Journal Comment

The Platinum Group Metals

'In its short commercial life, titanium has been tagged 'the wonder metal'
As strong as steel, it weighs only half as much;
Heavier than aluminium, it is twice as stong'

Time Magazine 11 August 1952

The papers in this issue are a selection from the 'Advanced Metals Initiative: The Light Metals Conference 2010', held at the CSIR, the home of much of the materials science work in the last few decades.

Today the 'light metals' are well known to be, lithium, magnesium, aluminium, silicon and titanium, from the lowest atomic number to the highest. Strictly in terms of the periodic table, the metal beryllium should be included as being the lightest of the structural metals. Although commonly by-passed today by virtue of its toxicity, beryllium was on the list when I was commissioned in the mid 1950s to undertake a first-world investigation of the commercial potential of the new nuclear and light metals.

In 11 of the 15 papers in this issue, the focus is on titanium, and this continues to receive major attention in Southern Africa, for good reason. There are very large potential resources in the form of titaniferous magnetites, beach sands, and existing slag dumps. Moreover, titanium has been and still is a most technically enticing element.

In the immediate post-war years, titanium was the wonder metal—the future and possibly a replacement for aluminium in supersonic aircraft and transport vehicles and in chemical plants—to replace stainless steel because of its high corrosion resistance.

As a young inexperienced chemical engineer, I had a mind-boggling initiation through the extensive and sophisticated facilities in the US Bureau of Mines Research Stations and the equivalent facilities in Canada and the UK, where I learned for the first time of the sophisticated high vacuum induction and electron beam facilities needed to handle titanium metal and the various technologies to purify the metal and convert it to usable forms. It was on this trip that I learned the contemporary buzzword 'tickle four' as the main component in the titanium chain, standing for titanium tetrachloride ($TiCl_4$), the ubiquitous intermediate compound suitable for the Kroll process for the production of titanium metal ingot and most other forms of this element. At that time in South Africa, the first black mineral beach sands plant had been commissioned in KwaZulu-Natal, and I soon found myself leading a team of South Africans operating a pilot plant in the UK treating ilmenite from Umgababa, with the ultimate aim of producing tickle four for metal or pigment production.

The titanium metal bubble soon burst because of the cost and complexity of converting the raw materials into fabricated metal plate and other extruded forms, and also because of the low fatigue resistance and its affinity for hydrogen and nitrogen to form brittle hydrides and nitrides. The Umgababa plant was soon abandoned and it was some twenty years later that the large beach sands plants around Richards Bay were established using an electric arc furnace to produce iron and a titanium slag that was accepted around the world for tickle four production.

It is fascinating to me to note the papers in this issue that provide current test work to improve on the economics of tickle four production and its conversion to titanium metal and the alternative routes to titanium powder. It was even more fascinating to read of the expansion of the rapid prototype additive manufacturing equipment in South Africa in industry, at the universities, and at research facilities. This, together with laser beam, 3D layering methods and high vacuum electron beam and deposition methods, is contributing to establishing a competitive industry that will provide the highly complex products needed to compete globally. Titanium is a remarkable alloying constituent with a host of remarkable products such as the medical stent alloy of Ti and Ni with its unique phase change from a martensitic to austenitic structure at body temperatures.

There should be a good future for sophisticated titanium and other light metal end products. One hopes these could be established in suitable cluster industries associated with other major undertakings such as the automobile component, foundry and injection moulding industries, so as to create the many thousands of job opportunities demanded in the priority list.

Titanium oxides and hydrates are equally remarkable. Crystalline titanium dioxide has a brilliant colourless transparency, transmitting all the visible and ultra violet wavelengths of light with high refractive index. Soon the world markets were to take over the fine powder of such 'TiOX' as the finest 'whiter than white' pigment and filler. This also is best made from tickle four and represents the main global sales of titanium products.

At the Second UN Geneva Conference on peaceful uses of Atomic Energy in 1954, I listened to a paper from Harwell presented by Dr Spence on the recovery of the few parts per billion of uranium from seawater using granular titanium hydrate as one of the more successful absorbents. These granules had highly active surface areas running to many square metres per gram. Pilot-plant tests had shown the process was technically feasible but the cost was prohibitively high at that time when the value of U3O8 was of the order of $15/lb. More recent work in Japan and the US showed that similar processes could be operated at ca. $100/lb. Present uranium prices are moving up above $50/lb.

South Africa has a forefront position in low-cost engineering concepts for moving high volumes of liquids through particulate absorbents in countercurrent systems so as to absorb and recover valuable constituents. There are estimated to be many trillions of tons of uranium in the oceans, enough to underwrite nuclear fission power for many millennia or until fusion power becomes a reality.

Journal Comment *(continued)*

The directives from the Government Science and Technology Forum have proclaimed that 'nanotechnology' is a favoured research field. Recent media reports have pointed to a South African initiative to market an air filter based on 'nano-titanium' material, which will remove even the smallest virus from aircraft cabins, hospitals or other living spaces. It is based on titanium dioxide, which is transparent to ultraviolet light, which is lethal to all forms of virus or bacteria; so the absorbent can be cleansed and regenerated *in situ* easily and quickly.

Let us not forget the other light metals, some of which are the subject of papers in this issue. There is nothing yet on lithium, the lightest of the metals. It was the first element to undergo a man-induced nuclear fission reaction in the Cavendish Laboratories, directed by Rutherford, in which the enormous energy released was quantitatively measured to be exactly according to the famous Einstein equation $E=MC^2$. Lithium is now once again on the hot list as the basis of the lithium ion batteries, which are almost certainly going to be the energy rechargeable compact power systems for the future electric transport vehicles and solar and wind power storage systems, not to mention the many billions of cell phones or other never ending portable IT novelties.

Once again South African scientists are in a prominent position since the CSIR has reportedly master patents in this field. Opportunities abound but they demand long range priority in providing appropriate high-tech skills. There is no doubt that a focus on the light metals deserves such a high priority.

Let us expect many more such contributions to this Journal in future years. ◆

R.E. Robinson