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MATRIC NO: 15/SCI09/006
COURSE CODE: CHM 321
COURSE NAME: INORGANIC CHEMISTRY 2

 APPLICATION OF TRANSITION METAL IN ORGANIC CHEMISTRY

Organic chemistry: This is the chemistry sub-discipline involving the scientific study of the structure, properties and reactions of organic compounds and materials, i.e; matter in its various forms that contain carbon atoms . study of structure includes many physical and chemical methods to determine the chemical compound and chemical constitution of organic compounds and materials; study of properties includes both physical and chemical properties and uses similar methods to evaluate chemical reactivity, with the aim to understand the behavior of the organic matter in its pure form (when possible) but also in solutions, mixtures, and fabricated forms and the study of organic reactions includes probing their scope through use in preparation of target compounds.

Transition elements can be applied as catalysts in the following reactions:

OXIDATION REACTIONS:

The epoxidation, dihydroxylation and aminohydroxylation reactions of alkenes, especially their asymmetric variants, continue to attract considerable attention. The basic principles were covered in the previous review. The use of fluorous solvents has now been demonstrated formany transition metal catalysed reactions. One advantage that they offer for catalyticepoxidation is the fact that molecularoxygen has a high solubility in fluorous solvents. The combination

of O2 with pivalaldehyde and manganese catalysts hasbeen shown to be effective for epoxidation of alkenes in aracemic and enantioselective sense. The fluorous soluble ligand afforded a manganese complex which was insoluble incommon organic solvents, but soluble in the fluorous phase.Indene was converted into indene oxide with high enantioselectivity,although other substrates afforded low selectivity The fluorous phase, containing the active catalyst,could be recycled. Manganese salen complexes have also now been successfullyimmobilised within polymer supports, and still provide high

Whilst the enantiomerically pure manganese salen complexes are still often the most enantio selective available for epoxidation of unfunctionalised alkenes, alternative systems are often reported. For example, End and Pfaltz have used rutheniumbis (oxazoline) complexes to provide up to 69% ee in the epoxidation of stilbene.

The use of methyltrioxorhenium as a catalyst for epoxidationcontinues to attract attention. Herrmann and co-workershave shown that a combination of methyltrioxorhenium withpyrazole affords a highly efficient catalyst for the epoxidation of alkenes. Styrene was converted cleanly into styrene oxide with this catalytic combination.

Reduction reactions

The reduction of various functional groups can often be achieved using transition metal catalysts and a suitable reducing agent: often molecular hydrogen, silanes, boranes orhydrides. Amongst all of the possibilities, metal-catalysed hydrogenation has been the most widely studied, especially asan asymmetric process.Some recently reported examples of rhodium-catalyse dasymmetric hydrogenation of alkenes include the conversion ofthe enamide into the derivatised amino alcohols and the regioselective hydrogenation of dienyl acetate into the allyl acetate both using the Me-DuPhos ligand .Reports of new ligands for asymmetric hydrogenation of alkenes continue to appear, often providing highly selective examples.Ruthenium catalysed hydrogenation of alkenes is also popular,and an interesting example has been provided by Bruneau,Dixneuf and co-workers. The achiral substrate is hydrogenatedwith an enantiomerically pure ruthenium complex into compound , which behaves as propionic acid attachedto a chiral auxiliary. The achiral auxiliary in the substrate is converted into an enantiomerically enriched one prior to a subsequent auxiliary controlled functionalisation.

Lewis acid catalysed reactions:-

Lewis acids are able to catalyse a wide range of reactions. Theaddition of cyanide to aldehydes is one such reaction and hasbeen studied by many groups. Recently, North, Belokon andco-workers have used a titanium (salen) complex to catalyse

the addition of trimethylsilylcyanide to benzaldehyde withlow catalyst loadings. Less work has been reported on theenantioselective addition of cyanide to imines, although it providesa useful route to Î±-amino acids (Strecker synthesis). However, there have been several reports of the enantio selective variant of this reaction by aluminium catalysts,non-metallic catalysts, and with the zirconium catalysts, reported here. The imine is converted into the Î±-aminonitrile with good yield and enantio selectivity Scandium triflate is a good catalyst for the allylation of aldehydes with allylsilanes and stannanes. Aggarwal and Vennallhave detailed the allylation of aldehydes followed by in situ acylation.36 Benzaldehyde allylsilane and acetic anhydride undergo coupling to provide the homoallylic acetate withscandium triflate as the catalyst Kobayashi and co-workers have shown that a three component system comprising of benzaldehyde an amine,such as aniline and allylstannane affords the homoallylicamine The reaction works more quickly in the presence of sodium dodecylsulfate SDS, which provides amicellar system .The allylation of isolated imines with enantiomerically pure palladium complexes has been achieved with up to 82%enantiomeric excess.

 DIFFERENT TYPES OF TRANSITION METALS AND THEIRE USES AND APPLICATION IN ORGANIC
 CHEMISTRY

* Vanadium: This is a medium-hard, [ductile](https://en.wikipedia.org/wiki/Ductility), steel-blue metal. Some sources describe vanadium as "soft", perhaps because it is ductile, [malleable](https://en.wikipedia.org/wiki/Malleable) and not [brittle](https://en.wikipedia.org/wiki/Brittle). Vanadium is harder than most metals, it has good resistance to corrosion and it is stable against [alkalis](https://en.wikipedia.org/wiki/Alkali) and [sulfuric](https://en.wikipedia.org/wiki/Sulfuric_acid) and [hydrochloric](https://en.wikipedia.org/wiki/Hydrochloric_acid) acids.[[13]](https://en.wikipedia.org/wiki/Vanadium#cite_note-HollemanAF-13) It is [oxidized](https://en.wikipedia.org/wiki/Oxidation) in air at about 933 [K](https://en.wikipedia.org/wiki/Kelvin) (660 °C, 1220 °F), although an oxide [passivation](https://en.wikipedia.org/wiki/Passivation_%28chemistry%29) layer forms even at room temperature. [Oxidation states](https://en.wikipedia.org/wiki/Oxidation_states) for vanadium are +2, +3, +4 and +5. Low valency vanadium is usually stabilized with [carbonyl](https://en.wikipedia.org/wiki/Carbonyl) ligands. Oxo ligands for example in [vanadyl ions](https://en.wikipedia.org/wiki/Vanadyl_ion) are common when the valency increases. In most compounds outside the oxidation state of +5, vanadium is [paramagnetic](https://en.wikipedia.org/wiki/Paramagnetic), hampering [NMR spectroscopy](https://en.wikipedia.org/wiki/NMR_spectroscopy). Typical vanadium precursors are [vanadium(III) chloride](https://en.wikipedia.org/wiki/Vanadium%28III%29_chloride) and its adduct with [THF](https://en.wikipedia.org/wiki/THF) .Organometallic chemistry of vanadium is well developed, although it has mainly only academic significance. [Vanadocene dichloride](https://en.wikipedia.org/wiki/Vanadocene_dichloride) is a versatile starting reagent and even finds some applications in organic chemistry.[[25]](https://en.wikipedia.org/wiki/Vanadium#cite_note-wilkinson-25) [Vanadium carbonyl](https://en.wikipedia.org/wiki/Vanadium_carbonyl), V(CO)6, is a rare example of a paramagnetic [metal carbonyl](https://en.wikipedia.org/wiki/Metal_carbonyl). Reduction yields V(CO)−
6 ([isoelectronic](https://en.wikipedia.org/wiki/Isoelectronic) with [Cr(CO)6](https://en.wikipedia.org/wiki/Hexacarbonylchromium)), which may be further reduced with sodium in liquid ammonia to yield V(CO)3−
5 (isoelectronic with Fe(CO)5)l3(THF)3 and [vanadium tetrachloride](https://en.wikipedia.org/wiki/Vanadium_tetrachloride).
* Chromium: **Chromium** is a [chemical element](https://en.wikipedia.org/wiki/Chemical_element) with symbol **Cr** and [atomic number](https://en.wikipedia.org/wiki/Atomic_number) 24. It is the first element in [group 6](https://en.wikipedia.org/wiki/Group_6_element). It is a steely-grey, [lustrous](https://en.wikipedia.org/wiki/Luster_%28mineralogy%29), hard and brittle [metal](https://en.wikipedia.org/wiki/Metal)[[4]](https://en.wikipedia.org/wiki/Chromium#cite_note-4) which takes a high polish, resists [tarnishing](https://en.wikipedia.org/wiki/Tarnishing), and has a high melting point. Metal alloys account for 85% of the use of chromium.[[35]](https://en.wikipedia.org/wiki/Chromium#cite_note-36) The remainder is used in the [chemical](https://en.wikipedia.org/wiki/Chemical_industry), [refractory](https://en.wikipedia.org/wiki/Refractory), and [foundry](https://en.wikipedia.org/wiki/Foundry) industries. Although organochromium chemistry is heavily employed in industrial catalysis, relatively few reagents have been developed for applications in [organic synthesis](https://en.wikipedia.org/wiki/Organic_synthesis). Two are the [Nozaki-Hiyama-Kishi reaction](https://en.wikipedia.org/wiki/Nozaki-Hiyama-Kishi_reaction) (1977) (transmetallation with organonickel intermediate) and the [Takai olefination](https://en.wikipedia.org/wiki/Takai_olefination) (1986)(oxidation of Cr(II) to Cr(III) while replacing halogens). In a niche exploit, certain [tricarbonyl(arene)chromium complexes display benzylic activation](https://en.wikipedia.org/wiki/Benzylic_activation_and_stereocontrol_in_tricarbonyl%28arene%29chromium_complexes).

Nickel: **Nickel** is a [chemical element](https://en.wikipedia.org/wiki/Chemical_element) with symbol **Ni** and [atomic number](https://en.wikipedia.org/wiki/Atomic_number) 28. It is a silvery-white lustrous [metal](https://en.wikipedia.org/wiki/Metal) with a slight golden tinge. Nickel belongs to the [transition metals](https://en.wikipedia.org/wiki/Transition_metal) and is hard and [ductile](https://en.wikipedia.org/wiki/Ductility). Pure nickel, [powdered](https://en.wikipedia.org/wiki/Pulverization) to maximize the reactive [surface area](https://en.wikipedia.org/wiki/Surface_area), shows a significant chemical activity, but larger pieces are slow to react with air under [standard conditions](https://en.wikipedia.org/wiki/Standard_conditions_for_temperature_and_pressure) because an oxide layer forms on the surface and prevents further corrosion ([passivation](https://en.wikipedia.org/wiki/Passivation_%28chemistry%29)). Even so, pure [native](https://en.wikipedia.org/wiki/Native_metal) nickel is found in Earth's crust only in tiny amounts, usually in [ultramafic rocks](https://en.wikipedia.org/wiki/Ultramafic_rock),[[4]](https://en.wikipedia.org/wiki/Nickel#cite_note-4)[[5]](https://en.wikipedia.org/wiki/Nickel#cite_note-5) and in the interiors of larger [nickel–iron meteorites](https://en.wikipedia.org/wiki/Iron_meteorite) that were not exposed to oxygen when outside Earth's atmosphere. The global production of nickel is presently used as follows: 68% in stainless steel; 10% in nonferrous [alloys](https://en.wikipedia.org/wiki/Alloy); 9% in [electroplating](https://en.wikipedia.org/wiki/Electroplating); 7% in alloy steel; 3% in foundries; and 4% other uses (including batteries)[[8]](https://en.wikipedia.org/wiki/Nickel%22%20%5Cl%20%22cite_note-%3A7-8).

Nickel is used in many specific and recognizable industrial and consumer products, including [stainless steel](https://en.wikipedia.org/wiki/Stainless_steel), [alnico](https://en.wikipedia.org/wiki/Alnico) magnets, coinage, [rechargeable batteries](https://en.wikipedia.org/wiki/Rechargeable_battery), electric guitar strings, microphone capsules, plating on plumbing fixtures,[[66]](https://en.wikipedia.org/wiki/Nickel#cite_note-66) and special alloys such as [permalloy](https://en.wikipedia.org/wiki/Permalloy), [elinvar](https://en.wikipedia.org/wiki/Elinvar), and [invar](https://en.wikipedia.org/wiki/Invar). It is used for plating and as a green tint in glass. Nickel is preeminently an alloy metal, and its chief use is in nickel steels and nickel cast irons, in which it typically increases the tensile strength, toughness, and elastic limit. It is widely used in many other alloys, including nickel brasses and bronzes and alloys with copper, chromium, aluminium, lead, cobalt, silver, and gold

* Copper: **Copper** is a [chemical element](https://en.wikipedia.org/wiki/Chemical_element) with symbol **Cu** (from [Latin](https://en.wikipedia.org/wiki/Latin_language): *cuprum*) and [atomic number](https://en.wikipedia.org/wiki/Atomic_number) 29. It is a soft, malleable, and [ductile](https://en.wikipedia.org/wiki/Ductility) metal with very high [thermal](https://en.wikipedia.org/wiki/Thermal_conductivity) and [electrical conductivity](https://en.wikipedia.org/wiki/Electrical_conductivity). A freshly exposed surface of pure copper has a reddish-orange color. Copper is used as a conductor of heat and electricity, as a [building material](https://en.wikipedia.org/wiki/Building_material#Metal), and as a constituent of various metal [alloys](https://en.wikipedia.org/wiki/Alloy), such as [sterling silver](https://en.wikipedia.org/wiki/Sterling_silver) used in [jewelry](https://en.wikipedia.org/wiki/Jewelry), [cupronickel](https://en.wikipedia.org/wiki/Cupronickel) used to make marine hardware and [coins](https://en.wikipedia.org/wiki/Coins), and [constantan](https://en.wikipedia.org/wiki/Constantan) used in [strain gauges](https://en.wikipedia.org/wiki/Strain_gauge) and [thermocouples](https://en.wikipedia.org/wiki/Thermocouples) for temperature measurement. Copper does not react with water, but it does slowly react with atmospheric oxygen to form a layer of brown-black copper oxide which, unlike the [rust](https://en.wikipedia.org/wiki/Rust) that forms on iron in moist air, protects the underlying metal from further corrosion ([passivation](https://en.wikipedia.org/wiki/Passivation_%28chemistry%29)). A green layer of [verdigris](https://en.wikipedia.org/wiki/Verdigris) (copper carbonate) can often be seen on old copper structures, such as the roofing of many older buildings[[14]](https://en.wikipedia.org/wiki/Copper%22%20%5Cl%20%22cite_note-%3A0-14) and the [Statue of Liberty](https://en.wikipedia.org/wiki/Statue_of_Liberty).[[15]](https://en.wikipedia.org/wiki/Copper#cite_note-15) Copper [tarnishes](https://en.wikipedia.org/wiki/Tarnish) when exposed to some [sulfur](https://en.wikipedia.org/wiki/Sulfur) compounds, with which it reacts to form various [copper sulfides](https://en.wikipedia.org/wiki/Copper_sulfide).[[16]](https://en.wikipedia.org/wiki/Copper#cite_note-16)

Copper(III) is most often found in oxides. A simple example is potassium [cuprate](https://en.wikipedia.org/wiki/Cuprate), KCuO2, a blue-black solid.[[52]](https://en.wikipedia.org/wiki/Copper#cite_note-52) The most extensively studied copper(III) compounds are the [cuprate superconductors](https://en.wikipedia.org/wiki/Cuprate_superconductor). [Yttrium barium copper oxide](https://en.wikipedia.org/wiki/Yttrium_barium_copper_oxide) (YBa2Cu3O7) consists of both Cu(II) and Cu(III) centres. Like oxide, [fluoride](https://en.wikipedia.org/wiki/Fluoride) is a highly [basic](https://en.wikipedia.org/wiki/Base_%28chemistry%29) [anion](https://en.wikipedia.org/wiki/Anion)[[53]](https://en.wikipedia.org/wiki/Copper#cite_note-53) and is known to stabilize metal ions in high oxidation states. Both copper(III) and even copper(IV) fluorides are known, [K3CuF6](https://en.wikipedia.org/wiki/Potassium_hexafluorocuprate%28III%29) and [Cs2CuF6](https://en.wikipedia.org/wiki/Caesium_hexafluorocuprate%28IV%29), respectively.[[42]](https://en.wikipedia.org/wiki/Copper#cite_note-Holleman-42) The major applications of copper are electrical wire (60%), roofing and plumbing (20%), and industrial machinery (15%). Copper is used mostly as a pure metal, but when greater hardness is required, it is put into such alloys as [brass](https://en.wikipedia.org/wiki/Brass) and [bronze](https://en.wikipedia.org/wiki/Bronze) (5% of total use).[[21]](https://en.wikipedia.org/wiki/Copper#cite_note-emsley-21) For more than two centuries, copper paint has been used on boat hulls to control the growth of plants and shellfish.[[79]](https://en.wikipedia.org/wiki/Copper#cite_note-79) A small part of the copper supply is used for nutritional supplements and fungicides in agriculture.[[43]](https://en.wikipedia.org/wiki/Copper#cite_note-Boux-43)[[80]](https://en.wikipedia.org/wiki/Copper#cite_note-Applications_for_Copper-80) [Machining](https://en.wikipedia.org/wiki/Machining) of copper is possible, although alloys are preferred for good [machinability](https://en.wikipedia.org/wiki/Machinability) in creating intricate parts.

* Zinc: **Zinc** is a [chemical element](https://en.wikipedia.org/wiki/Chemical_element) with symbol **Zn** and atomic number 30. It is the first element in [group 12](https://en.wikipedia.org/w/index.php?title=Column_12_element&action=edit&redlink=1) of the [periodic table](https://en.wikipedia.org/wiki/Periodic_table). In some respects zinc is chemically similar to [magnesium](https://en.wikipedia.org/wiki/Magnesium): both elements exhibit only one normal oxidation state (+2), and the Zn2+ and Mg2+ [ions](https://en.wikipedia.org/wiki/Ion) are of similar size. Zinc is the 24th most abundant [element in Earth's crust](https://en.wikipedia.org/wiki/Abundance_of_elements_in_Earth%27s_crust) and has five stable [isotopes](https://en.wikipedia.org/wiki/Isotope). The most common zinc [ore](https://en.wikipedia.org/wiki/Ore) is [sphalerite](https://en.wikipedia.org/wiki/Sphalerite) (zinc blende), a [zinc sulfide](https://en.wikipedia.org/wiki/Zinc_sulfide) mineral. The largest workable lodes are in Australia, Asia, and the United States. Zinc is refined by [froth flotation](https://en.wikipedia.org/wiki/Froth_flotation) of the [ore](https://en.wikipedia.org/wiki/Ore), [roasting](https://en.wikipedia.org/wiki/Roasting_%28metallurgy%29), and final [extraction](https://en.wikipedia.org/wiki/Extractive_metallurgy) using [electricity](https://en.wikipedia.org/wiki/Electricity) ([electrowinning](https://en.wikipedia.org/wiki/Electrowinning)).

[Organozinc](https://en.wikipedia.org/wiki/Organozinc_compound) chemistry is the science of compounds that contain carbon-zinc bonds, describing the physical properties, synthesis, and chemical reactions.Many organozinc compounds are important.[[140]](https://en.wikipedia.org/wiki/Zinc#cite_note-142)[[141]](https://en.wikipedia.org/wiki/Zinc#cite_note-143)[[142]](https://en.wikipedia.org/wiki/Zinc#cite_note-144)[[143]](https://en.wikipedia.org/wiki/Zinc#cite_note-145) Among important applications are

* The Frankland-Duppa Reaction in which an [oxalate](https://en.wikipedia.org/wiki/Oxalate) [ester](https://en.wikipedia.org/wiki/Ester) (ROCOCOOR) reacts with an [alkyl halide](https://en.wikipedia.org/wiki/Alkyl_halide) R'X, zinc and [hydrochloric acid](https://en.wikipedia.org/wiki/Hydrochloric_acid) to form the α-hydroxycarboxylic esters RR'COHCOOR[[144]](https://en.wikipedia.org/wiki/Zinc#cite_note-146)
* The [Reformatskii reaction](https://en.wikipedia.org/wiki/Reformatskii_reaction) in which α-halo-esters and aldehydes are converted to β-hydroxy-esters
* The [Simmons–Smith reaction](https://en.wikipedia.org/wiki/Simmons%E2%80%93Smith_reaction) in which the carbenoid (iodomethyl)zinc iodide reacts with alkene(or alkyne) and converts them to cyclopropane
* The [Addition reaction](https://en.wikipedia.org/wiki/Addition_reaction) of organozinc compounds to form [carbonyl](https://en.wikipedia.org/wiki/Carbonyl) compounds
* The [Barbier reaction](https://en.wikipedia.org/wiki/Barbier_reaction) (1899), which is the zinc equivalent of the magnesium [Grignard reaction](https://en.wikipedia.org/wiki/Grignard_reaction) and is the better of the two. In presence of water, formation of the organomagnesium halide will fail, whereas the Barbier reaction can take place in water.
* On the downside, organozincs are much less nucleophilic than Grignards, and they are expensive and difficult to handle. Commercially available diorganozinc compounds are [dimethylzinc](https://en.wikipedia.org/wiki/Dimethylzinc), [diethylzinc](https://en.wikipedia.org/wiki/Diethylzinc) and diphenylzinc. In one study,[[145]](https://en.wikipedia.org/wiki/Zinc#cite_note-147)[[146]](https://en.wikipedia.org/wiki/Zinc#cite_note-148) the active organozinc compound is obtained from much cheaper [organobromine](https://en.wikipedia.org/wiki/Organobromine_compound) precursors
* The [Negishi coupling](https://en.wikipedia.org/wiki/Negishi_coupling) is also an important reaction for the formation of new carbon-carbon bonds between unsaturated carbon atoms in alkenes, arenes and alkynes. The catalysts are nickel and palladium. A key step in the [catalytic cycle](https://en.wikipedia.org/wiki/Catalytic_cycle) is a [transmetalation](https://en.wikipedia.org/wiki/Transmetalation) in which a zinc halide exchanges its organic substituent for another halogen with the palladium (nickel) metal center.
* The [Fukuyama coupling](https://en.wikipedia.org/wiki/Fukuyama_coupling) is another coupling reaction, but it uses a thioester as reactant and produces a ketone.

Zinc has found many applications as catalyst in organic synthesis including asymmetric synthesis, being cheap and easily available alternative to precious metal complexes. The results (yield and [ee](https://en.wikipedia.org/wiki/Enantiomeric_excess)) obtained with chiral zinc catalysts are comparable to those achieved with palladium, ruthenium, iridium and others, and zinc becomes metal catalyst of choice.

* Palladium:

**Palladium** is a [chemical element](https://en.wikipedia.org/wiki/Chemical_element) with symbol **Pd** and atomic number 46. It is a rare and lustrous silvery-white metal discovered in 1803 by [William Hyde Wollaston](https://en.wikipedia.org/wiki/William_Hyde_Wollaston). He named it after the [asteroid Pallas](https://en.wikipedia.org/wiki/2_Pallas), which was itself named after the [epithet](https://en.wikipedia.org/wiki/Epithet) of the Greek goddess [Athena](https://en.wikipedia.org/wiki/Athena), acquired by her when she slew [Pallas](https://en.wikipedia.org/wiki/Pallas_%28daughter_of_Triton%29). Palladium, [platinum](https://en.wikipedia.org/wiki/Platinum), [rhodium](https://en.wikipedia.org/wiki/Rhodium), [ruthenium](https://en.wikipedia.org/wiki/Ruthenium), [iridium](https://en.wikipedia.org/wiki/Iridium) and [osmium](https://en.wikipedia.org/wiki/Osmium) form a group of elements referred to as the [platinum group](https://en.wikipedia.org/wiki/Platinum_group) metals (PGMs). These have similar chemical properties, but palladium has the lowest melting point and is the least dense of them.

The largest use of palladium today is in catalytic converters.[[38]](https://en.wikipedia.org/wiki/Palladium#cite_note-unctad-38) Palladium is also used in jewelry, [dentistry](https://en.wikipedia.org/wiki/Dentistry),[[38]](https://en.wikipedia.org/wiki/Palladium#cite_note-unctad-38)[[39]](https://en.wikipedia.org/wiki/Palladium#cite_note-39) [watch](https://en.wikipedia.org/wiki/Watch) making, blood sugar test strips, aircraft [spark plugs](https://en.wikipedia.org/wiki/Spark_plug), [surgical instruments](https://en.wikipedia.org/wiki/Surgical_instrument), and [electrical contacts](https://en.wikipedia.org/wiki/Electrical_contact).[[40]](https://en.wikipedia.org/wiki/Palladium#cite_note-40) Palladium is also used to make professional [transverse (concert or classical) flutes](https://en.wikipedia.org/wiki/Transverse_flute).[[41]](https://en.wikipedia.org/wiki/Palladium#cite_note-41) As a commodity, palladium [bullion](https://en.wikipedia.org/wiki/Bullion) has [ISO currency codes](https://en.wikipedia.org/wiki/ISO_currency_code) of XPD and 964. Palladium is one of only four metals to have such codes, the others being [gold](https://en.wikipedia.org/wiki/Gold), [silver](https://en.wikipedia.org/wiki/Silver) and platinum.[[42]](https://en.wikipedia.org/wiki/Palladium#cite_note-42) Because it absorbs hydrogen, palladium is a key component of the controversial [cold fusion](https://en.wikipedia.org/wiki/Cold_fusion) experiments that began in 1989.