

Method of generating thermal energy US 20130276771 A1

Editor's Note. This is the first in what might be a series of articles 'disentangling' interesting patents related to LENR- related phenomena. This document is not in itself meant to be 'the patent' but merely an account of the experimental work it reveals.

A huge number of patents are filed with the USPTO every year. In 2015 total applications/grant numbers were 629,000, an increase of 50% over 2005, when the number reported was 417,000. Many of these contain ideas and methods that may never be implemented, indeed some may never be read by anyone but the inventor and the patent office.

I am told that this particular patent has been linked (at least) in LENR Forum before, and I have the assignees permission to re-publish. Public domain or not, I consider it proper to ask since this will be an edited version. This edit is because it is a relatively long and convoluted document, and it is my intention to showcase only the scientific content, and to strip out the legalese required for a patent, but not for 'technical' readers. It is IMHO a remarkable piece of work, and I am hoping to establish contact with a colleague of the original inventor, the late A.J. Groszek, to further illuminate (perhaps) aspects of this discovery. My first thought is that this is 'Low-temperature Hydrinos at work'. What do you think?

Please note that this document has been extensively edited, and further researchers are directed to the original patent filing on the web. In particular the patent document contained more elaborated data-sets showing heat production. This editor has also emboldened small portions of the text in this edited version, mostly those which seem particularly important.

US 20130276771 A1 - Abstract.

This invention relates to a method of generating thermal energy, by contacting the surface of a metal with hydrogen gas, forming a surface having hydrogen absorbed thereon. The hydrogenated surface is then exposed to an oxygen atmosphere, when the oxygen component reacts with the absorbed hydrogen to produce thermal energy. In between these two steps, the metal surface is activated with an atmosphere comprising water. Thermal energy given off during this process is reported to be considerably higher than can be accounted for by chemistry alone.

Inventor Aleksander Jerzy Groszek

Asignee Microscal Two Limited

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Background

Methods of generating thermal energy are of use in many different industries. Particularly of use are methods of storing potential thermal energy which may be released as required. It is also useful to be able to recharge such an energy source, so that more thermal energy can be generated on demand.

WO2009/040539 describes a method of activating compositions comprising transition metals selected from at least one of gold, nickel, copper, ruthenium, molybdenum and platinum. In this document it is described that heat may be generated by the physical and chemical interactions of solid surfaces with gases. The heat evolution may be measured using flow-through micro-calorimetry. A flow-through microcalorimeter may be used to measure the uptake of gases, heat evolution, the sorption of gases and their displacement with carrier gases at a range of temperatures and pressures.

Previously the inventors have found that heat is produced when a metal having hydrogen absorbed thereon is reacted with a pulse of oxygen. **The present inventor has surprisingly found that much more thermal energy may be generated by modifying the surfaces of the metal which may be in the form of powder, particle, flake, fibre, sponge, or is deposited on a support.** Suitable supports include TiO₂, silica, graphite or iron oxides. The metal preferably has a purity of at least 99% and most preferably a purity of at least 99.99%.

This invention provides an effective, efficient and/or environmentally friendly method of generating thermal heat, preferably using low cost materials. It is a further object of the present invention to provide a rechargeable method of generating thermal energy. The figure below shows that the **process in this set-up yields up to 5.3x the expected thermal output.**

The Method and Claims.

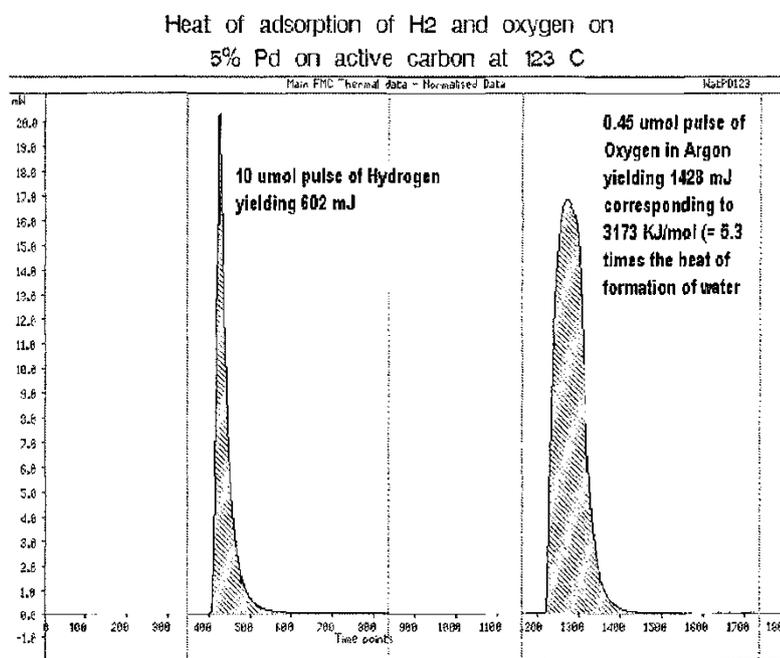
Editors note- some claims are omitted to reduce repetitions where they have been previously described. They have also been changed from a numerical list to a more 'connected' account.

The system provides a method of generating thermal energy as follows:

- (i) Exposing the a surface of a metal to an atmosphere comprising hydrogen and/or a hydrogen source to form a surface having hydrogen absorbed onto it.
- (ii) Exposing this hydrogenated surface to an atmosphere comprising oxygen and/or an oxygen source, causing the oxygen to react with the absorbed hydrogen and produce thermal energy.
- (iii) Where before performing step (ii) the surface is activated with an atmosphere comprising water.

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There is also provided an energy storage apparatus comprising:

- (iv) A vessel containing metal.
- (v) A means for contacting the metal with an atmosphere comprising hydrogen to absorb hydrogen onto the surface of the metal.
- (vi) A means for exposing the metal having hydrogen absorbed thereon to an atmosphere comprising water.
- (vii) A means for exposing the metal to an atmosphere comprising oxygen.

Here “vessel” means a gas tight container, which comprises a means for introducing and releasing a specific gas, or mixture of gases, such that the atmosphere in the vessel may be controlled. The metal surface to be hydrogenated is a transition metal, one or more of gold, nickel, copper, ruthenium, molybdenum, tungsten, cobalt, silver, platinum, iron, palladium. This metal may also be in the form of an alloy of two or more metals. **Preferably for this variant of the method the metal employed may be gold or most preferred, palladium.**

It is important to note that after the hydrogenation step (i) - see page 2- and before exposing the surface to an oxygen atmosphere (ii) at least a portion of the hydrogen which is absorbed

on the surface of the metal is desorbed. For this reason, prior to step (ii) the surface of the metal is from 0.1% to 20% saturated with absorbed hydrogen. This hydrogenated metal is then exposed to atmosphere comprising from 0.1 to 100 μmol of water per gram of metal. Finally the metal surface is exposed to an atmosphere comprising from 0.1 to 50 μmol of oxygen per gram of metal. The oxygen may be delivered in the form of pulses of gas. The metal surface is recharged when required by contact with an atmosphere comprising hydrogen to re-form a hydrogenated surface. This process may be carried out continuously by repeating each step (i, ii) in turn. At this point in the patent document another factor is introduced. 'Claim 15. ...**exposing the surface having hydrogen absorbed thereon to an atmosphere comprising one or more noble gases.**'

Editors comment: I suspect the above is the chosen method for reducing/redistributing hydrogen on the metal surface, the desirability of which is mentioned elsewhere. The experimental work which resulted in this patent seems to have focused mainly on surfaces comprising (a) palladium (b) cobalt and iron and gold, although data suggests other metals have been tested. The methods employed were apparently similar in all cases.

Further Description.

The role of water. The inventor surprisingly found that if the surface of a metal is activated with water before or after it is hydrogenated, when the metal is subsequently exposed to an oxygen source, the heat generated by the reaction of the oxygen and the absorbed hydrogen is significantly more than if the metal is not treated or activated with water. **This result is surprising since typically when looking to activate metal surfaces water is avoided.**

For example WO2009/040539 teaches that "in one embodiment of the present invention, preferably prior to activation of the composition, the composition is exposed to a vacuum. Treatment of the composition in this way has the advantage that unwanted water and gaseous impurities are removed from the composition prior to activation. In another embodiment of WO2009/040539, the composition is exposed to an atmosphere comprising nitrogen prior to activation". Thus, this patent teaches away from exposing the composition to water, and indeed that water is unwanted. **Not so in the case of this invention, where water is shown not to have a deleterious effect on energy evolution.**

The heat generated by the reaction of oxygen atoms with the adsorbed hydrogen occur only as long as the adsorbed hydrogen is available and not totally consumed by the interactions. However, re-absorption of the hydrogen restores the capacity of the metal, for example gold and palladium, to produce these exceptionally high generations of heat. **This process is therefore reversible.**

It is evident that the hydrogen atoms chemisorbed on the metal display extraordinary ability to dissociate oxygen molecules, a highly endothermic process, and then produce exceptionally high heats of the interaction with the oxygen atoms. **It seems therefore that at least a part**

of the chemisorbed hydrogen atoms is in a state of very high potential energy, but the nature of these energetic atoms remains unknown. However, the abnormally high heat evolutions described herein offer considerable opportunity for the development of novel sources of energy.

Note. It will be understood that the term absorption as used here does not preclude adsorption of gases on to the surface of the metal.

The metals used may contain absorbed oxygen. At least some of this oxygen may be removed or partially removed during exposure of the metal to hydrogen. Exposure to hydrogen may reduce the oxides, but preferably some hydrogen is absorbed by the reduced metal atoms or on the unreduced metal oxide groups in the form of chemisorbed atoms.

The Metal Hydrogenation Step- parameters

In step (i) – see page 3 - the surface of the metal is exposed to an atmosphere comprising hydrogen and/or a hydrogen source. Preferably, prior to exposing the surface of a metal to an atmosphere comprising hydrogen and/or a hydrogen source to absorb hydrogen thereon, the surface of the metal is purged with an inert gas at approximately 120° C. In this way, gaseous and other impurities present on the surface of the metal may be removed. Prior to exposure of the surface of the metal with an atmosphere comprising hydrogen and/or a hydrogen source, it may be exposed to an atmosphere comprising nitrogen and/or a noble gas. The noble gas may be selected from argon, neon, helium, or a mixture of two or more thereof. Most preferably the noble gas is argon. Editors Note: It is not totally clear if this 'purging' process is carried out just once, or is repeated regularly during continuous operation.

For some metals, such as palladium, hydrogen can be absorbed at room temperature, from 10 to 130°C.

When the metal is or comprises gold, preferably hydrogen absorption is carried out at from 20 to 130° C.

When the metal is or comprises nickel, preferably hydrogen absorption is carried out at from 150 to 250° C.

When the metal is of comprises copper, preferably hydrogen absorption is carried out at from 120 to 180° C.

When the metal is or comprises ruthenium, preferably hydrogen absorption is carried out at from 50 to 200° C.

When the metal is or comprises molybdenum, preferably hydrogen absorption is carried out at from 150 to 250° C.

When the metal is or comprises tungsten, preferably hydrogen absorption is carried out at from 150 to 250° C.

When the metal is or comprises cobalt, preferably hydrogen absorption is carried out at from 150 to 250° C.

When the metal is or comprises silver, preferably hydrogen absorption is carried out at from 150 to 250° C.

When the metal is or comprises platinum, preferably hydrogen absorption is carried out at from 50 to 150° C.

When the metal is or comprises iron, preferably hydrogen absorption is carried out at from 150 to 250° C.

Hydrogenation, measurement etc.

Preferably, the surface of the metal is exposed to an atmosphere comprising from 0.1% to 100% vol of hydrogen, optionally mixed with an inert gas, to preferably obtain a chemisorbed hydrogen content per gram of metal, from 5 to 100 μmol . More preferably, the surface of the metal is exposed to atmosphere comprising from 80% vol to 100% vol of hydrogen, optionally mixed with an inert gas, to obtain a hydrogen content of the metal ranging from 5 to 50 μmol per gram of the metal

The term “a surface of a metal having hydrogen absorbed thereon” means that the surface has hydrogen atoms chemisorbed onto it. How much hydrogen is absorbed onto the surface may be measured by a thermal conductivity detector which senses and determines the amount of hydrogen in the effluent emerging from the FMC (Flow-through Microcalorimeter) containing the test metal sorbent. Such detectors are known in the art, for example those described in Kung, H. H et al, Journal of Physical Chemistry B 2005, 109, 5498-5502

Such a hydrogenated surface is capable of producing intense heat evolution on contact with molecular oxygen. **For example from 0.1 g to 1.0 g of a metal powder containing at least 10 micromoles of chemisorbed hydrogen atoms will interact with approximately 0.5 micromoles of molecular oxygen to produce 300 - 500 kJmol^{-1} of heat.**

Inventor's comments

The inventor has seen the largest increases in heat generation when prior to step (ii) (exposing the surface having hydrogen absorbed thereon to an atmosphere comprising oxygen and/or an oxygen source) at least some of the hydrogen which is absorbed onto the

surface of the metal is desorbed. Without wishing to be bound by theory, it is thought that this allows regulation and a substantially even distribution of the strongly absorbed hydrogen atoms on the surface of the metal.

After step (i) and before step (ii) at least a portion of the hydrogen which is absorbed on the surface of the metal is desorbed. Desorbing at least a portion of the absorbed hydrogen may be achieved by flowing an inert gas or nitrogen over the surface having hydrogen absorbed thereon. Preferably nitrogen gas is used to desorb at least a portion of the absorbed hydrogen from the surface of the metal. Preferably at least 50%, at least 70%, at least 80% or at least 90% of the initially absorbed hydrogen is desorbed from the metal before step (ii) is carried out based on the total amount of hydrogen absorbed in the metal. After the desorption step preferably, at least between 50% and 5% of the hydrogen remains absorbed in the metal based on the total amount of hydrogen initially present. Without wishing to be bound to any particular theory it is thought that exposure of the surface having high levels of hydrogen absorbed thereon to excessive amounts of oxygen tends to produce liquid water which is associated with low heat evolution. It is thought that evolution of high heats (for example, two, three, four, five or more times the heat of water formation) is not accompanied by the formation of excess water and appears to be related to the reaction (s) between the chemisorbed hydrogen and dissociated oxygen atoms.

Preferably either after step (i) or after step (i) followed by a desorption step, the surface of the metal is from 0.1% to 10% or 20% saturated with absorbed hydrogen. The saturation of the surface with absorbed hydrogen is measured by determining the desorbed hydrogen with a thermal conductivity detector.

Adding Water

Before performing step (ii) the surface of the metal is activated with an atmosphere comprising water. The surface may be activated by exposing it to an atmosphere comprising water before, or after the surface is hydrogenated, for example by wet hydrogen gas, or a wet carrier gas. More preferably still, the surface is activated by exposing it to an atmosphere comprising water after the surface is contacted with an atmosphere comprising hydrogen to form a surface having hydrogen absorbed thereon.

Preferably, the surface of the metal is exposed to an atmosphere comprising from 0.01 μmol to 100 μmol of water per gram of metal. More preferably, the surface of the metal is exposed to atmosphere comprising from 1 to 10 μmol of water per gram of metal. If low levels of water are used in the activation step (for example, less than 0.01 μmol of water per gram of metal) then the level of increase in generation of thermal energy upon exposure to oxygen compared to when the metal is not exposed to water is small. It was also found that if high levels of water are used in the activation step (for example, greater than 100 μmol , or greater than 150 μmol , of water per gram of metal then the metal may be deactivated, it is thought that at such high levels the water prevents or reduces the interaction of the absorbed hydrogen with the oxygen and/or oxygen source. Preferably, the surface of the metal is exposed to water which

is not generated by reaction of hydrogen and oxygen on the surface of the metal. Instead, preferably, “fresh”, new water is added to the system. **The water is actively added to the system, it is not present as a result of a reaction.**

Oxygen, Hydrogen and Noble gases

The oxygen source may be pure oxygen gas having a purity of at least 95%, air, oxygen in an inert gas carrier (*argon, neon and helium are specifically mentioned*), or mixtures of one or more thereof. The oxygen source may for example be or comprise hydrogen peroxide and/or ozone. The reaction is best carried out under conditions such that liquid water is not formed on the surfaces by the reaction of the oxygen and/or oxygen source with the absorbed hydrogen. For metal particles deposited on microporous solids having high surface areas relatively higher levels of water vapour may be tolerated. More preferably, in step (ii) the surface having hydrogen absorbed thereon is exposed to an atmosphere comprising from 0.1 to 50 μmol of oxygen per gram of metal, from 1 to 50 μmol of oxygen per gram of metal, or from 0.05 to 10 μmol of oxygen per gram of metal.

Preferably, prior to hydrogenation the metal surface is purged by an inert carrier gas, at approximately 120° C. In this way, gaseous and other impurities present on the surface of the metal may be removed. An atmosphere comprising nitrogen and/or a noble gas may be used. The noble gas may be selected from argon, neon, helium, or a mixture of two or more thereof. Most preferably the noble gas comprises argon since **the inventor has surprisingly found that if argon is used as a carrier gas for the pulse(s) of oxygen much larger amounts of heat are generated**

Surface area of the powders also needs to be considered. Preferably, the surface is exposed to an atmosphere comprising from 0.5 to 150 μmol of hydrogen per 0.1 to 500 m^2/g specific surface area of the palladium or molar equivalent of cobalt and iron. More preferably, the surface is exposed to an atmosphere comprising from 1 to 100 μmol of hydrogen per 0.1 to 500 m^2/g specific surface area of the palladium or molar equivalent of cobalt and iron. The specific surface area of the metal may be measured by any suitable known technique, for example by a BET adsorption method. It will be understood that the oxygen may be provided as gaseous oxygen, or a source of oxygen, such as hydrogen peroxide. The source of oxygen may be non-gaseous. The inventor found that if the surface having hydrogen absorbed thereon is exposed to an atmosphere comprising less than 0.05 μmol of oxygen per gram of metal then significant heat is typically not generated.

Pulsed Oxygen.

The surface having hydrogen absorbed thereon may be exposed to a pulse of oxygen and/or a source of oxygen. As used herein the term “pulse” is used to describe exposure to a specified gas for a short period of time, typically seconds, or minutes. A ‘pulse’ is not meant to describe a continuous or extended period of exposure of a gas to the composition. A

continuous flow of an atmosphere comprising oxygen, for example oxygen diluted in an inert carrier gas may be used. However, in this case, preferably the amount of oxygen does not exceed the limits stated above.

The surface having hydrogen absorbed thereon may be exposed to repeated pulses of oxygen and/or sources of oxygen. The present inventor have found that by exposing the surface to repeated pulses of oxygen and/or sources of oxygen, large heat effects are seen after several pulses, until little or no heat effect is observed after further additions of pulses of oxygen and/or sources of oxygen. Without wishing to be bound by any particular theory, it is thought that heat effects are observed until all, or almost all of the hydrogen absorbed on the surface has been consumed.

Recharging the system.

After the surface having hydrogen absorbed thereon has been exposed to an atmosphere comprising oxygen and/or a source of oxygen, and preferably after at least some, and preferably all of the absorbed hydrogen has been consumed, the surface may be recharged by contacting it with an atmosphere comprising hydrogen to recreate a hydrogen-rich surface. Thus, the surface may be “recharged” and the process may be repeated. **The method may be performed as a continuous process for the generation of thermal energy by repeating steps (i) and (ii) in turn.**

Systems with no ‘water step’.

Surfaces of both palladium and cobalt/iron show that large amounts of thermal heat may be generated **even in the absence of an activating water step** as described below.

- (i) contacting a surface comprising (a) palladium or (b) cobalt and iron with an atmosphere comprising hydrogen and/or a hydrogen source to form a surface having hydrogen absorbed thereon.
- (ii) Exposing the surface having hydrogen absorbed thereon to an atmosphere comprising oxygen and/or an oxygen source, wherein the oxygen reacts with the absorbed hydrogen to produce thermal energy.

Palladium is known to absorb hydrogen at ambient temperatures and pressures. This absorption of hydrogen is exothermic and it is generally accepted that it occurs after dissociation of hydrogen molecules into atoms. This process may take place during the exposure of palladium immersed in different inert atmospheres, such as nitrogen, helium and argon even when the partial pressure of hydrogen in the gas mixtures falls to very low values. The preferential adsorption of hydrogen is very rapid at room temperatures, producing sharp evolution of heat.

Desorption of the absorbed hydrogen with a flow of nitrogen is relatively slow at room temperature and a pressure around Bar G. 8000 volumes of nitrogen flow being required to

completely desorb hydrogen from palladium powder under these conditions. Desorption times may be longer for finer powders and supported Pd particles, the rates of desorption being indicated by the shape of the heat endotherms. Generally, the rates of desorption are relatively low allowing introduction of pulses of reactants, such as oxygen, into the flow of carrier gas, which then interact with the absorbed hydrogen.

Exceptionally high heat evolution is observed when the surface comprises cobalt and iron together. The inventor has found that if the surface comprises only pure cobalt or iron, the exceptionally high heat evolution is not seen. **Accordingly, the synergistic combination of cobalt and iron is advantageous.** Around 1 wt % cobalt relative to the amount of iron is optimal. If the surface comprises more than 5 wt % cobalt, no additional effect is observed relative to the effect observed when the surface comprises 1 wt % cobalt relative to the amount of iron. Thus on economic grounds a low percentage of cobalt can be used without disadvantage. A 1 wt % cobalt/iron alloy may be produced by co-grinding cobalt and iron powders in a vibratory ball mill or other conventional techniques. Similar alloys can be produced by, for example, co-grinding palladium and iron and nickel and iron.

The reaction using cobalt and iron may be carried out at from 180° C. to 220° C., optimally at 195° C. to 205° C and exposed to atmosphere comprising from 1 to 100 μmol of hydrogen per gram of palladium or molar equivalent of cobalt and iron, preferably an atmosphere comprising from 5 to 50 μmol of hydrogen per gram of palladium or molar equivalent of cobalt and iron.

It is assumed always that oxygen molecules contacting the adsorbed hydrogen atoms dissociate into atoms and then rapidly interact with the adsorbed or absorbed hydrogen. **As previously mentioned, this generated heat exceeds the accepted heat of formation of water from molecular H_2 and O_2 .** Evolution of heat may be affected by helium and argon accompanying oxygen interacting with the hydrogen absorbed by palladium.

Other metals and alloys

It was found that small gold particles supported on TiO_2 leads to a marked increase in the generation of heat produced by the reaction with oxygen. This may also be partly caused by an activating effect of the supporting TiO_2 . For palladium particles supported on an active carbon this effect was detected at temperatures exceeding 100° C. On the other hand, the heat generation by the interaction of oxygen with pure Pd powder at 25° C. is markedly greater than the heat generated at 125° C. For gold, conversely, the interaction with oxygen at 125° C. produces much more heat than that determined at room temperatures.

The palladium may be an alloy. Palladium may be present in combination with one or more of gold, nickel, copper, ruthenium, molybdenum, tungsten, cobalt, silver, platinum, iron. The palladium is preferably in the form of powders, particles, fibres, flakes or sponges. Palladium or cobalt and iron may be deposited on a support, such as TiO_2 , silica, graphite or iron oxide. The palladium or cobalt and iron respectively preferably have a purity of at least 99% and

most preferably a purity of at least 99.99%. The purity of the respective metals may be measured using atomic spectroscopy.

The cobalt and iron may be an alloy or alloys. Cobalt and iron may be present in combination with one or more of gold, nickel, copper, ruthenium, molybdenum, tungsten, silver, platinum, palladium. The cobalt and iron are preferably each in the form of powders, particles, fibres, flakes or sponges or mixtures thereof, or each deposited on a support. Preferably, the cobalt is deposited on the iron. Preferably, the iron is in the form of flakes.

Note on preferred operating pressures

The present invention may be carried out at pressures from atmospheric pressure (approximately 10^5 Pa/g) to 150 bar/g (1.5×10^7 Pa/g). Most preferably the pressure is between atmospheric pressure (approximately 10^5 Pa/g) and 30 bar/g (3×10^6 Pa/g).

Exemplary Experiment 1. 6 Pulses of Oxygen input (in brief)

For those interested the original patent contains much more information and accounts of further experiments together with data tables.

Equipment. The surface energy measurements were carried out using a Microscal Flow-trough Microcalorimeter as described in Chemistry and Industry 25 Mar. 1965, pages 482 to 489 and Thermochemica Acta, 312, 1998, pages 133 to 143. In the experiments described the tubes were extensively purged with the gases under examination to remove the oxygen adsorbed on the walls of the tubes.

The adsorption experiments were conducted by exchanging the flow of nitrogen for those of pure hydrogen, oxygen, noble gas or the gas under investigation. The resulting exposures of the metals to the gases were maintained for seconds or minutes for the pulse experiments, or hours to achieve complete saturation, i.e. until no further uptake of the interacting gases was recorded by the thermal conductivity detector.

The pulses were separated by nitrogen flows long enough to remove any oxygen or noble gas that was not retained (absorbed) by the metal powders. In order to ensure that the pulses of the gases passing through stainless steel capillaries are free from any impurities, especially any adsorbed oxygen on the internal walls of the steel tubing, purification of the internal walls of the tubing was carried out in each case, before the exchanges, for example, by passing at least 100 cc of each gas through the tubing before their exchanges with nitrogen flows.

The abnormal heat generated can reach, for example five to twelve times higher than the heat of formation of gaseous water from molecular hydrogen and oxygen, which offers the development of new sources of energy for domestic and industrial purposes.

Protocol and results. 0.251 g of palladium powder was exposed to a hydrogen atmosphere at 25° C. The palladium powder was then exposed to 0.45 µmol of oxygen in an argon carrier gas. This resulted in 1706 mJ of heat being evolved, which equates to 3791 kJ/mol of heat per mol of oxygen.

The palladium was again exposed to 0.45 µmol of oxygen in an argon carrier gas. This time 1488 mJ of heat were evolved, which equates to 3306 kJ/mol of heat per mol of oxygen.

The palladium was again exposed to 0.45 µmol of oxygen in an argon carrier gas. This resulted in 1413 mJ of heat being evolved, which equates to 3140 kJ/mol of heat per mol of oxygen.

The palladium was then exposed to a further 0.45 µmol of oxygen in a nitrogen carrier gas. This resulted in 618 mJ of heat being evolved, which equates to 1373 kJ/mol of heat per mol of oxygen.

The palladium was then exposed to another pulse of 0.45 µmol of oxygen in a nitrogen carrier gas. This resulted in 658 mJ of heat being evolved, which equates to 1456 kJ/mol of heat per mol of oxygen.

The sample of palladium was then exposed to a final 0.45 µmol of oxygen in a nitrogen carrier gas. This resulted in 668 mJ of heat being evolved, which equates to 1489 kJ/mol of heat per mol of oxygen.

FIG. 1 (see page 3 above) shows the heat evolution at 123 C of a 10 micromole pulse of hydrogen and 0.45 micromole pulse of oxygen mixed with argon (1 cc of 1% vol of oxygen in argon) on 53 mg of Pd/carbon sample containing 5% wt of Pd.

The heat of adsorption of oxygen follows that produced by the hydrogen pulse and its partial desorption by the nitrogen carrier gas before its interaction with 0.45 µmol of oxygen generating heat evolution of 1428 mJ equivalent to 3173 kJ/mol/O₂. **This heat evolution exceeds that of the formation of water from molecular hydrogen and oxygen by a factor of 6.6.**

The high heat evolution was obtained after the Pd particles deposited on an activated carbon were exposed to 5 µmol pulse of water before the interactions with hydrogen and oxygen. The water pulse was almost completely absorbed and is not visible in the figure.

Citations.

Patent	Filed	Granted	Assignees	Title
US4118340 *	7. Jun 1976	3. Oct. 1978	National Distillers And	Novel polymerization catalyst

Patent	Filed	Granted	Assignees	Title
			Chemical Corporation	
US5012719 *	12. Jun 1987	7. May 1991	Gt-Devices	Method of and apparatus for generating hydrogen and projectile accelerating apparatus and method incorporating same
US6534033 *	7. Jan. 2000	18.Mar2003	Millennium Cell, Inc.	System for hydrogen generation
US8697027 *	24. Aug. 2009	15. Apr. 2014	Alliant Techsystems Inc.	Methods and systems of producing hydrogen and oxygen for power generation, and power source
US20050026007 *	28. Jul 2003	3. Feb. 2005	Herman Gregory S.	Method and system for collection of hydrogen from anode effluents
US20100178240 *	22. Oct. 2009	15. Jul 2010	Commissariat A L'energie Atomique	Catalytic system for generating hydrogen by the hydrolysis reaction of metal borohydrides
WO2005118137A1 *	3. Jun 2005	15. Dec. 2005	Microscal Limited	Method for activating a catalyst
WO2009040539A2 *	25. Sept. 2008	2. Apr. 2009	Microscal Limited	A method of activating a composition

Interesting information, and possibly of great interest to those arguing about erroneous calorimetry in any or all of the countless P&F electrolysis experiments performed since 1989. I once again remind those interested to 'go to the source. This is NOT in any way a patent, it is merely a documentary account of the contents of a patent which is possibly 300% longer than this piece.

Looking ahead I am establishing contact with a researcher who actually worked with the original inventor on this project and may have more information later- I am hoping for some images of the equipment in action.

Alan Smith. 11/11/2016.