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The Crucible

Is Vanadium the Material for Energy Storage?

A Look at Brazil's Considerable Mineral Wealth

Have Tantalum Lessons Been Learned?

The magazine of the Minor Metals Trade Association

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The MMTA promotes essential elements that add quality, safety and enjoyment to our lives.

The MMTA is the world's leading minor metals industry organisation.

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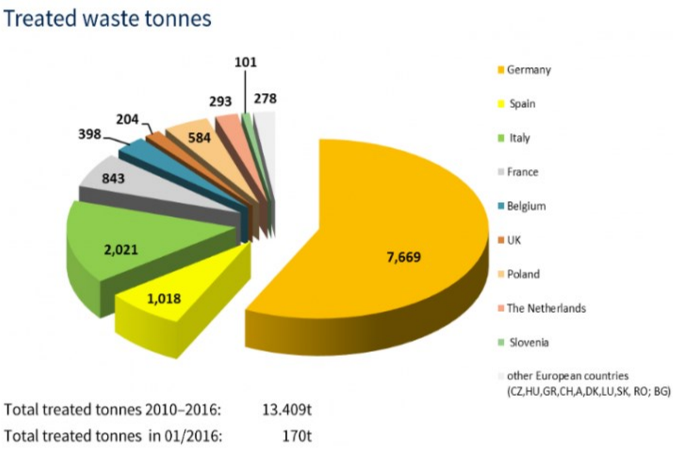
Photovoltaic Recycling

Gina Evangelidis, MMTA

The European solar industry grew by 15% in 2015, continuing Europe's reign as the chief continent for solar powered energy. Germany is currently the biggest player in Europe's renewable energy game with a total capacity of 39,700 MW and was, until China's recent increase in photovoltaic (PV) power capacity, the world's leader.

Germany's largest thin-film PV power system, Waldpolenz Solar Park in Leipzig, contains 550,000 thin-film modules that at end of life will require recycling. This is a true reflection of a steadily growing PV power industry and with this growth comes a huge responsibility for the modules that are created to facilitate energy supply.

Disclosure: I am a keen advocate for renewable energy and sustainability. It simply does not make sense to me that, at a time when technology is advancing at such a phenomenal rate, we would continue to create conventional energy systems that are wasteful or damaging to the environment. And, if given the choice, it seems absurd that we would choose to use a finite resource when we can harness the infinite power of the sun. However, I do accept that the modules are not infinite; they have potential to become waste in huge proportions.



There are companies which specialise in recycling PV modules, with over 13,000 tonnes of solar energy products recycled since 2010. Let's take the PV CYCLE Association as an example: PV CYCLE is a legal compliance and waste management service, dealing with products that fall under WEEE (waste electrical and electronic equipment) and Battery Producer Responsibility legislation. PV CYCLE is representative of its members—PV manufacturers, importers and installers, and claims to be the first to offer take-back and recycling solutions on a global level for all types of PV technology.

Through their members and partnerships, they offer a simple, accessible solution for the PV industry. Those wishing to recycle larger quantities (typically between 40 and 80 modules) can arrange for pick-up and direct transportation to the recycling site and those with smaller quantities can take the modules to their nearest collection point, either PV CYCLE's or those operated by the municipal network, depending on local regulation. These collection points hold the modules until their containers are full, at which stage the products are taken to be recycled and the raw materials are extracted.

Indium, selenide, gallium, silicon dioxide and cadmium telluride can all be recovered from PV modules, alongside elements such as aluminium and copper, which plays a huge role in resource sustainability.

PV CYCLE state that 'a separation by technology and particularly from other waste streams is key to a high recycling output.' This output can then be used in glass packaging or insulation, totally new products, plastic products, aluminium/copper products and more. A maximum of 5% of recovered raw material ends at landfill, if applicable at all.

Silicon based and non-silicon based PV are recycled through differing technologies, but both yield impressive results. Silicon based PV modules use a mainly mechanical process, whilst non-silicon based PV uses a predominantly chemical process.

The silicon based high yield PV recycling process separates the frame, junction box and cable to allow differing materials to be recovered on separate recycling lines. Through shredding, milling and various thermal and mechanical processes around 90% of a silicon based module is recycled. This figure is likely to increase as PV CYCLE has recently seen a new recycling record of 96% in industrial-scale performance.

In contrast, non-silicon based PV uses chemicals to separate the materials, employing some mechanical techniques later to further refine the materials recovered. These boast a 97% recycling yield. Both silicon based and non-silicon based recycling methods go way above the 70% overall recycling efficiency in the WEEE industry.

PV materials' recovery is not a profitable venture. This is, in part, because of the low volume of waste, but other factors, such as transport costs and the tools required to recycle, currently still outweigh the potential profit from trading the recovered materials. This is why PV CYCLE works through a collective approach throughout Europe; they want to boost volumes and increase the economic viability of the process through economies of scale.

Another key cost stems from WEEE. Simply falling under WEEE adds cost: for administration, product labelling and campaigning responsibility – amongst others. Of course, these costs will vary from business to business, but they can place an additional burden on a very essential industry.

On average, PV modules have a healthy lifespan of around 20-25 years, and though the PV recycling industry is relatively small with around 12 companies in the business, it will surely grow with the increasing demand. This growth gives the industry a real opportunity to show commitment to sustainability.

References:

1. PV Module Recycling: Industry Standards & Best Practice, PV Cycle Association, 2016, http://www.pvcycle.org.uk/
2. SolarPower Europe's press release on March 3rd 2016, http://www.solarpowereurope.org/
3. Minor Metals in Renewable Energy Technologies, MMTA, http://www.mmta.co.uk/uploads/2014/09/22/160613_renewable_energy_technologies_and_minor_metals.pdf
4. **Image Source: PV Cycle Association**

Spider web metal

Inspired by the 'liquid wire' technique in spider webs, scientists have created novel composite fibres which extend like a solid and compress like a liquid.

Pulling on a sticky thread in a spider's web and letting it snap back shows that the thread never sags but always stays taut - even when stretched to many times its original length.

This is because any loose thread is immediately spooled inside the tiny droplets of watery glue that coat and surround the core gossamer fibres of the web's capture spiral.

"The thousands of tiny droplets of glue that cover the capture spiral of the spider's orb web do much more than make the silk sticky and catch the fly," said Fritz Vollrath from Oxford University.

"Surprisingly, each drop packs enough punch in its watery skins to reel in loose bits of thread. And this winching behaviour is used to excellent effect to keep the threads tight at all times, as we can all observe and test in the webs in our gardens," Vollrath said.

The novel properties observed and analysed by the scientists rely on a subtle balance between fibre elasticity and droplet surface tension.

The team was also able to recreate this technique in the laboratory using oil droplets on a plastic filament.

This artificial system behaved just like the spider's natural winch silk, with spools of filament reeling and unreeling inside the oil droplets as the thread extended and contracted.

"While the web is simply a high-tech trap from the spider's point of view, its properties have a huge amount to offer the worlds of materials, engineering and medicine," said Herve Elettro, a doctoral researcher at the Universite Pierre et Marie Curie in France.

"Our bio-inspired hybrid threads could be manufactured from virtually any components," explains Elettro....including metals.

"These new insights could lead to a wide range of applications, such as microfabrication of complex structures, reversible micro-motors, or self-tensioned stretchable systems," he said.

The study was published in the journal PNAS.

Vanadium: the material for energy storage?

Tamara Alliot, MMTA

Vanadium may be seeking a leading position in the renewable energy revolution. The tricky issue of energy storage could be solved with vanadium redox flow batteries (RFBs). Currently, the lack of options for effective energy storage impedes the maximum utilisation of renewables such as wind energy and photovoltaics, especially those located in remote areas of the world, potentially without access to an electricity grid.

Vanadium is the 22nd most abundant element in the Earth's crust, although rarely found naturally in its metallic form. Instead, vanadium can be found in over 100 different minerals. However, it is also not exactly a 'new kid on the block' in the metals world. Vanadium's first commercial application was in 1905, when Henry Ford came across this metal at a racing event with a spectacular crash involving a French car. Ford picked up a fragment of the vehicle and was surprised by how hard and light it was. He sent the piece for analysis, and the lab discovered that there was a small percentage of vanadium in the steel. Although this steel was not available in the USA, Ford nevertheless commissioned an essential component of his own vehicle to be made from this steel. By 1927, when the Model-T was discontinued (around 15 million vehicles had been made) gears, axels, shafts, springs and suspension were made of vanadium steel.

To follow on from the article 'A very brief history of Swordmaking' in last month's Crucible, Damascus steel has been shown to be so strong and durable due to its vanadium content. As little as 0.02% vanadium was responsible for the steel's high quality.

In addition to its other properties, an unusual effect of vanadium has been demonstrated in feeding tests on chickens and rats, which have shown that this metal has growth-promoting effects and seems to stimulate the metabolism.

Energy storage batteries are just the latest application for this extraordinary element.

Vanadium redox flow batteries

Vanadium flow batteries are unfortunately too big and heavy to replace the lithium batteries found in your phone. These batteries are instead used for large, stationary, long-term energy storage, or to supply remote areas, or provide backup power. This type of technology is essential to create a more efficient, reliable, and cleaner electrical energy market.

Energy storage is one of the main factors limiting the spread of renewables. Solar and wind power is intermittent and not necessary produced at the 'correct' time of day to meet peak demand (apparently, in the UK this is around 7:45 in the evening, halfway through a soap opera, when there is a mass tea-making frenzy). Therefore, storing energy effectively would mean that we no longer need to use the 'readily available' sources, such as coal and oil, and can call upon the stored energy at peak times and then refill the store when the renewable energy is abundant on a sunny or windy day; just like a water reservoir.

How do these batteries work?

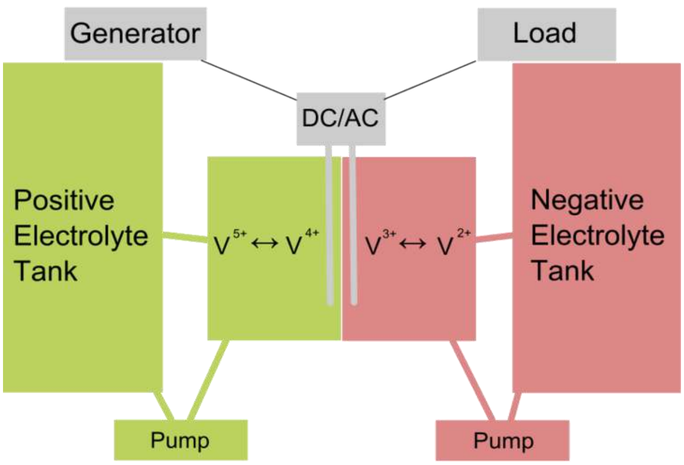


Image :https://commons.wikimedia.org/wiki/File:Vanadium_battery.svg

The name "redox" refers to chemical reduction and oxidation reactions employed in the RFB to store energy in liquid electrolyte solutions which flow through a battery of electrochemical cells during charge and discharge.

Typically, batteries store energy and generate electricity by a reaction between two different materials – generally solid zinc and manganese. In flow batteries, these materials are liquid and have different electric charges. Both are pumped into a "cell" where the electric current is generated. A tiny membrane separates the two liquids, so they are able to react, but don't come into direct contact.

Vanadium is used in these batteries, as it can convert back and forth from its various states, which can carry different positive charges. As only one material is used, the risk of cross contamination is eliminated. The liquids have an indefinite lifespan, so replacement costs are low, and there are no waste disposal problems. Additionally, battery life is extended, potentially infinitely.

In flow batteries, the energy production and capacity are independent of each other. Energy is stored in tanks, whereas the capacity depends only on the amount of liquid stored. This provides great design flexibility not possible with other batteries. They are also safer, as the two liquids do not mix causing a sudden release of energy.

Battling with lithium-ion batteries

Vanadium RFBs are thought by some to be a true challenger to the lithium-ion battery, which has recently benefitted from price drops and increased production (not to mention the Tesla-related hype), but for stationary energy batteries, vanadium RFBs may be the better choice.

Vanadium RFB makers, such as Imergy, are insistent that their batteries deliver cheaper, more reliable, stationary energy storage than other battery technologies.

1,000 ESP30 redox flow units from Imergy are to be delivered over the next three years, destined for deployment in India, where they will store solar-generated electricity for off-grid consumers and businesses in rural areas. This sets a new record for the largest RFB order for any manufacturer, and gives this technology a chance to be proved on a large scale, especially in a high temperature environment, where RFBs are said to operate more safely—an important attribute in most parts of India and Africa.

One area where RFBs could be of particular use is in the 'off-grid world', where micro-grids and domestic storage coupled with distributed renewables offer a cheap alternative to full-scale electrification. Renewables plus storage would replace costly, polluting diesel generators. This would also include some more economically developed parts of the world, including island communities. This does not rule out their use in grid-connected areas where legislation and increased renewables use are pushing the need for effective energy storage.

Most of the physical footprint of a vanadium flow battery consists of plastic containers. Despite this, the issue of cost is one that must be taken into consideration, with high-quality vanadium being expensive; however recovered vanadium can also be used, thus potentially lowering the price, and importantly, these batteries are able to produce energy at a lower cost than from the grid.

When it comes to longevity, flow batteries have a clear advantage over lithium-ion, which realistically only have 2,000 or 3,000 cycles of useful life, according to some industry experts.

Vanadium batteries can have a 20 to 30-year life span, as there is no deterioration in the quality of the electrolyte as there is with other batteries, and even after this period of time, the vanadium can be recovered and re-used.

Sumitomo Vanadium Redox Flow Battery

To increase capacity in a lithium-ion battery, more cells need to be added, whereas with a vanadium RFB more electrolyte is simply added, meaning that the larger the battery, the cheaper it becomes per kilowatt-hour.

All this begs the question:

Why are we all talking about lithium-ion batteries if vanadium RFBs are superior?

This is a tricky one and may, in fact, all come down to consumer 'confidence'. Many large corporations are backing lithium-ion batteries, and for the buyers of these batteries there is reassurance that if there are any problems the battery can be easily replaced. Vanadium RFBs are, as yet, much less well-known, and may not carry the same level of confidence, or vested interests.

Supply of vanadium

Vanadium is mined, and supplies are currently dominated by China, South Africa, Russia and the US.

Vanadium has a medium risk of supply shortage and a high political risk, due to this concentration of supply.

As previously mentioned, it is not necessary to have high quality vanadium for the purpose of these RFBs, and reclaimed or recycled vanadium is a suitable source. Much vanadium is a by-product of the mining process and is often wasted, meaning that there is a large supply available in tailings and slags that could potentially be retrieved and utilised.

Sources:

http://www.greentechmedia.com/articles/read/Pressure-Mounts-on-Imergy

http://www.businessgreen.com/bg/analysis/2458694/vanadium-the-beautiful-metal-that-stores-energy

Brazil:

Considerable Mineral Wealth

Tom Butcher, Independent Consultant

In addition to its base metal, oil and other natural resources, Brazil has considerable wealth in a variety of minor metals.

Brazil has been having a very hard time of it recently. Whether it has brought it upon itself is, of course, a matter of opinion. For supporters of suspended President Dilma Rousseff, everybody else is to blame. For the opposition, it is of course, Ms Rousseff, ex-president Lula de Silva, and their Workers' Party (PT) who are behind the country's current malaise.

Not least, there's been "Operation Car Wash" – the Petrobras corruption scandal. It seems a little like the play "The Mousetrap" in London – the longest running play of any kind, ever (63 years). One wonders for how long "Operation Car Wash" will run.

I had an interesting conversation with one of my friends the other day, a pre-eminent Brazilian financial journalist living in São Paulo, who said that people outside Brazil more often than not fail to understand both just how staggeringly corrupt Brazilian politics are and the enormity of the sums involved in the Operation Car Wash scandal. Whether we will ever learn all the lurid details, though, remains anybody's guess.

And the country is really hurting from the downturn in demand from China for its commodities. In 2013, at the height of the boom, China overtook the U.S. as Brazil's largest trading partner. According to Stratfor: "*In 2013, nearly 83 percent of Brazil's exports to China were in commodities, including soybeans, iron ore and crude oil.*" From \$46 billion (19% of the country's total exports) in 2013, exports to China dropped to a little over \$40 billion in 2014, and to under \$36 billion in 2015.

Finally, amongst so many other things, there was the tragedy when the Fundão dam at Samarco's mine burst on November 5 last year, killing at least 19 people, leaving hundreds homeless, and wiping out an entire village, in addition to causing catastrophic damage to the local environment. Whatever the culpability may be of Vale and BHP Billiton (joint owners of Samarco), the effect on their businesses both in Brazil and worldwide will probably be significant. A civil suit lodged by the Brazilian Federal Public Prosecution Service is now seeking some 155bn real (US\$43.4 billion) in damages.

These few "local difficulties" aside, Brazil still has a huge amount going for it, if only just in terms of its natural resources, which are considerable.

I thought, therefore, that it might be worth taking a quick look, excluding oil, at just some of its mineral resources, especially its minor metals' resources.

It should be noted that whilst many of the figures I quote are for 2014, they may (and probably have) changed significantly in the last year and more. But, if nothing else, they do illustrate both the scale of Brazil's wealth and how it ranks with that of other countries. I have also quoted Brazilian-sourced figures, as opposed to ones sourced from the U.S. Geological Survey.

Niobium and Tantalum

First and foremost, Brazil is both the world's largest producer and the largest exporter of niobium (or, as many here in the U.S. would say, columbium – even though its name was officially changed back in 1949). Followed by Canada and Australia, it also has the world's largest reserves of the metal.

According to the Brazilian SUMARIO 2015 CAPA - Departamento Nacional de Produção Mineral, the country boasts reserves of 10,827,843 tons (contained mineable metal), constituting 98.2% of global reserves and, in 2014, accounted for 93.7% of world niobium production.

Niobium: World Mine Production
(Metric Tons - Nb_2O_5 Contained in Concentrate)

	2012	2013	2014^P
Brazil	*82,214*	*76,899*	*88,771*
Canada	4,707	5,260	5,000
Other Countries	375	1,000	1,000
Total	***87,299***	***83,159***	***94,771***

Notes: ^{P} – Preliminary Figures

Source: SUMARIO 2015 CAPA - Departamento Nacional de Produção Mineral

The latest figures from the U.S. Geological Survey, published in January 2016, for Brazil's mine production are 50,000 tonnes (niobium content) for both 2014 and, estimated, for 2015..

The country's largest mine (and niobium deposit) is located south of Araxá in the state of Minas Gerais and operated by Companhia Brasileira de Metalurgia e Mineração – CBMM. The second largest is the Catalão mine east of Catalão in the state of Goiás which Anglo American announced, at the end of April, it had sold (together with its phosphate business in Brazil) to China Molybdenum for some US$1.5 billion in cash.

As a good way of securing its niobium supply, this deal, together with the deals struck back in 2011 (when a consortium of five Chinese companies acquired a 15% minority stake in CBMM for US$1.95 billion in cash) and in 2013 (when it bought Rio Tinto's majority stake in the Northparkes copper mine in Australia for more than US$800 million), could, perhaps, be seen as a precursor to China Moly's deal to buy the Tenke Fungurume copper mine in the DRC from Freeport-McMoRan DRC Holdings Ltd., to secure its supply of cobalt.

Perhaps not surprisingly, in addition, Brazil is not only a producer of tantalum, but also home to large reserves. Once again, according to the Brazilian SUMARIO 2015 CAPA - Departamento Nacional de Produção Mineral, the country hosts reserves of 34,279 tons (contained mineable metal), constituting 33.8% of global reserves and, in 2014, accounted for 10.0% of world tantalum production.

Tantalum: World Production of Mineral Concentrate (Metric Tons)

	2013	2014[P]
Rwanda	600	600
DRC	200	200
Brazil	*185*	*118*
Mozambique	115	85
China	60	60
Nigeria	60	60
Ethiopia	8	40
Burundi	20	14
Canada	5	-
Australia	-	-

Notes: [P] – Preliminary Figures

Source: SUMARIO 2015 CAPA - Departamento Nacional de Produção Mineral

Brazil's tantalum reserves are to be found mainly at the Pitinga mine (operated by Mineração Taboca), in the municipality of Presidente Figueiredo-AM, in the state of Amazonas, and owned by Peruvian group Minsur SA.

The mineable reserves in this mine are about 175 Mt of ore (columbite-tantalite), with 35,000 tons of Ta_2O_5 contained. A "polymetallic" ore deposit, the Pitinga mine also contains cryolite (Na_3AlF_6), together with other minerals such as lithium, yttrium, niobium, tin, uranium and thorium.

Other occurrences of titanium are to be found in the northeast of the country in the states of Paraiba, Rio Grande do Norte, and Ceará. Elsewhere it is to be found in Bahia, and the states of Roraima, Rondonia, Amapá, Minas Gerais and Goiás.

Image: Shutterstock

Some Other Minor Metals

Whilst there has been no production of rare earths in Brazil since 2013, a year in which the country produced some 600 tons (2,700 tons in 2012) of monazite from the stockpiles of the Indústrias Nucleares do Brasil (INB) in São Francisco do Itabapoana, the country does host 22,000 tons of reserves, constituting some 17.4% of total global reserves.

In addition to some uranium, Brazil also produces a number of other minor metals, none of them in any very large quantity (although it is the world's ninth largest producer of cobalt), but probably worth noting anyway.

(Continues over)

Other Minor Metals: Production and Reserves (Tons)

	2012	2013	2014p	% Global Production	Reserves	% Global Reserves
Cobalt	1,750	1,871	1,350	3.4	85,000[g]	1.2
Chromium	472,501	485,951	716,674	2.4	570,000[g]	0.1
Lithium	7,084	7,982	8,519	1.3	48,000[g]	0.4
Manganese	2,796	2,833	2,723	15.3	116,000,000[h]	18.3
Titanium	70,952	80,285	83,112	1.2	2,300,000[i]	0.3
Tungsten	381	494	510	0.6	27,825[g]	0.8
Vanadium	0	0	1,032	1.3	175,000[g]	1.1
Zircon	20,425	24,687	23,659	1.5	2,485,000[j]	3.2

Notes:	[a] – primary metal	[f] – vanadium pentoxide
	[b] – mineral lump and chromite concentrate	[g] – contained mineable metal
	[c] – concentrate	[h] – measurable reserves
	[d] – ilmenite concentrate and rutile	[i] – mineable ilmenite
	[e] – metal contained in concentrate	[j] – contained mineable mineral

Source: SUMARIO 2015 CAPA - Departamento Nacional de Produção Mineral

Other Metals

Apart from the minor metals mentioned above, Brazil is, of course, a major large-scale producer of base metals. In 2015, it was the world's third largest producer of iron ore, and bauxite and alumina. In addition, it was the fifth largest producer of tin, the sixth of nickel, and the eighth largest of aluminum metal.

Where from here?

For those who believe in it, Brazil displays all the signs of having falling under the "resource curse". Whatever may be the case, the end of the commodities boom certainly helped strip the country naked economically. Whilst it remains to be seen whether Ms Rousseff's interim replacement, Michel Temer, and his team can set the country firmly on the road to recovery, Brazil still has mineral resources of which many countries would be envious. One can only hope that, going forward, their abundance, and the wealth they represent, are judiciously managed.

Gallium– the practical joker's metal

Gallium has a low melting temperature, in fact so low that it will melt in the palm of your hand, luckily it is not harmful to health either which opens a world of opportunities.

Work a bit slow? A fun way to pass the time is to fashion teaspoons from gallium which moulds easily and looks very similar to aluminium when set. Make a cup of tea for a colleague and watch their amazement as their spoon disappears while stirring.

For interested parties, teaspoon moulding kits and gallium for exactly this purpose are available on the internet.

http://www.techinsider.io/gallium-safe-metal-liquid-mercury-2016-5

Book recommendation: 'The Disappearing Spoon: and other tales of madness, love, and the history of the world from the Periodic Table of elements', Sam Kean, 2010, ISBN 978-0-316-05164-4

A QUICK LOOK AT UK EU REFERENDUM

The future of the United Kingdom in the EU will be put to the vote in a referendum on the 23rd June. With the campaigns on both sides of the debate becoming increasingly hostile, we will attempt to consider some of the key issues that are likely to affect the sector in the event of the UK deciding to leave the EU.

If the vote is for a British exit or 'Brexit'. then there will follow a 2-year 'transition' period; this is the time between the UK notifying the European Council of its intention to depart and the actual departure of the UK, although many believe that much longer would be needed to renegotiate Britain's new relationship with the EU.

What is currently unclear is which model of relationship the Leave campaign envisages for the future: being part of the European Economic Area (EEA) or European Free Trade Association (EFTA), such as Norway or Switzerland, would mean that the UK would continue to be bound by the very 'freedom of movement' principle those wishing to leave object to, and the UK would, in effect, be likely to retain all EU product standards, financial regulations, employment regulations and make substantial financial contributions to the EU in return for access to the market.

The UK would, of course, begin a process of negotiating its own trade agreements with the EU and other countries with which the EU currently has trade agreements, and some believe this would free the UK. Remain campaigners counter, however, that there would be no incentive for the EU—however much it intended to continue its trade relationship with the UK—to offer terms more favourable than those offered to other EU members, as it might lead to other members demanding to leave. And it is questionable whether third countries would be willing to offer the same trade terms to a single nation as to the EU as a whole.

For commodities, it seems there would be a significant potential impact were the UK to leave. For those based outside the EU, access to the UK market may not change significantly; however if the UK and the EU failed to agree trade terms, trade would take place under WTO rules, and there could be increased tariffs on UK goods.

For those UK firms trading with EU counterparties, new trading requirements could be introduced, and as the UK would no longer be part of the Customs Union, new customs tariffs could be created.

At the recent Holman Fenwick Willan breakfast briefing, those with physical commodity trading contracts involving parties based in the UK or elsewhere in the EU were advised to review these in the event of a Brexit, particularly in the case of long-term or master contracts. Other contract issues to consider would be currency and import/export and transit procedures, which may be affected.

A big concern for businesses is whether EU legislation, such as REACH, will continue to apply to UK-based companies importing into the EU, or indeed whether the UK government will implement similar domestic legislation. Again, it appears that this will depend on the type of relationship the UK chose to adopt with the EU.

Whichever way the vote goes, this referendum is certainly an historic moment for the UK.

The outcome of the referendum will be known on the 24th June.

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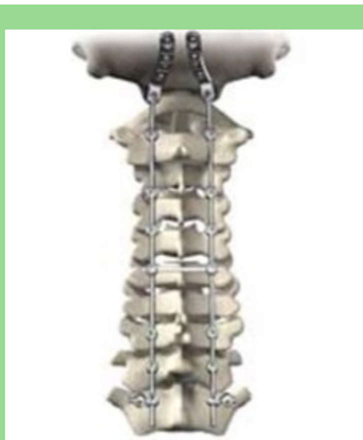
Holman Fenwick Willan Commodities Bulletin April 2016—Brexit—Key Questions for the Commodities Sector

'Tritanium' Posterior Lumbar Cage



Following many years of research and development, world leading medical technology company, Stryker, has announced its new Tritanium Posterior Lumbar Cage, designed to assist lumbar spinal fixation for those with degenerative disc disease.

The cage uses a 3D-printing process to create a proprietary porous titanium alloy (Tritanium) able to mimic spongy bone tissue (cancellous bone) and integrate with the patient's own bone, as well as provide the desired radiographic properties to enable doctors to evaluate the fusion in the longer term.

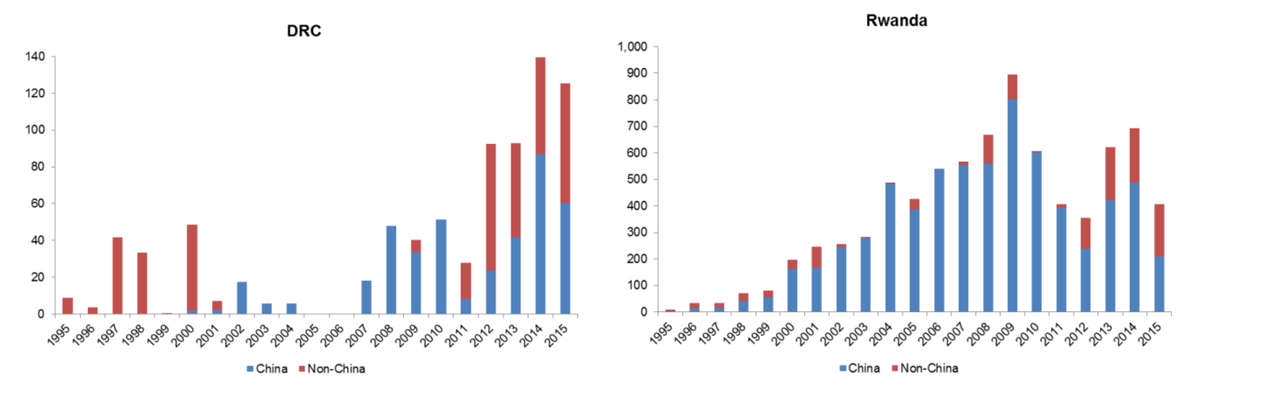
Source: 3D printed spine mimics bone, ASM International May 01, 2016 http://www.asminternational.org/news/industry/-/journal_content/56/10180/26286598/NEWS

Tantalum: Lessons learned, or will history repeat itself? Time will tell.

In 2015, an estimated 62% of global tantalum supply came from Africa, 45% of it from Central Africa, mainly from Rwanda and the DRC. That was not the case in the past and it may not be the case in future. Much depends on whether or not the industry has learned the lessons of the last 15 or so years, and on whether or not it makes the same mistakes again, given that the nature of the industry has changed in many ways.

Although there had long been both conventional and artisanal ("pick and shovel") tantalum production in Africa, it was not until the late 1990s that artisanal mining in Central Africa became a major factor, with the rise in output fuelled by rapid growth in demand for computers, mobile telephones and other consumer electronics that use components containing tantalum. Prior to that, global supply had come mostly from conventional mines in Australia, Brazil and elsewhere, and from slags generated during tin smelting. Slags were once the main source of tantalum, and are still of significance (about 11% of supply in 2015) but their importance fell after the tin crash of the mid-1980s that led to the demise of tin mining in Thailand, where tantalum-rich ores were produced. Even as recently as the mid-2000s, conventional mining still held the number 1 spot, with the Wodgina and Greenbushes mines in Australia alone making up perhaps 60% of total supply.

Recorded imports of tantalum ores and concentrates from the DRC and Rwanda (estimated tonnes Ta_2O_5)



The first real upset came in the early 2000s when rapidly growing demand for tantalum, coupled with a wholly unfounded belief that a shortage of tantalum was imminent, saw market prices spike at US$350/lb Ta_2O_5 (US$772,000/t), which is about six times today's price. A number of major buyers locked-in to long-term supply contracts at the prevailing price. Demand then turned down, there was no shortage and prices tumbled. Buyers were left facing huge financial write-downs and large tantalum inventories that remained in the system for years. Those inventories were made even larger by the US government selling its strategic stockpile of tantalum, albeit over a period of several years.

While that was happening, artisanal supply from Central Africa was growing, as shown in the accompanying charts. The very nature of artisanal mining means that tantalum produced in this way is far lower-cost than material produced from conventional mining. There was a snag, however. Much of the material from Central Africa was coming from the eastern DRC, smuggled out through Rwanda and other countries, and used to fund the various warring factions. The name "conflict tantalum" appeared. Given the uncertainty over where tantalum was really being mined, most processors outside China simply stopped buying ore from anywhere in the region. That, of course, does not mean that they stopped buying downstream materials, such as K-salt (potassium fluorotantalate) or tantalum metal, which were then much harder to trace back to the original mine source.

As time went on, the availability of cheap Central African material made it harder and harder for conventional miners to win the contract prices they needed to continue producing. Although individually negotiated, the contract prices were based on market prices. In late 2008 the Australian producer Talison (formerly Sons of Gwalia and now known as GAM) tried to impose a large increase in its contract prices, which were then probably uneconomic for the company. With the global economic collapse in full swing, very low market prices and a substantial inventory already in the system, it failed and stopped producing, which came as another shock.

Prices did go up again, prompting the by-then GAM to restart production in 2011. That did not last long because prices fell again, resulting in another closure. While all this was going on, the Tanco mine in Canada closed, Marropino in Mozambique failed, the much-vaunted mega-projects in Egypt and Saudi Arabia flatlined and most of the junior mining projects have struggled to raise finance.

What has been happening more recently? Of great importance have been the moves by both governmental organisations and the tantalum industry to clean up the supply chain for Central African tantalum. In the USA, the Dodd-Frank legislation requires SEC-listed companies to report on their sourcing of materials that could be from countries identified as sources of conflict minerals. Contrary to popular belief, Dodd-Frank does not prohibit the purchase of such materials. Companies do, however, have to report whether they are not buying such material, are buying such material or are simply not sure. The last two are a PR nightmare.

It has forced companies to put their supply chains under the microscope, all the way back to the mine. That is not an easy task but "bagging and tagging" systems have been introduced. Industry itself has taken more control over the supply chain, in some cases introducing "closed pipe" initiatives. This has all made a difference, although work remains to be done and smuggling from the DRC via Rwanda continues, albeit it mostly for reasons of simple tax evasion. The net result is that processors in countries other than China are now more willing to purchase material from Central Africa than they were a few years ago, as the charts show. It is worth noting that most major Chinese processors have been very careful about their sourcing for some years.

There are also signs of resurgence in conventional mining. The large Mibra mine in Brazil is now essentially captive to the processor GAM and its future looks secure, at least for the next couple of years until the contract expires and has to be renegotiated. Pitinga, the other large Brazilian mine is expanding, and that expansion will likely continue for several years.
In Australia, reopening of the legacy mines does not seem to be on the cards at the moment but there are several projects in the near-horizon pipeline that could increase tantalum production significantly, along with good potential for increased tantalum supply coming as a by-product of lithium production.

What does the future hold? It is perhaps a good idea to look at past events (and hope that lessons have been learned). Demand for tantalum is not going to suddenly surge; there are no major new applications coming. Overall demand will grow gently, at best.

The artisanal mining sector in Central Africa has been legitimised, not entirely but sufficiently. Increased demand could be met from those sources, quickly and now generally guilt-free. Supply from Australia offers a wholly legitimate option but it will to some extent depend upon the lithium market.

Much will hinge on whether or not the tantalum space has learned from the mistakes of the past and become more rational. Underlying tantalum prices should rise from current levels but not dramatically or erratically. A fall in market prices would render the conventional mining sector uneconomic and would make even artisanal mining somewhat unattractive. Another spike in market prices would surely follow. This has happened before and only time will tell if it happens again.

Personal Cooling System

A team of scientists at Pennsylvania State University is working on a new generation of wearable cooling units which they hope will ultimately be built into firefighting clothing or athletics wear. Previous materials either contained lead or environmentally unfriendly coolants, whilst also being rigid and fragile.

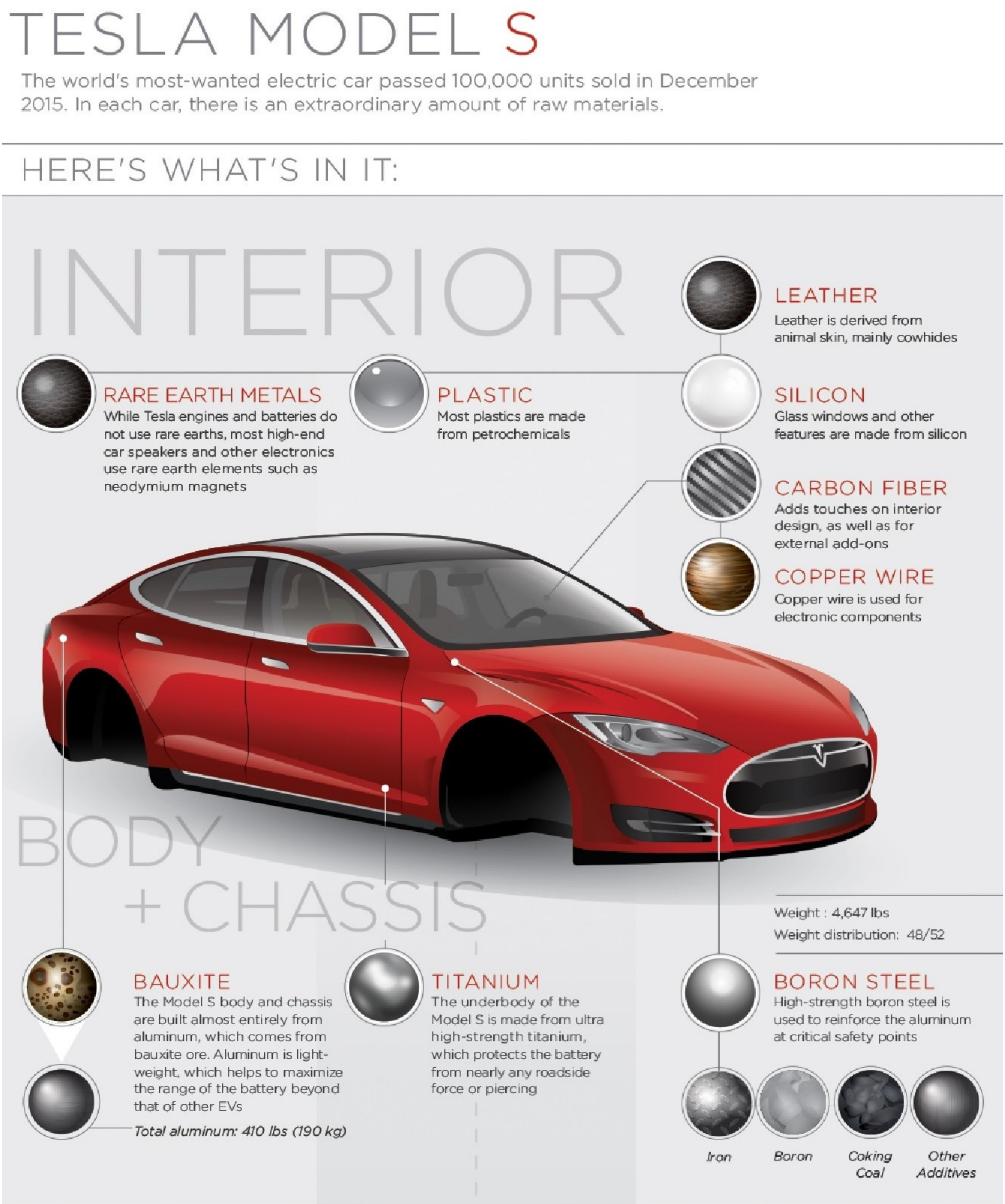
Using a flexible nanowire made of titanium dioxide infused with barium and strontium ions, they have produced a lightweight material that can be attached to different surfaces, including clothing, using an adhesive tape.

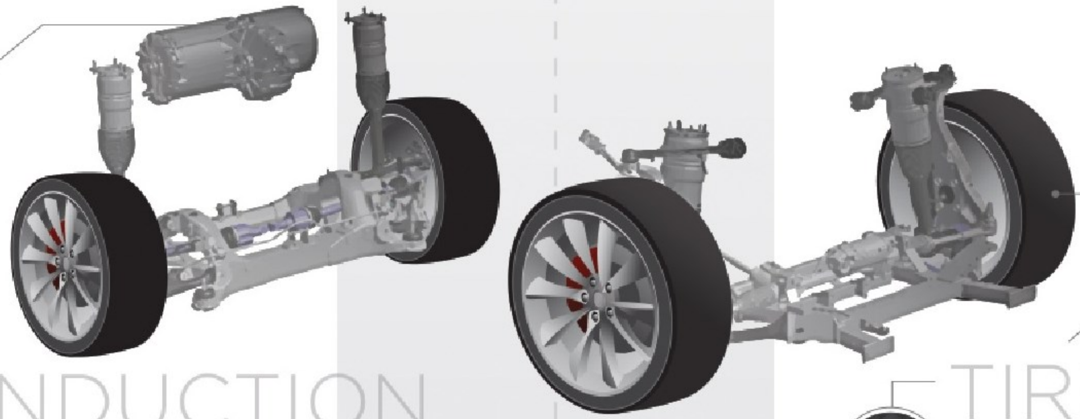
Image caption — *Flexible electrocaloric fabric of nanowire array. Courtesy of Qing Wang/Penn State*

What's inside a Tesla Model S?

Visual Capitalist produces some fantastic infographics, and they kindly gave the Crucible permission to reproduce them. After the popularity of 'What's in an iPhone 6', we're getting inside another consumer of minor metals:

For more illuminating infographics go to http://www.visualcapitalist.com/





INDUCTION ENGINE

STEEL
The stationary piece of the engine, the stator, is made from both copper and steel

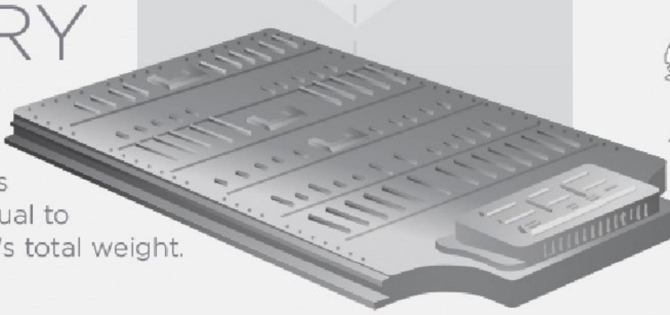
COPPER
Tesla's high-performance copper rotor motor delivers 300 horsepower and weighs 100 lbs (45.4 kg)

TIRES

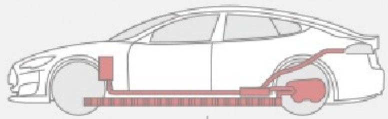
RUBBER
Natural rubber comes from rubber trees, but today 70% of US rubber is synthetic, made from petrochemicals

BAUXITE
Aluminum alloy wheels

BATTERY



The Tesla battery pack weighs 1,200 lbs (540 kg), which is equal to about 26% of the car's total weight.



This puts the car's center of gravity a mere 44.5 centimeters off the ground, giving the car unprecedented stability.

HERE'S WHAT'S IN EACH CELL:

⊕ CATHODE

An NCA formulation is used with the approximate ratio:

- 80% Nickel
- 15% Cobalt
- 5% Aluminum
- Lithium

⊖ ANODE

- Silicon
- Graphite (natural or synthetic) to hold lithium ions

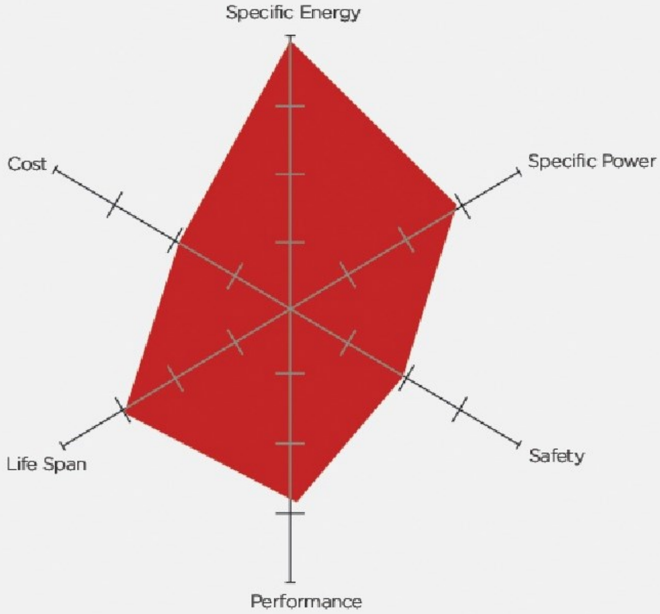
ELECTROLYTE

- Lithium Salt

OTHER

- Copper or Aluminum Foil

BATTERY PROFILE



Source: Battery University

Hypersonic Air Travel

Hypersonic travel that could propel people from London to Sydney in just two hours is one step closer to reality, following a successful test.

The project, which saw US and Australian military scientists combine resources, is on track to launch in 2018 after its latest engine trial hit the target speed of Mach 7.5 - more than seven times the speed of sound.

It could revolutionise global air travel and provide cost-effective access to space, Alex Zelinsky, the chief Australian scientist working on the project said.

For a jet or rocket to be classified as hypersonic, it must travel at five times the speed of sound, or Mach 5. The latest trial at the world's largest land testing site in Australia saw a rocket hit the target speed of Mach 7.5 (5760 miles per hour), reaching an altitude of 279 kilometres.

"We want to be able to fly with a hypersonic engine at Mach 7," Michael Smart, a hypersonic expert from the University of Queensland who is working on the test, told the AFP. "You could fly long distances over the Earth very, very quickly.

"It's also very useful as an alternative to a rocket for putting satellites into space."

The team isn't the only group to be looking at hypersonic technology. Earlier this year, a concept design for the Antipode, which could travel from London to New York in just 11 minutes at 12,427 miles per hour, was released.

Spike Aerospace, an engineering company in Boston, also unveiled plans last year to develop a 12 to 18 seater supersonic private jet that could cross the Atlantic in under four hours. Airbus also filed a patent for a jet called Concorde 2 that could make the journey in an hour.

Source: http://www.telegraph.co.uk/technology/2016/05/18/two-hour-sydney-london-flight-on-track-for-2018-launch/

Holman Fenwick Willan Breakfast Seminar Summary

Members and associates of the MMTA were welcomed to the offices of Holman Fenwick Willan on 26th May for a breakfast seminar on Counterparty Insolvency, Warehouse Fraud and a short Brexit Q&A.

After networking over breakfast, Marc Weisberger, a partner at the firm with extensive experience of trading and investment transactions, restructurings and trade finance across the energy, metals and softs markets, welcomed the attendees with a case study on 'When is a sale not a sale? The Res Cogitans judgment in the Supreme Court'.

This judgment from the 11th May 2016 is relevant to you if:

- You sell on open account terms
- You have retention of title clauses in your sales contracts
- You expect your buyer to consume or transform your material before payment

Graham Denny then presented on Trade Credit Insurance, with a particular focus on the new Insurance Act 2015, which comes into force on 12th August 2016. The main changes brought in by this Act are as follows:

- The concept of "fair presentation of risk" to "replace utmost good faith". Introduction of new knowledge regime.
- Introduces proportionate remedies for breach of the duty of fair presentation.
- Warranties:

  -Abolition of "basis of contract" clauses.

  -Suspensory effect of breach of warranty.
- Clauses excluding or limiting liability for a loss of a particular kind / at a particular time or location not to apply to a loss of a different kind / at a different time or location.
- Fraudulent claims: insurer liable for losses up to fraudulent act but can treat the policy as terminated from time of fraudulent act.

Graham went on to talk about the Enterprise Act 2016 which, from May 2017, will add new provision into the Insurance Act 2015.

Craig Neame was the final speaker, with a fascinating—and entertaining - look at Warehouse Fraud. He began by looking at the differences between warehousing for fast moving consumer goods and metals storage.

He then went on to cover some of the issues that can go wrong with warehousing including theft, fire, acts of god and a recent example of fraud— looking at Qingdao in China.

The MMTA would like to thank HFW for hosting this event and for providing such interesting and thought provoking presentations.

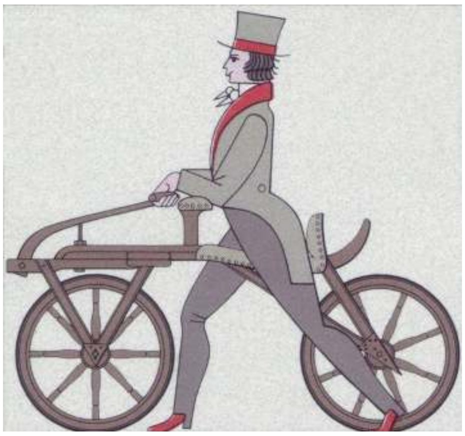
Materials selection in Bicycles

Tamara Alliot, MMTA

The humble bicycle, popular since… well that's quite a disputed date, but from the early 1800s, the ancestors of the modern-day bicycle were certainly in use. One prominent version was the Draisienne, invented in France and patented in 1818. Charles, Baron von Drais, of Sauerbrun devised a front wheel capable of being steered, added a padded saddle, and an armrest in front of the body, which assisted in exerting force against the ground. This first invention is more like a children's balance bike and basically increases walking speed rather than requiring any pedalling. (see image below right). The French influence on the these machines stuck, with bicycles known as 'velocipedes' until around 1869, at which point the word bicycle came into common usage.

Bicycle usage is still going strong today (and even growing). From the thrifty commuter to the Tour de France, this tried and tested mode of transport is used by millions every day around the world.

It is of no surprise that there is a huge choice of bicycle technologies and designs, with their relative positives and negatives analysed in great detail on cycling forums and in magazines. Here, we will focus on the bicycle frames and what material they are made of. This choice has a dramatic effect on the way a bicycle rides, its weight, durability, and, importantly, its cost.



A sketch of the Draisienne velocipede from around 1818

Alloy

To people working in the metal industry, a frame claiming to be made of 'Alloy' seems incredibly vague, but in the cycling world 'Alloy' frames always mean an alloy of aluminium. These bikes tend to be light, cheap and therefore quite popular.

A cyclist may say, however, that an aluminium alloy bike is harsher to ride and doesn't absorb road vibrations as well as other materials. Another downside is the material's tendency to fatigue and fail more quickly than, say, a steel or titanium frame. The average alloy bike has a life expectancy of 4-6 years, if well used.

Some aluminium alloys commonly used in bike frames are Aluminium 2024-T4 which contains small amounts of Cr, Cu, Fe, Mg, Mn, Si, Ti and Zn; and Aluminium 6061-T6 which contains the same alloys as the 2024, but with slightly different proportions. Aluminium alloy 6061 is a medium to high strength heat-treated alloy with a higher strength than other alloys. It has very good corrosion resistance and very good weldability, although reduced strength in the weld zone. It has medium fatigue strength. It has good cold formability in the temper T4, but limited formability in T6 temper. Not suitable for very complex cross sections. Another alloy choice would be Aluminium 7075-T6, a very high strength material used for highly stressed structural parts. Some applications beyond bike frames for this particular alloy are aircraft fittings, gears and shafts, fuse parts, meter shafts and gears, missile parts, regulating valve parts, worm gears, keys, aircraft, aerospace and defence applications; and all terrain vehicle sprockets.

Steel

Steel is a classic bicycle material choice, both sturdy and long lasting. If the bike is looked after appropriately, then a steel bike can last a lifetime. If oiled and cleaned, a steel bike won't rust with the added benefit of not fatiguing like aluminium alloys and will wear well. The obvious issue when compared to aluminium is that steel is much heavier; however, if a high grade of steel is used, this difference is lessened significantly. These high quality steel bikes tend to be hand-made, and this is, of course, reflected in the price. It is possible to get a bargain steel bike, but be prepared when lifting it!

Steel bike aficionados say that a steel bike offers a more comfortable ride than aluminium, so if you are looking for a pleasant journey and durability, steel may be the right choice for you. Common steel alloys in bicycles are high strength steel alloys (generally chromium-molybdenum); one of the most successful older steels was Reynolds "531", a manganese-molybdenum alloy steel.

Beryllium

Yes, really!

A US manufacturer briefly offered a frame made of beryllium tubes (bonded to aluminium lugs), but given the health worries of this material and the price ($26,000 for frame and fork), perhaps unsurprisingly, they never really caught on. Reports stated that the ride was very harsh, but the frame was also very laterally flexible.

Magnesium

Very much a choice for racing bicycles, magnesium is a very lightweight material, offering a 34% weight saving by volume compared to aluminium. Other positive attributes of magnesium include the highest dampening rate of all structural metals and a better fatigue life.
One small issue is that these bikes cost upwards of £3000.

AZ61 alloy, from which some of these racing bikes are made, contains 92% magnesium.

A Paketa custom made magnesium bicycle

Titanium

Titanium is often seen as the perfect frame material for bicycles, whether for racing or commuting, but what exactly is it that makes this metal such a sought-after material, and why is it that in reality, it is not actually that popular?

Titanium certainly has its positives after looking at the other choices; it doesn't rust like steel, doesn't fatigue or give way to rumbling road vibrations like aluminium alloys; it is also strong and won't crack like some non-metallic options, for example carbon fibre.

The main problem with titanium bikes is the price. The metal itself is not that expensive, but due to its properties, it is difficult, and therefore expensive, to cut and weld. If corners are cut during the manufacture of titanium bikes, contamination can happen, causing potentially catastrophic failure when in use.

A titanium bike is a carefully considered purchase, made by someone who is looking for quality at a high price, you are certainly looking at over £2000 for one of these bikes.

Usually, Grade 9 titanium is used for bike frames. This alloy contains 94.5% Ti, 3% aluminium and 2.5% vanadium, and is used because it combines the variety of benefits of other grades, but with an ease of machining not seen in other similar alloys This means that it is significantly stronger than the 'pure' grades of titanium, but is easier to weld and make into something useful; essential for keeping prices down to a vaguely sensible level.

In the interest of fairness, I should also mention that carbon fibre bicycles are also available, as well as frames constructed from more exotic materials, such as bamboo!

Sources: http://depts.washington.edu/matseed/mse_resources/Webpage/Bicycle/Bicycle%20Materials%20Case%20Study.htm

http://www.londoncyclist.co.uk/bike-made/

http://www.paketabike.com/index.cfm?page=technology

https://roadcyclinguk.com/gear/what-should-your-next-bike-be-made-from-carbon-vs-aluminium-vs-steel-vs-titanium.html#fUFMQV79cCxLxtq6.97