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The novel magnecular species of hydrogen and oxygen with increased specific weight and energy content

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Dedicated to Amedeo Avogadro (1776–1856)

Abstract

In this paper we review the new chemical species of *magnecules* introduced in preceding works (see monograph, R.M. Santilli, Foundations of hadronic chemistry with applications to new clean energies and fuels. Boston-Dordrecht-London: Kluwer Academic Publisher, 2001 for a general review), which consist of individual atoms, radicals and ordinary molecules bonded together into stable clusters under a new internal attractive force originating from the toroidal polarization of the orbitals of atomic electrons under strong external magnetic fields. We then introduce, apparently for the first time, the hypothesis of new chemical species of hydrogen, oxygen and other gases with magnecular structure called *MagneHydrogen*TM, *MagneOxygen*TM, etc. or *MagneH*TM, *MagneO*TM, etc. for short (international patents pending). We then present the experimental evidence according to which the latter gases possess specific weight and energy content greater than the corresponding values of the same gases with conventional molecular structure. We show that the use of MagneH and MagneO in fuel cells implies: (1) an increase of fuel cells voltage, power and efficiency; (2) a decrease of storage volumes; and (3) a significant decrease in operating costs. The equipment for the industrial production of MagneH and MagneO is identified. We also study a particular form of MagneH with specific weight of about 7 times that of the hydrogen which is particularly suited for use as fuel in internal combustion engines, and show that such a new species implies: (i) the elimination of liquefaction of conventional hydrogen as currently used by BMW, GM, and other car manufacturers; (ii) performance essentially equivalent to that of the same engine when operating on gasoline; and (iii) the achievement of cost competitiveness of MagneH with respect to fossil fuels, of course, when produced in sufficiently large volumes. We also indicate that the liquefaction of MagneH and MagneO is predicted to cost significantly less than ordinary gases (in view of a mutual attraction among magnetically polarized magnecules which does not exist in conventional gases), and that their use as fuel for rocket propulsion is expected to imply a significant increase of the payload, or a corresponding decrease of boosters weight. All the above advances are dependent on the features of the selected equipment for the production of MagneH and MagneO (including electric power, pressure, etc.), as well as the duration of the processing. The paper ends with the indication of other applications of the new chemical species, the solicitation of independent experimental verifications, and the identification of new intriguing open problems. © 2002 International Association for Hydrogen Energy. Published by Elsevier Science Ltd. All rights reserved.

Keywords: Magnecules; Magnehydrogen; Hadronic chemistry

1. Introduction

Hydrogen is emerging as one of the primary alternative fuels for the large scale replacement of gasoline and other fossil fuels, including its use for internal combustion engines, fuel cells, rocket propulsion and other applications.

However, hydrogen is a fuel with the lowest specific weight among all available fuels. In fact, hydrogen has a specific weight of 2.016 atomic mass units (a.m.u.). By comparison, gaseous hydrocarbons can have specific weight which are a multiple of these values, as in the case of natural gas, methane, acetylene and other gaseous fuels.

This low value of specific weight and the current high cost for its production, have caused serious technological, logistic and financial problems which have prevented hydrogen from achieving a large scale replacements of fossil fuels until now.

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Among the existing problems, we mention the following ones:

- (1) The low specific density of hydrogen prevents its automotive use in a compressed form because of the need for excessively large storage requirements, as well as seepage through containers walls. For instance, gasoline contains about 115,000 British Thermal Units (BTU) per American gallon (g) while hydrogen has an energy content of about 300 BTU per standard cubic foot (scf). As a result, the *gasoline gallon equivalent of hydrogen* is given by $115,000 \text{ BTU} / 300 \text{ BTU} = 383 \text{ scf}$. Therefore, the equivalent of a 20 g gasoline tank would require 7660 scf of hydrogen which is a prohibitive volume for storage in an ordinary car.
- (2) As proved by hydrogen fueled automobiles built by the German automakers BMW, the American automaker GM, and other car manufacturers, the achievement of a sufficient range for ordinary automotive use requires the *liquefaction of hydrogen*. By recalling that hydrogen liquifies at a temperature of -252.8°C close to absolute zero degree, it is evident that the liquefaction of hydrogen, its transportation in a liquified form and the permanent storage of such a liquid state in a car implies dramatic expenditures. It then follows that the current automotive use of hydrogen is excessively more expensive than gasoline.
- (3) The automotive use of hydrogen implies a loss of about 35% of the power of the same engine when operated with gasoline, as established by available hydrogen powered cars. This is evidently due to the low energy content of hydrogen, with consequential combustion of more moles to reach the same performance as that with gasoline.
- (4) In view of the above, the automotive use of hydrogen produced from regenerating methods implies an *oxygen depletion* greater than that caused by the combustion of fossil fuels for the same power and performance, where "oxygen depletion" has been introduced by this author to characterize *the permanent removal of breathable oxygen from our atmosphere* [1]. This oxygen depletion persists when hydrogen is produced via electrolytic separation of water and the use of electricity from fossil fuel powered plants. Said oxygen depletion is absent only when hydrogen is produced via the electrolytic separation of water and the use of electricity produced via solar, hydro and other methods not requiring atmospheric oxygen.
- (5) The automotive use of liquid hydrogen is dangerous because of the possible transition of state from liquid to gas in the event of a malfunction of the cryogenic equipment or other reasons.

The use of hydrogen in fuel cells is afflicted by similar problems which are inherent in the low specific weight of conventional hydrogen.

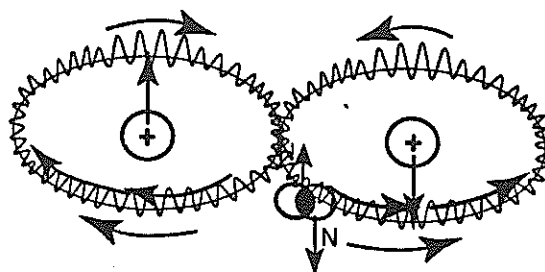


Fig. 1. A schematic view of the *isochemical model of the hydrogen molecule*, here represented at absolute zero degree temperature without any rotation, which was introduced by Santilli and Shillady in Ref. [2] (see [5] for a comprehensive review). The main assumption is that, when at short distances of the order of the size of their wavepackets ($10^{-13} \text{ cm} = 1 \text{ fm}$) and in singlet coupling, electrons experience a new *strongly attractive valence force* resulting in a quasi-particle state called *isoelectronium*. The most stable orbit then results to be oo-shaped with each o-branch distributed around each nucleus, thus having opposing rotations, a feature of fundamental character for the new chemical species of hydrogen introduced in this paper. Needless to say, the deep correlation-bond of two valence electrons into the isoelectronium is not a permanent bound state, but has a finite meanlife depending on the considered molecule, its excitation state, and other factors studied in Ref. [5].

In this paper we introduce, apparently for the first time, a new chemical species of hydrogen as well as oxygen and other gases which alleviates, if not resolves the above problems due to their increased specific weight and energy content.

The studies underlying the proposed new chemical species can be summarized as follows. In Refs. [2,3] (see also the comprehensive review in monograph [5]) R.M. Santilli and D.D. Shillady introduced the *isochemical model of the hydrogen, water and other molecules* (Figs. 1 and 2) which permitted the achievement, apparently for the first time in chemistry, of a numerical representation of binding energies, electric and magnetic moments, as well as other molecular features exact to the desired digit. The new models also achieve the first restriction of valence correlations to *electron pairs*, as established experimentally, exhibits perturbative series converging dramatically faster than those of quantum chemistry (with consequential major reduction of computer time), and resolve other vexing problems of current molecular chemistry (see [5] for details).

These results were achieved by assuming that two valence electrons couple themselves into a singlet state at short distances, called *isoelectronium*, with a new, strongly attractive force due to the deep overlapping of the electron wavepackets. The new *strong valence force* results to be nonlinear (in the wavefunctions), nonlocal (e.g., of integral type) and nonpotential (e.g. of contact zero-range type). Also, the new force can be thought as the previously missing molecular equivalent of the nuclear strong interactions (the evident understanding is that the use of the word "strong" referring

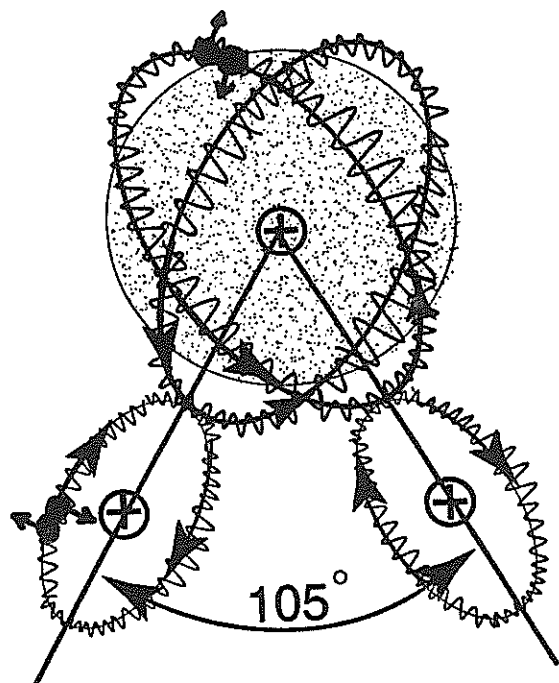


Fig. 2. A schematic view of the *isochemical model of the water molecule*, here represented at absolute zero degrees temperature without any rotation, which was submitted by Santilli and Shillady in Ref. [3] (see monograph [5] for a comprehensive review and enlargement). The main assumption is that the bond in each radical HO and OH is characterized by a new *strong valence force* originating in the deep correlation of valence electron pairs in singlet coupling at short distances, called *isoelectronium*. Note that the distribution of the electron orbits in each radical HO and OH is perpendicular to the molecular plane HOH, as experimentally established, a feature also of fundamental relevance for this paper.

to electrons has no connection with the “strong interactions” in hadron physics). The strong nature of the new valence force then permits an essentially exact representation of binding energies and other molecular features. By comparison, the exact use of quantum axioms still misses 2% of binding energies, with much greater departures from experimental data (at times even in the sign) regarding electric and magnetic moments, and other molecular features.

Being nonlinear, nonlocal and nonpotential, the new strong valence force cannot be represented with the Hamiltonian alone, thus requiring at least one second operator. As such, the new strong valence force is outside any dream of scientific treatment via conventional quantum mechanics and chemistry, since the latter are strictly linear, local and potential (i.e., the systems are entirely described by a linear, local, and differential Hamiltonian). In view of these limitations, new mathematical, physical and chemical theories had to be worked out for the invariant treatment of the new strong valence force. These new formulations are known under the name of *hadronic mechanics*, *superconductivity*

and chemistry and are reviewed in detail in monograph [5].

Hadronic chemistry is based on the lifting of the basic unit, from its simple value $I=+1$ currently used in chemistry (and dating back to biblical times) to the most general possible integro-differential operator of hermitian or nonhermitian, single-valued or multi-valued character, with corresponding lifting of all possible conventional associative products $A \times B$ among generic quantities A, B (such as numbers, functions, operators, etc.)

$$I = +1 \rightarrow \hat{I} = \hat{I}(t, r, p, \psi, \partial_k \psi, \dots) = 1/\hat{T},$$

$$A \times B \rightarrow A \hat{\times} B = A \times \hat{T} \times B,$$

$$I \times A = A \times I = A \rightarrow \hat{I} \hat{\times} A = A \hat{\times} \hat{I} = A \quad (1.1)$$

with corresponding liftings of the entire mathematical and physical structure of conventional theories. All conventional linear, local and potential effects are represented with the usual Hamiltonian, while all nonlinear, nonlocal and nonpotential effects are represented with the generalized unit \hat{I} . Consequently, hadronic chemistry has various branches, called *iso-*, *geno-* and *hyper-*chemistry which are characterized, correspondingly, by *single-valued hermitian*, *single-valued-nonhermitian*, and *multi-valued-nonhermitian generalized units*. These branches are used for the invariant treatment, respectively, of *closed-isolated systems with nonhamiltonian internal effects*, *open-irreversible systems*, and *irreversible multi-valued biological structures* (see Ref. [5] for a general review of hadronic chemistry and its main background references).

This paper deals with molecular structures considered as isolated from the rest of the universe. As a result, the applicable branch of hadronic chemistry is *isochemistry*. The background structure model of the hydrogen and water molecule are, therefore, those of Figs. 1 and 2. The new chemical species of hydrogen, oxygen and other gases presented in this paper are another development permitted by the novel isochemistry.

Note, in particular, that a strong correlation-bond of valence electron pairs into the isoelectronium implies that the molecular orbit is oo-shaped with each o-branch distributed around each nucleus (Fig. 1). A property of fundamental character for the new chemical species of hydrogen and oxygen, is that *the directions of rotation of coupled valence pairs around the respective two nuclei are opposite to each other*. This feature is mandatory for a scientifically credible structure model of the hydrogen because the assumption of orbits encompassing the two nuclei, in addition to serious instabilities, would imply the possibility of a magnetic polarization of the hydrogen, as discussed in more detail later on, which prediction is dramatically disproved by experimental evidence since the hydrogen is diamagnetic. By comparison, such a diamagnetic character is easily recovered for the isochemical structure of Fig. 1 because a

magnetic polarization would yield *opposing* magnetic polarities in the two atoms which cancel out when inspected at large distance due to the very small inter-atomic distances.

The reader should also note that our study is based on semiclassical *orbits* because of their conceptual effectiveness particularly during the intuitional phase, with the understanding that a more rigorous treatment is that in terms of *orbitals* as conventionally understood in chemistry (probability distributions). The use of semiclassical *orbits* is also preferred to indicate that the new species of hydrogen, oxygen and other gases presented in this paper have a purely *physical*, rather than chemical, origin. Needless to say, all notions introduced in this papers in terms of orbits have a simple extension to the corresponding notions in terms of orbitals, which extension is left to the interested reader for brevity.

Note finally that the presentation of this paper has been limited to that at a semiclassical level for clarity of the basic notions and results. The reformulation in terms of the new isomathematics for first and second quantization yields no new results and it is left to the interested reader.

2. The new chemical species of Santilli magnecules

A scientific notion of basic importance for this paper is the new chemical species of *electromagnecules* which was first submitted by this author in paper [4] of 1998 and then presented in a comprehensive form in the recent monograph [5].

Electromagnecules are clusters generally composed of individual atoms, parts of conventional molecules (called radicals or dimers) and ordinary molecules under a new internal bond originating from the electric and magnetic polarizations of the orbits of at least some peripheral atomic electrons. Due to the dominance of magnetic over electric polarizations indicated below, electromagnecules are generally called *Santilli magnecules*.

The basic notion underlying magnecules is a property well known in atomic physics (see, e.g., Ref. [6]), according to which, when an atom is exposed to a sufficiently strong external magnetic field, the orbits of its peripheral electrons cannot be freely distributed in all space directions, and must acquire a *toroidal distribution* with consequential creation of a new magnetic dipole moment North–South caused by the rotation of the electron charges in said toroid. Such a dipole is evidently aligned along the symmetry axes of the toroidal distribution in such a way to have magnetic polarities opposite to the external ones, as illustrated in Fig. 3.

It should be noted that the magnetic polarization of an atom also implies the polarization of the intrinsic magnetic moments of electrons and of nuclei, as illustrated in Fig. 1. As a result, the magnetic bond between polarized atoms is actually composed of *three parallel attractive forces* among opposite polarities.

Atoms, radicals or molecules with toroidal polarization of their atomic orbits then bond to each other in chains of

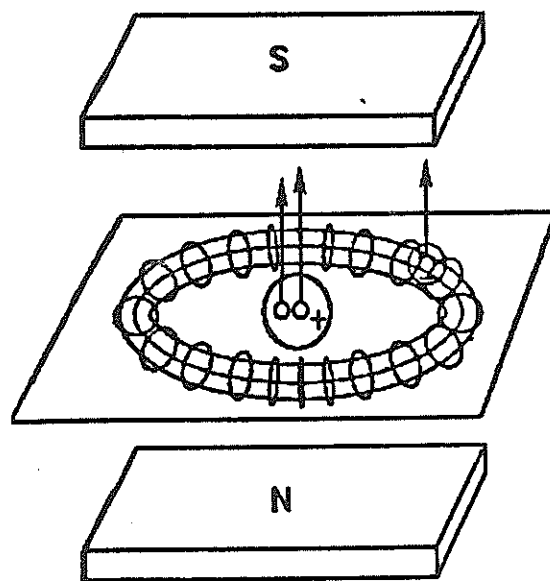


Fig. 3. A schematic view of the *toroidal polarization of the orbits of peripheral atomic electrons* when subjected to a sufficiently strong external magnetic field. Note the additional polarization of the intrinsic magnetic moments of nuclei and of peripheral atomic electrons, thus resulting in the availability of *three parallel magnetic moments* all suitable to create a new bond.

opposing polarities North–South–North–South–..., resulting in the formation of magnecules schematically illustrated in Fig. 4.

Note that the toroidal polarization of atomic orbits creates a magnetic field which is not generally detectable in the conventional space distribution of the same orbits. Simple calculations show that such a field is quite strong since it is of the order of 1415 times the value of the intrinsic magnetic field of the nucleus of hydrogen (the proton). As a result, the toroidal polarization of the orbits of peripheral atomic electrons does indeed create a new field sufficiently strong to originate a new chemical species.

The first computation of the value of the magnetic moment of toroidal polarizations of atomic orbits and its use for the creation of a new chemical species was apparently presented for the first time by the author in Ref. [4]. The first verification of its numerical value as being 1415 times the value of the proton magnetic moment was done by Kucherenko and Aringazin [7]. An in depth study of the toroidal polarization of atomic orbits was done by Aringazin [8] and reviewed in Appendix 8A of monograph [3].

Predictably, these studies have established that the toroidal polarization of atomic orbits requires magnetic fields so strong that they cannot be today realized at macroscopic distances in our laboratories. Nevertheless, these strong magnetic fields are indeed available at *atomic distances*, as we shall see.

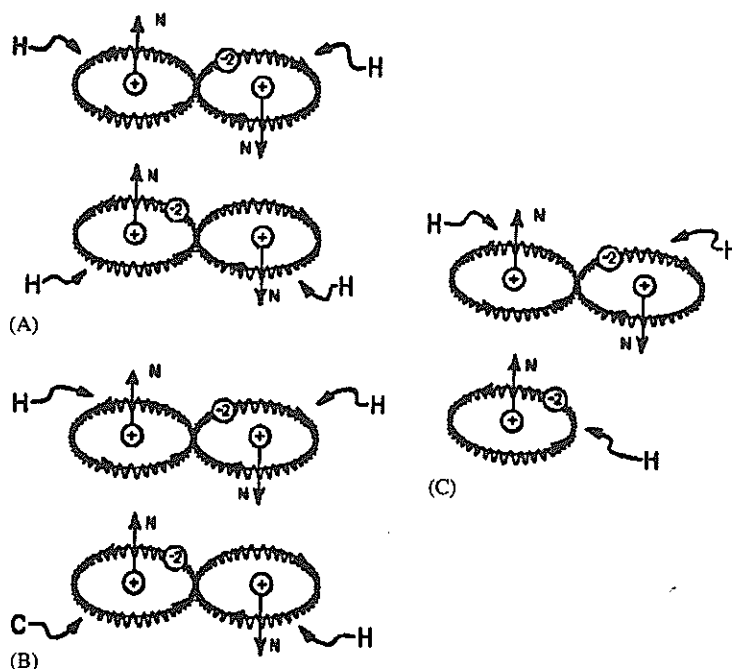


Fig. 4. A schematic view of *elementary magnecules* composed of a diatomic molecule bonded to an individual atom or to another diatomic molecule via opposing magnetic polarities of the toroidal polarization of the orbits of individual atoms.

An important feature of magnecules is that *the magnetic polarization occurs in each individual atom*, rather than in a molecule as a whole. This implies that the new chemical species of magnecules can be formed for all possible gases irrespective of whether they are diamagnetic (such as hydrogen) or paramagnetic (such as oxygen).

Therefore, *the primary technological objective underlying the industrial and scientific production of substances with magnecular structure rests in the control of the space distributions of the orbits of individual atoms, rather than molecules.*

It should be noted that magnetic polarizations are *individually* unstable, because, as soon as the external magnetic field is terminated, the conventional space distribution of the orbits is reacquired due to rotations and other motions caused by temperature. However, *coupled* opposing magnetic polarities of two or more atoms are instead stable because, when the external magnetic field is removed, rotations and other motions due to temperature apply to the cluster of bonded atoms as a whole. As a result, magnecules are stable at ordinary temperatures and pressures.

It should also be noted that electric polarizations are essentially reducible to ellipsoidal deformations of electron orbits with consequential predominance of one charge at one end and the opposite charge at the other end. Whether individual or coupled, such ellipsoidal deformations are evidently terminated by collisions, rotations and other

effects due to temperature, and this explains the dominance of magnetic over electric polarizations.

Nevertheless, the reader should keep in mind that no magnetic effect exists without an electric counterpart. Even though less relevant, electric polarizations cannot be ignored on strict scientific grounds. As a result, the term scientifically more appropriate for the new chemical species is that of "electromagnecules" [5].

Recall that all magnetic effects are known to cease at a temperature called the *Curie Temperature*. This is also the case for magnecules which decompose at a certain temperature varying from substance to substance, which temperature is generally of the order of the combustion temperature.

The new chemical species of magnecules most investigated until now is that of the combustible gas known under the name of *Santilli MagneGasTM* produced via recyclers called *hadronic reactors of molecular type* [5]. This particular gas is produced by flowing a liquid feedstock (such as fresh or salt water, antifreeze and oil waste, city and farm sewage, crude oil, etc.) through a submerged electric arc between carbon-base consumable electrodes.

In essence, the electric arc separates the liquid molecules in part or in full, vaporizes the carbon of the electrodes, and forms a plasma of mostly ionized H, C and O atoms and their radicals such as CH and HO at about 10,000°F. The flow of the liquid continuously removes the plasma from the electrode tips and controls the subsequent thermochemical

reactions. The H, C and O atoms and their radicals are exposed to the extremely intense magnetic fields at atomic distances of the electric arc, by acquiring in this way a toroidal polarization of their orbits, as discussed in more detail later on.

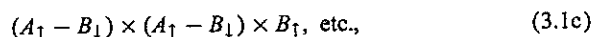
The name "MagneGas" was introduced by the author to denote all gases with the new magnecular structure, thus including all combustible gases produced by submerged electric arcs within all possible liquid feedstocks, as well as magnetically polarized gases which are not necessarily combustible.

The resulting MagneGas has a magnecular structure (from which it derives its name) because it results to be constituted of clusters of individual H, C and O atoms, CH and OH radicals, single valence bonds C–O, double valence bonds C=O, and conventional molecules H₂ and CO (that with triple valence bond) with traces of O₂, CO₂, H₂O and other substances (see monograph [5, Chapters 7 and 8] for brevity).

3. Environmental relevance of the new species of magnecules

The new chemical species of magnecules has recently emerged as possessing considerable environmental relevance because it permits the industrial production of cost competitive new gaseous fuels whose combustion exhaust is so clean as to require no catalytic converters, as it is the case for MagneGas (see certification [9]). This important feature is due to the increased specific weight, enhanced thermochemical reactions, as well as the capability of eliminating hydrocarbon chains in a gaseous fossil fuel in favor of clean burning magnecular clusters with specific weight and energy output similar to those of the original gaseous hydrocarbon.

The increased specific weight caused by the new chemical species of magnecules is evident. Let us denote the conventional valence bond with the symbol "·", the new magnetic bond with the symbol ×, and the magnetic polarization of generic atoms A, B, ... with the symbols $A_{\uparrow}, A_{\downarrow}, A_{\uparrow}, A_{\downarrow}$, etc. Suppose that the original gas has a conventional diatomic structure with valence bond A–B. Then, the creation of a magnecular structure in such a gas can be schematically represented:



with the understanding that the correct formulation should be that via columns, rather than rows, since the bond occurs between opposing polarities of different atoms as shown in Fig. 4.

It is then evident that the above magnecular structure increases the specific weight of the original gas. The actual

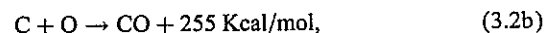
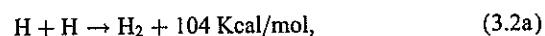
value of the increase depends on a variety of features indicated later on, including the intensity of the external magnetic field, the pressure of the gas, the duration of the gas treatment, and other factors.

Note that, while the original gas has the unique molecular structure A–B, the resulting new species has a variety of structures, again, depending on the used equipment and treatment. While the molecular structure A–B is constant, the corresponding magnecular structure is not constant in the sense that magnecules can break down into fragments due to collisions, and then recombine with other fragments forming different magnecules. This feature has been experimentally verified (see next section), and it is called *magnecular mutation* [5].

Therefore, the specific weight of a gas with magnecular structure is a statistical average of the specific weight of all magnecules existing in the gas, and not that of one individual magnecule. Despite these mutations, said magnecular specific weight is constant under constant conditions of pressure and temperature, as we shall see.

The increased energy content of combustible gases with magnecular structure, which is released in the thermochemical reactions of the combustion, is an evident consequence of the increased specific weight, as well as of the following new features:

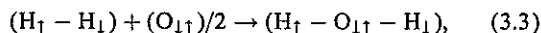
- (i) The presence in magnecules of individual uncoupled atoms, as established by experimental evidence [5], which atoms combine at the time of the combustion, thus releasing additional energy. For instance, MagneGas produced from liquid feedstocks of fossil origin has an energy content (in BTU/scf) up to three times that predicted by quantum chemistry, because its magnecular clusters contain isolated H, C and O atoms which, at the time of the combustion, recombine along the known reactions



thus releasing additional energy which is completely absent in a conventional molecular gas where the presence of isolated atoms is prohibited by nature.

- (ii) Polarized atoms release energy in their thermochemical reactions in amount greater than that released by unpolarized atoms. Consider, for instance, the water molecule $H_2O = H-O-H$ where the individual H–O and O–H radicals have the characteristic angle of 104 degrees. As is well known, the orbits of the two dimers H–O and O–H have a distribution which is perpendicular to the plane of the molecule H–O–H, as illustrated in Fig. 2. This implies that, in order to become part of the water molecule, an H atom must first reduce its space distribution to a toroidal form, precisely as

existing in magnecules. It then follows that a polarized H atom releases more energy when bonding with oxygen as compared to the energy released by unpolarized atoms, the excess energy being given by that needed for the proper polarization. Differently stated, the reaction



where the two orientations in the oxygen $O_{\uparrow\uparrow}/2 \rightarrow$ occur at 104° angle, is predicted to release more Kcal/mol than the conventional value 57 Kcal/mol of reaction (3.2c) among unpolarized atoms. By remembering that the actual structure of water remains vastly unknown following about 150 years of quantitative research, it has been conjectured in Ref. [5] that the actual structure of the water molecule is given by the combination of molecular and magnecular bonds $(H_{\uparrow} - O_{\uparrow\uparrow} - H_{\downarrow})$, as illustrated in Fig. 2, plus rotations and other motions due to temperature. In fact, such a model verifies the indicated experimental evidence of the perpendicular character of the orbits of the H–O and O–H radicals with respect to the molecular plane H–O–H, represents the diamagnetic nature of the water molecules, and permit a quantitative-numerical representation of the binding energy, electric and magnetic moments of the water molecule which, for the first time in chemistry, is accurate to the desired digit [2,3,5].

- (iii) Magnetically polarized diatomic molecules with a sufficient number of electrons can acquire new internal bonds due to the magnetic polarization of non-valence electrons, with consequential additional energy storage. This feature has been experimentally detected for the case of the CO molecule exposed to intense magnetic fields which shows under infrared scans the presence of *two new IR peaks* (see later on Fig. 8). These new peaks evidently characterize new bonds besides those characterized by conventional valence couplings. Since all available valence electrons are used in the triple valence bonds of the CO molecule, the new peaks can only be explained with the toroidal polarization of internal non-valence electrons, resulting in new magnetic bonds North–South–North–South, as illustrated in Fig. 5. Since every atomic bond implies an energy storage, it is evident that this third feature constitutes a third novel method for energy storage. Note that the latter method is also applicable to *inert gases* which, in this way, can indeed store energy (although not of thermochemical nature), contrary to a rather popular belief.

Needless to say, some of the above bonds have a *negative* binding energy. The important aspect is that the *combined effects* due to magnecular clustering implies an increased energy content. Equivalently we can say that the weaker nature of the magnecular over the molecular bond directly implies an increased energy output under combustion. This is due to the presence of H, C and O isolated atoms under a magnecular bond weaker than the molecular one, thus

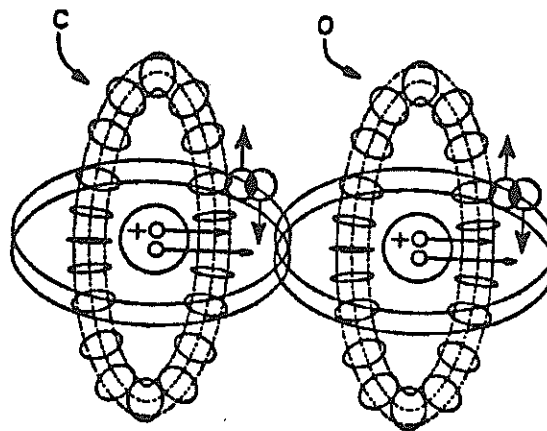


Fig. 5. A schematic view of a conceivable interpretation of new infrared peaks existing in the CO molecules exposed to very intense magnetic field as shown in Fig. 8. Since each peak requires a new internal force and all valence electrons are used in the triple bond of the CO molecule, the attractive force responsible for the new peaks *cannot* be of valence type. It is, therefore, conjectured that, since the CO molecule was exposed to strong magnetic field, the new attractive force originates from the toroidal polarization of the orbits of internal non-valence electrons in both the C and O atoms, thus producing new bonds from opposing magnetic polarities. Note that the model of this figure is extendable to other molecules (note the exclusion of the hydrogen molecule for this new internal bond due to the lack of the necessary electrons in addition to those for valence bonds).

permitting the formation under combustion of conventional molecules H_2 , CO, H_2O , etc. and consequential release of energy which would be otherwise absence.

A further possibility for increased energy output for combustible gases with magnecular structure is due to the apparent weakening of conventional valence or covalence bonds within magnecular clusters. This feature is supported by the experimental evidence of up to 15% oxygen in the combustion exhaust of MagneGas which would be impossible in the event all its CO content has the conventional triple valence bond.

As a result of these and other aspects, it then follows that combustible gases with magnecular structure are definitely preferable over those with conventional molecular structure.

For details in these aspects we refer the interested reader to papers [8]. The particular case of breaking down hydrocarbon chains and their replacement with clean burning magnecular clusters (international patents pending) requires a specialized study in a future paper.

4. Experimental evidence for the new species of magnecules

The experimental detection of *magnecules* is rather difficult, thus requiring particular scientific care before

venturing judgments, because all available analytic equipment has been conceived, tested and extensively used for the detection of the different chemical species of *molecules*.

Some of the difficulties are due to the fact that magnecules are *less stable* than molecules, particularly at high temperatures, and actually cease to exist at their Curie Temperature. As a result, numerous analytic equipment *decompose* magnecules into their conventional molecular constituents, thus giving the *perception* of lack of novelty, while in reality no measure of the species to be detected has actually occurred.

Other difficulties are due to the fact that the detecting means of various analytic equipment stimulate the recombination of isolated atoms (such as C and O) into conventional molecules (such as CO), thus resulting in the detection of substances which, in reality, do not exist in the species to be tested. A clear illustration is given by infrared measurements of MagneGas produced from antifreeze as liquid feedstock which have systematically indicated the apparent presence of about 47% of CO. This result is soon proved to be a mere "experimental belief" by the analyst, because the combustion exhaust of magnegas (which is fully molecular because beyond the magnecules Curie temperature) contains about 5% of CO₂, rather than the 35% CO₂ needed for the combustion in atmosphere of a gas containing 47% CO.

What has in reality happened is that *the analytic equipment itself has altered the species to be tested*, by turning individual C and O atoms, single valence bonds C–O and double valence bonds C=O present in the magnecules into the conventional (triple valence bonds) CO detected by the instrument.

Other difficulties are due to the extrapolation of measurements which are generally true for molecular, but not for magnecular substances. An illustration is given by the use of infrared analytic equipment which can only detect individual *radicals*, rather than complete molecules. For the case of a conventional molecular species the extrapolation of a radical (such as H–O) to the corresponding molecule (such as H₂O) is certainly correct. However, for the case of a gas created under strong magnetic fields, such as MagneGas, such extrapolation is a pure personal belief by the analyst, rather than an experimental measurement. This occurrence is due to the fact that MagneGas contain individual radicals (such as H–O) without the corresponding complete molecule, due to the evident partial decomposition of the water molecule by the electric arc, and the trapping of its fragments in magnecules.

At any rate, claims for the existence of a given percentage of water (as well as hydrocarbons and other substances) in MagneGas achieved via infrared measurements are soon dismissed as "experimental beliefs" by the absence of corresponding peaks in mass spectrometry.

Other difficulties occur in the use of micrometric feeding lines which are certainly acceptable for tests of gases with conventional molecular structure, but not for gases with magnecular structure. In fact, there is significant experimen-

tal evidence of anomalous adhesion to the walls of instruments *even for the case of diamagnetic molecules*, which occurrence is called *magnecular adhesion* [5]. Moreover, magnecules of what are generally considered to be *light gases* have been detected to exist all the way to 1000 a.m.u. and more. Therefore, the interior walls of micrometric feeding lines are soon clogged up by small magnecules in said anomalous adhesion, as a result of which *the heavy species to be tested is prevented even by micrometric feeding lines from entering the instrument, let alone be tested*.

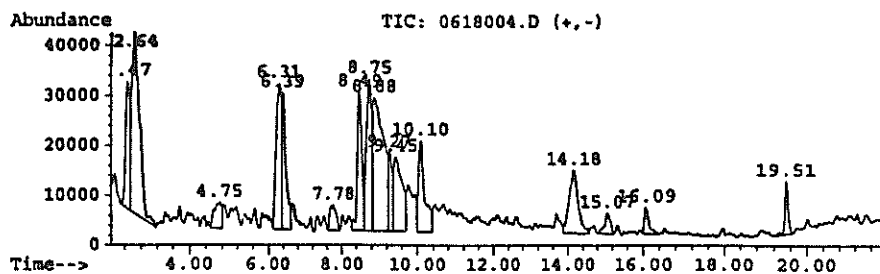
This occurrence is particularly severe for *liquid magnecules* which can have a specific weight of tens of thousands a.m.u. The use of micrometric feeding lines in liquid chromatography then yields the "experimental belief" that the magnecules do not exist, as often experienced by the author at some of the best analytic laboratories, when in reality the magnecules were detectable by a microscope or even by the naked eye (e.g., as dark spots in liquids originally transparent [5]). Again, the sectional area of the feeding line was so small to prevent the species to be tested even to enter the instrument, let alone conduct measurement of scientific value.

When magnecules are actually detected, analysts often conclude that the instrument is malfunctioning because the blank after the test shows peaks essentially identical to those of the actual scans. In reality, this feature is considered a *necessary condition* for the detection of magnecules (depending on the instrument used) because of their anomalous adhesion throughout the interior of the instrument, which adhesion is so pervasive to require flushing with an inert gas at high temperature.

It then follows that no analytic test on magnecules can be considered complete without the following: (1) print-outs of the blank prior to any feeding of a magnecular gas to verify the absence of any species; (2) print-outs of scans while feeding the magnecular gas; and (3) print-outs of the blank following the removal from the instrument of the magnecular gas to verify that at least some of the magnecular species have remained in the instrument via anomalous adhesion.

Additional difficulties are due to the possible elusion of various species all superimposed in one or more peaks, a feature occurring in particular for the short elusion times typical of recent analytic equipment. In this case the analyst slices the peaks and, in so doing, essentially identifies the *individual constituents* of the species, and *not* the species itself. These constituents are generally given by ordinary molecules, resulting in a claim of lack of novelty, when in reality the chemical species constituting the magnecular gas had not separated, as necessary for a scientific result. In turn, this feature requires the use of analytic instruments with the longest possible elusion time, generally of the order of 20 min or more, a feature which is unnecessary for the test of molecules.

Stated in different terms, analytic measurements of magnecules put the emphasis where it should be, in the proper separation and identification of each peak, rather than the



Retention Time	Area	Area %	Ratio %
Total Ion Chromatogram			
2.474	1753306	5.386	32.724
2.644	5091514	15.641	95.030
4.754	641528	1.971	11.974
6.307	2737749	8.411	51.098
6.390	2211258	6.793	41.272
7.782	592472	1.820	11.058
8.490	2357396	7.242	43.999
8.754	2784829	8.555	51.977
8.882	5357812	16.460	100.000
9.265	1123809	3.452	20.975
9.448	2421234	7.438	45.191
10.098	1946292	5.979	36.326
14.177	2129791	6.543	39.751
15.073	435208	1.337	8.123
16.085	389822	1.198	7.276
19.509	577433	1.774	10.777

Fig. 6. A typical GC-MS scan from 40 a.m.u. to 400 a.m.u. of a gas with magnecular structure obtained on June 19, 1998 at the analytic laboratory of *National Technical Systems* at the *McClellan Air Force Base* in Sacramento, California, via the use of a HP GC model 5890, a HP MS model 5972 and a HP IRD model 5965, the equipment being operated under conditions quite unusual for conventional molecular gases identified in Ref. [5]. The peculiarity of the above MS scan is that the tested MagneGas was produced from an electric arc between consumable graphite electrodes submerged within pure water (also known as "AquaFuel"), in which case the heaviest molecular species is CO_2 . Therefore, the scan here considered should have solely shown a peak at 44 a.m.u. On the contrary, the latter peak is unidentifiable and replaced by a variety of peaks in macroscopic percentages none of which was identified by the computer following a search among all molecules existing in the memory banks of the *McClellan Air Force Base* (see Ref. [5, Chapter 8 for details]).

identification of their constituents, because, when properly tested, each identifiable chemical species results in an identifiable peak, and not in a collection of peaks.

For these and several other difficulties in detecting *magnecules* with *molecular* analytic equipment, methods and insights, we refer the interested reader to monograph [5, Chapter 8].

With the understanding that analytic equipment specifically conceived, developed and tested for the detection of *magnecules* does not exist at this writing, the most effective equipment identified by the author after considerable search is given by gas chromatographic mass spectrometers (GC-MS) necessarily equipped with infrared detectors (IRD), and generally referred to as GC-MS/IRD.

The joint use of an IRD attached to the GC-MS is truly mandatory for a serious detection of *magnecules*. In essence, the sole GC-MS detection of a conventional molecule is not sufficient for its identification on rigorous scientific grounds, because there is the need of at least one independent verification. An effective alternative method for such a verifi-

cation is the IRD. When, and only when, the identification of the *same* peak is established in *both* the GC-MS and the IRD, then, and only then, the analyst can express a serious scientific result, because various possible alternative interpretations may occur when only one of these two methods is used.

In the transition to tests of *magnecules* the need for the *joint* use of GC-MS equipped with IRD becomes mandatory. In fact, *only the GC-MS/IRD permits the test of the same peak under both MS and IR scans*. If two separate instruments are used, namely, a GC-MS and, separately, an IRD, the above joint MS and IR tests of the same peak is impossible, resulting in a plethora of ambiguities with consequential departure from true experimental settings.

The need for the joint GC-MS/IRD for the analytic detection of *magnecules* is also mandatory because of the general tendency of identifying any MS peak with one or another *molecule*, identification which is eliminated for the case of *magnecules* by the test of the same peak with the IRD, as illustrated below.

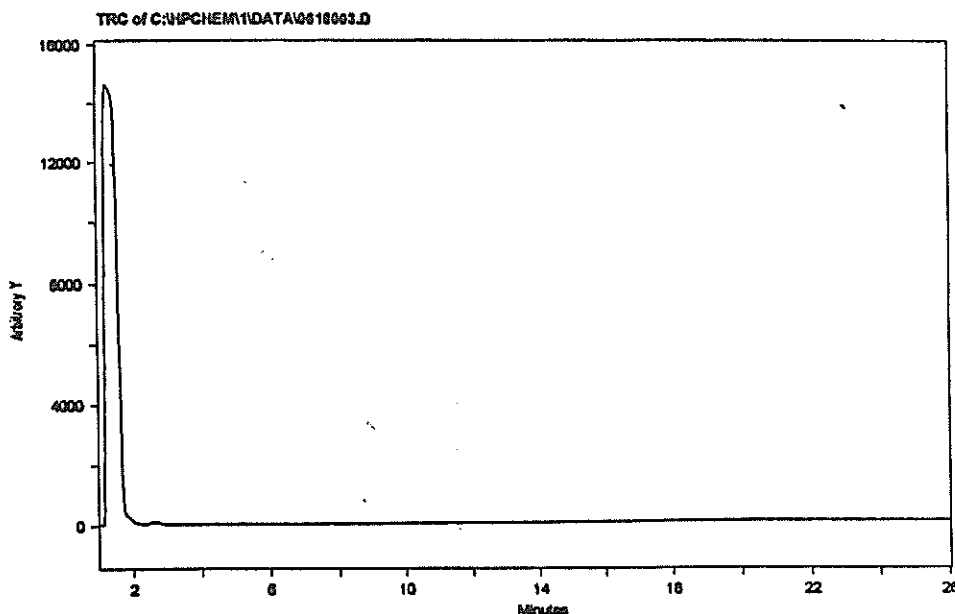


Fig. 7. The IR signature of MS scan of the preceding figure (under the same conditions, for the same gas and for the same range of 40–400 a.m.u.) confirming that the sole conventional molecule contained in the tested gas is CO_2 at 44 a.m.u., and that all anomalous peaks of the MS scan of Fig. 6 have no IR signature at all. These features establish beyond *credible* doubt the emergence of a new chemical species *not* based on any of the various types of valence, the only open scientific issue being its proper identification. The magnecular hypothesis remains the sole possible following the elimination of valence bonds, due to the creation of the gas under the very intense magnetic fields at atomic distance from electric arcs (see later on for more details).

Also, numerous GC-MS/IRD equipment of recent construction has been found to be inadequate to detect magnecules because of various reasons, such as: their detection means destroy the magnecules to be detected (as is the case for detection via strong ionization beams); the elution time is excessively short; the type of admitted column is insufficient (e.g., because its sectional area is inappropriate for large magnetically polarized magnecules); and for other reasons.

The best GC-MS/IRD identified by the author after considerable search are given by the old HP GC model 5890, HP MS model 5972 and HP IRD model 5965 operated with special precautions indicated in Ref. [5], such as: the use of the largest possible feeding lines; the cryogenic cooling of the latter; the selection of the appropriate type of column with the appropriate sectional area; the use of the column at the lowest admissible operating temperature; the use of the longest possible elution time; and other requirement which are inessential for molecules, yet essential for magnecules.

With a clear understanding of the scientific caution needed to avoid “experimental beliefs”, *magnecules are generally detected via MS peaks in macroscopic percentages (that is, clearly above the background), which peaks result to be unknown following computer search among all known molecules (Fig. 6), the same peaks having no signature under the IRD at the atomic weight of the MS peak, the*

only IR signatures being those of the much lighter radicals and molecules constituting the cluster (Figs. 7 and 8).

The lack of IR signature for magnecules establishes that the peaks detected in the GC-MS cannot possibly be molecules, particular for the case of large clusters with atomic weight of the order of hundreds of a.m.u. for which spherical symmetry (necessary to have no IR signature) cannot be credibly suspected. After eliminating valence bonds, the only remaining possibility for explaining the internal attractive force necessary to create magnecules is that such forces are of magnetic and electric nature, thus implying the birth of the new chemical species of electromagnecules.

The reader should be aware of the existence of a vast number of experimental measurements on magnecules which could be only partially reproduced in monograph [5], let alone in this paper. This evidence establishes the anomalous *magnecular adhesion* (indicated earlier), the equally anomalous *magnecular mutation* (change of magnecules in time), and other anomalies.

The latter occurrence was proved via test with the GC-MS/IRD on MagneGas produced from water as liquid feedstock (also known as Aquafuel) via: (1) the recording of the MS spectrum at one time; (2) The recording of the MS spectrum 30 min later which showed dramatic changes in the preceding spectrum even though all conditions and feeding remained unchanged; and (3) The verification that

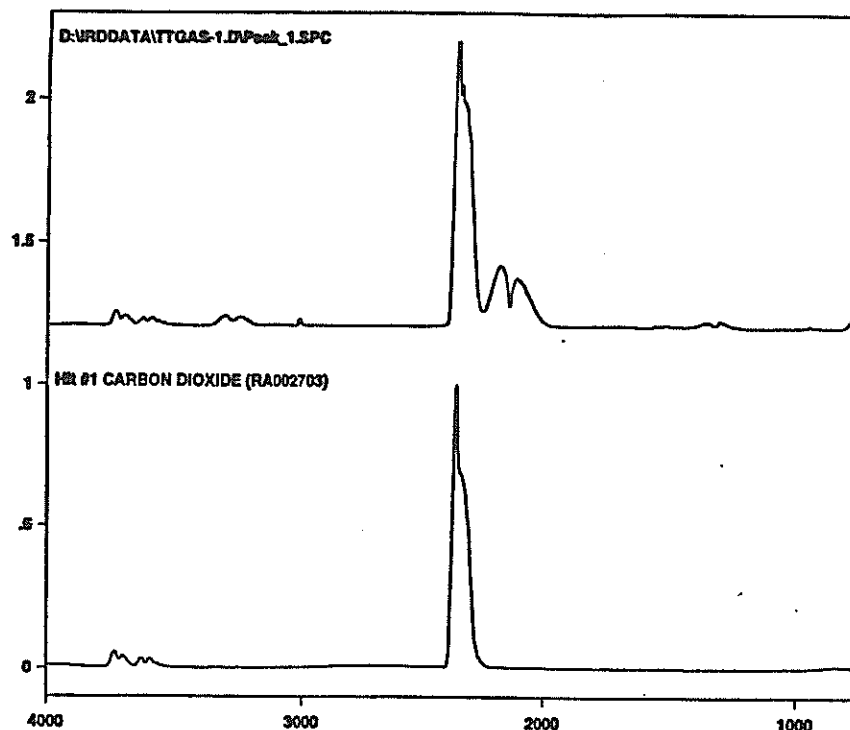


Fig. 8. A reproduction of the IR scan of a magnetically polarized CO gas conducted at the *Pinellas County Forensic Laboratory* in Largo, Florida, on July 25, 1998, via the use of a HP GC model 5890-II, a HP MS model 5970 and a HP IRD model 5965B. Note the appearance of two additional IR peaks (top view) which are absent in the conventional unpolarized molecule (bottom view). The creation of *new internal bonds within a conventional molecule which are not of valence type* is, therefore, beyond credible doubt, the only open scientific issue being the identification of their new origin. Once valence bonds are eliminated, the only plausible interpretation known at this writing is that via internal magnetic bonds as illustrated in Fig. 5.

the IR signature of both scans remained unchanged, thus confirming that the mutation has occurred solely in the *magnecular clusters*, and not in any valence substance.

The above mutations have also established the presence in magnecules of individual uncoupled atoms, e.g., because of numerous increases or decreases of peaks by one a.m.u., establishing the accretion or loss of one H atom, with similar numerical changes for C and O atoms, or for H–O, C–H and other radicals.

Additional characteristics established by this experimental evidence relates to the equally anomalous *mutation of physical properties* for magnetically polarized substances, including macroscopic changes in specific densities, visible alterations in chemical reactions and other anomalies.

5. The hypothesis of the new chemical species of MagneHydrogenTM and MagneOxygenTM (international patents pending)

In this paper we submit, apparently for the first time, the hypothesis that conventional hydrogen H₂ and oxygen O₂ gases can be turned into a new species with

magnecular structure here called *MagneHydrogenTM* and *MagneOxygenTM*, or *MagneHTM* and *MagneOTM* for short (international patents pending).

The foundations of the above hypothesis are essentially those given in preceding sections. As recalled earlier, the hydrogen molecule is diamagnetic and, therefore, it *cannot* acquire a total net magnetic polarity. Nevertheless, the orbits of the *individual H atoms* can acquire a toroidal polarization under a sufficiently strong external magnetic field. The opposite magnetic moments of the two H atoms then explain the diamagnetic character of the hydrogen molecule as illustrated in Fig. 1.

The aspect important for the hypothesis of MagneH and MagneO is that the toroidal polarization of the orbits of the electrons of the individual H atoms, plus the polarization of the intrinsic magnetic moments of nuclei and electrons in the H₂ molecule is sufficient for the creation of the desired new chemical species with bigger specific weight, because the new bonds can occur between pairs of individual H atoms, as illustrated in Fig. 4.

The creation of MagneO is expected to be considerably simpler than that of MagneH because oxygen is paramagnetic, thus having electrons free to acquire an overall

magnetic polarity which is absent for the case of MagneH. Nevertheless, the achievement of a significant increase of the specific weight of the oxygen will require the toroidal polarization of at least some of the peripheral atomic electrons, in addition to a total magnetic polarization.

The primary technological objective is therefore that of achieving physical conditions and geometries suitable for the joint polarization of *atoms*, rather than molecules, which favors their coupling into chains of opposing magnetic polarities (Fig. 9). In the final analysis, the underlying principle here is similar to the magnetization of a ferromagnet, which is also based on the polarization of the orbits of unbounded electrons. The main difference (as well as increased difficulty) is that the creation of MagneH requires the application of the same principle to a *gaseous*, rather than a solid substance.

Under the assumption that the original gases are essentially pure, MagneH can be schematically represented

$$(H_T - H_L) \times H_T, \quad (5.1a)$$

$$(H_T - H_L) \times (H_T - H_L), \quad (5.1b)$$

$$(H_T - H_L) \times (H_T - H_L) \times H_T, \text{ etc.} \quad (5.1c)$$

while MagneO can be schematically represented

$$(O_T - O_L) \times O_T, \quad (5.2a)$$

$$(O_T - O_L) \times (O_T - O_L), \quad (5.2b)$$

$$(O_T - O_L) \times (O_T - O_L) \times O_T, \text{ etc.} \quad (5.2c)$$

where the arrows now indicate possible polarizations of more than one electron orbit.

By keeping in mind the content of the preceding sections, the achievement of the above magnecular structure does imply that MagneH and MagneO have specific weight and energy content greater than the corresponding values for unpolarized gases. The numerical values of these expected increases depend on a variety of factors discussed in the next section, including the intensity of the external magnetic field, the pressure of the gas, the time of exposure of the gas to the external field, and other factors.

A first important feature to be subjected to experimental verification (reviewed later on) is the expected increase of specific weight. By recalling that the gasoline gallon equivalent for hydrogen is about 383 scf, the achievement of a form of MagneH with five times the specific weight of conventional hydrogen would reduce the prohibitive volume of 7660 scf equivalent to 20 g of gasoline to about 1500 scf. This is a volume of MagneH which can be easily stored at the pressure of 4500 pounds per square inch (psi) in carbon fiber tanks essentially similar in volume to that of a gasoline tank. As a result, the achievement of MagneH with sufficiently high specific weight can indeed eliminate the

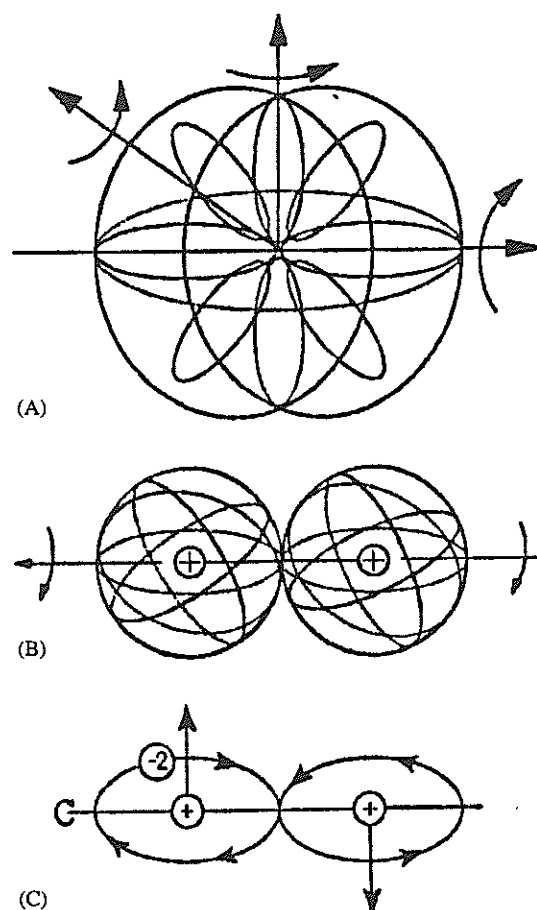


Fig. 9. A schematic view of the main steps in the magnetic polarization of the hydrogen molecule. Due to rotations in all space directions, the H_2 molecule has a spherical symmetry (responsible for its lack of IR signature) with the radius of the order of magnitude of the diameter of the H atom (again, when referred to orbits rather than orbitals), as in View A. The main technological objective for the creation of MagneH is the removal of *all* rotations. This process is schematically represented in this figure via the use of an external magnetic field (not shown for simplicity) suitable to create the reduction of the molecule, first, to two discernible H atoms, as in View B, and then to the planar configuration of View C via the elimination of the rotations of the individual H atoms. The final state is a structure which, in semiclassical approximation and at absolute zero degree temperature, the electrons orbits are located in a plane. We recover in this way the physical law that, in the absence of external perturbations or quantum uncertainties, *orbits are distributed within a plane*, as it is the case for planetary orbits. When quantum uncertainties are added in the presence of a strong external magnetic field, the exactly planar configuration is evidently lost in favor of a toroidal configuration, thus recovering in this way the main feature of the new chemical species of MagneH, as studied in detail in Refs. [5,8].

expensive liquefaction of hydrogen in automotive use, with consequential reductions of costs.

Another basic feature to be subjected to experimental verification (reviewed later on) is that the combustion of MagneH and MagneO releases more energy than the combustion of conventional H and O gases, particularly when all features (i), (ii) and (iii) of Section 3 are realized. It then follows that

- (I) the use for internal combustion engines of MagneH with a sufficiently high specific weight is expected to eliminate liquefaction, yield essentially the same power as that produced with gasoline, and produce a dramatic decrease of operating costs;
- (II) the use of MagneH and MagneO in fuel cells is expected to yield a significant increase of voltage, power and efficiency; and
- (III) the use of liquefied MagneH and MagneO as fuels for rocket propulsion is expected to permit an increase of the payload, or a decrease of the boosters weight with the same payload.

Moreover, recent studies scheduled for a separate presentation have indicated that the *liquefaction of MagneH and MagneO appears to occur at temperatures bigger than those for conventional gases*, thus implying an additional reduction of costs. This expectation is due to the fact that magneules tend to aggregate into bigger clusters with the increase of the pressure, evidently due to their magnetic polarizations, which feature evidently favors liquefaction.

The experimental evidence supporting this expectation is that, while compressing a gas with magnecular structure, there is an increase of the volume needed for the same pressure increase although at increased pressures. Specifically, measurements have established that the compression of MagneGas in a high pressure cylinder which may require 40 scf of MagneGas for the increase from 100 to 200 psi, the compression of the same gas in the same cylinder from 3000 to 3100 psi will require about 50 scf.

In turn, these features establish that *gases with magnecular structure have nonlinear deviations from the perfect gas law, and their Avogadro number is not constant with the variation of pressure, temperature and volume*. All these anomalies, which are beyond any credibility for molecular structure, are easily explained for magneules by their breakdown into fragments due to collisions, their recombination with other fragments, and their tendency to aggregate with increase of the pressure, with the consequential decrease of the Avogadro number.

It is evident that the same principles outlined above also apply for other gases, and not necessarily to H and O gases alone. In fact, the processing of any gaseous fossil fuel via the principles here considered permits the increase of its specific weight as well as of its energy output, thus permitting a consequential decrease of storage volume, increase of performance and decrease of costs.

6. The new magnecular interpretation of H₃ and O₃

As is well known, a species with molecular weight of about 3 a.m.u., corresponding to H₃, is routinely detected in GC-MS scans, while O₃ has been known for over one century under the name of *ozone*. These species are generally interpreted as being due to some form of valence bonds. In this section we point out that such a valence interpretation may imply the violation of a number of laws in particle physics. On the contrary, the magnecular interpretation as in Eqs. (5.1a) and (5.2a) appears to resolve these problematic aspects. At any rate, the existence of the species H₃ and O₃ provides evident support for the existence of species with bigger molecular weight.

A triple valence bond for H₃ may imply the violation of Pauli's exclusion principle (and other physical laws), because, under our strong valence bond, it would imply the bond of a third electron to a pre-existing valence pair. In turn, this would imply the existence of at least two electrons with the same quantum numbers in the same energy level, an occurrence clearly prohibited by Pauli's exclusion principle.

The assumption of a weaker notion of valence (such as that of contemporary quantum chemistry) would indeed permit a form of valence bond for the third hydrogen atom in the H₃ structure. However, such a model would have other inconsistencies, such as the prediction that the hydrogen molecule is paramagnetic, as studied in detail in Ref. [5].

Independently from that, various laws in particle physics prohibit a bond between a valence electron pair (which is necessarily a Boson due to its singlet nature) and a third electron (which is a Fermion). In any case, vast experimental evidence has established that valence correlations-bonds only occur in *pairs*. Serious studies of the valence origin of the H₃ bond would, therefore, require a basic revision of the entire valence theory.

This and other violations of basic physical laws can be resolved with the interpretation that H₃ has the magnecular structure

$$H_3 = (H_{\uparrow} - H_{\downarrow}) \times H_{\uparrow} \quad (6.1)$$

In this case only two electrons are bonded into a singlet pair with the same energy although antiparallel spins as requested for the verification of Pauli's principle, while the electron of the third H atom is magnetically bonded to one of the other two H atoms, thus being in an energy state different from that of the preceding valence pair, with consequential lack of applicability of Pauli's exclusion principle.

In the case of ozone O₃, the molecule O₂ possesses free electrons for possible additional valence bonds. Nevertheless, the possible violation of Pauli's exclusion principle for triple valence bonds remains. Also, as discussed in detail in the next section, the origin of ozone (notoriously achieved via electric discharges) indicates the presence at its creation of strong magnetic fields, with consequential toroidal polarization of the orbits of at least some of the valence electrons.

It then follows that the magnecular structure of the ozone

$$O_3 = (O_{\uparrow} - O_{\downarrow}) \times O_{\uparrow}, \quad (6.2)$$

with internal coupling similar to those of the magnecule (6.1), cannot be ruled out.

The plausibility of the magnecular interpretation of H_3 and O_3 provides grounds for the search for similar magnecular structures with bigger number of atomic constituents, which is the central objective of this study.

7. Industrial production of MagneHydrogen™ and MagneOxygen™ (international patents pending)

As indicated earlier, the magnetic polarization of the orbits of peripheral atomic electrons requires extremely strong magnetic fields of the order of billions of Oersted which are of simply impossible realization in our laboratories with current technologies, that is, at distances of the order of inches or feet. These magnetic fields cannot be realized today even with the best possible superconducting solenoids cooled with the best available cryogenic technology.

The only possible, industrially useful method of achieving magnetic fields of the needed very high intensity is that based on direct current (DC) electric arcs with currents of the order of thousands of Amperes (A) when considered at atomic distances, i.e., of the order of 10^{-8} cm. As illustrated in Fig. 10, the magnetic field created by a rectilinear conductor with current I at a radial distance r is given by the well known law

$$B = kI/r, \quad (6.1)$$

where $k=1$ in absolute electromagnetic units. It then follows that, for currents in the range of 10^3 A and distances of the order of the size of atoms $r = 10^{-8}$ cm, the intensity of the magnetic field B is of the order of 10^{13} Oersted, thus being fully sufficient to cause the magnetic polarization of the orbits of peripheral atomic electrons.

Under the above conditions schematically represented in Fig. 10, atoms with the toroidal polarization of their orbits find themselves aligned one next to the other with opposing polarities which attract each other, thus forming magnecules. The electric arc decomposes the original molecule, thus permitting the presence of isolated atoms or radicals in the magnecular structure as needed to increase the energy output (Section 3).

In this way, the process transforms the original gas with its conventional molecular structure into a new chemical species consisting of individual atoms, radicals and complete molecules all bonded together by attractive forces among opposite magnetic polarities of the toroidal polarization of the orbits of peripheral atomic electrons.

In the event the original gas has a simple diatomic molecular structure, such as H_2 , the magnecular clusters are composed of individual polarized H atom and ordinary polarized molecules H_2 as in Fig. 4. In the event the original gas has the more complex diatomic structure of O_2 , the magnecular

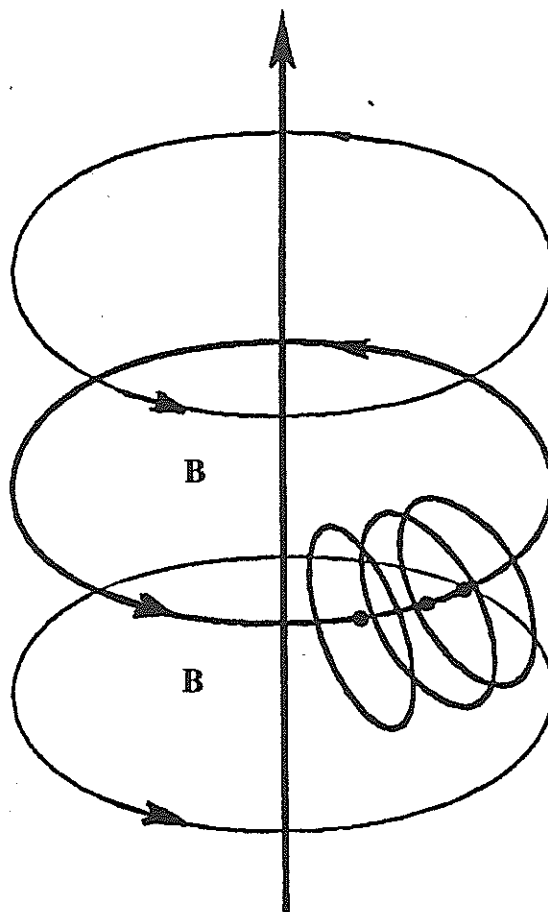


Fig. 10. A schematic view of the geometry of the magnetic field B at atomic distances from an electric arc. Note the counterclockwise circular geometry of the field, its extremely high intensity, the consequential toroidal polarization of atomic orbits (here schematically represented with circles), the consequential compression of various polarized atoms in the same magnetic line, and the resulting bonds of the latter into clusters, called Santilli magnecules, via the strongly attractive forces of opposing polarities.

clusters are composed of individual polarized O atoms, O–O single bonds, and O_2 molecules with additional internal bonds as in Fig. 5. In the event the original gas has the more complex diatomic structure CO with triple valence bonds, the magnecular clusters are more complex and are generally composed of individual C and O atoms, single bonds C–O, double bond C=O, conventional molecules CO and O_2 with internal new bonds as in Fig. 5, plus possible C-complexes. Original gases with more complex conventional molecular structure evidently imply more complex magnecular clusters with all possible internal atomic arrangements.

It is evident that the resulting new species is not composed of all identical magnecules, and it is composed instead of a variety of magnecules from a minimum to a maximum

number of atomic components, which have been measured to reach 1000 a.m.u. and even more. The specific weight of the magnecular gas is then given by the average weight of all different magnecules, as indicated earlier.

Needless to say, a number of alternative methods for the industrial production of MagneH and MagneO are possible as identified in the existing patent applications. An alternative method worth mentioning here is the use of solenoids. The reader should however be aware that the latter cannot decompose molecules. Therefore, the MagneGases produced via the use of electric discharges and solenoids are different.

Another type of MagneH important for this study is that obtained from MagneGas [5]. When MagneGas is produced from a hydrogen rich liquid feedstock (such as water or liquids of fossil origin), it may contain up to 60% hydrogen in a form already polarized by the electric arc used for its production. Therefore, the hydrogen content of MagneGas is indeed a particular form of MagneH which can be separated via a variety of available technologies, such as filtration, cryogenic cooling and other processes.

This particular form of MagneH (whose features are identified in the next section) is particularly suited as fuel for internal combustion engines, rather than for fuel cells. This is due to the expected presence of very small C and O impurities which do not permit their use in fuel cells.

This particular type of MagneH derived from MagneGas has already been tested for automotive usage and proved to have a performance essentially similar to that of gasoline without any need of liquefaction, as needed instead by hydrogen vehicles currently tested by BMW, GM and other automakers. The tests were conducted via the conversion of two Honda and one Ferrari cars to operate on the new fuels (see [5] for brevity).

Above all, this particular type of MagneH has resulted to be cost competitive with respect to fossil fuels, of course, when produced in sufficiently large volumes. This cost competitiveness is due to a variety of factors, including (see [5] for detail):

- (1) the use of hydrogen rich wastes as liquid feedstock, such as city and farm sewage, antifreeze and or oil waste, etc., which implies an *income*, rather than a cost;
- (2) the possible utilization of steam at 400°C produced by the cooling of the highly esoenergetic processes of the reactors, which steam can be used for other *income producing applications*, such as desalting seawater via evaporation, production of electricity via turbines, heating of buildings, and other income producing uses; and
- (3) the unusually high efficiency of Santilli hadronic reactors of molecular types used for the process which brings the cost of electricity down to 0.005/scf.

Specific equipment and designs for the industrial production of MagneH, MagneO, and other magnetically polarized gases are available on request.

8. Experimental evidence on MagneHydrogen™ and MagneOxygen™

It is now important to review the experimental evidence supporting the existence of MagneH and MagneO. For this purpose the author had constructed by technicians in Florida a rudimentary apparatus based on the use of automotive sparks powered by an ordinary car battery, the system operating at about 15 psi. Two types of MagneO, denoted by MagneO1 and MagneO2, were produced from pure oxygen for comparative purposes.

This type of MagneO was tested in lieu of ordinary oxygen in a 2-cell proton exchange membrane (PEM) fuel cell operated with conventional high purity hydrogen. The membrane material was Nafion 112; the catalyst in the electrodes was platinum acting on carbon; the plates for heat transfer were given by two nickel/gold plated material; the temperature of the fuel cell was kept constant via ordinary cooling means; the current was measured via a HP 6050A electronic load with a 600 W load module; a flow rate for oxygen and hydrogen was assigned for each current measurement; both oxygen and hydrogen were humidified before entering the cell; the measurements reported herein were conducted at 30°C.

The results of the measurements are summarized in Figs. 11–13 which report relative measurements compared to the same conditions of the cell when operated with ordinary pure oxygen. As one can see, these measurements show a clear increase of the voltage, power and efficiency of the order of 5% when the cell was operated with MagneO1 and MagneO2. The increase was consistent for both samples except differences within statistical errors.

To appraise these results, one should note that the types of MagneO used in the test were produced via rudimentary equipment based on intermittent sparks operated with an ordinary automotive battery, and with the pressure limited to 15 psi. By comparison, the industrial production of MagneO should be done with an array of arcs each operated with continuous currents of thousands of Amperes, and at pressures of thousands of psi. It is evident that the latter conditions are expected to imply a significant increase of the performance of the fuel cells when operated with MagneO. Still bigger increases in voltage, power and efficiency occur when the fuel cells are operated with both MagneO and MagneH for the reasons discussed in Section 3. These latter tests are under way and are contemplated for reporting in a future paper.

In summary, the systematic character of the experimental results, combined with the limited capabilities of the used equipment, appear to confirm the hypothesis of new forms of hydrogen and oxygen with magnecular structure capable of producing an industrially significant increase in voltage, power and efficiency of fuel cells. Independent measurements are here solicited for the finalization of these issues.

Additional tests were conducted with MagneH produced from MagneGas as indicated in the preceding section.

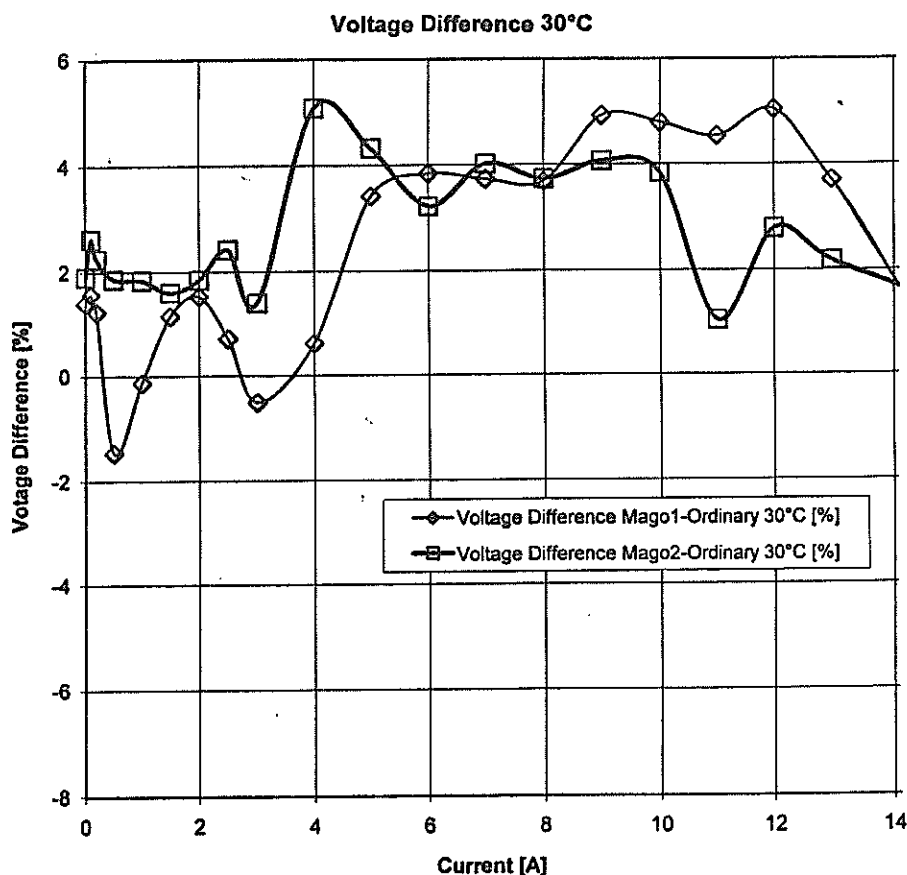


Fig. 11. A schematic view of the voltage increase in a test fuel cell operated with ordinary pure hydrogen and the two samples of MagneO produced by rudimentary equipment.

MagneGas was first produced by using antifreeze waste as liquid feedstock. The combustible gas was then passed through 5 Armstrong zeolite filters, which essentially consist of a microporous molecular sieve selecting a gas via the so-called "molecular sieving," or molecular size exclusion. The filtered gas was then subjected to the following three measurements:

- (1) This type of MagneH was first subjected to analytic measurements by a laboratory via Gas Chromatography (CG) and independent tests for confirmation were conducted via Fourier Transform Infrared Spectroscopy (FTIS). All measurements were normalized, air contamination was removed, and the lower detection limit was identified as being 0.01%. The results are reported in Fig. 14. As one can see, these measurements indicate that this particular type of MagneH is composed of 99.2% hydrogen and 0.78% methane, while no carbon monoxide was detected.
- (2) The average specific weight of this type of MagneH was measured by two independent laboratories as being 15.06 a.m.u., while conventional pure hydrogen has the specific weight of 2.016 a.m.u., thus implying a 7.47 fold increase of the specific weight of conventional hydrogen.
- (3) The same type of MagneH used in the preceding tests was submitted to CG-MS scans via the use of a HP GC 5890 and a HP MS 5972 with operating conditions specifically set for the detection of magneCules (Section 5 and Ref. [5]). The results of these third tests are reproduced in Fig. 15. As one can see, by keeping in mind the results of GC-FTIS of Fig. 14, the GC-MS measurements should have shown only two peaks, that for hydrogen H_2 at about 2 a.m.u., and that for methane CH_4 at about 16 a.m.u. On the contrary, these GC-MS tests confirm the existence of a large peak at about 2 a.m.u. evidently representing hydrogen, but do not show any peak at 16 a.m.u. proportional to the 0.78%

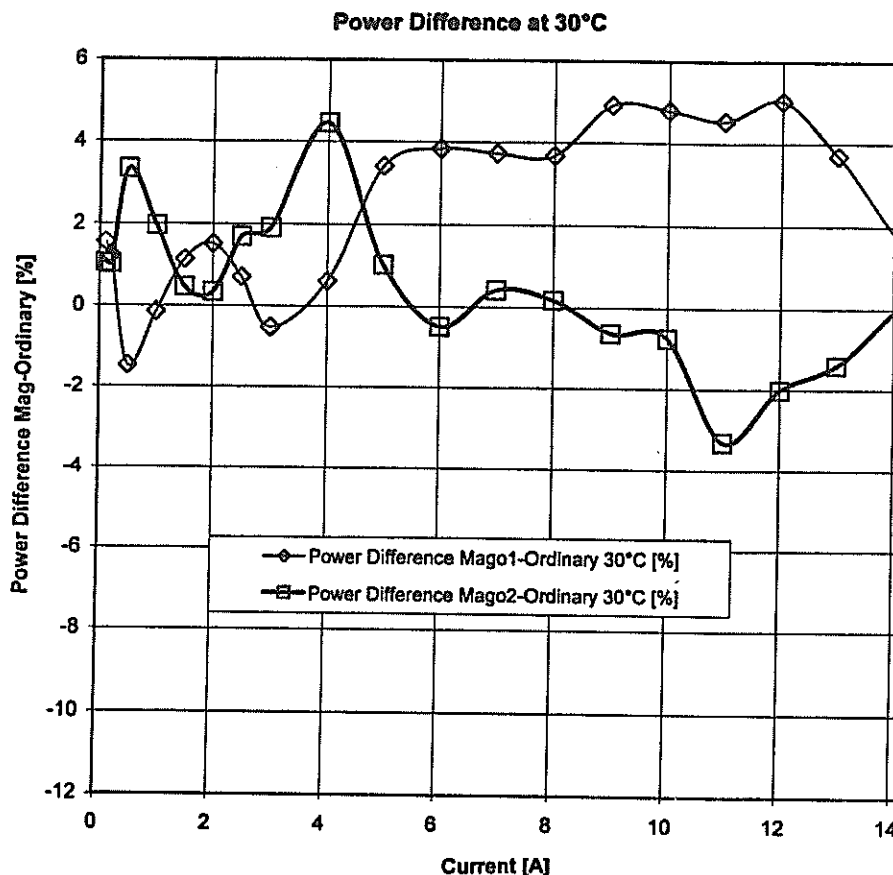


Fig. 12. A schematic view of the power increase in a test fuel cell operated as in Fig. 11 confirming the results of the latter.

of methane, and exhibit instead the presence of a considerable number of additional peaks in macroscopic percentages all the way to 18 a.m.u. This GC-MS scan establishes the existence beyond credible doubt of a magnecular structure in the type of MagneH here studied. Note, in particular, the existence of well identified peaks in macroscopic percentage with atomic weight of 3, 4, 5, 6, 7, 8 and higher values which peaks, for the gas under consideration here, can only be explained as magnecules composed of individual H atoms as well as H molecules in increasing numbers.

The above measurements (1), (2) and (3) confirm the capability to produce hydrogen, oxygen and other gases with a multiple value of their standard specific weight, and consequential increased energy content.

9. Conclusions

Despite the known uneasiness created by novelty, the rather vast experimental evidence, only partially reproduced

in this paper to avoid a prohibitive length, supports the following results:

- (1) The existence in nature of a new chemical species whose bonding force is not of valence type (from the absence of infrared signature and various other evidences as in Figs. 6 and 7), which has been interpreted by this author as being due to the only fields available in a molecular structure, the electric and magnetic fields, and called electromagnecules in general, the name Santilli magnecules being used to denote the dominance of magnetic over electric effects (Section 2). Other researchers may prefer different nomenclatures and search for esoteric fields other than the electric and magnetic fields, with the understanding that the non-valence novelty of the new species is outside scientific debate.
- (2) The existence of a form of hydrogen with about seven times the atomic weight of molecular hydrogen which eliminates the need for liquefaction in automotive use, while having a power output essentially similar to that of gasoline, and being cost competitive with respect to

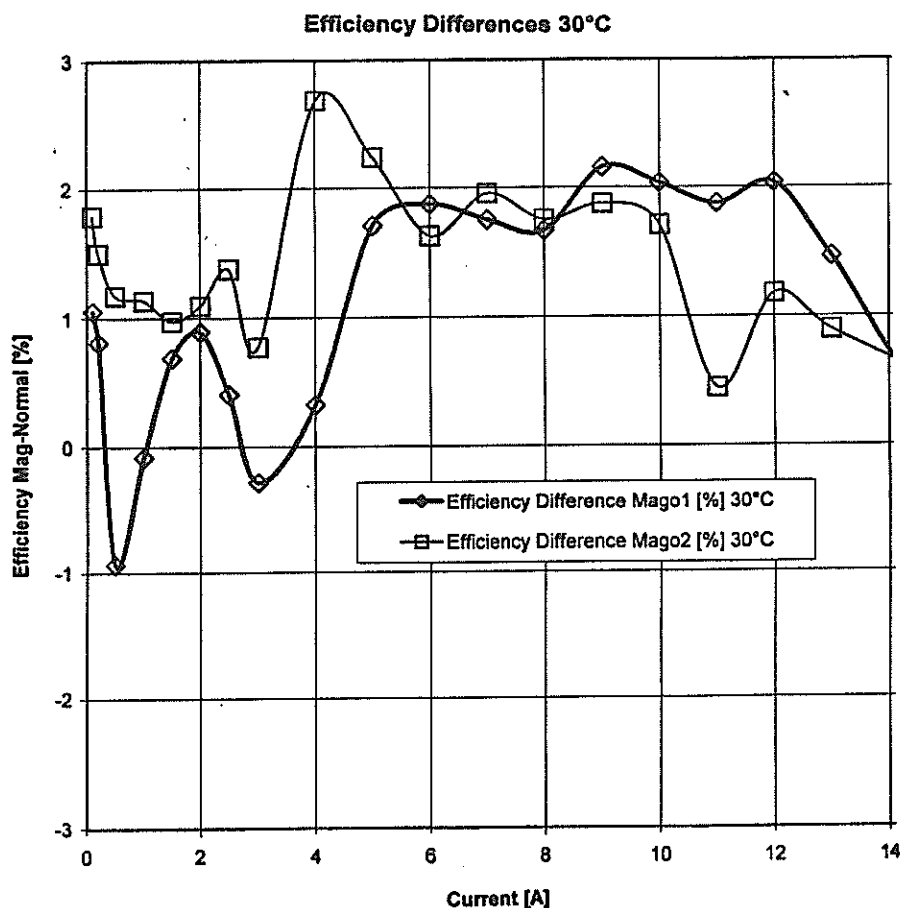


Fig. 13. A schematic view of the efficiency increase in a test fuel cell operated as in Fig. 11, which provide additional confirmation of the latter results.

fossil fuel when produced in large scale. This is the new species of hydrogen, called by this author MagneH™ (international patents pending) which is derived via filtering, cryogenic separation or other means from the new combustible fuel called Santilli MagneGas™ (international patents pending). The latter gas is produced via DC electric arcs between carbon-base consumable electrodes submerged within a hydrogen rich liquid feedstock, such as fresh or salt water, anti-freeze or oil waste, city or farm sewage, crude oil, etc.

- (3) The industrial capability of turning conventional hydrogen and oxygen into new species with bigger atomic weight and energy content for use in fuel cells with increased voltage, power and efficiency.
- (4) The existence of new forms of liquid hydrogen and oxygen for rocket propulsion with increased thrust, and consequential increased payload or decreased boosters' weight with the same payload.

- (5) The experimental evidence of dramatic departures from quantum chemistry in support of the covering hadronic chemistry [5].

Evidently, these studies are in their infancy and much remains to be done, both scientifically and industrially. Among the existing intriguing open problems we mention:

- (A) The identification of new analytic equipment specifically conceived for the detection of magnecules. In fact, researchers in the field know well the dramatic insufficiency for tests on magnecular substances of currently available analytic equipment specifically conceived for molecular substances.
- (B) The identification of the possible frequency at which magnecules may have an infrared signature. For instance, the detection of methane in the MagneH tests of Fig. 14 has a mere indicative value, rather

Component	Gas
Hydrogen	99.2
Carbon monoxide	None detected
Carbon dioxide	None detected
Methane	0.78
Ethane	None detected
Ethene (ethylene)	None detected
Ethyne (acetylene)	None detected

Fig. 14. A summary chart of the analytic measurements via GC and, independently, via FTIS on the particular type of MagneH produced via zeolite filtering of MagneGas originating from ordinary tap water. Note the detection of 99.2% H₂, 0.78% of methane and no measurable CO.

than being an actual experimental fact. In any case, the detection of methane is not confirmed by at least one second independent test to achieve final scientific character. Also, a peak at 16 a.m.u. which is necessary in the GC-MS scans of Fig. 15 to confirm the presence of methane (CH₄), is missing. Finally, the original MagneGas is created in the 10,000 °F of electric arcs at which temperature no methane can survive. In view of the above, a more plausible possibility is that the "methane" detected by the analyses of Fig. 14 is, in reality, the infrared signature of a magneucle.

- (C) The study of the liquefaction of MagneGases on a comparative basis with the liquefaction of the same gases with conventional molecular structure. This study is recommended particularly for rocket propulsion, due to the expected new species of liquid magneucle [5], the liquefaction itself at a temperature bigger than the conventional ones, the increase in trust and the reduction in liquefaction costs.

(D) The study of the possible storage of energy in inert gases via the mechanism of internal magnetic polarization and resulting new molecular bonds illustrated in Figs. 5 and 8. In fact there exist patents as well as reported test engines operating on inert gases which are generally dismissed by academia because of the believed "inert" character of these cases. Perhaps, a more open mind is recommendable for truly basic advances.

- (E) The study of nonlinear deviations from the perfect gas law and the Avogadro number which are inherent in magnecular clustering since they can break down into fragments due to collision and then have different recombinations, resulting in a population with generally varying number of constituents, while keeping constant statistical averages.

Needless to say, the author solicits the independent verification of all results presented in this paper without which no real scientific advance is possible.

In closing with a personal note, the author dedicates this paper to the memory of *Amedeo Avogadro*, who was born in Turin, Italy, in 1776 and died there in 1856. The author conducted his graduate studies in theoretical physics at the *University of Turin*, and had the privilege of holding the chair of nuclear physics at the *A. Avogadro Technical Institute* in Turin, Italy, from 1965 to 1967. In this way, the author had access to historical records which gave him the opportunity of studying Avogadro's original contributions, and some of the comments of the time.

As well known to historians, the constancy of Avogadro's number was strongly opposed by scientists of his time, and became scientifically established as a pillar of contemporary chemistry only with the work by another Italian physicist, *Stanislao Canizzaro* in 1858, unfortunately after Avogadro's departure.

The perception by this author in studying these historical documents has been the emergence of Amedeo Avogadro as a towering scientific mind, not only because of his capability to be dramatically ahead of the science of his time, but also for the scientific balance and open mind solely dedicated to the pursuit of new scientific knowledge, which is the true essence of research. The new findings tentatively presented in this paper are dedicated to Amedeo Avogadro in memory of his teaching and example.

Acknowledgements

The author would like to thank Professors A.K. Aringazin, J. Dunning-Davies, J.V. Kadeisvili and several other colleagues and technicians for generous assistance in the completion of this paper. Particular thanks are due to the referees of the *International Journal of Hydrogen Energy* for simply invaluable critical comments.

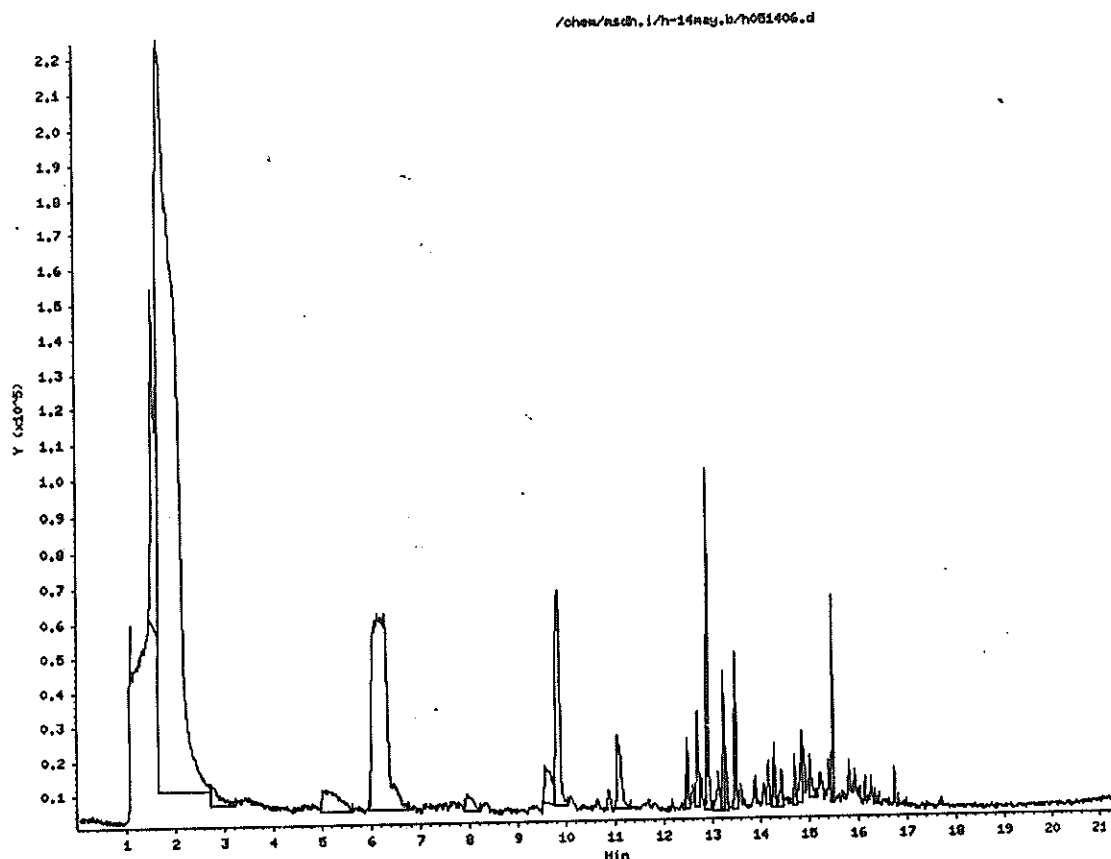
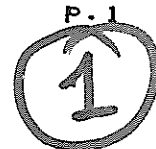


Fig. 15. A reproduction of one of the GC-MS scans of the same type of MagneH used in the tests of Fig. 14. Note the confirmation of the dominant existence of hydrogen at about 2 a.m.u., and the presence of new species which do not exist in the GC and FTIS tests of Fig. 14, thus establishing the existence of a new non-valence chemical species. Particularly significant are macroscopic peaks (here intended as peaks definitely outside the background) at 3, 5, 6, 8, and 10 a.m.u. which, for this particular type of gas, can only be interpreted as *clusters of hydrogen atoms and molecules* due to the absence of other elements in that range of atomic weight. These measurements establish beyond reasonable scientific doubt the industrial production of MagneH, MagneO and other magnetically polarized gases whose atomic weight, and consequential energy content are a multiple of those for conventional molecular values.

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**ADSORPTION RESEARCH INC.**6175-D Shamrock Court
Dublin, OH 43016Ph.: 614-798-9090
Fax: 614-798-9091**FAX MESSAGE**

To: Dr. Ruggero M. Santilli & Kenneth H. Heffner
USMagneGas, Inc.
Fax: 727-507-8261 / IBR: 727-934-9275
From: Kent Knaebel
Date: June 15, 2004
Subject: Separation and Molecular Weight Measurements of MagneGas™ and
MagneHydrogen™

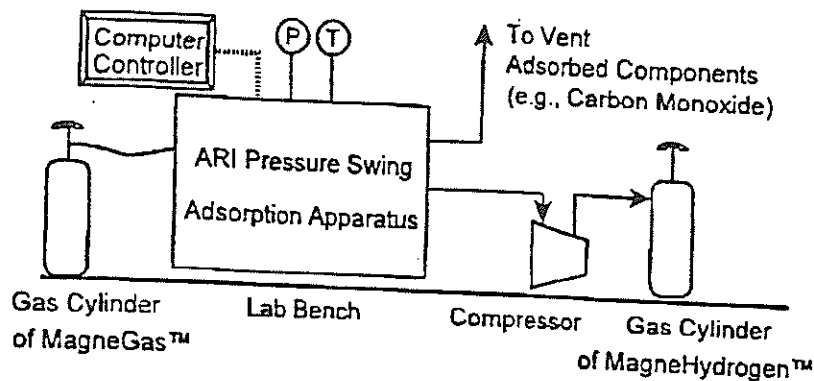
Dear Ruggero and Ken:

First, I will explain briefly our separation process, then I will explain how we measured molecular weights. To supplement the latter description, a data & calculation sheet is attached.

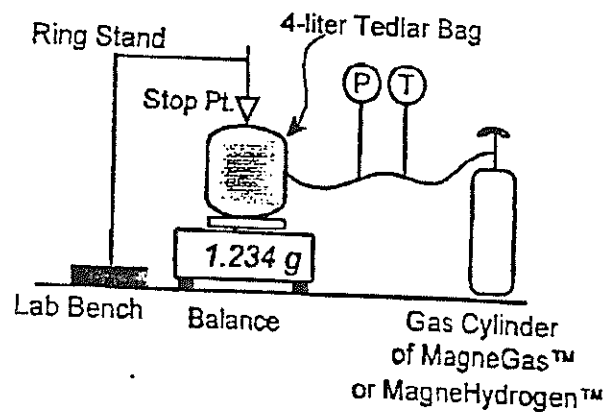
ARI conducted two separation trials using two different approaches to perform the separation. The first trial used a reduced copper catalyst bonded to an alumina substrate for removing carbon monoxide from the "MagneGasTM" fuel sample. The premise was that the copper would exhibit attraction for the pi-bonds of the carbon monoxide. Unfortunately, this approach was not effective.

The second test employed 5A zeolite, a microporous molecular sieve. The premise was that a separation could be effected by molecular dimensions, exploiting the 'molecular sieving' effect. That is, it employs size exclusion, in addition to van der Waals forces. In subsequent off-line analyses, that test was shown to produce superior product, i.e., practically free of carbon monoxide. The third test employed 13X zeolite. The results of analyses from that test, however, are not known to ARI.

A semi-continuous, semi-automated separation was performed at ambient temperature employing a pressure swing adsorption (PSA) cycle using 5A zeolite to separate the gas components, removing the free carbon monoxide portion of the MagneGasTM sample, yielding MagneHydrogenTM. Both gases were subsequently tested to determine their average molecular weights. The schematic diagram below shows the general features of the apparatus.



Concerning the measurements of molecular weight you requested, we conducted the measurements in a calibrated volume, into which a measured mass of gas was admitted. By determining the mass per volume, and applying the ideal gas law, we were able to estimate the molecular weight. A sketch follows.



Generally, the measurements were accurate within 1% error, while the difference between the average values was about 3.5%. Therefore, we consider the difference to be real and not an artifact of measurement discrepancies. As mentioned earlier, a copy of the spreadsheet containing the data and calculations is attached.

Sincerely yours,

Kent S. Knaebel

MagneHydrogen™

(CO-Free)

 $V \text{ (m}^3\text{)} =$

0.004970517

0.38

(pct. dev.)

 $P_{\text{room}} \text{ (psia)}$

14.09

97147.12613

Pa

 $T_{\text{room}} \text{ (}^{\circ}\text{C)}$

26

299.15

K

 $MW_{\text{air}} \text{ (g/mol or amu/molecule)}$

29

$$M_{\text{prod}} = (m \cdot R \cdot T) / (V \cdot P) + M_{\text{air}}$$

 $M_{\text{prod}} \text{ (g/mol or amu/molecule)} = 15.05958998$

Trial Mass Change (g)

1 -2.672

2 -2.735

3 -2.704

4 -2.715

5 -2.7065

std= 0.026337552

error%= -0.973122202

MagneGas™

(Approx. 4.2% CO)

 $V \text{ (m}^3\text{)} =$

0.004970517

 $P_{\text{room}} \text{ (psia)}$

14.1

97216.0737

Pa

 $T_{\text{room}} \text{ (}^{\circ}\text{C)}$

25.75

298.9

K

 $MW_{\text{air}} \text{ (g/mol or amu/molecule)}$

29

$$M_{\text{feed}} = (m \cdot R \cdot T) / (V \cdot P) + M_{\text{air}}$$

 $M_{\text{feed}} \text{ (g/mol or amu/molecule)} = 15.5953946$

Trial Mass Change (g)

1 -2.578

2 -2.633

3 -2.616

4 -2.599

5 -2.6065

std= 0.023530123

error%= -0.902747843

CALCULATIONS

Hydrogen				DATA	
P_{room} (psia)	14.17	97698.70669	Pa	Trial	Mass Change (g)
T_{room} (°C)	25.8	298.95	K	1	-5.283
				2	-5.277
				3	-5.26
MW_{air} (g/mol or amu/molecule)	29			4	-5.312
MW_{H_2} (g/mol or amu/molecule)	2.01594			5	-5.158
$V = (m \cdot R \cdot T) / (P \cdot (M_{\text{H}_2} - M_{\text{air}}))$				m =	-5.258
V (m³) =	0.004957161	4.957161307	L	std =	0.058961852
				error% =	-1.121374136

Helium				DATA	
P_{room} (psia)	14.24	98181.33968	Pa	Trial	Mass Change (g)
T_{room} (°C)	26.2	299.35	K	1	-4.904
				2	-4.948
MW_{air} (g/mol or amu/molecule)	29			3	-4.923
MW_{He} (g/mol or amu/molecule)	4.0026			4	-4.884
$V = (m \cdot R \cdot T) / (P \cdot (M_{\text{He}} - M_{\text{air}}))$				5	-4.91475
V (m³) =	0.004983872	4.983872467	L	std =	0.027293162
				error% =	-0.55531635

RESULTS

In the following equations, $f = \text{Feed}$, $\text{co} = \text{CO}$, $i = \text{arbitrary other component}$, $p = \text{Product}$, $\text{MagneHydrogen}^{\text{TM}}$. The "feed" and "product" designations refer to the ARI Pressure Swing Adsorption Separation Apparatus, which performed the separation.

$$\text{MW-f} = X_{\text{co}} \cdot \text{MW-co} + \text{SUM} (X_i \cdot \text{MW-i}) = 15.60 \text{ (g/mol or amu/molecule)}$$

$$\text{MW-p} = \text{SUM} (X_i \cdot \text{MW-i}) / (1 - X_{\text{co}}) = 15.06 \text{ (g/mol or amu/molecule)}$$

Using that equation yields a feed mole fraction of CO, $X_{\text{co}} = 0.0417$.

Again, this is just an estimate, and it relies on the assumption that the PSA unit quantitatively removed CO from the mixture.

In addition, the molecular weight measurement may be off by about 1%, too.

That potential error is not large enough to explain the difference of the numbers (considering multiple trials were run).

Table 1: Molecular Weight
(Determined with Constant Volume System Calibrated with Hydrogen and Helium)

Gas	Molecular Weight (g/mol or amu/molecule)
MagneGas TM [Feed]	15.60
MagneHydrogen TM [Product]	15.06
Ordinary Hydrogen [for comparison]	2.016



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SPL3464B
3/19/02

SPECTRALAB TEST REPORT FOR US MAGNEGAS

REQUESTED BY: Leon Toups, President, US MagneGas

SUBJECT: Analysis of MagneGas Processed to Remove Carbon Monoxide

SUBMITTED SAMPLES:

Samples A and B were submitted stored in low pressure cylinders at about 15 psig.

SUMMARY OF RESULTS:

The chemical composition of the submitted gas samples were determined by gas chromatography (GC) and Fourier-transform infra-red spectroscopy (FTIR). These analyses and those for prior gas samples are presented in the Tables of Results.

Based on a conventional chemical analysis utilizing gas chromatography, gas sample B was found to contain primarily hydrogen (55.2 %) and carbon monoxide (48.6 %) in similar amounts. Minor components included air (1.9 %), carbon dioxide (0.2 %), and a distribution of hydrocarbons composed primarily of methane (1.3 %), ethyne (0.03 %), ethene (0.05 %) and ethane (0.01 %). The amount of air was not included in the composition of the gas. The sample composition of sample B is similar to previous sample analyses reported in SPL3331 and SPL3346 except that acetylene was much lower in sample B than in previous samples. Sample A on the other hand, was found to contain virtually all hydrogen (99.2 %) with only small amounts of methane (0.8 %) and air (3.5 %) present. Again, the amount of air was not included in the composition of the gas. No carbon monoxide or carbon dioxide was detected. Nor were any higher hydrocarbons detected. FTIR analysis results confirmed the GC results for samples A and B.

SPL3464B

PROCEDURES/RESULTS:**Gas Chromatography (GC)**

GC analysis was performed by injecting the sample within a 0.86 ml sample loop using an HP-5880A GC with a thermal conductivity detector (TCD). The separation of the components was obtained using a 15 ft long, 1/8 in od column packed with 80/100 mesh Porapak S and a 12 ft long, 1/8 in od column packed with 60/80 mesh molecular sieve 5A. The columns were placed in series, using switching valves, to separate hydrogen, oxygen, nitrogen, methane and carbon monoxide, while the remaining components, carbon dioxide, ethene, ethyne, ethane and higher molecular weight hydrocarbons, were analyzed with the Porapak S column connected directly to the TCD. Temperature programming was used to provide an efficient analytical method. Two separate analyses were performed. Known gas mixtures were used to calibrate the TCD. Representative chromatograms are presented in Figures 1 and 2. Results are presented in Table I.

The results of the analysis of sample B was similar to previous analyses of samples produced from anti-freeze mixtures of either ethylene glycol or propylene glycol and water. The removal of all components except hydrogen from sample B was largely successful. Only a small amount of methane and air remained after purification.

Fourier Transform Infrared Spectroscopy (FTIR):

The test was conducted per Spectralab test procedure STP 135. FTIR spectra were obtained using a Perkin Elmer model 1650 FTIR with Spectrum for Windows software. The submitted gas sample and calibration standards were each analyzed in a 10cm gas cell at atmospheric pressure. The background run for each standard was obtained on an evacuated cell. Component compositions were calculated from the absorbance values at 3310 cm^{-1} for ethyne (acetylene), 3014 cm^{-1} for methane, 2360 cm^{-1} for carbon dioxide, 2171 for carbon monoxide and 949 cm^{-1} for ethane (ethylene). The calibration standard for acetylene (1%), carbon dioxide (1%), methane (1%) and ethylene (1%) was obtained from Supelco (Scott Specialty Gas #0104216). The calibration standard for carbon monoxide (50%) and hydrogen (50%) was supplied by Matheson (lot #105-06-03669). Representative sample spectra are presented in Figures 3 and 4.

Results are presented in Table II with previous results of analyses conducted on SPL3331 and 3446.

APPROVALS:

MM

Michael J. Manka, Ph. D.

Jack Brand, Lab Director

SPL3464B

Table I
GC Analyses
Conventional Chemical Composition¹

Component	Gas A	Gas B	Prior results SPL3331	Prior results SPL3446
Hydrogen	99.2	55.8	50.0	53.4
Carbon monoxide	None detected ²	42.6	42.9	41.9
Carbon dioxide	None detected ²	0.17	0.7	2.5
Methane	0.78	1.25	2.4	1.0
Ethane	None detected ²	0.01	0.02	0.01
Ethene (ethylene)	None detected ²	0.08	0.3	0.2
Ethyne (acetylene)	None detected ²	0.03	3.9	0.9

¹ Results are normalized and exclude the amount of air present.

² The detection limit is <0.01 %.

Table II
FTIR Analyses
Conventional Chemical Composition

Component	Gas A	Gas B	Prior results SPL3331	Prior results SPL3446
Carbon monoxide	None detected*	45.5	44.6	42.8
Ethyne (acetylene)	None detected	0.05	4.5	1.2
Methane	0.8%	1.1	1.4	1.0
Carbon dioxide	0.01%	0.3	1.5	3.0
Ethene (ethylene)	None detected	0.08	0.6	0.3
Hydrogen (not measured)	Assumed balance	Assumed balance	Assumed balance	Assumed balance

* Detection limit ~ 0.1%.

Data File: /chem/msdh,1/h-14may.b/h051406.d

Date : 14-MAY-2001 11:29

Client ID: #2 Filtered

Sample Info: #2 Filtered

Instrument: msdh.i

Operator: DP

Column diameter: 0.53

Column phase: RTX-624

/chem/msdh,1/h-14may.b/h051406.d

