

Excess Energy from Chemical Reactions of Water (H₂O and/or D₂O)

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Abstract

Some combustible substance has been found from chemical reactions of water (H₂O and/or D₂O) using methods of electrolysis and catalysis. Experimental results indicate that the combustible substance was generated through transferring electrons from water and it is shown dual properties of inorganic water and organic compounds. The oxidation, including combustion and wet oxidation, of this combustible substance will release a large amount of heat energies, therefore, it is an ideal and infinite energy. Scientific evidence demonstrated that the formation and oxidation of the combustible substance are the real, common and main sources of excess energy reported in the field.

Introduction

Some combustible substance shown organic properties (CSSOP) has been found during electrolyzing water consisted of proper catalysts. The objectives of this work are to shed light on the nature of the CSSOP and on the basis of which to develop a clean and renewable energy. Thousands of papers and reports on excess energy from cold fusion [1-6] and hydrino process [7-9] provided convincing evidence to support the discovery in this work, meanwhile, the experimental results and theories presented for CSSOP unlocked the nature of energy anomalies reported in the field. This is a preliminary achievement in scientific research, future work is planning to discuss extensive experimental problems and detailed mechanism.

Experimental Methods

Electrolysis of light water with iron (anode) and nickel (cathode) was performed with two kinds of methods: alternating current using high voltage up to 220 V and high current density up to 20 A/cm² (electrode) lasted for around one minute; direct current using low voltage of 12 V and low current density about several mA/cm² maintained for a couple of days. The electrolysis in the former case is responsible for excitation and in the later case for electrocatalysis. The crux of the matter in experiments is how to select proper catalysts and make them formed active sites for water conversion. A considerable variety of methods and many materials treated in a variety of ways can be used to prepare this catalytic system, however, the compound additive must have four functions: activation function such as methyl violet, initiation function such as carbethoxy carbene (:CHCOOC₂H₅), oxidation-reduction function such as transition metal (Fe, Mn) complex[10] and electron transport function such as compounds containing conjugated double bonds (e. g. naphthalene and its derivatives). The chemical additives possessed of various functions in electrolyte need to combine together forming a group of multifunction to bring into play a synergetic action. Some high reactive intermediates such as carbene need to prepare in situ, i.e. , it must be a newborn one. To sum up, the experimental methods used here lay equal stress on both electrolysis and catalysis. The total amount of

the catalysts in electrolyte was about 10^{-4} (wt.) of total solution. The pH of electrolyte was controlled in the range of 6-7 and regulated with small additions of sulfuric acid. The experiments were carried out under normal atmospheric pressure and temperature. The calorific value of the CSSOP was measured by using oxygen bomb calorimeter, the density was measured by using gravimeter bottle. Elements of carbon and hydrogen were analyzed with combustion method that was based on the chemical properties of samples and combustion products. Element oxygen was analyzed by using oxygen analyzer. Infrared spectra of the CSSOP were obtained by using infer-red analyzer. To put it briefly, chemical composition, molecular structure and physicochemical properties of the CSSOP involved in the electrolyte were analyzed and measured at any time with proceeding of the reaction.

Experimental Results

Experimental results indicate that water has been converted into the CSSOP that exhibits properties of organic compounds. The products in this reaction were a mixture not only in chemical composition but also in molecular weight something like synthetic fuels from syngas. The experimental results obtained from each time of experiments were different with others, thus the data provided here were only a range of them.

In short, some significant results of our interest are as follows. (1) Analysis of elemental composition shows that there are elements of carbon, hydrogen and oxygen in the electrolyte, as a matter of course, the element carbon is only a reflection of the electronic configuration. The elemental composition of pure CSSOP is similar to hydrocarbons and alcohols respectively. (2) The most prominent property of the CSSOP is its combustibility, including combustion and wet oxidation[11,12]: the CSSOP can be fired when it has higher concentration and if at lower concentration the CSSOP will be oxidized in a slow rate being called liquid phase oxidation[11] or there exist some catalysts in reaction being called catalytic wet oxidation[12]. The calorific value of pure CSSOP is similar to hydrocarbons and alcohols respectively. (3) The CSSOP is composed of two kinds of products: one of them is hydrocarbon type like liquid fossil fuels, another one is oxygenated type like alcohols that can be regarded as semi-finished products. (4) The density of the CSSOP is less than water and higher than organic fuels in the range of $0.80\sim 1.00\text{g/cm}^3$ for hydrocarbon type and $0.75\sim 0.80\text{g/cm}^3$ for oxygenated type. (5) The specific resistance of the CSSOP is varied extremely: it is very large at this time like an insulator and it is very small at another time like a superconductor. (6) It is probably existed some "living molecule" in the CSSOP system, which was testified by the fact that the CSSOP is burning continuously when putting ordinary water into it. (7) The infrared spectra of the CSSOP show that there exist big adsorption peaks of methyl and methylene. In fact, the infrared spectra are only an indication for existence of isoelectronic species of methyl and methylene, which will be explained in the section of discussion. (8) The CSSOP can be storable in a stable state for a long time. (9) The CSSOP exists in one of three states: solid, liquid or gaseous somewhat similar to water. (10) Generally speaking, no reaction heat is released or reaction heat is very small in the formation process of the CSSOP. (11) Basically, there are no oxygen and hydrogen gases evolved in the reaction. In broad outline, the chemical composition, molecular structure and physicochemical properties of electrolyte are varied with electrolytic conditions, catalysts used and reaction time: water in electrolyte is converting to the CSSOP continuously until the percent conversion of water reaches 100%.

Theoretical Basis

Isoelectronic principle shows that so long as two molecules have the same total number of atoms and electrons (or valence electrons) then they will have the same electronic configuration and bonding scheme, resulting in that they must have the similar properties, which is the theoretical basis of the CSSOP. This viewpoint is consistent with the idea that the precise arrangement of the links (bonds) determines chemical properties [13]. The CSSOP and hydrocarbon have the similar properties because they are isoelectronic species. In the same way, the experiments by using light water as raw material reported in this work are completely suitable for heavy water because both H₂O and D₂O are isoelectronic species, leading to that they have similar properties. Moreover, electrolysis is a powerful means to drive chemical reactions to occur and catalysis can create new pathways for chemical reactions.

Combustible Substance Shown Organic Properties (CSSOP)

According to the molecule structure of water, once two electrons are transferred from each molecule of water, it is only six valence electrons left. In this case, oxygen atom in water has two covalent bonds with hydrogen and two nonbonding electrons. Based on Lowest-Possible Energy Principle and Hund's Rule, water molecules will be situated in one of two states: singlet or triplet state . Both states are isoelectronic species of methylene carbene H₂C: and both are high reactive intermediates, from which the CSSOP was formed. It is understood that the formation of the CSSOP is due to the transfer of electrons in water without undergoing permanent changes of the chemical bonds. The elemental composition and properties clearly show that the CSSOP is an organic compound but it is originated from inorganic water. The CSSOP is a new kind of material that was produced from a new kind of chemical reaction we have never known before. The precise structure of the CSSOP remains to go further into a study.

Compared the CSSOP with water, they have the same chemical composition as viewed from a whole, but their structure and properties are entirely different. Compared CSSOP with hydrocarbon, they have the same number of atoms and electrons, electronic configuration and bonding scheme, i.e., they have the similar structure and properties. The nucleus of oxygen but the electronic configuration of carbon and bonding scheme of organic compound indicate that the CSSOP is not only an isoelectronic species of hydrocarbon but also a duality substance in structure and properties. The most prominent characteristic of the CSSOP is its combustibility, including combustion and wet oxidation. Taking in consideration of this point of view, the CSSOP is a clean and renewable energy that is able to be used for replacing fossil fuels. On the basis of structure, property and reaction of the CSSOP, it may be called organic water or oxygen fuel.

Chemical Origins of Excess Heat

An aqueous electrochemical experiment with a palladium cathode in a heavy water electrolyte produces excess heat that is far beyond ordinary chemical reactions, which is attributed to nuclear reaction called cold fusion or Low Energy Nuclear Reactions or Condensed Matter Nuclear Science [14,15]. Mills and his colleagues Performed a electrolysis with a K₂CO₃ light water electrolyte consisted of certain catalysts at a nickel cathode, in which excess power is produced, accounting for it by hydrino process that a new energy source is caused by releasing the latent energy stored in the hydrogen atom [16-17]. As we known, electrolysis is a useful method for oxidation-reduction of water and it is frequently used in the experiments for cold fusion and hydrino process. In case some contaminants and/or impurities as catalysts added to the electrolytic system, regardless of

being conscious or unconscious, the production of the CSSOP cannot avoid and the oxidation (wet oxidation or catalytic wet oxidation) of the CSSOP will release a large amount of reaction heat. Based on our experiments and study, the main sources of excess heat from cold fusion and hydrino process are attributed to the formation and oxidation of the CSSOP obtained from electrolysis and catalysis of water. Cold fusion and hydrino process have been published thousands of papers and reports that provide compelling evidence to confirm the observation presented in this work, and in turn, the theories and facts claimed in this article will unlock the nature of the energy anomalies in the field.

1. In the process of the formation and oxidation for the CSSOP, the basic materials used are water and oxygen and the methods adopted are electrolysis and catalysis, which is very similar to most laboratories of cold fusion and hydrino process. However, the chemical additives used in most experiments of cold fusion and hydrino process are not possessed of all the necessary and sufficient functions, actually they were accidentally added to the reaction system in the form of contaminants and/or impurities. In other words, the experiments performed in cold fusion and hydrino process were aimed at hydrogen (H or D) physics instead of chemistry of water and oxygen, as a result, the reaction conditions were hard to meet the needs of the CSSOP formation completely, which may be the real reasons why sometimes the production of the excess heat was at low levels and lack of reproducibility in the experiments of cold fusion and hydrino process.

2. The phenomenon called “heat after dead” [18,19] is explained by following fact: owing to the reaction rate of wet oxidation for the CSSOP was usually lower than that of formation reaction, the reaction heat remained in releasing with oxidizing of the CSSOP although the formation reaction of it has already stopped.

3. “Positive feedback” [20,21] implies that increasing the cell temperature increases the excess enthalpy, which is consistent with the principle of chemistry: increasing the reaction temperature increases the reaction rate (Arrhenius Equation) [22,23], including the rate of formation and oxidation of the CSSOP.

4. H₂O and D₂O have the same number of atoms and electrons, so that they have similar chemical properties, suggesting that H₂O and D₂O exhibit similar behavior in reaction, when and only when, the reaction is chemical reaction. That is the reason why light water gets the similar experimental results with heavy water for excess heat production [21,24].

5. Almost all of experiments that give higher levels of excess heat production were certain to use the method of electrolyzing water (H₂O or D₂O)[25-27]. As it should be, only under those circumstances, the formation reaction of the CSSOP is dominant reaction and the CSSOP is primary products.

6. A surprising amount of carbon was found on the cathode surface [28-29]. The only possible source of such large amount of carbon would be stemmed from decomposing or carbonating of the CSSOP.

7. Hydrocarbon oil has been found in cold fusion cell, which causes an incident of explosion [30]. In our opinion, hydrocarbon oil is just the CSSOP containing deuterium.

8. In the experiments of cold fusion, many have the production of excess heat but no

nuclear products were detected [24,27], some have the generation of nuclear products but no excess heat was found [31,32], and some others the production of both excess heat and nuclear products were reported [24,33,34]. Those results indicate that excess heat and nuclear products were originated from two kinds of reactions that have nothing in common.

9. Catalytic effects play a very important role in the experiments of cold fusion [35,36] and hydrino process [4,15], which furnishes convincing proof to our findings.

10. A potentially important point is that a chemical source of excess heat originated from oxidation of the CSSOP produced from electrolysis and catalysis of water has been found, and the excess heat production in quantities can reach and be far beyond that observed from experiments in cold fusion or hydrino process. The truth of “excess heat far beyond ordinary chemical sources” in cold fusion is that the reaction heat was released from oxidation of the CSSOP, in which the excess heat is actually stemmed from chemical reactions of water existed in whole electrolytic cell and from whole course of reaction period, but it was entirely reckoned to be the energy produced from nuclear reactions of a few deuterons induced by a few palladium atoms on cathode surface.

Predictions and Examinations

Excess heat is mainly generated from the formation and oxidation of the CSSOP that is generated from the chemical reactions of water (H_2O or D_2O) and oxygen. Roughly speaking, without water (H_2O or D_2O) and oxygen (or air) there will be no excess heat production, whether the experiments are in the CSSOP, in cold fusion, or in hydrino process. In order to examine and verify the existence of the CSSOP, it can analyze and measure the chemical composition, molecular structure and physicochemical properties of electrolyte. On the basis of experimental results and theoretical approach in this study, it is predicted that the isoelectronic atom of carbon and the isoelectronic species of carbonaceous organic compounds are bound to be found with disappearance of oxygen and water regardless of displaying with data, signals or peaks, provided there exists excess heat in electrolyzing system of water (H_2O or D_2O). As it does, the CSSOP in electrolyte is bound to be on the decrease with releasing heat. To be sure, the electrolyte is able to be fired or has a calorific value if the yield of the CSSOP reached a level high enough.

Conclusions

1. Combustible substance generated from electrolyzing water (H_2O and/or D_2O) consisted of some proper catalysts shows organic structure and property, therefore, it can be used as a clean and renewable energy.

2. Experiments from cold fusion and hydrino process provided compelling evidence to confirm the discovery in this work, meanwhile, oxidation (combustion or wet oxidation) of the combustible substance will release a large amount of heat energies that prove to be the real, common and main sources of excess power reported in the field.

3. Despite many problems remain to be solved in experiment and theory, the most important reward of all is that a clean and infinite energy called organic water or oxygen fuel produced from chemical reactions of water has been found.

References

1. Fleischmann, M. and Pons, S. 1989, "Electrochemically Induced Nuclear Fusion of Deuterium", *J. Electroanal. Chem.*, 261, 301-308.
2. Mallove, E. 1991. *Fire from Ice: Searching for the Truth Behind the Cold Fusion Furor*, John Wiley and Sons. Available Now from Infinite Energy Magazine.
3. Storms, E. 1991, "Review of Experimental Observations about Cold Fusion Effect", *Fusion Technol.*, 20, 433.
4. Rothwell, J. 2004, *Cold Fusion and The Future*. E-book from www. LENR-CANR. Org.
5. Beaudette, C. G. 2000. *Excess Heat. Why Cold Fusion Research Prevailed*. Concord Oak Grove Press.
6. Fleischmann, M. 2002. "Searching for the Consequences of Many-Body Effects in Condensed Phase Systems". *Proceedings of the 9th International Conference on Cold Fusion*, May 19-24, Beijing, China, P. III.
7. Mills, R. L. and Good, W. R. 1994. "Dihydrino Molecule Identification", *Fusion Technol.* 25, 103-120.
8. Mills, R. L. and Good, W.R. 1995. "Fractional Quantum Energy Level of Hydrogen", *Fusion Technol.* 28, 1697-1706.
9. Mills, R. L., Ray, P., Dha, B., Nansted, M., Chen, X. and He, J. 2002. "New Power Source from Fractional Quantum Energy Levels of Atomic Hydrogen that Surpasses Internal Combustion," *J. Mol. Struct.*, 643, 1-3, PP. 43-54.
10. Higuchi, M., Ikeda, I. And Hirao, T. 1994. "A Novel Synthetic Metal Catalytic System," *J. Org. Chem.*, 25, 1072-1078.
11. Pintar, P. and Levec, J. 1992. "Catalytic Liquid-phase Oxidation of Refractory Organic in Waste Water," *Chem. Eng. Sci.*, 47, 2395-2400.
12. Margolis, L. Y. "On the Mechanism of Catalytic Oxidation of Hydrocarbons," *J. Catal.*, 21, 93-101.
13. Breslow, R. 1997. *Chemistry Today and Tomorrow*, American Chemical Society, Jones and Bortlett Publishors, Inc., PP.6-7.
14. Mallove, E. F. 2003. LENR and Cold Fusion Excess Heat. *10th International Conference on Condensed Matter Nuclear Science*, Aug. 24-29, Cambridge, Massachusettes, USA.
15. Storms, E. K. 2005. Why You Should Believe Cold Fusion is Real. *American Physical Society Meeting*, Los Angeles.

16. Rhillips, J., Mills, R. L. and Chen, X. M. 2004, "Water Bath Calorimetric Study of Excess Heat Generation in Resonant Transfer Plasmas," *J. Appl. Phys.*, 96, 6, 3090-3102.
17. Mills, R., Ray, P., Dhandapani, B., Good, W., Jansson, P., Nansteel, M., He, J. and Voigt, A. 2004. "Spectroscopic and NMR Identification of Novel Hydrino Ions in Fractional Quantum Energy States Formed by an Exothermic Reaction of Atomic Hydrogen with Certain Catalysts," *European Physical Journal, Appl. Phys.*, 28, 83-104.
18. Jiang, X. L. and Wen, X. W. 2002. "Torsion Field Effect and Axion Model in Electrical Discharge Systems," *Proceedings of the 9th International Conference on Cold Fusion*, May 19-24, Beijing, China, PP.147-150.
19. Tian, J., Liu, B., Lia, X. Z., Yu, W. Z., Mei, M.Y., Cao, D.X., Li, A.L., Li, Jing, Zhao, Y. G. and Zhang, C. 2002. "Excess Heat and Heat After Death in a Gas-loading Hydrogen Palladium System," *Proceedings of the 9th International Conference on Cold Fusion*, May 19-24, Beijing, China, PP.360-366.
20. Hagelstein, P. L., Mckubre, M. C. H., Nagel, D.J., Chubb, T.A. and Hekman, R. J. 2004. "New Physical Effects in Metal Deuterides," *A Report to DOE for Review*.
21. Miles, M. H., Arman, H. D., Carrick, J. D., Gren, C. K., Haggerty, K. A., Kin, H. Y., Ky, A. G., Markham, J. E., Meeks, C. F. and Noga, D. E. 2002. "The Elevation of Boiling Points in H₂O and D₂O Electrolytes," *Proceedings of the 9th International Conference on Cold Fusion*, May 19-24, Beijing, China, P.246.
22. Laidler, K. J. 1972. *Chemical Kinetics* (2nd Ed.), McGraw-Hill Book Company, New York, PP. 49-60.
23. Boudart, M. 1968. *Kinetics of Chemical Processes*, Prentice-Hall Inc., Englewood Cliffs, New Jersey, PP. 47-50.
24. Celani, F., Spallone, A., Marini, P., Stefano, V. di, Nakamura, M., Mancini, A., D'Agostaro, G., Righi, E., Trenta, G., Quercia, P. and Catena, C.2002. "Electrochemical D Loading of Palladium Wires by Heavy Ethyl-Alcohol and Water Electrolyte, Related to Ralstonia Bacteria Problematics," *Proceedings of the 9th International Conference on Cold Fusion*, May 19-24, Beijing, China. PP.29-35; Ohmori, T., Yamada, H., Narita, S. and Mizuno, T. "Excess Energy and Anomalous Concentration of ⁴¹K Isotopes in Potassium Formed on/in A Re Electrode During the Plasma Electrolysis in K₂CO₃/H₂O and Solutions," *ibid.*, PP. 284-294.
25. Niedra, J. M., Fralick, I. T., Fralick, G. C. and Baldwin, R. S. 1996, "Replication of the Apparent Excess Heat in a Light Water Potassium Carbonate Nickel Electrolytic Cell," *NASA Technical Memorandum 107167*.
26. Bush, R. T. and Eaghton, R. D. 1993. "Calorimetric Studies for Several Light Water Electrolytic Cells with Nickel Fibre Cathodes and Electrolytes with Alkali Salts of Potassium Rubidium and Cesium," *Fourth International Conference on Cold Fusion*, Lahaina, Maui.

27. Patterson, J. A. 1994. *US Patent* No. 5, 318, 675; 1994. No. 5, 372, 688; 1996. 5, 494, 559.
28. Chicea, D. 2002. "On New Elements on Cathode Surface after Hydrogen Isotopes Absorption," *Proceedings of the 9th International Conference on Cold Fusion*, May 19-24, Beijing, China, PP. 29-35.
29. Chicea, D. 2003. "Comment on Carbon Production in Deuterium-metal System," *10th International Conference on Condensed Matter Nuclear Science*, Aug. 24-29, Cambridge, Massachusetts, USA.
30. Grant, P. M., Whipple, R. E., Alcaraz, A., Haas, J. S. and Anderson, B. 1994. "Hydrocarbon Oil found in the Interior of a Cold Fusion Electrolysis Cell after Fatal Explosion," *Fusion Technol.*, 25, 207.
31. Arapi, A., Ito, R., Sato, N., Itagaki, M., Narita, S. and Yamada, H. 2002. "Experimental Observation of the New Element Production in the Deuterium and/or Hydride Palladium Electrodes, Exposed to the Low Energy DC Glow Discharge," *Proceedings of the 9th International Conference on Cold Fusion*, May 19-24, Beijing, China, PP. 1-4.
32. Passell, T. O. 2002. "Evidence for Lithium-6 Depletion in pd Exposed to Gaseous Deuterium and Hydrogen," *Proceedings of the 9th International Conference on Cold Fusion*, May 19-24, Beijing, China, PP. 299-304.
33. Kozima, H. 2002. "A Explanation of Data Sets Observed by Mekubre Et Al. (Excess Heat), CLARKE (Null Results of 4He, RHe) and CLARKE ET AL. (Tritium) With ARATA CELL," *Proceedings of the 9th International Conference on Cold Fusion*, May 19-24, Beijing, China, PP. 182-185.
34. Giudice, E. Del, Ninno, A. De, Frattolillo, A., Porcu, M. and Rizzo, A. 2002. "Production of Excess Enthalpy in the Electrolysis of D₂O on Pd Cathodes," *Proceedings of the 9th International Conference on Cold Fusion*, May 19-24, Beijing, China, PP.82-86.
35. Case, L. 2002. "There Is a Fleischmann-Pons Effects. The Process Is Electrolytic, But the Effect Is Catalytic," *Proceedings of the 9th International Conference on Cold Fusion*, May 19-24, Beijing, China, PP. 22-23.
36. Storms, E. 2004. "An Update of LENR," *11th International Conference on Condensed Matter Nuclear Science*, Oct. 31-Nov. 5, Marseille, France.

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