Kroll process alternative emerges

Up until now the Kroll process has been the go-to technology for the extraction of titanium metal. Now Metalysis has begun the commercialisation of its alternative method, based on FFC technology. So, we have to ask: is this the end of Kroll? *Metal Powder Report* caught up with Metalysis CEO Guppy Dhariwal and Dr Kartik Rao, Director of Business Development, to discuss.

Back in 2009 we spoke to engineers at Metalysis concerning its development of the FFC process for the cost-effective extraction of titanium. Now in 2013 the company is on the brink of commercialising the process — and, crucially for the current market, has successfully applied it to the processing of rare earth metals as well.

Since 2009 the titanium and tantalum market has changed, only now recovering from the recession which slowed down — and, in some cases,

Figure 1: Guppy Dhariwal, CEO of Metalysis.

stopped — mining and production. A strong and stable market now is for tantalum capacitors, notes Dr Kartik Rao, Director of Business Development at Metalysis. The metal is becoming more widely used in consumer electronics, such as tablets and mobile phones. And while titanium is used extensively in aerospace and biomedical applications, there is potential to significantly increase its use in other industries as it becomes more affordable.

"We believe we can widen potential markets besides current users, such as aerospace," Dr Rao stated. Possible end users, he notes, include the desalination industry — where there is a need for saline-resistant materials, such as titanium — as well as the automotive and the chemical industries.

To meet these new markets, Metalysis has developed its electrolysis process to the extent that it can be commercialised. "We've recently developed a machine which can process 50 tonnes of tantalum or titanium and are now looking at finding a partner to develop a 10,000 tonne plant specifically for titanium, similar to an aluminium extraction plant," Guppy Dhariwal explained.

Moreoever, rutile sand, a source of naturally occurring titanium ore, can now be turned into titanium powder in a single step. According to Dhariwal, rutile sand is sourced in Australia, Sri Lanka, Sierra Leone, and some of it is mined and beneficiated to make synthetic rutile, but some of it can also come directly from beach sand.

"Since 2009 Metalysis has moved the whole thing forward," Dhariwal said, adding that there have also been 25 new patents developed. "The original technology used pressed performs, which had to be heat sintered, then crushed. But now we can take rutile sand at a 100 micron size and feed it straight into the machine. A similar process can be used with pigment grade titanium dioxide. We are continually trying to find ways to reduce cost and improve scalability."

The end product has also been improved. According to Dr Rao, the powder has high flow, is near spherical, and has improved packing density, and is suitable for HIP and MIM. It is also suitable for additive manufacturing and laser sintering. Currently the powder size input can depend on the customer.

The Metalysis process can also make alloys that would not be cost effective by traditional processes. Dhariwal says the process could potentially revolutionise alloy production. "Because they are entirely solid state, they can be blended in any ratio, and metals with significantly different densities or melting points can be alloyed. Many more types of alloys can be produced," he explained. The alloys can be tailored for applications within a range of industries, including automotive, marine, electronics, clean energy and aerospace.

Rare earth innovation

The development of the process to produce rare earth metals comes at a time when both the market for the metals, and resource potential, is at its highest peak. Metalysis began to develop the production of rare earth metals using their technology in recent years and have been approached by several parties interested in the potential of the elements.

Despite their name, rare earth elements are relatively plentiful in the Earth's crust. However, because of their geochemical properties, rare earth elements are typically dispersed and not often found concentrated as rare earth minerals in economically exploitable ore deposits. Until 1948, most of the world's rare earths were sourced from placer sand deposits in India and Brazil. Through the 1950s, South Africa took the status as the world's rare earth source, after large veins of rare earth bearing monazite were discovered there. Through the 1960s until the 1980s, the Mountain Pass rare earth mine in California was the leading producer.

Today, the Indian and South African deposits still produce some rare earth concentrates, but they are dwarfed by the scale of Chinese production. China had produced more than 95% of the world's rare earth supply, mostly in Inner Mongolia, even though it had only 37% of proven reserves. (Note: these numbers have since been reported to have slipped to 90% and 23%, respectively, by 2012.) However, back in June 2012, China published a white paper stating the aim to improve the sustainability of its own resources while encouraging other countries to exploit their own materials.

Dr Rao offers his theories on this issue: "Because it takes 6-10 years to mature a mine, countries outside China have had to take their time to catch up. But in the next few years it's likely that rare earth metal resources will have considerably increased, and technology to process the materials will be highly sought after."

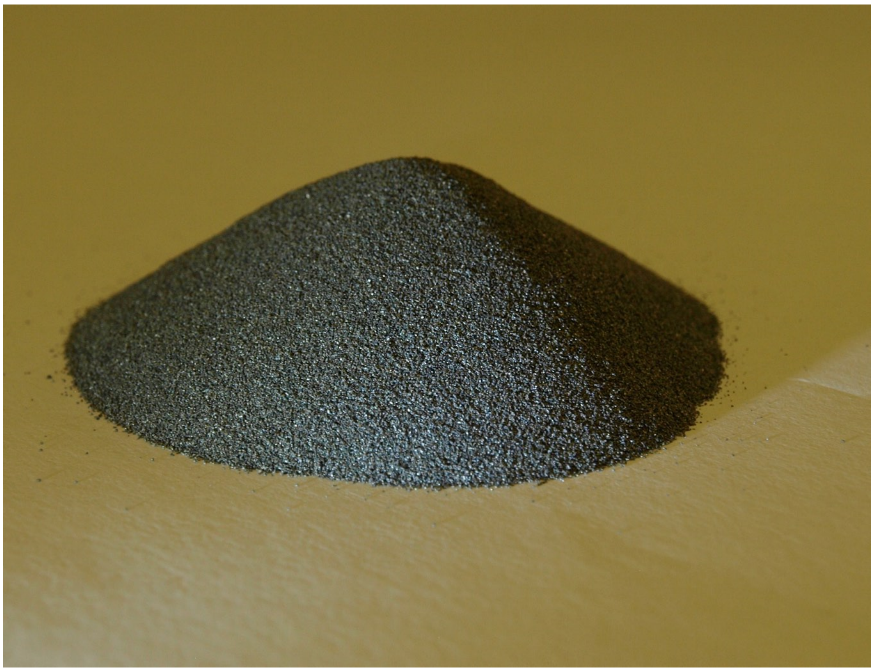

Figure 2: The end result: natural metal in powder form.

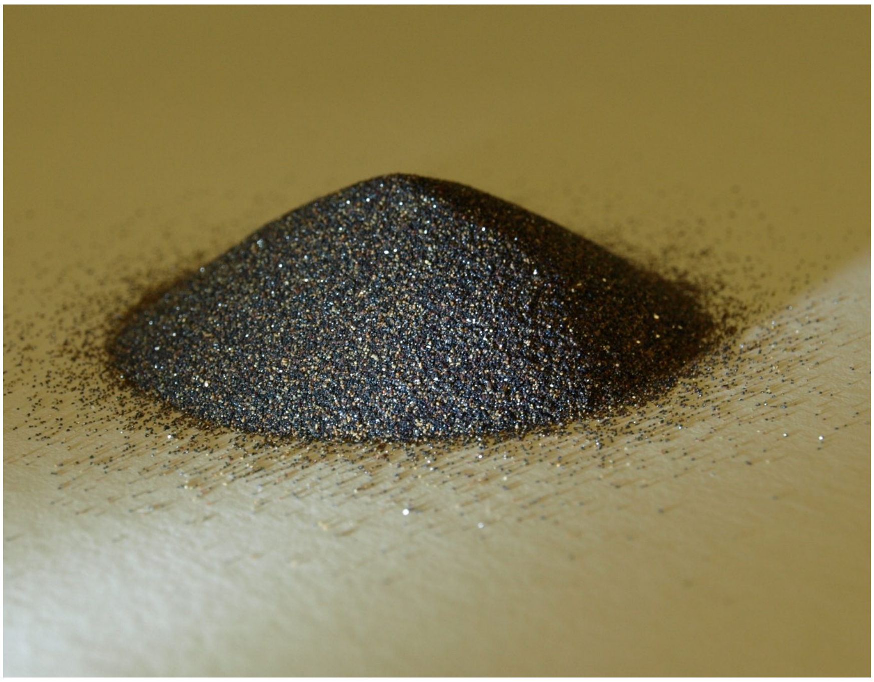

Figure 3: The oxide powder which is turned into metal powder in a single step.

On the Metalysis process

According to Dhariwal, the Metalysis' process can currently produce neodymium, terbium, and a terbium-nickel based alloy. The Metalysis process has been used to demonstrate both neodymium and terbium in its elemental state, and terbium-nickel in the form of an alloy, by reduction of their corresponding oxides. Since the process is conducted in the solid state, it is possible to produce a homogenous alloy in a single step, unlike conventional technologies where numerous melt stages are necessary to obtain the desired alloy composition. Micro-structural analysis of the synthesised terbium-nickel powder clearly illustrates this fact, advocating the capabilities of the process.

Neodymium is used as a component in alloys to make high-strength neodymium magnets. These are used in microphones, loudspeakers, in-ear headphones, and computer hard disks. Larger neodymium magnets are used in high power versus weight electric motors (for example, in hybrid cars) and generators (for example, aircraft and wind turbine electric generators). Neodymium is usually refined for general use and is a fairly common element. Most of the world's neodymium is mined in China.

As a component of Terfenol-D (an alloy that expands and contracts when exposed to magnetic fields more than any other alloy), terbium is used in actuators, in naval sonar systems and in sensors. However, most of the world's terbium supply is used in 'green' phosphors (which are usually yellow).

Metalysis claims its process is more energy efficient and less expensive when compared with existing methods for rare earth production. This is because it produces the metals directly from oxides in a single step. Producing these metals at reduced cost and with a lower impact on the environment could widen access to these metals and the resulting magnets.

The Metalysis process is also capable of making alloys in one step. According to Dhariwal, it will now work on producing magnetic alloys in larger quantities, such as neodymium-iron-boron.

"Using the Metalysis process to successfully create rare earth metals means we can replicate the success we have achieved in the development of a process for high-value metals such as titanium and tantalum," Dhariwal explained. "The Metalysis process will help develop the new sources of rare earths from countries outside of China by processing them using our new, environmentally benign, lower cost production process."

Dr Rao is optimistic about the future opportunities. "The markets are growing, and we have now been given the opportunity to prove we can do it, working with people to look at commercially viable markets," he said. "This is still at the R&D stage, but as it's a development of current technology, it hopefully won't take too long to develop further."

About the author

During her eight-year tenure at Elsevier, Liz Nickels has covered many industry-related topics, including plastic composites, plastic additives, filtration, desalination, pumps, wastewater, and, of course, powder metallurgy. For the last four years she has served as assistant editor of *Metal Powder Report* magazine and online editor of www.metal-powder.net. Before joining Elsevier, she worked at GTI Specialist Publishers on a range of magazines promoting professional construction jobs to UK graduates.
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