International Platinum Group Metals Association

NEWS

Autumn 2012

www.ipa-news.com

Diesel Cars Becoming Much Cleaner

Tighter emissions legislation and technological developments go hand in hand

Over the last four decades, developments in diesel engine technology have provided an encouraging basis for the promotion of diesel vehicles worldwide.

Several emissions control systems take advantage of the catalytic properties of the platinum group metals (PGMs) and play a vital part in controlling releases of carbon monoxide, hydrocarbons, particulate matter, and oxides of nitrogen from diesel vehicle exhausts. These systems, in combination with the use of ultra-low sulphur diesel fuel, will continue to further reduce emissions from diesel engines.

On 12th June 2012 the International Agency for Research on Cancer (IARC), a part of the World Health Organization, classified diesel engine exhaust as carcinogenic to humans. This decision followed a review of evidence, including a U.S. study that measured particulate matter from diesel exhaust in underground mines and linked it to lung cancer among workers.

In making this assessment the IARC did not distinguish between emissions from old diesel engines and emissions from modern diesels using advanced emissions control, although it did acknowledge the progress of regulatory action and tighter emissions standards for diesel engines in North America and Europe.

The vital role of PGMs for clean air

The use of catalyst and diesel particulate filter (DPF) technology has made a significant contribution to reducing emissions from diesel engines in recent years, resulting in the cleanest-ever diesel engine-out emissions.

In the DPF, platinum combined with base metal oxides promotes the catalytic reactions that burn away the particulates (comprising mostly carbon soot combined with unburned or partially burned fuel) which the filter has trapped.

To meet tighter legislation on particulate emissions in Europe, DPFs have been used in all new light duty diesel vehicles since 2009, in addition to a diesel oxidation catalyst (DOC). In the DOC, an oxidizing reaction converts carbon monoxide (CO) and unburned hydrocarbons (HC), and a reduction reaction converts oxides of nitrogen (NOx) to produce carbon dioxide (CO_2), nitrogen (N_2), and water (H_2O).

This technology has enabled particulate emissions limits to be met that are 80% lower than those in 2005 and 96% lower than the first European diesel emission regulations in 1993.

Stricter emission legislation to come

Stringent emissions legislation in the USA has been met with the fitment of a DPF on heavy duty diesel trucks for the control of particulate matter since 2007. The U.S. Environmental Protection Agency (EPA) indicates that diesel accounts for less than 6% of all particulate matter in the air.

In addition, European legislation for new trucks and buses, due to come into force in 2013, will require fitment of a DPF. Further significant improvements to air quality are anticipated from the introduction of tighter legislation to cover non-road diesel engines such as those used in mining and construction equipment.

Within this sector, diesel retrofit technologies have demonstrated their ability to significantly reduce diesel emissions at reasonable costs without jeopardizing vehicle or machine performance.

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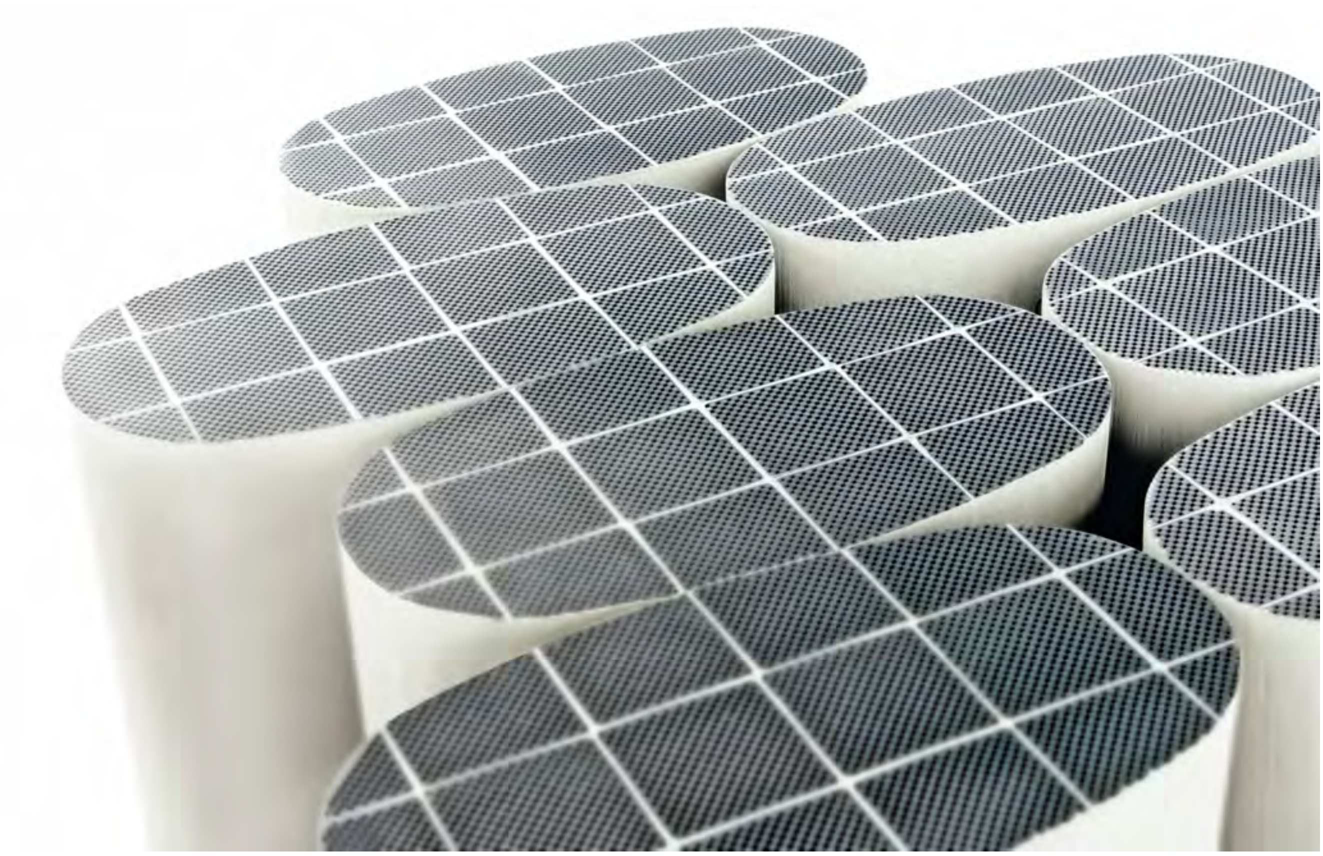


Uncoated substrate for a diesel particulate filter; source: Johnson Matthey

One barrier to the wider use of PGM-based emissions control to minimise particulate emissions is the lack of availability of low sulphur diesel fuel in certain markets.

It becomes obvious that recycling from used material such as catalysts makes a sustainable contribution to the management of the valuable resource of platinum group metals, and preserves the environment to a high degree.

The Chinese Case

For example, China has had to delay the implementation of its China IV emissions legislation for heavy-duty diesel from January 2010 to January 2012 due to the lack of low sulphur fuel. Whereas Chinese refining companies are actually technically able to produce the required fuel quality, the main issue lies with the costs associated to the upgrade of diesel refineries and the distribution of this type of diesel.

Diesel prices in China are still regulated by the state, and introducing low sulphur diesel nationwide would require a substantial increase in diesel prices or similar financial incentives to match the costs to the manufacturers. Usually, emissions standards are implemented with corresponding fuel standards, thereby China IV would have actually required diesel containing only 50ppm of sulphur. Instead, the government decided that the lower fuel standard 350ppm which corresponds to the China III regulation (equivalent to Euro III) would be sufficient for the first months of 2012, and it is not expected that 50ppm diesel will be available before July 2013, as suppliers and the government first have to agree on financial incentives or price increases to market this type of diesel.

Once the availability issue for low sulphur diesel is solved, it is expected that other regions of the world adopt limits similar to those of Europe and North America, thereby enabling the efficient use of PGM after-treatment to reduce harmful emissions.

Technology to reduce emissions already exists

In its recent announcement, the IARC called for wider environmental protection from diesel exhaust. The International Platinum Group Metals Association considers it important to recognize that the technology to control diesel emissions already exists. Moreover, IPA strongly encourages continuing research in diesel engine and catalyst technology to enable legislators to continue to tighten vehicle emission standards worldwide. The development of PGM-based technology supports the automotive industry and its intentions to comply with coming emission legislations.

Platinum group metals and their catalytic properties contribute to the promotion of the future health and wellbeing of all. ■

Tania Bossi, Communications Manager, IPA.

Catalytic Converters for Motorcycles Face Strong Boom in China

Heraeus sees big potential in exhaust catalysts for small engines

When people think about catalytic converters, they mainly have in mind automobiles, where these have been required as an environmental protection measure for years. But for the emission control of small engines in lawnmowers, leaf blowers, chain saws, and motorcycles catalysts are used, too.

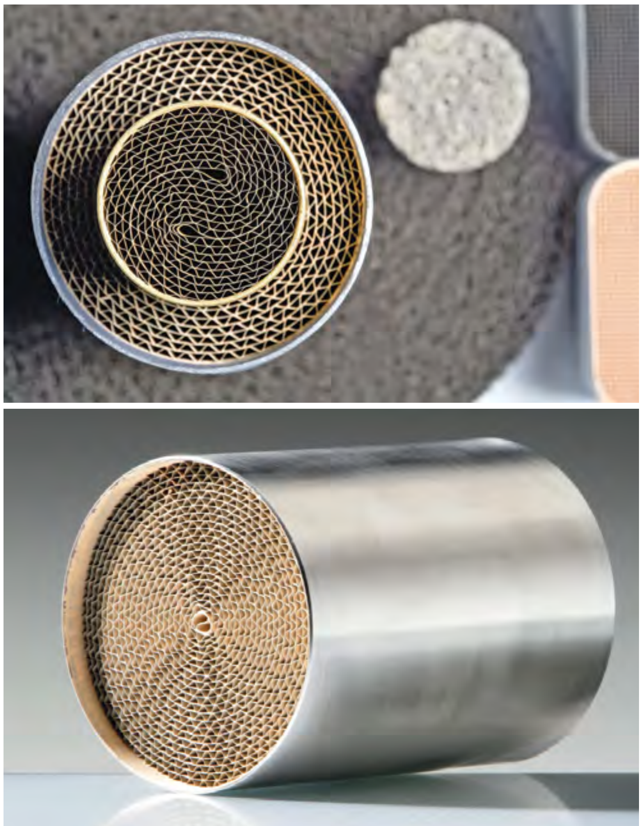
Many Asian countries are accustomed to using two-wheel vehicles for transportation, and the growth in urbanization additionally fuels the boom for motorcycles and other two-wheel vehicles.
One example for this is China: About 25 million motorcycles are produced there each year and over half of all the motorcycles ridden in the world have been build in a Chinese factory. The country is the world's biggest producer of motorcycles with over 400 exporting enterprises employing more than 3 million workers[i]. The rapid development of the Chinese motorcycle industry has led to severe emission problems which the government has aimed to tackle by implementing new emissions legislation in 2010. China now requires motorcycles with combustion engines to have catalytic converters. This has spurred strong demand for new exhaust catalysts.

PGMs enable exhaust catalytic converters for small engines

The catalytic converters contain special coatings made of precious metals such as platinum, palladium, and rhodium. The coating converts the toxic byproducts of combustion into harmless substances – without using up the precious metal itself. Heraeus supplies such. The substrates for the catalysts are cylindrical metal honeycombs or knitted wires built into the exhaust system. These structures support an extremely reactive surface that allows the toxic substances to be quickly and efficiently converted during operation. The thin catalyst coatings, with nanometersized particles of platinum, palladium, and rhodium, are highly resistant under extreme temperature conditions and can be tailored to individual applications.

For many years, the Heraeus precious metals and technology Group has had its own production and sales facilities in rapidly growing regions in Asia. Heraeus Limited, its first subsidiary in China, was founded in Hong Kong in 1974. With dental products, precious metals products, quartz glass, sensors, and specialty light sources, the family-owned company has a strong presence in the Chinese market, employing more than 2,700 people at several production sites and technology centers (Beijing, Hong Kong, Shanghai, Zhaoyuan, Changshu, Danyang, Shenyang, Sihui, and Taicang).

In Danyang, for example, Heraeus Catalysts (Danyang) Co. Ltd. produces emission catalysts for motorcycles in China.



Motorcycle catalyst; source: Heraeus

The joint venture company was founded in 2008 with Jiangsu Golden Changjiang Environmental Protective Motor Muffler Co. Ltd., one of China's largest manufacturers of mufflers. Catalysts have been produced and sold in Danyang since January 2010. The catalysts, coated with precious metals, are a high-quality product that removes pollutants from emissions. The Heraeus joint venture partner integrates these catalysts into mufflers before supplying them to motorcycle manufacturers. ■

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[i] According to 2010 numbers; source: China Motorcycle News www.chinamotorcyclenews.com

Krastsvetmet Develops New Palladium-Based Alloys for the Jewellery Market

The economic crisis of recent years both in Russia and across the world has had a direct impact on the jewellery market within the mass consumption sector, with a shift away from traditional higher cost alloys such as those from palladium, towards cheaper adornments made from silver and non-precious metals. Despite this decline, interest in palladium has not dropped but rather has retained its niche in the Russian jewellery market. At the same time the widespread application of palladium in jewellery production is hindered by the restricted range of palladium-based jewellery alloys available in the jewellery market.

To overcome this issue, the Russian company Krastsvetmet initiated a range of research and engineering work aimed at the development and production of new palladium-based jewellery alloys of 850, 900, 950 and 990 grades. Manufacturing processes have now commenced and various jewellery items have been produced based on the newly developed alloy compositions.

The Russian plant Krastsvetmet is one of the world leading refiners of platinum group metals (PGMs), gold and silver. The high quality of Krastsvetmet's traditional products – PGMs, gold and silver ingots and powders – is recognized and highly regarded worldwide.

In recent years Krastsvetmet has been actively developing new PGM production lines that are outside the traditional areas for the plant. Specifically, the company launched the production of PGM chemical compounds; fine wire drawing and the manufacturing of catalyst gauze for the chemical industry; the production of glass melting machines and glass feeders for the glass fibre industry, as well as thermocouple wire production. Analytical facilities have been enhanced with the establishment of a laboratory for quality control and metallographic study of macro-and microstructure of the alloys and semi-finished products, equipped with modern facilities including electron microscopy.

Krastsvetmet fills gap by testing and producing high-grade Pd alloys

As mentioned above, one of the recently added activities is the development of high grade (850 – 990) palladium alloys and their test in applications.

Palladium alloys are obtained by induction melting in an inert atmosphere, followed by casting into a copper mold. Thermal treatment conditions of ingots and plastic deformation characteristics of semi-finished jewellery items have been identified. The research work involved the analysis of various palladium alloy fusibility diagrams published in scientific literature followed by a selection of the components producing both a continuous series of solid solutions and intermediate intermetallic phases in palladium compounds. The latter can be used as dopants improving the technological properties of the alloys.

The experimental part consisted of producing various alloys, evaluating their microstructure at various stages of the heat treatment and plastic deformation, measuring the alloys' hardness, estimating an elongation ratio, and finally, using them in the casting, stamping and chain-making stages in the jewellery production process.

As a result of the research the following 850, 900, 950 and 990 grade palladium alloys have been recommended for industrial application (see Table).

TYPES OF PALLADIUM JEWELLERY ALLOYS

No.	Alloy Components	Alloy Grade	Hardness, HV		Elongation, %		Density
			Hard	Soft	Hard	Soft	
1	Pd, Cu, Ni, Zn, In, Ga	850, 900	220	63–126	3	25–35.5	11.34–11.50
2	Pd, Ir, Co, Cu	900, 950	183	100–110	1.5	45	11.6–11.75
3	Pd, Co, Ir, Ag, Fe, Cu	950, 990	173.8–124.1	132.1–83.7	2, 2	21, 29	11.75–11.85

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The first group includes 850 and 900 grade alloys based on a palladium-copper-nickel-zinc alloy doped with indium and gallium. The alloys of this group are widely used in jewellery production at Krastsvetmet, not only for casting, but also for most kinds of plastic working including machine chain production. These alloys have a beautiful white colour, relatively low hardness when annealed (HV = 63 – 126 kgf/mm^2), high coefficient of elongation at break (25 – 35%), and can be well polished.

The second group includes 900 and 950 grade alloys based on palladium-cobalt-copper with an iridium modifying agent. Alloys in this group are of a beautiful white colour; they do not contain nickel; have the hardness of HV=100 – 110 kgf/mm^2 when annealed; can be well polished and used for most kinds of plastic working, in addition to micro casting.

The third group includes high grade palladium-based jewellery alloys of white colour suitable for jewellery production of up to 990 fineness, both by investment micro casting and plastic deformation techniques in chain production including machine methods. These alloys contain cobalt, iridium, copper, silver and iron in addition to palladium.
The required technology for producing the proposed alloy that involves induction melting of the charge, consisting of either pure components or including preformed master alloys, has been developed at Krastsvetmet.

Melting is carried out in a vacuum induction furnace that is filled with an inert gas after degassing. The design of the unit allows loading small amounts of master alloy into the melt in the course of melting.

Chains produced using high-grade Pd alloys; source: Krastsvetmet

Palladium ingot; source: Krastsvetmet

The melt is poured into the fixed copper demountable mold by tilting the crucible-inductor unit. The ingots removed from the mold are cleaned of surface defects and samples are taken for analysis before the ingots are hammer-worked to produce initial billets of the required dimensions, which are then used in jewellery production.

Using this process, the alloys of the third group (950 and 990 grades) are forged into rods of a square cross-section (15 x 15 mm). The rods are rolled and drawn into the wire suitable for chain production. The wire reels are heat treated in the muffle furnace at 800°C for 10 minutes and then used for the manufacture of jewellery chains by ‘Sisma Automatic Machine’ (with an argon arc welding link). The chains produced are successfully forge-worked and “diamond” treated.

As a result of these developments, Krastsvetmet’s palladium-based jewellery alloys of 850, 900, 950 and 990 grades are of fine appearance and for direct use in jewellery production consistent with normal production processes. ■

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On the Occasion of the IPA's 25th Anniversary We Present:
25 Prominent and Promising Applications Using Platinum Group Metals

The International Platinum Group Metals Association (IPA) was founded in 1987 and has since then dedicated its work to promoting the use and knowledge of Platinum Group Metals (PGMs). PGMs play a vital role at the heart of everyday living. One in four goods manufactured today either contains PGMs or has PGMs play a key role in their manufacture. These noble metals will also be central to our future choices in the fields of power generation, transportation, healthcare and a host of other areas.

PGMs are uniquely durable and can be used extremely efficiently meaning that a very little goes a very long way. Their recyclability means that they have a very long lifecycle, allowing them to contribute significantly to the protection of the environment by reducing any negative impact which is normally associated with metal waste disposal. Over 96 per cent of PGMs collected for recycling are successfully recovered through highly-efficient processing techniques.

1. Aircraft Turbines

Civilian air fleets are primarily propelled by turbofan jet engines. Air is forced into the combustion chamber by a series of fans and compressors, then mixed with fuel and ignited. The gas temperature augments as the gas is compressed throughout the engine, and the efficiency of the engine rises dependent on this gas temperature. Advances in technology have led to an increase in the operating temperature, meaning that the materials used have to withstand higher and higher temperatures (1500°C or more). In order to protect the blades from these extreme temperatures, internal air cooling and coatings are used. Also, the blades must be protected against corrosion. Platinum-aluminide coatings are a well-established technology to provide protection against corrosion and their surface allows a further thermal barrier layer to be applied that protects the blade from high temperatures. ■

2. Autocatalysts

By far the largest use of PGMs today is for automobile catalytic converters, a pollution control device fitted to cars, trucks, motorcycles, and non-road engines. Platinum, palladium and rhodium are coated onto a substrate housed in the exhaust system and act as catalysts to reduce levels of carbon monoxide, hydrocarbons and oxides of nitrogen to legislated levels.

Autocatalysts convert over 90 per cent of hydrocarbons, carbon monoxide and oxides of nitrogen from gasoline engines into less harmful carbon dioxide, nitrogen and water vapour. Autocatalysts also reduce the pollutants in diesel exhaust by converting over 90 per cent of hydrocarbons, carbon monoxide and particulate matter into carbon dioxide and water vapour.

Diesel engines operate at lower temperatures than gasoline engines and run with a leaner gas stream containing lots of oxygen. Under these conditions platinum is a more active catalyst for the conversion of CO and hydrocarbons to harmless emissions. However, the addition of some palladium to the platinum catalyst can improve its thermal stability. This is an advantage when reducing diesel particulate matter (PM) from the exhaust. This process involves trapping the PM, or soot, in a filter and then raising the temperature of the system to oxidise the soot to carbon dioxide. At these higher temperatures palladium improves the thermal durability of the catalyst, helping it perform optimally for the lifetime of the vehicle.

As the number of cars on the road increases, further cuts in pollution per vehicle are needed to keep improving air quality. Many governments, including those of the fast growing emerging markets of Brazil, Russia, India, and China – the BRIC countries –, are putting legislation in place to catch up with the standards already implemented in the US, Europe and Japan. Catalysts are now also required on construction and agricultural equipment in many markets. ■

3. Cancer Drugs & Treatment

PGMs' role in the fight against cancer is twofold: as the active ingredient in chemotherapy drugs and in radio-active implants for radiation therapy (brachytherapy).

In the first of these, platinum compounds cisplatin, carboplatin and oxaliplatin have the unique quality of inhibiting the splitting and growth of cancerous cells. These compounds have been particularly successful in the treatment of testicular and ovarian cancers. More recently, palladium compounds have also been successfully tested.

In brachytherapy, implants are made of platinum with the active ingredient of iridium isotopes. These are placed

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directly into tumours, giving a high radiation dose to the tumour while reducing the effect on surrounding healthy tissue.
CarboPalladium-103, a radioactive isotope of palladium, is seeing promising applications in the treatment of prostate cancer. A newly emerging added area of research is potential use in the treatment of breast cancer. Here, still using the principles of brachytherapy, small seeds of Palladium-103, which releases very low doses of radiation over the course of two-months, are permanently implanted directly into the centre of the tumour. The procedure is done in an outpatient setting under local anaesthesia and the patient can go home after a few hours.

Rhodium foil has found its way into mammography x-ray machines. ■

4. Ceramic Capacitors

Multi-layer ceramic capacitors (MLCC) store energy in electronic devices in the form of an electrostatic field. Typically, they consist of two coated conducting plates separated by an insulating material called the dielectric. They are used in broadcasting equipment, mobile telephones, computers, electronic lighting and high voltage circuits to name but a few applications, which all have one thing in common: they require a high reliability. Hence, due to their conductivity, durability, high temperature stability and oxidation resistance, palladium, and to a less extent platinum, are the materials of choice to coat multi-layer ceramic capacitors. ■

5. Computer Hard Disks

Computers have impacted on nearly every aspect of our professional and personal lives in the last two decades. The performance of computer hard disks is reliant upon a complex structure of layered materials, including platinum and ruthenium. Advances in consumer electronics and the increased need for data storage have seen hard disk drives expand their number of applications outside computing, and find use in digital TV recorders and home data centres. The adoption of perpendicular magnetic recording (PMR) technology saw an increase in the ruthenium content, in order to increase the data storage capacity per unit area. This is in keeping with the predictions of Moore's Law, which portends the doubling of data storage density every 18 months. ■

6. Crucibles

Because of their hardness, high melting points and high temperature stability PGMs are the perfect materials for industrial crucibles where high temperatures are necessary to produce chemicals and synthetics with the utmost efficiency. The high temperature stability, melting points and corrosion resistance of platinum, rhodium, and iridium and their alloys allow for higher temperatures to be achieved in crucibles, a key factor in any chemical process.
The "nobility" of PGMs is also crucial. High purity conditions are required for these processes and PGMs' high temperature stability means that they do not contaminate the products being fabricated.

Due to its high melting point and resistance to chemical attack, iridium is the preferred material for crucibles used in the production of high purity single crystals of various metal oxides. Crucibles normally take the form of a cylindrical tube onto which a flat base is welded.

A variety of crystals are grown by a number of different techniques. The principal method of growth involves the pulling of a single crystal from a pool of molten salts contained in the crucible. ■

7. Dental

Palladium, and to a much lesser extent platinum, are the principal platinum group metals used in dental restorations. The metals are usually mixed with gold or silver as well as copper and zinc in varying ratios to produce alloys suitable for dental inlays, crowns and bridges. Small amounts of ruthenium or iridium are sometimes added.

The most common application is in crowns, where the alloy forms the core onto which porcelain and other materials are bonded to build up an artificial tooth. The aim of using PGMs in dental alloys is to provide strength, stiffness and durability whilst the other alloyed metals provide malleability. ■

8. Electrodes & Other Electronics

Platinum, palladium, rhodium and iridium are used to coat electrodes, the tiny components in all electronic products which help establish electrical contact between non-metallic parts of a circuit and control the flow of electricity.

Smaller amounts of palladium are used in conductive tracks in hybrid integrated circuits (HIC) and for plating connectors and lead frames.

Palladium is widely used in electronics applications on account of its electrical conductivity and its durability. Palladium-containing components are used in virtually every type of electronic device, from basic consumer products to complex military hardware. Although each component contains only a fraction of a gram of metal, the sheer volume of units produced results in significant consumption of palladium. ■

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Ethylene absorber helps to reduce spoilage of fresh fruits and vegetables; © Kzenon - Fotolia.com

11. Fuel Cells

Fuel cells are electrochemical devices that convert the energy of a chemical reaction directly into electricity, with heat and water as by-products. The fuel and oxidant (oxygen or air) are supplied externally, enabling them to continue operating as long as they are fed. So, unlike batteries, they never "run out". Platinum and ruthenium play a large role in the technology. Platinum is the catalyst which converts hydrogen and oxygen to heat, water and electricity. Palladium will likely also play a role in the fuel cell, as well, but it is unknown yet how big.

Since most fuel cells are hydrogen based and often require ultra pure hydrogen to operate effectively, palladium will be important to this technology, too. Palladium can be used to generate, purify, store and detect hydrogen, thus performing many important functions in a hydrogen economy. ■

9. Ethylene Absorber

Ethylene is an odourless, colourless gas. Whilst it can be man made, it is also often produced by plants and released into the surrounding atmosphere. Most fruit and vegetables are affected by ethylene as it is a plant hormone that accelerates the ripening of fruit.
Controlling the ethylene concentration in the atmosphere in which fresh fruits and vegetables are stored can have a significant impact on the level of spoilage, quality and shelf life which in turn helps reduce wastage. A palladium based ethylene scavenger named E+™ Ethylene Remover has been developed that helps to keep fruit and vegetables in tip top condition from harvesting and right through its journey to our homes.
Key to the palladium based technology is the interaction of a specific precious metal, palladium, with a carefully selected zeolite support to remove ethylene at low and room temperature. ■

10. Forensic Staining

The science of forensics is most famous for its detection of fingerprints and, in more recent times, the matching of DNA samples.
Osmium tetroxide (the metal's most common form) is used as a stain for fingerprints and DNA. It is relatively inert and does not harm the samples while efficiently revealing fats by binding at double bonds of unsaturated lipids and imparting a dense brownish or black colour. ■

12. Glass

Platinum and rhodium are used in the fabrication of vessels that hold, channel and form the high-quality molten glass that is used, for example, for LCD and plasma screens. With their unique properties, they are able to withstand the harsh conditions under which the raw materials for the glass are melted, including the heat of usually 1650° C.

Row of plasma screens; © Pavel Losevsky - Fotolia.com

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Unlike base metal alloys, platinum and platinum alloys do not react to glass, nor do they oxidize or scale at high temperatures, thereby maintaining the purity of the glass. Rhodium is alloyed with platinum in various proportions from 5 per cent rhodium up to 30 per cent rhodium. The addition of rhodium increases the strength of platinum alloy equipment and extends its life. ■

13. Hydrogen Purification

The discovery of palladium's remarkable ability to absorb hydrogen has since led to uses which take advantage of this affinity. As a thin membrane, palladium will allow hydrogen to permeate through the membrane, but block all other gases. The further discovery of the stability of palladium-silver alloys and the ability to manufacture membranes of these alloys made hydrogen purification using palladium–silver membranes possible. ■

14. Implants

Platinum and iridium are used in aural implants that electrically stimulate the auditory nerve to replace damaged or malfunctioning cochleas in those suffering from deafness. The electrical conductivity, durability, biological compatibility and oxidation resistance of these PGMs make them perfect for the electrodes in the implants.
Likewise, platinum and iridium can be found in retinal implants to improve damaged or deteriorating eyesight. ■

15. Jewellery

Due to its rarity and purity, and its natural white colour, associated with its enduring quality and resistance to tarnishing, platinum has been used for decoration since the 7th century BC. Today, platinum is a very popular metal for bridal jewellery in many countries and as fashion jewellery in Asia in particular. With the rise of consumer wealth, China has become the largest market accounting for 50 per cent of the world's platinum jewellery off take.
Palladium, iridium and ruthenium are used in jewellery as an alloy with platinum to optimize platinum's working characteristics and wear properties. Palladium is also used as an alloying element in white gold.

As jewellery metal on its own palladium has become attractive as a wedding band for men because it is strong, durable and its low density allows bigger and bolder jewellery designs to be created and worn with ease. In recent years, palladium has attracted a growing number of fashion-forward jewellery designers. ■

16. Military

Electronic equipment used by the military has platinum wiring and coating on the circuits which are crucial for functionality. Fuel cells with platinum catalysts are widely used in the military for soldier portable power, submarines, warships, and unmanned aerial and ground vehicles. ■

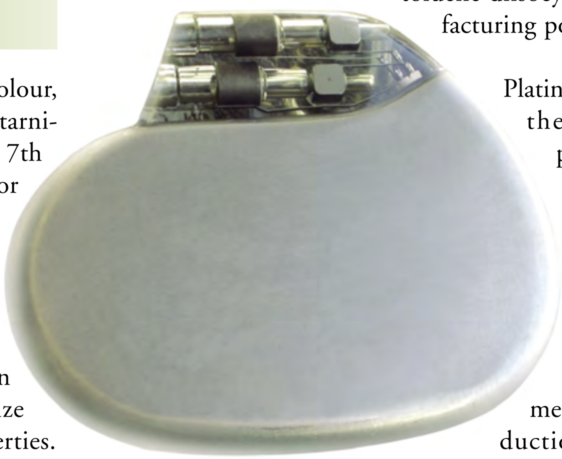
17. Neuromodulation

A neuromodulation device delivers electrical impulses to nerves (usually in the spinal column) or directly to the brain. Such devices are used to treat chronic pain and diseases such as Parkinson's. Similar to pacemakers, this involves an implanted pulse generator to which leads with platinum-iridium electrodes are attached. ■

18. Nitric Acid & Other Chemical Catalysts

Nitric acid is made in three stages. The first step is the oxidation of ammonia gas with air to form nitric oxide. In order to achieve high conversion efficiency, this is normally carried out at pressure over a platinum-rhodium catalyst. The nitric oxide is cooled and further oxidised to form nitrogen dioxide, which is then absorbed in water to nitric acid.

The principal end-use of nitric acid is in the production of nitrogen fertilizers, an important source of plant nutrients. Non-fertilizer uses include the production of: explosive-grade ammonium nitrate; adipic acid, for making nylon, and toluene diisocyanate, for manufacturing polyurethane.



Pacemakers contain platinum-rhodium electrodes; © WoGi - Fotolia.com

Platinum is also used in the production of paraxylene (PX), and a palladium catalyst is used in the production of purified terephthalic acid (PTA). PX and PTA are intermediates in the production of polyethylene terephthalate (PET) used for plastics and polyester textiles. ■

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19. Pacemakers & Defibrillators

Platinum can be fabricated into very tiny, complex components. As it is inert, platinum does not corrode inside the body, while allergic reactions to platinum are extremely rare. As a result, platinum has been used increasingly as a biomaterial. The noble metal also has good electrical conductivity, which makes it an ideal electrode material.

Pacemakers, used to treat heart disorders which result in slow or irregular heartbeat, usually contain at least two platinum-iridium electrodes, through which pulses of electricity are transmitted to stabilise the heartbeat. Platinum electrodes are also found in pacemaker-like devices which are used to help people at risk of fatal disturbances in the heart's rhythm. This risk can be minimised by implanting a device known as an Internal Cardioverter Defibrillator (ICD) which sends a massive electric charge to the heart as soon as it detects a problem.

Catheters, flexible tubes which can be introduced into the arteries, are widely used in modern, minimally-invasive treatments for heart disease. Many catheters contain platinum marker bands and guide wires, which are used to help the surgeon guide the device to the treatment site. The radio-opacity of platinum, which makes it visible in x-ray images, enables doctors to monitor the position of the catheter during treatment.
Coronary stents are another device which is manufactured using platinum alloys (together with chromium). ■

20. Petroleum Refining

Since the 1950s, platinum catalysts have been used in petroleum refineries to reform naphtha into high octane blending components for gasoline (i.e., reformates). This process is called catalytic reforming. Manufacturers of petroleum catalysts coat substrates (e.g., alumina) with platinum solutions. Palladium is used by some refiners for upgrading certain refinery feeds in a process known as hydrocracking. Iridium can also be used in conjunction with platinum in a few niche reforming applications. ■

21. Photography

Platinum and palladium processes for producing photographic prints have been known since the mid 1800s and the early days of photography. As a process descended from the Cyanotype, it was known as Platinotype. Both metals are still used as an alternative process today in producing archival and museum suitable prints. In this form, palladium and platinum are very nearly interchangeable. ■

22. Sensors

Platinum is used for a variety of sensor applications, including oxygen sensors in car exhaust systems. Oxygen sensors are used to help run a gasoline engine more efficiently. The oxygen content is related to the amount of unburned fuel remaining in the engine. The sensor is made of a porous platinum coating on both the inside and the outside of the zirconia tube. The outside is exposed to the exhaust, whereas the inside remains exposed to normal air. The zirconia tube is heated by the exhaust and becomes an ionic conductor. As the oxygen content in the atmosphere at each platinum sensor is different, there will be a potential difference between them. This difference is monitored, and changes are used to control the fuel flow through the engine to ensure that the gas/fuel mixture allows for complete combustion of the fuel. ■

23. Thermocouples

A thermocouple consists of two wires of different metals joined together at one end to enable the temperature of the joint between the two metals to be calculated. Platinum and platinum-rhodium alloys are used for three high temperature standard grades of thermocouples. ■

24. Silicones

Silicones are very durable materials with high resistance to chemical corrosion, fire and extreme temperatures. They are also pliable, waterproof and electrically insulating.
Platinum is used in the manufacture of speciality silicones: adding a platinum compound to the silicone mixture catalyses the cross-linking process which results in the formation of a silicone product with the desired properties.

Platinum catalysts are also used in the production of silicone adhesive that - in the shape of pressure sensitive adhesive - makes notes stick to a surface, a common everyday product that almost everybody uses. ■

25. Water Treatment

Palladium is a very promising catalyst for a process of purifying groundwater contaminated by certain toxic substances that have previously been difficult to remove. The contaminants in question are termed halogenated volatile organic compounds (VOCs). VOCs are some of the most pervasive groundwater pollutants in the United States. These tend to be hydrocarbons that are used as solvents, degreasers, and used in the production of paints and adhesives.

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The United States Geological Survey indicated that in a 2002 study of 1500 drinking water wells, 44 per cent contained at least one VOC. Numerous studies are now underway to pioneer techniques to use palladium as a catalyst to promote the chemical conversion of the contaminants into benign end products in the presence of added hydrogen gas. The reaction essentially replaces the chlorine atoms in the contaminant with hydrogen. ■

Tania Bossi, Communications Manager, IPA.

More about the various uses of PGMs can be found here:

www.ipa-news.com

www.platinum.matthey.com

www.stillwaterpalladium.com

Sustainable Development and Metals: Are We Asking the Right Questions?

Industrial and consumer product manufacturers, retailers and many other branches/sectors are increasingly interested in reducing the environmental and social impacts, as well as optimising the societal benefits, of their products. They are doing this for a variety of reasons such as reducing costs, meeting regulatory and customer expectations, to show progress on their own commitments to create more environmentally and socially responsible products, reducing their contribution to global warming and minimising their exposure to undue supply chain risks (e.g. due to being associated with conflict minerals). In recent years, the focus of these companies' improvement efforts has expanded to include the environmental and social (i.e., sustainability) performance of the materials they purchase and the companies that supply those materials.

One of the key questions for decision makers in companies that want to improve the sustainability of their supply chain is: "how do I select materials for my products that meet traditional technical and cost consideration but that are also produced in an environmentally and socially responsible manner"? To answer this broad question they come to firms like mine (Five Winds Strategic Consulting) and seek out information on where and how materials are produced. Typical questions that are asked include:

- Where do the materials come from?
- What is the carbon footprint of the material (i.e., is the material carbon intense)?
- What is the water footprint?
- Is there any unmanageable environmental or human health risk associated with the material?
- What are the working conditions of the labourers who produce the material?
- Does the country of origin receive a fair share of the wealth created from developing its resources?
- Is that wealth distributed fairly and equitably (e.g. does is go toward the development of the country of origin)?
- If I use this material can it be recaptured or recycled and brought back into the economy?
- Is there already recycled content in the material?

Selection criteria of authorities

Governments and regulatory authorities also have a set of questions when it comes to environmental and socio-economic aspects of how materials are produced. These include:

- Are we getting a fair share of the revenue from the resources developed in our jurisdiction?
- What are the environmental impacts of resources consumed in my jurisdiction?
- Do we have the policies, incentives, programs and market frameworks in place to ensure materials used in our economy are managed efficiently and then recovered and reused?
- Do we have a secure supply of critical materials needed for our industries?

Similar to companies, governments and regulators are also asking questions about the environmental footprint of materials to inform their own procurement decisions.
All of the above are good questions; but there is another set of questions that are often not being asked. These questions are related to the benefits to society from the mining, refining, and smelting operations that produce minerals and metals, examples of these types of questions include:

- Does the production of the materials create long term stable jobs?
- What other types of economic development does the production of the material create?
- Do the companies that produce the materials contribute to community development?

A life cycle oriented view is crucial

Another area that decision makers in end use markets, and governments, are sometimes not properly considering is: what are the life cycle environmental benefits from the use of

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the mineral or metal in a product? A classic example of this type of benefit in the platinum industry is the use of platinum group metals (PGMs) in catalytic converters which significantly reduce the release of smog related emissions, which in turn has significant human health benefits.

So what is the set of questions, or information, needed to get a complete picture of the sustainability performance of mineral and metals, as well as other materials? In my experience decision-makers need to consider a range of impacts and benefits across the full life cycle of the material and the products they go into, including end-of life of the product and future applications of the recovered materials in similar or different product systems. Some key aspects include:

- Does the material perform the function needed in the product or process in an optimal way? Does it work?
- Are the life cycle impacts of the material in the specific product system understood?
- Are there any human or environmental health impacts that need to eliminated, avoided or managed to ensure safe use of the material?
- Can the resource base and the materials that come from it be managed sustainably?
- What are the total costs of using the material? What are the costs relative to alternatives?
- Has the material been developed in a manner that minimises environmental and social impacts and optimises social benefits?
- Are the players along the value chain meeting high standards of performance when it comes to environmental and social practices?

Unfortunately, evaluating materials across all of these areas is not easy because the data and information available on some of these questions can be uneven. Globalisation makes it difficult to track where materials come from and while existing databases can tell us the relative carbon footprint of a range of materials, they cannot easily tell us what the societal benefit of applying those materials in products is.
Today, what I often see are judgements, and decisions, being made on the sustainability performance of materials based on the cradle to gate footprint of a material, along with purchase price and technical criteria. In the future, I believe we will develop the ability to evaluate materials more comprehensively in ways that incorporate a life cycle based view of how materials are produced and used in society. ■

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Imprint
Information pursuant to Sec. 5 TMG and Sec. 55 RSTV

IPA NEWS is the bi-annual newsletter of the International Platinum Group Metals Association.
To receive future issues please email info@ipa-news.com.
Documents and publications indicated by name are on the responsibility of each individual author.

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