, collectors, frothers, e.g., alkyl hydroxamic acids, ortho-nitro alkyl phenols, methyl isobutyl carbinol
- ☐ Ilmenite ore concentrate: 30% - 50% TiO₂ content

TITANIUM PROCESSING

The Metal and Galvanic Industries

Ilmenite Sulfate Process: From FeTiO_3 to Titanium Dioxide Pigment TiO_2

Leaching

- ☐ Dissolution in sulfuric acid, conversion to titanium oxysulfate
- ☐ Processing TiOSO_4 at 120°C to hydrated Titanium Hydroxide
- ☐ Heating in a Calciner, Temp: $800 - 1050^\circ\text{C}$
- ☐ $\text{FeTiO}_3 + 2\text{H}_2\text{SO}_4 \rightarrow \text{FeSO}_4 + \text{TiOSO}_4 + 2\text{H}_2\text{O}$
- ☐ Removal of Ferrous sulfate FeSO_4
- ☐ $\text{TiOSO}_4 + 2\text{H}_2\text{O} \rightarrow \text{TiO(OH)}_2 + \text{H}_2\text{SO}_4$
- ☐ $\text{TiO(OH)}_2 \rightarrow \text{TiO}_2 + \text{H}_2\text{O}$
- ☐ Purity $\geq 99.50\% \text{ TiO}_2$

Hydrolysis

Calcination

Carbothermic Reduction Process: From FeTiO_3 to Titanium Tetrachloride (g), TiCl_4

Carbothermic Reduction

- ☐ Heating using reducing agent carbon, Temp: $900 - 1400^\circ\text{C}$
- ☐ Fluidized Bed Reactor, Temp: $> 1000^\circ\text{C}$, with chlorine, coke
- ☐ Fractional distillation of volatile chlorides
- ☐ $\text{FeTiO}_3 + \text{C} \rightarrow \text{Fe} + \text{CO} + \text{TiO}_2$
- ☐ Titanium Slag: TiO_2 , Pig Iron: Fe
- ☐ $\text{TiO}_2 + 2\text{Cl}_2 + \text{C} \rightarrow \text{TiCl}_4 + \text{CO}_2$
- ☐ Titanium Tetrachloride: (g) TiCl_4
- ☐ refined (g) TiCl_4

Carbochlorination

Refining

VACUUM ARC FURNACE

Processing: From Titanium Tetrachloride (g) TiCl_4 to Titanium Ingots, Bars, Ti

Sintering

Melting

- ☐ Molten Mg, stainless-steel vessel, Temp: $800 - 850^\circ\text{C}$
- ☐ Heating, Temp: $1200 - 1400^\circ\text{C}$
- ☐ Melting, Temp: $1700 - 1800^\circ\text{C}$
- ☐ $\text{TiCl}_4 + 2\text{Mg} \rightarrow 2\text{MgCl}_2 + \text{Ti}$
- ☐ Titanium sponge: pressing, compacting
- ☐ Vacuum Arc Furnace: Ti sponge
- ☐ Ti Ingots, Bars



Further Processing

- ☐ forging, rolling, and machining to product formats
- ☐ e.g., Grade 1,2,3,4, HPT, CP Titanium, 3N, 4N, 5N

TRANSPORTATION SUPPORT SERVICES

Supply Chain Integration



Tailored logistics support services are available to B2B Partners, outsourcing their supply chain needs, including secure storage in warehouses, freight rail transportation, and specialized service providers for cargo handling and management, to ensure products get to market on time and within budget.

MODES OF TRANSPORTATION

- Trucks: for short distance hauls and last-mile delivery
- Trains: for long-distance transport of products, goods
- Ships: for large volumes of commodities via ocean freight

TRANSLOADING FACILITIES

- Access to distribution centers, warehouses, and storage space
- Secure transfer of commodities between modes of transportation, e.g., rail-to-ship

LOGISTICS SUPPORT SERVICES

- Optimized shipping processes, analysis, including route planning, cost calculation, carrier identification, shipment tracking, and tracing for precision, real-time product movement

TITANIUM PRODUCT FORMATS

Industrial Formats for Titanium, Ti

Tailored product formats can be made accessible to B2B Partners, based on achieved off-take agreements. The highlighted products on this page are a selection of possible product alternatives available for trade.

Ilmenite,
 FeTiO_3 Concentrate



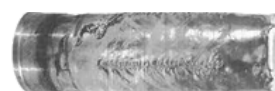
Titanium Dioxide,
 TiO_2 Concentrate



Titanium Tetrachloride,
 TiCl_4



Ingots



Billets



Plates



Sheets, Flats



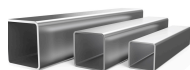
Pipes, round



Pipes, round



Tubes, square



Titanium Dioxide,
 TiO_2 Pigments



Grade 5 Titanium,
 Ti-6Al-4V



PRIMARY TITANIUM COMMODITIES

Classes and Standards

High-Purity Titanium

☐ High-Purity Titanium (HPT), unalloyed

- ☐ 5N Purity $\geq 99.999\%$
- ☐ 4N5 Purity $\geq 99.995\%$
- ☐ 4N Purity $\geq 99.99\%$
- ☐ 3N Purity $\geq 99.9\%$

☐ Commercially pure (CP) Ti, unalloyed

- ☐ Grade 1,2,3,4,
- ☐ ASTM B348, DIN 17850
- ☐ EN 3.7025, EN 3.7035, Grade 1, 2
- ☐ Purity $\geq 99.50\%$

Titanium-based alloys and chemical compounds

$\alpha + \beta$ alloys

☐ Grade 5 Titanium, Ti-6Al-4V alloy

- ☐ AMS-T-9047, DIN 17851
- ☐ ASTM B348-5, bars, billets
- ☐ ASTM B265, B863, strips, sheets, plates

☐ Grade 5 Titanium, Ti-6Al-4V alloy

- ☐ ASTM B348-5
- ☐ Additive Manufacturing
- ☐ Powder, Purity $\geq 99.50\%$

chemical compound

☐ Titanium Dioxide TiO_2 Pigments

- ☐ ASTM D476, ASTM D1394
- ☐ Powder, Paints
- ☐ Purity $\geq 99.50\%$

β alloys

☐ Beta Titanium Alloy, Ti-3Al-8V-6Cr-4Mo-4Zr

- ☐ AMS 4957, DIN 17851, Beta C
- ☐ ASTM B348-19, bars, wires
- ☐ ASTM B977/B977M-19, ingots, billets

☐ Titanium-Niobium alloys, Ti47Nb53

- ☐ ASTM B884, ASTM B394, DIN 17860, DIN 17861
- ☐ ISO 23515, ISO 7209:2023, AWS A5.16
- ☐ High Corrosion-Resistance, Industrial Use
- ☐ Billets, bars, plates, sheets, strips, tubes, pipes

all alloy categories

☐ Titanium alloyed with Pd, Al, V, or Mo

- ☐ ASTM B337, B338, B861, B862 DIN 17851
- ☐ Tubes, Pipes

Other Standard Measurements

☐ Chemical Methods, Analytics

- ☐ ASTM F2924-14, ASTM B988-18
- ☐ ASTM B329, Powder density
- ☐ Powder metallurgy, Ti-6Al-4V
- ☐ DIN 55912-2, ISO 591-1:2000
- ☐ Titanium Dioxide TiO_2

☐ Designation System, Calibration, Delivery, Environmental

- ☐ ISO 23515:2022, Titanium, alloys, designation system
- ☐ DIN 17034, ISO 17025, Calibration laboratories, materials
- ☐ DIN 17862, DIN 17860, Technical delivery conditions
- ☐ DIN EN ISO 14001, Environmental, Water Resources

GLOSSARY

Abbreviations, Definitions

Froth Flotation	a mineral processing technique that separates valuable materials from tails based on differences in their surface properties, specifically their hydrophobicity (water-repelling) or hydrophilicity (water-attracting).
Electric Arc Furnace	a furnace that uses an electric arc to heat and melt metals, by passing an electric current through them. Key components are a furnace chamber, electrodes (e.g. graphite), a power source, and a system for charging and discharging the furnace.
Electrowinning	an electrolytic process used to recover metals from a solution by depositing them onto a cathode using an electric current. Base metals like zinc, nickel, copper, and cobalt can be recovered through electrowinning.
Standardization Institutes	ISO: International Organization for Standardization EN: European Norm/ Standard ASTA: American Society for Testing Materials DIN: Deutsches Institut für Normung

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