



PATENTED TANTALOX® PROCESS TANTALUM & NIOBIUM OXIDES

by François Cardarelli

Canadian Patent 2,849,787 C

- ☐ Fluoride-free process (No HF)
- ☐ Caustic fusion - Alkaline process
- ☐ Recycling chemicals and water
- ☐ High recovery, low OPEX and small footprint
- ☐ Tantalite, columbite, pyrochlore, and Ta-Nb by-products
- ☐ Tungsten, tin, zirconium, rare earth oxides as co-products

180.948

73 Ta
Tantalum

92.906

41 Nb
Niobium



TANTALUM | NIOBIUM (COLUMBIUM) | TUNGSTEN



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Sometimes, concentrates of columbite-tantalite, pyrochlore, scheelite and wolframite originating from Central Africa and South America are mined and sold illegally and referred to as “**Conflict Minerals**”. Some of these Conflict Minerals can make their way into the supply chains of the products used around the world. Therefore it is a **strict policy** at *Electrochem Technologies & Materials Inc.* to **avoid sourcing and purchasing** Conflict Minerals from conflict-affected regions and high-risk areas as defined by OECD guidance.

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Moreover as some niobium and tantalum concentrate sometimes could contain naturally occurring radioactivity materials (NORM) originating from their natural content of thorium and uranium and their decaying radionuclides that are classified by United Nations (UN) as Radioactive Dangerous Goods of Class 7 *Electrochem Technologies & Materials Inc.* is **NOT permitted to process nor to purchase radioactive materials** and therefore it will require from potential suppliers to comply and to provide an official certificate that guarantee that the raw materials are not classified as radioactive nor they contains harmful impurities above regulation limits.

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TANTALOX® is a registered trademark of *Electrochem Technologies & Materials Inc.*



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OUTLINE

- ❖ Canadian Patent and Trademark
- ❖ Key Advantages and Benefits
- ❖ Plethora of Feedstocks and Raw Materials
- ❖ Commercial Production since 2016
- ❖ Comparison:
 - TANTALOX® vs. K-Salt Process
 - TANTALOX® vs. Thermite-Chlorination
- ❖ Recycling Non-conventional Materials
- ❖ Commercial Products (Oxides and Salts)
- ❖ Testing and Qualification of Raw Materials
- ❖ Products Inventory
- ❖ Further Inquiries

180.948

73 Ta
Tantalum

92.906

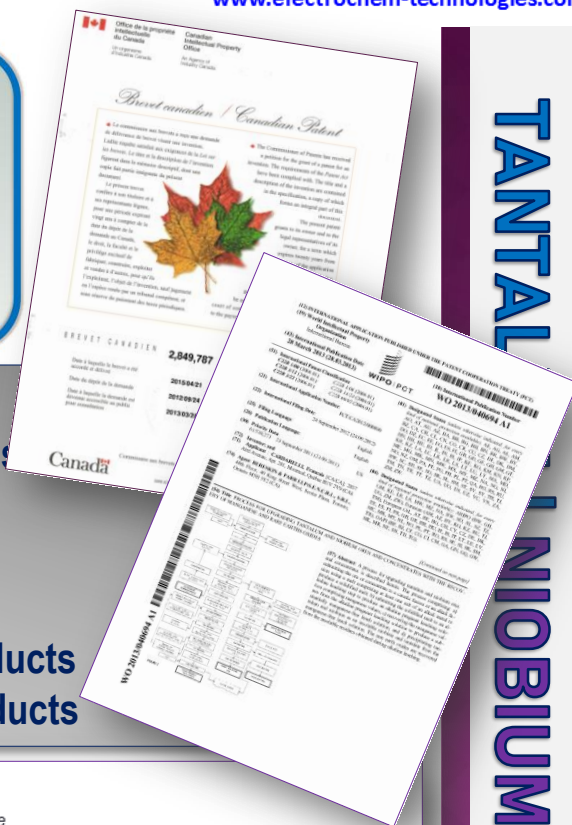
41 Nb
Niobium

TANTALUM | NIOBIUM (COLUMBIUM) | TUNGSTEN

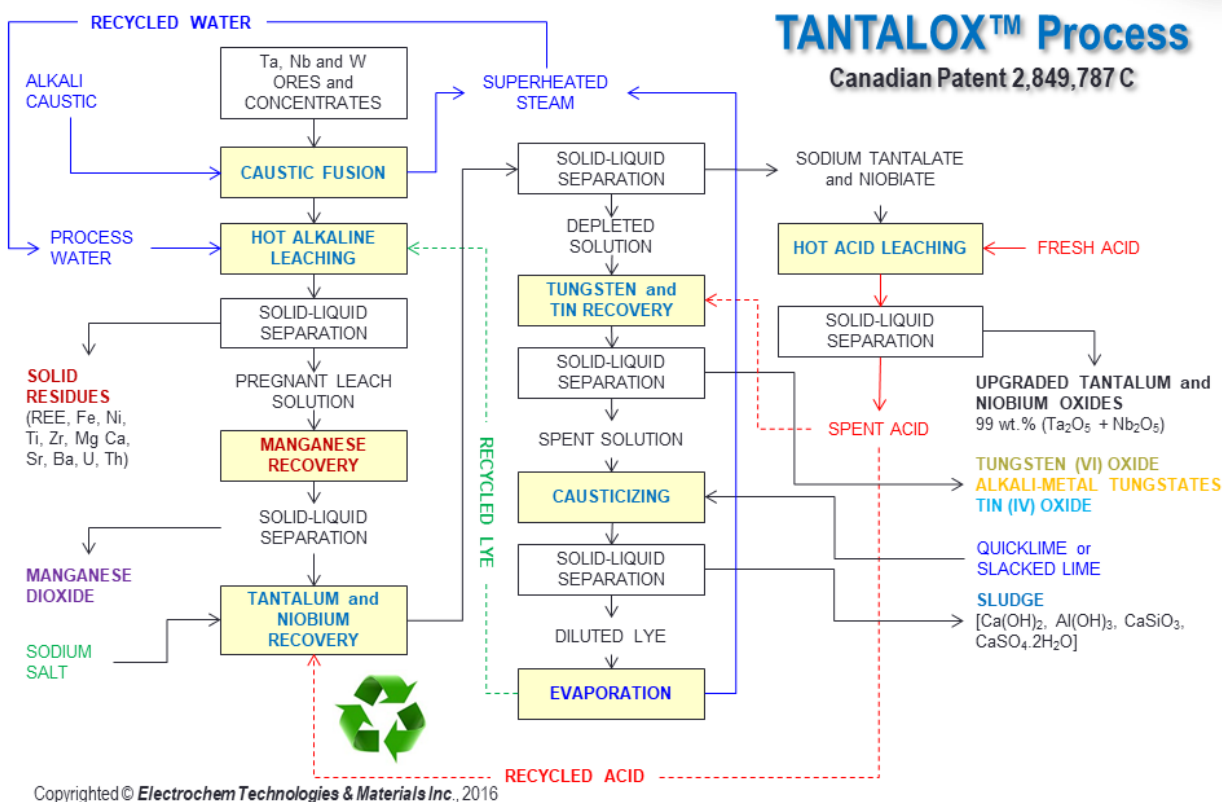


PATENTED **TANTALOX® PROCESS** TANTALUM & NIOBIUM OXIDES

- ❑ Fluoride-free process (no HF)
- ❑ Caustic fusion (600-800°C) – Alkaline process
- ❑ KOH or NaOH routes and water leaching
- ❑ Recycling of chemicals and reusing water
- ❑ High recovery and low production cost
- ❑ W(VI), Sn(IV), Zr(IV), Ln(III) oxides as co-products
- ❑ Tantalite, columbite, pyrochlore, and by-products



François Cardarelli (2015) Process for upgrading tantalum and niobium ores and concentrates with the recovery of manganese and rare earth oxides. Canadian Patent 2,849,787 C (Granted: April 21st, 2015)



TANTALUM (COLUMBIUM) | TUNGSTEN



PATENTED
TANTALOX® PROCESS
 TANTALUM & NIOBIUM OXIDES



**A PLETHORA OF FEEDSTOCKS
 CAN BE PROCESSED WITH HIGH YIELDS**

Synthetic concentrates, sludges, and slags

Ta - W - Sn
Ta - Nb - W
Ta - Ti - Zr - Hf

Microlite
 $(\text{Ca,Na})_2\text{Ta}_2\text{O}_6(\text{O, OH, F})$

Tantalite
 $(\text{Fe,Mn})\text{Ta}_2\text{O}_6$

Carbide sludge

Pyrochlore
 $(\text{Na}_2\text{Ca})\text{Nb}_2\text{O}_6(\text{O, OH, F})$

Wodginite
 $(\text{Fe,Mn})(\text{Sn,Ti})\text{Ta}_2\text{O}_8$

Bariopyrochlore
 $(\text{Ba}_{2-x}\text{Sr}_x)(\text{Nb,Ti})_2(\text{O,OH})_7$

Columbite
 $(\text{Fe,Mn})\text{Nb}_2\text{O}_6$

Columbite
 $(\text{Fe,Mn})\text{Nb}_2\text{O}_6$

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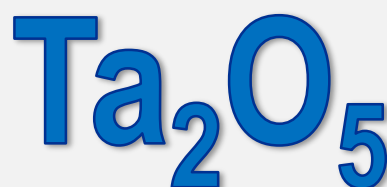


TANTALUM | NIOBIUM (COLUMBIUM) | TUNGSTEN

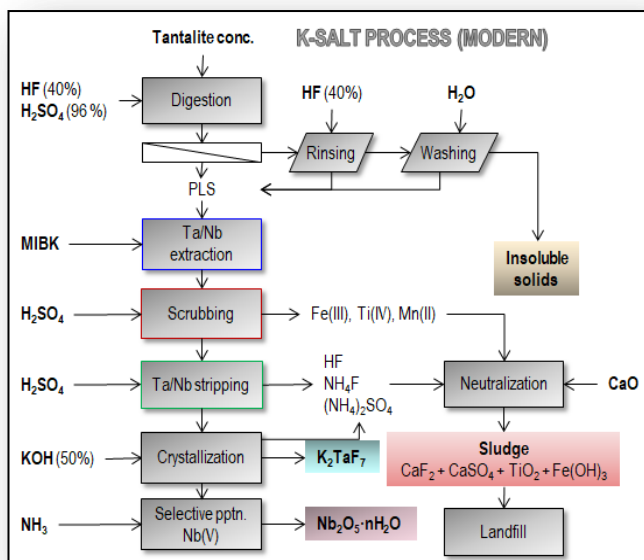




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TANTALUM | NIOBIUM (COLUMBIUM) | TUNGSTEN



TANTALOX®
 vs.
K-Salt process:
HF digestion +
Solvent extraction
(Tantalite, Columbite, Microlite)

K-Salt Process

- ☐ Digestion in hot HF-H₂SO₄
- ☐ Separation of Nb, Ta and impurities by solvent extraction with MIBK
- ☐ Losses of HF and H₂SO₄ values by Fe(III), Mn(II), Zr(IV)
- ☐ Neutralization of spent acids
- ☐ K₂TaF₇, high purity Ta₂O₅ and Nb₂O₅

CONS

- ☐ HF and MIBK pose EH&S issues
- ☐ High OPEX and CAPEX
- ☐ Specialized equipment
- ☐ Highly skilled operators
- ☐ 6-7 tons of sludge per ton of feed
- ☐ Recycling HF is expensive

TANTALOX® Process

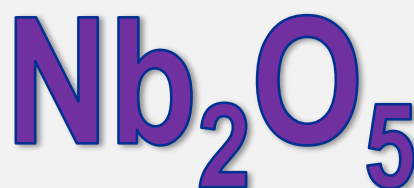
- ☐ Fluoride-free (No HF)
- ☐ Caustic fusion - Alkaline process
- ☐ KOH or NaOH routes
- ☐ Water leaching
- ☐ Separation of Fe, Mn, Ti, Si
- ☐ W, Sn, Zr, Hf, and Y as co-products
- ☐ Ta₂O₅, Nb₂O₅ and upgraded oxides

PROS

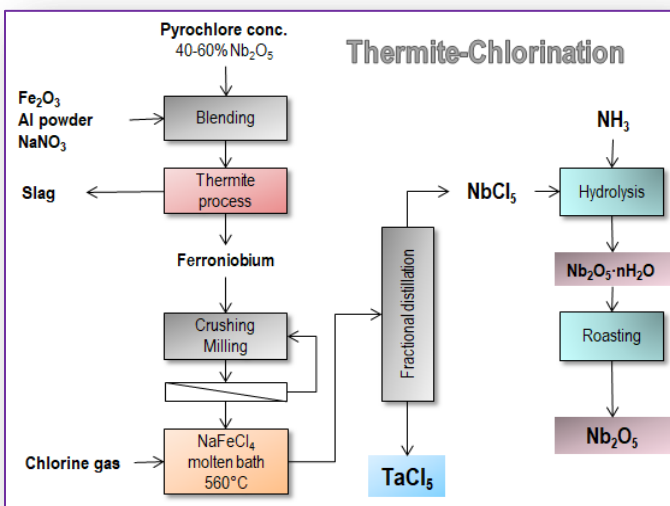
- ☐ Affordable chemicals
- ☐ Low OPEX and small footprint
- ☐ On-shelf equipment
- ☐ +98% recovery Ta₂O₅
- ☐ Low environmental footprint
- ☐ Recycling water and chemicals



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TANTALOX®
VS.
Conventional route
for pyrochlore:
Aluminothermic reduction
+ Molten salt chlorination

Thermite-Chlorination Processes

- ☐ FeNb produced by Thermite process
- ☐ Chlorination of FeNb in molten NaFeCl₄
- ☐ Separation of Nb and Ta by fractional distillation of metal chlorides
- ☐ Nb(V) and Ta(V) oxides obtained by hydrolysis with NH₃ and roasting
- ☐ Chlorine gas used to regenerate Fe(III) in the molten bath
- ☐ High purity Nb₂O₅ and TaCl₅

CONS

- ☐ Large scale operation
- ☐ High OPEX and CAPEX
- ☐ Chlorination poses EH&S issues
- ☐ Needs specialized equipment
- ☐ Highly skilled operators

TANTALOX® Process

- ☐ Fluoride-free (No HF)
- ☐ Caustic fusion - Alkaline process
- ☐ KOH or NaOH routes
- ☐ Water leaching
- ☐ Separation of Ca, Ba, Fe, Mn, Ti
- ☐ W, Sn, Zr, REE as co-products
- ☐ Nb₂O₅ and upgraded Nb oxide

PROS

- ☐ +98% recovery Nb₂O₅
- ☐ Low OPEX and CAPEX
- ☐ Addresses Ca and Na content
- ☐ Recycling water and chemicals
- ☐ Low environmental footprint

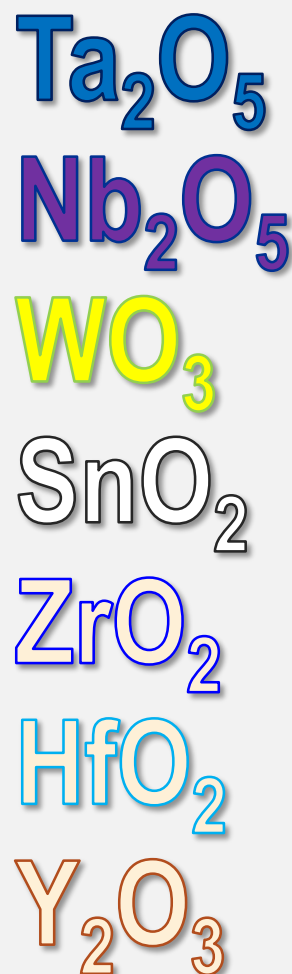


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Recycling non-conventional raw materials and industrial by-products

- ☐ Carbide sludge's
- ☐ Filter cakes
- ☐ Spent catalysts
- ☐ Thermal coatings
- ☐ Ta–Nb–W residues
- ☐ Capacitors scrap
- ☐ Production reverts
- ☐ Metallurgical slags
- ☐ Electrode coatings
- ☐ Synthetic concentrates



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UPGRADED TANTALUM OXIDE (UGTO)

95-98 wt.% ($\text{Ta}_2\text{O}_5 + \text{Nb}_2\text{O}_5$)

UPGRADED NIOBIUM OXIDE (UGNO)



TANTALUM(V) OXIDE

CAS No. [1314-61-0]



NIOBIUM(V) OXIDE

CAS No. [1313-96-8]



TUNGSTEN(VI) OXIDE

CAS No. [1314-35-8]



CESIUM TUNGSTATE

CAS No. [13587-19-4]



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Testing each feedstock prior processing



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SUMMARY

180.948

73Ta
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41Nb
Niobium

What can the TANTALOX® process actually do?

- ☐ Processes a plethora of feedstocks
- ☐ No HF and organic solvents
- ☐ Removes key impurities
- ☐ Monetizes co-products
- ☐ Rejuvenates reagents
- ☐ Recycles water
- ☐ High recoveries for Ta and Nb
- ☐ Upgrades complex by-products
- ☐ Reduces the consumption of chemicals
- ☐ Produces Ta_2O_5 , Nb_2O_5 and upgraded oxides



TANTALUM | NIOBIUM (COLUMBIUM) | TUNGSTEN



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Cesium tungstate (Cesium wolframate)

CAS No. [13587-19-4]

Saturated aq. solution
Lots of 1 kg, 5 kg, 25 kg

Tantalum(V) oxide (Tantalum pentoxide)

CAS No. [1314-61-0]

Form: white powder
Lots of 1 kg, 5 kg, 25 kg

Tungsten(VI) oxide (Tungsten trioxide)

CAS No. [1314-35-8]

Form: yellow powder
Lots of 5 kg, 25 kg, 100 kg

Niobium(V) oxide (Niobium pentoxide)

CAS No. [1313-96-8]

Form: white powder
Lots of 1 kg, 5 kg, 25 kg

Upgraded tantalum oxide (UGTO) min. 95 wt.% Ta₂O₅

Form: tan to white powder
Lots of 1 kg, 5 kg, 25 kg

Upgraded niobium Oxide (UGNO) min. 90 wt.% Nb₂O₅

Form: tan to white powder
Lots of 1 kg, 5 kg, 25 kg



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Do you have a question about TANTALOX® ?

- ☐ Ordering products
- ☐ Supplying raw materials
- ☐ Recycling reverts or residues
- ☐ Monetizing industrial by-products
- ☐ Qualifying and testing a novel feedstock
- ☐ Discussing a business opportunity
- ☐ Others



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