

Separating Ta and Nb using a dry process

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When Anders Ekberg gave the chemical element tantalum (Ta) its name in 1802, he could not have begun to guess how apt the name would prove to be. Tantalus, being the son of Zeus, may have been divine, but this did not make his life any easier. Now seen as the embodiment of temptation without satisfaction, he was doomed to eternally want and never receive, because of his behaviour, which was frowned upon by the Greek gods.

Not only are Ta and Nb found in the same minerals, they are also from the same group in the periodic table and have similar ionic sizes.

Encountered in many minerals of the columbite family, tantalum recovery has for decades perplexed chemists and mineralogists. Tantalum is used in electronics for its high capacitance-to-weight ratio and for many of its other advantages, including its reluctance to leak electrical charge. As a capacitor, tantalum forms part of many modern must-have items, such as cellphones, gaming consoles and automotive electronics.

Niobium (Nb), on the other hand, was named after Niobe, daughter of Tantalus. This element may not share the same glamour as tantalum, but is very useful in its own right and can be alloyed with steel to produce super-strength materials.

As the names of these elements have already alluded to, they are related in many ways – often to the frustration of anyone interested in the recovery of either one.

Not only are these metals found in the same minerals, they are also from the same group in the periodic table and, because of a phenomenon called lanthanide contraction, have similar ionic sizes.

Several efforts have been made to separate these two metals from their ores over the years, but with varying degrees of success.

Current industrial recovery and scientific research focuses on

a process called liquid-liquid extraction. Using this method, the metal-containing ores are dissolved in an aqueous hydrofluoric acid solution. After all the metal has been dissolved, tantalum values, which are more soluble in organic phases, are extracted into an organic solvent, such as octanol or methyl isobutyl ketone (MIBK).

Organic solvents such as these are hazardous to work with and can cause harm through inhalation or exposure to the skin. They are also possibly carcinogenic. Now add hydrofluoric (HF) acid to this already dangerous mix and one has an accident waiting to happen.

Aside from these short-term dangers, the storage and disposal of HF-containing organic solvents are equally problematic. Is it then perhaps possible to use hydrofluoric acid without having it in a liquid phase?

The other possible option is to use hydrofluoric acid in gaseous form. Gaseous hydrofluoric acid is very corrosive, so one needs to be cautious when working with it. Its high polarity, however, allows the gas to be easily captured onto a solid scrubbing material, such as alumina.

Can the gaseous hydrofluoric acid be used for separation?

The metal values of niobium and tantalum in mineral ores are in

oxide form. When these oxides are exposed to anhydrous gas-phase HF (AHF), they are converted to oxyfluorides ($\text{MO}_x\text{F}_{5-2x}$). These oxyfluorides are distinguished by the fact that they either decompose or volatilise at temperatures that are significantly different for niobium and tantalum analogues. Capitalising on this property, it may be possible to separate and purify these metals based on a thermal separation process.

First, as with liquid processes, the ore gets concentrated. The concentrate is then exposed to AHF at low temperatures to convert it to oxyfluoride form. The unreacted HF is either cycled back or scrubbed out, and the oxyfluorides are separated on the basis of their different volatilities. This cycle can be repeated or modified to include a hydrolysis process that converts oxyfluorides back to oxide values.

So, will it work? Quite possibly! This technique has been demonstrated by using the pure metal oxides, and is now being tested on ores.¹ By changing from a wet to a dry process, separating the oxides of tantalum and niobium may be a more elegant alternative to current industry practice. Unlike the unfortunate Tantalus, the recovery of tantalum may have a happy ending after all. 🍀

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¹ Patent Cooperation Treaty (PCT) application number: PCT/IB2011/051408.