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1999 APS Paper

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Introduction

Russ George has presented his work at two sessions of the American Physical Society (APS) in 1998 and 1999. These papers are presented on this page.

1999 APS Presentation

For the last many years the author (Russ George) has been engaged in research on nuclear phenomena in deuterated solids. It's become increasingly apparent that these phenomena occur not in bulk materials but rather in very small domains. (see the papers on sono-fusion eruptive phenomena on these web pages). The work of Claytor and Tuggle of Los Alamos National Labs has shown definitively that nuclear products, in their case tritium, were produced from nano-powder Pd in a D2 environment. Further work by the author with nano-particle palladium in 1998 in the lab of Dr. Y. Arata of Osaka who has reported extensively in the Japan Academy on production of 3He and 4He using nano particle Pd has been especially elucidating of the nano domain specificity of these reactions.

At the ICCF-7 conference in Vancouver, B.C. (April 98) one paper in particular reported on the observations of energy and helium phenomena when using particular palladium catalysts materials. The connection is of course that hydrogenation catalysts described by Case were as George first suggested almost certainly active because of the nano dimensional palladium particles. The author approached Dr. Les Case at the conference to discuss ideas for work together that effort led to the following paper.

Experiments such as those described by Case were ideally suited to the application of on-line mass spectroscopic analysis. These experiments were proposed by the author (George) using the EPRI (Electric Power Research Institute) Extrel Quadrapole Mass Spectroscope located at SRI International. Since the author has had a long standing relationship with both EPRI and SRI joint experiments were arranged whereby the author orchestrated, assembled, and with the close cooperation and active participation of SRI personnel, EPRI, and counsel from Les Case performed the experiments described below (which continue).

The following paper describes some of the preliminary results from those experiments. As you read the paper you can listen to a REAL AUDIO interview with Russ on National Public Radio's Science Friday ***Real Audio NPR Science Friday Interview*** *(Drag the Real Audio slider about 3/4 of the way through the segment to find Cold Fusion)*

(Preliminary Paper as presented at the American Physical Society Centennial Conference March 26th, 1999)

Production of ^{4}He from deuterium during contact with nano-particle palladium on carbon at 200° C and 3 atmosphere deuterium

pressure

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Abstract: When a suitable material (nano-particles of palladium on a carbon support) is saturated with deuterium gas (D_2) at a pressure of 3 atmospheres and 200 ^{o}C an isotopic temperature effect (D_2 is hotter) is accompanied by an increasing concentration of ^{4}He. The helium concentration as measured by on-line mass spectroscopy is observed to increase over several weeks ultimately reaching a concentration well in excess of the concentration of ^{4}He measured in the surrounding air. Control phases of experiments with both H_2 and D_2 (in an apparently inactive experiment) show neither excess heat nor increasing ^{4}He.

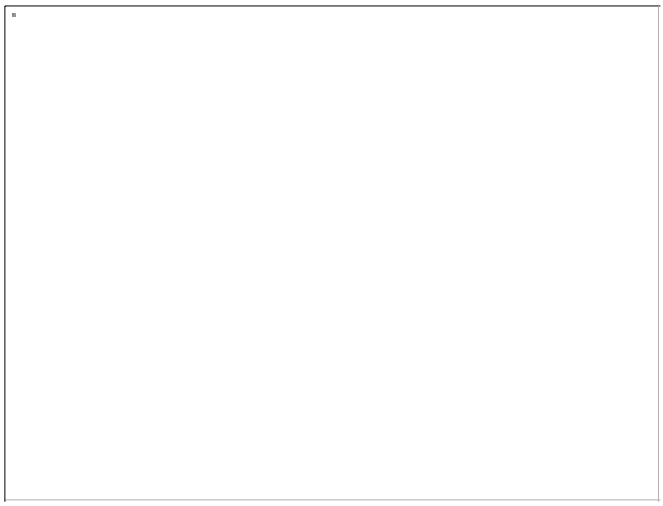
Recently, April 1998, Les Case (New Hampshire, USA) reported at the ICCF-7 scientific conference [1] his work with palladium on carbon materials where saturation with deuterium (D_2) gas and hydrogen (H_2) gas at elevated temperatures revealed an isotope dependent heating effect. This effect was reported to be observable as a higher steady state temperature in D_2 , more than 5° C and roughly equivalent to a few watts in his reaction vessel, when compared with H_2.

Further Case reported on observations of ^{4}He found at a concentrations above 10 ppm measured via giant sector mass spectroscopy at Oakridge National Laboratory. Recognizing Case's work bore similarities of nano-particle palladium, deuterium loading conditions, and helium findings George was familiar with from his own work he contacted Case with the purpose of proposing to replicate the nano-particle palladium on carbon experiments. Cooperating with Case by phone George designed new experiments to be operated within a laboratory provided by SRI International with the active participation of SRI scientists Fran Tanzella and Mike McKubre. We have now replicated and improved upon the measurement of ^{4}He from experiments with the identical materials reported by Case.

The experiments are operated while affixed to an Extrel quadrapole mass spectrometer belonging to the Electric Power Research Institute of Palo Alto, CA. and located at SRI International in near-by Menlo Park, CA. The material (~0.4% by weight Pd on carbon – G75/d) was provided by United Catalyst of Louisville, KY., the same palladium on carbon material used by Case. A variation to Case's experiment was made to conduct the reaction in 50cc stainless steel (SS) Nupro sample flasks (25mm x 135mm) considerably smaller than Case's standard 1.7 liter SS reaction vessels. The experiments are semi-permanently fixed via all metal SS Swagelok and Cajon fittings to an Extrel C-50 Quadrapole Mass Spectrometer. The mass spec is carefully configured and calibrated to provide baseline peak resolution of ^{4}He and D_2 in small gas samples at concentrations of helium down to a few hundred parts per billion (see figure 1). To minimize the deuterium background a liquid nitrogen carbon cold trap was employed on the inlet to the mass spec [2].

The experiment is run by initially loading the 50cc vessel with 10 grams of Pd

carbon material (0.5gm/cc) and high purity hydrogen (~ 0.1 ppm ^{4}He) to ~3.4 atm (50 psig). The vessel is repeatedly flushed to a LN_2 cold trapped vacuum (10^{-4} torr) and re-filled with H_2 to reduce any contaminants on the material. During the gas loading procedure a wrapped Joule heater on the outside of each vessel at about 10 watts establishes a steady state temperature of about 200° C as measured by an internal thermocouple. One vessel was then switched to D_2 via several flushes of high purity deuterium (~ 0.1 ppm ^{4}He) interspersed with evacuation to vacuum performed to remove the residual H_2. The vessels are located within a pair 2 liter dewars filled with vermiculite to help support and insulate them. A computer based data acquisition system collects power and temperature readings in the vessels on five-minute intervals.



Experiment Reactor Vessels (in center) and Dewars Prior to Start of the 28 Day Experiment

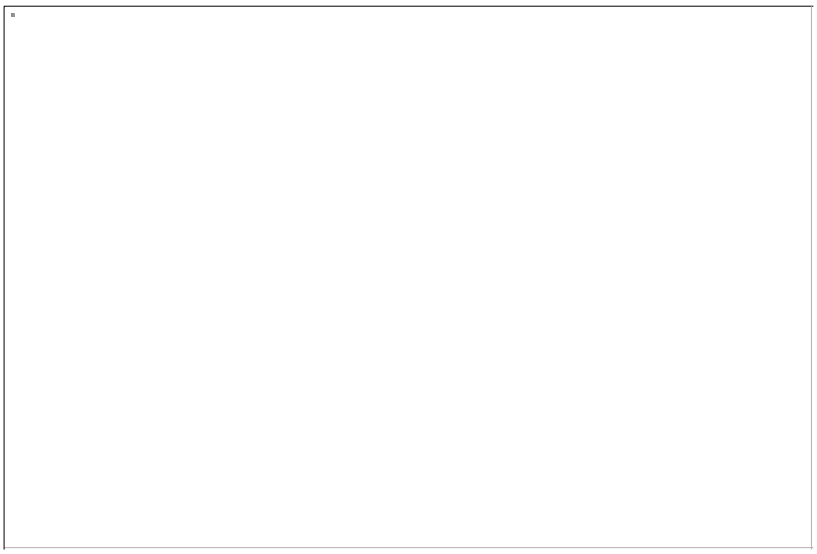
The protocol for helium analysis is to run three gas samples (two calibration control and one experiment sample) through the mass spectrometer, operated by Tanzella and George, one after another over the course of approximately half an hour. Prior to each sample a calibration background sample from the MS instrument and cold trap is analyzed to establish instrument background. The first and third samples are of lab air at ~20 torr, that is taken to be approximately 5.22 ppm ^{4}He based on earlier work and confirmed by the use of calibrated gas standards. These samples are allowed to fill the few ml volume manifold and then passed through the active carbon liquid nitrogen cold trap and into the mass spec. Between the samples the mass spec is evacuated to vacuum. The experiment vessel sample analyses are made in the same fashion. As the experiment is always exposed to this laboratory air it is important to carefully calibrate the mass spec and to insure that any helium found in the experiment vessel cannot be sourced from the helium available as contamination from the lab air. Based on a concentration of 5.22 ppm ^{4}He in the lab air and the pressure of ~3.4 atm in the experiment vessels the maximum helium concentration that could arise in the vessel from a diffusion leak into the vessel would be ~ 1.2 ppm ^{4}He.

At the start of the experiments the helium content of the D_2 and H_2 used to fill the vessels was measured and found to be 0.1 – 0.3 ppm ^{4}He or less. This

appears to be the limit of sensitivity of the mass spec instrument. Once the vessels were filled with D_2 and H_2 (as initial control) the gases were allowed to remain in the vessels for several days at ~ 200° C and then measured for ^{4}He. The ^{4}He was found to still be at the 0.1- 0.3 ppm level in both vessels essentially at the limit of sensitivity of the mass spec instrument.

After loading the now-modified vessel with D_2 and raising the temperature to about 200° C using about 9.3 watts of heating, helium was measured at 0.2ppm (the same level found in the D_2 source cylinder). The Joule heating for the control vessel was ~ 9.7 watts. Our thermometry / calorimetry at this point in time is insufficient to make any declaration as to an excess heat effect. After about 4 days the helium content of the D_2 vessel began to increase on a steady basis. (see data figure 2) while the other "control" vessel showed ^{4}He remaining at the instrument background level of 0.1-0.3 ppm. After several days observing that the background levels of helium had not grown in the control vessel while it appeared to be growing steadily in the D_2 vessel it was decided to flush the H_2 from the control vessel and add D_2. A series of several flushes to vacuum and fills with D_2 was undertaken finally leaving the vessel filled with ~3.4 atm D_2. Over the course of 27 subsequent days analysis samples were taken on a frequent but not quite daily basis (see data figure 1) while the paired vessels were held at ~ 200° - 210° C.

Helium steadily increased in the one vessel exceeding the potential "diffusion leak" concentration of 1.2 ppm on approximately day eight. By day 27 the helium content of the vessel had reached 11.0 ppm ($5x10^{16}$ atoms 4He) well above the ambient air concentration of 5.22 ppm. The rate of ^{4}He production conforms to approximately 90-100 milliwatts of power. This power output conforms very favorably to the expected power of ~100 milliwatts predicted from Case's originally reported power measurements when adjustment is made for the substantially smaller vessel used in these experiments. The "control" experiment tells us the helium we observe is coming from neither the walls of the experimental vessel nor from helium somehow entrained in the starting material and now being cooked out. It is believed this "control" cell is not producing helium because of inadequate flushing of the hydrogen with deuterium during the deuterium filling process. However it is noted that in the extensive experience of Case many palladium on carbon catalyst samples both from United Catalysts and other suppliers do not produce the observed isotopic heating effect.



Experimental Set-Up in SRI's Laboratory where the helium findings reported here were obtained. Experiments are in the center bounded by the Extrel Quadrapole Mass Spec on the right and control electronics to the left

To further confirm that helium was not trapped in the material before the start of this experiment a sample(~10mg UC G75-d catalyst) was analyzed in the laboratory of Prof. Y. Arata in Osaka Japan. Heating the sample to a temperature in excess of 1300° C in Prof. Arata's high vacuum QMS that is sensitive to approximately $1x10^6$ atoms of ^4He revealed no significant helium was released from the Pd carbon material [3].

Lending some support to this work is the published work of Y. Arata of Osaka Japan reported in the Japan Academy in 1997 [4] on anomalous heat and production of ^3He and ^4He in ratios highly skewed from natural abundance ratios when deuterium under high pressure is contacted with nano-particle palladium. George whose work in the field has recently focused on nano-domains as the location for these reactions collaborated with Arata in his laboratory in the summer and fall of 1997. That effort contributed to an assumption that the work reported by Case had commonalties to many experiments in this general field.

One feature of the apparent nuclear fusion reactions that this evidence suggests but is unexpected is the absence of energetic penetrating radiation (especially 14Mev neutrons and 23 Mev gammas) which are expected from D+D fusion under plasma or ion beam collision conditions. Further absent are lower energy neutrons that would result from energetic alpha particles (greater than 2 Mev) producing neutrons from spallation reactions on a variety of trace element nuclei. Case had reported that he had looked diligently for the signature of neutrons, tritium, and other energetic nuclear radiations. In spite of enlisting the support in this search of outside labs with suitable equipment to observe these kinds of products none have been observed.

A theoretical mechanism to explain the experimental results is desirable and this data may help us make progress in this direction. Two theoretical aspects of fusion must be attended to in any explanation. First one must somehow get past the Coulomb barrier and fuse the two deuterons. If this occurs then the resulting

compound nucleus is expected to decay into a ^{4}He nucleus in a time frame on the order of $1x10^{-22}$ seconds with the emission of a 23.8 Mev gamma. Since in the present reactions we do not see this energetic and penetrating gamma the second requirement is that this large amount of energy must be coupled to the lattice over a long time frame so that in small packets, phonons perhaps, the 23.8 Mev is conveyed away as heat.

Thus the reaction might be written D+D ® alpha + phonons (23.8Mev)

Conditions needed for such reaction are found within the condensed matter environment of deuterium saturated palladium. The rates of nuclear reactions can differ drastically from those expected in vacuum, due to strong inter-nuclear many-body correlation effects and/or the statistical-mechanical effects inherent in condensed matter systems *[5]*.

Additional experiments are now underway which will contribute to the understanding of these reactions. These include expanded mass spectroscopy studies quantify ^{3}He and its ratio with ^{4}He. Studies of the helium production rates of various similar materials are also scheduled to cross correlate with Case's report that some similar materials do not produce the observed deuterium heating effect. Materials and micro-chemical studies of the active and similar though inactive Pd carbon materials have also been initiated by the George with help from colleagues in allied organizations.

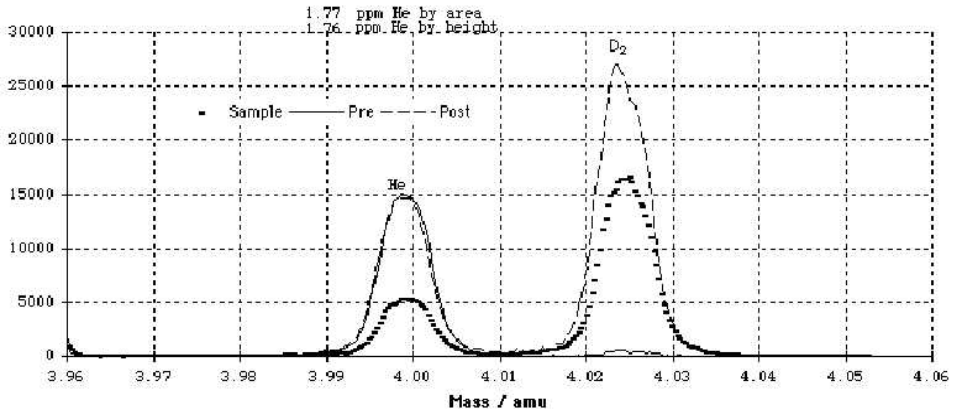


Figure 1 - Typical output from the Extrel Quadrapole mass spectrometer showing full baseline resolution of ^{4}He and D_2. During part of the time of these experiments this excellent mass resolution was somewhat less but did not diminish to less than full peak separation.

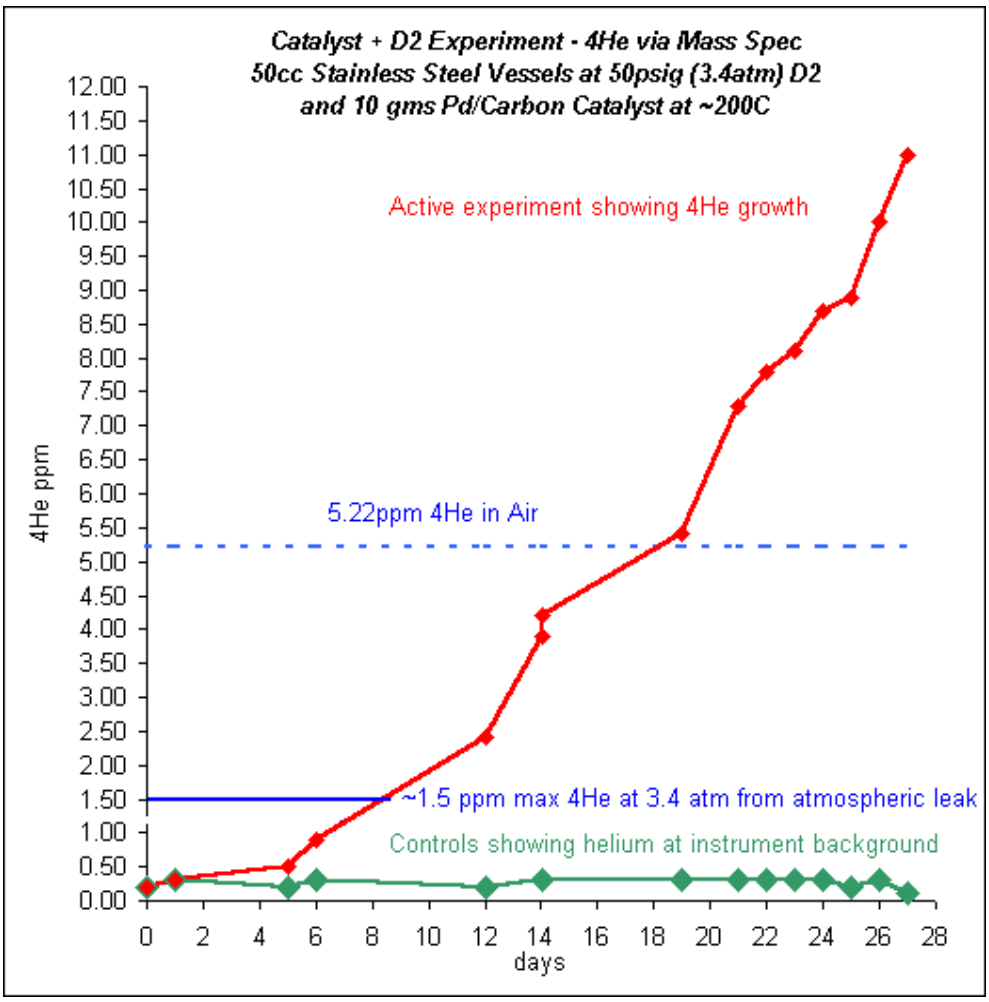


Figure 2- Chart of data showing increasing helium in "hot" experiment vs. no increase in control experiment. The control experiment started out with H_2 and was changed to D_2 after several days.

The author(s) acknowledge the assistance provided by Mike McKubre and Fran Tanzella (SRI International), Doug Perkins (United Catalysts of the Sud Chemie companies), Roger Ray and Len Marshall (mass spectroscopy Oakridge National Laboratory), Prof. John Dash (Physics Portland State University), Andrey Chuvilin (Boreskov Inst. Of Catalysis, Russia), and Tom Passell (EPRI Nuclear Power Division).

[1] Case, ICCF-7 Conference Presentation, Vancouver, B.C., Canada, April 1998 (soon to be published in conf. Proceedings)

[2] H. Farrar and B. Oliver, A Mass Spectrometer to Determine very low Levels of Helium in small Solid and Liquid Samples, J. Va. Sci. Technology, A4, 1740, 1968

[3] Personal communication Dr. Fran Tanzella present in Arata Laboratory for analysis

[4] Arata and Zhang, Presence of Helium (^{4}He, ^{3}He) Confirmed in Deuterated Pd-black by the "V_i Effect" in a "closed QMS" Environment, Japan Academy Series B Physical Sciences, April 1997

[5] Nuclear Fusion in Dense Plasmas, Setsuo Ichimaru, Reviews of Modern Physics Vol. 65, No.2, April 1993

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Details from this work have appeared in popular media including WIRED Magazine Oct. 98 and in various other news reports. Work by the author continues via d2fusion Technologies in cooperation with organizations and National Laboratories in the United States and abroad.

1998 APS Paper

Russ George presented this paper on March 19th, 1998 the first paper the American Physical Society has accepted that presents data showing proof of "sonofusion."

See the APS Web Site (http://www.aps.org/BAPSMAR98/abs/S4170002.html)

[U26.02] Experimental Evidence of Radiationless Aneutronic Nuclear Fusion in Metal Deuterides

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Abstract:

In experiments conducted beginning in 1989 have observed anomalous heat production and associated helium isotope production from novel experiments using high energy ultrasound and associated cavitation to load deuterium and hydrogen into metal lattices to high stoichiometric ratios. Monitoring of the experiments, which produce tens to hundreds of watts of anomalous heat and 10 ^17 atoms of helium, for radiation (neutron and gamma) has revealed no penetrating emissions. Arata and Zhang(Y. Arata and Y-C Zhang, Proc. Japan Acad. 73B), 1 (1997). have observed the same by-products, also with no high energy particles, in Pd powder that had been electrolytically loaded with D under pressures of 500-5000 atm. Both the ultrasonic and electrochemical methods described here are highly reproducible and repeatable techniques which readily produce these reactions upon demand. Many theories have tried to explain these phenomena including the theories of Scott and Talbot Chubb (S.R. Chubb and T.A. Chubb, talk presented this session.).

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