


Focus on palladium

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What do dental fillings, catalytic converters, mobile phones and jewellery have in common? They all make use of the metal palladium.

Palladium (chemical symbol Pd) is a precious metal found in the transition metal series of the Periodic Table. With a low relative abundance, there is just over 200 tonnes of this rare element available for use on our planet. However, palladium is needed for a huge range of applications, and particularly valued by scientists as a catalyst for chemical reactions.



Palladium is in a group of the periodic table with nickel and platinum. Like them, it is used for a diverse number of applications including jewellery and catalysts.

Palladium can react with up to 900 times its own volume of hydrogen gas (H_2), mostly without changing the metal's physical properties. When the palladium-hydrogen product is heated, the hydrogen is released again, returning to its original volume so it can be used. Chemists are studying the way that palladium does this in order to mimic it in new devices to store hydrogen for use as an environmentally-friendly replacement for petrol and diesel.

Transition metal catalysts, such as palladium, are of interest because they can change the number of other atoms they are connected to at any time (this is called their valency). Molecules which are bound to the metal can undergo reaction much more easily than an unbound molecule. The molecule then separates away as a changed product. In this process, the molecule is reduced or oxidized - electrons are transferred either to or from the molecule. In a catalytic cycle where the metal is not used up, the palladium then regains its original valency. Thus, a tiny amount of palladium can make product from a large amount of substrate molecule.



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A crystal of palladium with a mass of about 1g and about 1cm in length

Unreacted palladium metal has its greatest use in catalytic converters. These are employed in cars and other vehicles to reduce the amount of toxic and environmentally damaging pollutants that emerge from the exhaust pipe. For example, palladium transforms the damaging greenhouse gas nitrous oxide (N_2O), found in exhaust gases, to nitrogen (N_2) and oxygen (O_2) gases which are non-toxic and already common in the atmosphere. It also accelerates the very slow reaction of deadly carbon monoxide with atmospheric oxygen into the far less dangerous gas carbon dioxide.



Michael KR

The engine from a KTM 990 Super Duke motorbike, showing the catalytic converter

Palladium is also used in fine jewellery. It has a similar look to platinum but although it does not tarnish, it forms a faint bronze-coloured patina (oxide coating) when exposed to water vapour in the air. It can also be alloyed with gold to form a mixture called white gold. At less than half the price of platinum, palladium is becoming a very popular jewellery metal. These same properties also make the metal useful in dental fillings.



Eurico Zimbres

Ear-rings made from white gold, an alloy of gold and palladium; the gemstones are diamond and emerald.



A one ounce ingot of high purity palladium – a valuable commodity

Many rare metals, including Pd, are used in microelectronics for devices such as mobile phones and laptop computers. With increasing demand for more and more functions per device, components have to get smaller, requiring the use of specialized metals such as this. As such devices are now everyday objects the recycling of their rare metal components is now becoming paramount to their continued production. ‘Urban mining’ refers to the recycling of everyday personal devices for the tiny amounts of metal they have in their components – recycling your mobile phone is imperative for the future of technology.

Palladium is mined in Russia, South Africa and the Americas. It occurs naturally as an alloy (mixture of metals) with other precious metals such as gold or platinum, from which it must be separated by electrolysis before use. Although electrolysis is usually reserved for the extraction of the most reactive metals, it is also appropriate for the separation of two fairly similar metals, which would otherwise be difficult to separate.

Despite the appeal of this metal for all these purposes, supplies of palladium are running out, and the efforts to find cheaper alternatives are increasing. Chemists are developing catalysts made from cheaper metals such as iron and cobalt as alternatives to palladium. However, the usefulness of this beneficial metal is not due to run out any time soon. Recycling will mean that chemists as well as car-drivers and jewellery-wearers will be able to use it for decades to come.

Nessa Carson is a British postgraduate chemistry student at the University of Illinois. She works with metals – including palladium – as catalysts to invent new chemical reactions.