ALARMING OXYGEN DEPLETION CAUSED BY HYDROGEN COMBUSTION AND FUEL CELLS AND THEIR RESOLUTION BY MAGNEGAS™

Ruggero Maria Santilli

R&D Director, USMagnegas, Inc.
13100 Belcher Road, Largo, FL 33773, U.S.A.
Tel.: +1-727-507 9520, Fax: +1-727-507 8261, E-mail: ibr@gte.net

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Abstract

We recall that hydrogen combustion does resolve the environmental problems of fossil fuels due to excessive emission of carcinogenic substances and carbon dioxide. However, hydrogen combustion implies the permanent removal from our atmosphere of directly usable oxygen, a serious environmental problem called oxygen depletion, since the combustion turns oxygen into water whose separation to restore the original oxygen is prohibitive due to cost. We then show that a conceivable global use of hydrogen in complete replacement of fossil fuels would imply the permanent removal from our atmosphere of $2.8875 \times 10^7$ metric tons $O_2$/day. Fuel cells are briefly discussed to point out similarly serious environmental problems, again, for large uses. We propose the possibility of resolving these problems by upgrading hydrogen to the new combustible fuel called magnegas™,
whose chemical structure is composed by the new chemical species of magnecules, whose energy content and other features are beyond the descriptive capacities of quantum chemistry. In fact, magnegas contains up to 50% hydrogen, while having combustion exhaust with: 1) a positive oxygen balance (releasing more oxygen in the exhaust than that used in the combustion); 2) no appreciable carcinogenic or toxic substances; 3) considerably reduced carbon dioxide as compared to fossil fuels; 4) considerably reduced nitrogen oxides; and 5) general reduction of pollutants in the exhaust up to 96% of current EPA standards. We also discuss the possibility of further reducing carbon dioxide via suitable disposable sponges in the exhaust system, as well as the further reduction of nitrogen oxides with more efficient engine cooling and other means. The analysis therefore indicates that magnegas combustion exhaust already is dramatically below EPA standards, while the achievement of a completely clean exhaust is within technological reach. Therefore, magnegas appears to be an excellent upgrading of hydrogen, both, for direct combustion and for use in fuel cells. We finally indicate that one of the best applications of the new technology is that of processing crude oil in the magnegas reactors, by yielding a fuel dramatically cleaner than gasoline, at a cost smaller than that via refineries. In conclusion, crude oil, hydrogen and fuel cells remain indeed fully admissible in this new era of environmental concern, provided that they are treated via a basically new technology whose quantitative study requires a new chemistry, called hadronic chemistry [1-5].
As is well known, gasoline combustion requires atmospheric oxygen which is then turned into CO$_2$ and various HydroCarbon (HC). In turn, CO$_2$ is recycled by plants via the known reaction, $\text{H}_2\text{O} + \text{CO}_2 + (h\nu) \rightarrow \text{O}_2 + (-\text{(CH}_2\text{O)})$, which restores oxygen in the atmosphere. Essentially this was the scenario at the beginning of the 20-th century. The same scenario at the beginning of the 21-st century is dramatically different, because forests have rapidly diminished while we have reached the following unreassuring daily consumption of crude oil:

74.18 million of barrel per day
$= (74.18 \text{ million barrels/24h}) \times (55 \text{ gallons/barrel})$
$= 4.08 \times 10^9 \text{ gallons/24h}$
$= 1.54 \times 10^{13} \text{ cc/24h} \text{ (using 4 quarts/gallon and 946 cc/quart)}$

(1)
$= (4.08 \times 10^9 \text{ gallons}) \times (4 \text{ qrt./gallon}) \times (946 \text{ cc/qrt.}) / \text{day}$
$= 1.5438 \times 10^{13} \text{ cc/day}$
$= (1.5438 \times 10^{13} \text{ cc/day}) \times (0.7028 \text{ grams/cc})$
$= 1.0850 \times 10^{13} \text{ grams octane/day}$
$= (1.0850 \times 10^{13} \text{ grams}) / (114.23 \text{ grams/mole})$
$= 9.4984 \times 10^{10} \text{ moles n-octane/day}$

(see, e.g., [http://www.eia.doe.gov/emeu/international/energy.html](http://www.eia.doe.gov/emeu/international/energy.html)) where we have replaced, for simplicity, crude oil with a straight chain of n-octanes CH$_3$-(CH$_2$)$_6$-CH$_3$ with the known density of 0.7028 g/cc at 20° C. It should be indicated that data (1) do not include the additional large use of natural gas and coals, which would bring the daily combustion of all fossil fuel to the equivalent of about 120 million barrels of crude oil per day.

The primary environmental problems caused by the above disproportionate consumption of fossil fuel per day are the following:

1) Excessive emission of carcinogenic and other toxic substances in the combustion exhaust. It is well known by experts that gasoline combustion releases in our atmosphere the largest percentage of carcinogenic and other toxic substances as compared to any other source. The terms ”atmospheric pollution” are an euphemism for very toxic breathing.

2) Excessive release of carbon dioxide. It is evident that, under the very large daily combustion (1), plants cannot recycle the entire production of CO$_2$, thus resulting in an alarming increase of CO$_2$ in our atmosphere, an occurrence known as green house effect. In fact, by using the known reaction
\[ C_8H_{18} + \frac{25}{2}O_2 \rightarrow 8CO_2 + 9H_2O, \] we have the following alarming daily production of CO\(_2\) from fossil fuel combustion:

\[
\begin{align*}
(9.4984 \times 10^{10} \text{ moles } C_8H_{18}) \times (8/1) / \text{day} & = 7.5987 \times 10^{11} \text{ moles } CO_2 / \text{day} \\
& = (7.5987 \times 10^{11} \text{ moles}) \times (0.044 \text{ kg/mole}) / \text{day} \\
& = 3.3434 \times 10^{10} \text{ kg/day} \\
& = (3.3434 \times 10^{10} \text{ kg/day}) / (1000 \text{ kg/metric ton}) \\
& = 3.3434 \times 10^{7} \text{ metric tons/day}. 
\end{align*}
\] (2)

It is evident that plants cannot possibly recycle such a disproportionate amount of daily production of CO\(_2\). This has implied a considerable increase of CO\(_2\) in our atmosphere which can be measured by any person seriously interested in the environment via the mere purchase of a CO\(_2\) meter, and then compare current readings of CO\(_2\) with standard values on record, e.g., the percentage of CO\(_2\) in our atmosphere at sea level in 1950 was 0.033\% ± 0.01\% (see, e.g., Encyclopedia Britannica of that period). Along these lines, in our laboratory in Florida we measure a thirty fold increase of CO\(_2\) in our atmosphere over the indicated standard. We assume the reader is aware of recent TV reports of small areas in the North Pole containing liquid water, an occurrence which has never been observed before. Increasingly catastrophic climactic events are known to everybody.

3) Excessive removal of directly usable oxygen from our atmosphere, an environmental problem of fossil fuel combustion, which is lesser known than the greenhouse effect, even among environmentalists, but potentially more serious. The problem is called oxygen depletion, and refers to the difference between the oxygen needed for the combustion less that expelled in the exhaust. By using again the reaction \( C_8H_{18} + \frac{25}{2}O_2 \rightarrow 8CO_2 + 9H_2O \) and data (2), it is easy to obtain the following additionally alarming daily use of oxygen for the combustion of fossil fuel,

\[
\begin{align*}
(9.4984 \times 10^{10} \text{ moles octane/day}) \times (12.5 \text{ moles } O_2/1 \text{ mole octane}) & = 1.1873 \times 10^{12} \text{ moles of } O_2/\text{day} \\
& = (1.1873 \times 10^{12} \text{ moles of } O_2) \times (0.032 \text{ kg/mole } O_2) \\
& = 3.7994 \times 10^{10} \text{ kg } O_2/\text{day} \\
& = 3.7994 \times 10^7 \text{ metric tons/day}. 
\end{align*}
\] (3)
Again, this large volume of oxygen is turned by the combustion into CO$_2$ of which only an unknown part is recycled by plants into usable oxygen. Thus, the actual and permanent oxygen depletion caused by fossil fuel combustion in our planet is currently unknown. However, it should be indicated that the very existence of the green house effect is unquestionable evidence of oxygen depletion, because we are dealing precisely with the quantity of CO$_2$ which has not been re-converted into O$_2$ by plants.

Oxygen depletion is today measurable by any person seriously interested in the environment via the mere purchase of an oxygen meter, measure the local percentage of oxygen, and then compare the result to standards on record, e.g., the oxygen percentage in our atmosphere at sea level in 1950 was 20.946% ± 0.02% (see, e.g., Encyclopedia Britannica of that period). Along these lines, in our laboratory in Florida we measure a local oxygen depletion of 3%-5%. Evidently, bigger oxygen depletions are expected for densely populated areas, such as Manhattan, London, and Tokyo, or at high elevation. We assume the reader is aware of the recent decision by U.S. airlines to lower the altitude of their flights despite the evident increase of cost. This decision has been apparently motivated by oxygen depletion, e.g., fainting spells due to insufficient oxygen suffered by passengers during flights at previous higher altitudes.

The purpose of this note is to indicate that, whether used for direct combustion or in fuel cells, hydrogen combustion does not release carcinogenic and carbon dioxide in the exhaust, but causes an alarming oxygen depletion which is considerably bigger than that caused by fossil fuel combustion for the same energy. This depletion is due to the fact that gasoline combustion turns oxygen into CO$_2$ part of which is recycled by plants into O$_2$, while hydrogen combustion turns atmospheric oxygen into H$_2$O. This process permanently removes oxygen from our planet in a directly usable form due to the excessive cost of water separation to restore the original oxygen balance. By assuming, for simplicity, that gasoline is solely composed of one octane C$_8$H$_{18}$, thus ignoring other isomers, the combustion of one mole of H$_2$ gives 68.32 Kcal, while the combustion of one mole of octane produces 1,302.7 Kcal. Thus, we need $19.07 = 1302.7/68.32$ moles of H$_2$ to produce the same energy of one mole of octane.

In turn, the combustion of 19.07 moles of H$_2$ requires 9.535 moles of O$_2$, while the combustion of one mole of octane requires 12.5 moles of O$_2$. Therefore, on grounds of the same energy release, the combustion of hydrogen...
requires less oxygen than gasoline (about 76% of the oxygen consumed by the octane).

The alarming oxygen depletion occurs, again, because of the fact that the combustion of hydrogen turns oxygen into water, by therefore permanently removing usable oxygen from our planet. When used in modest amounts, the combustion of hydrogen constitutes no appreciable environmental problem. However, when used in large amounts, the combustion of hydrogen is potentially catastrophic on environmental grounds, because oxygen is the foundation of life.

At the limit, a global use of hydrogen as fuel in complete replacement of fossil fuels would render our planet uninhabitable in a short period of time. In fact, such a vast use of hydrogen would imply the permanent removal from our atmosphere of 76% of the oxygen currently consumed to burn fossil fuels, i.e., from Eqs. (2) and (3), we have the following permanent oxygen depletion due to global hydrogen combustion:

\[
76\% \text{ oxygen used for fossil fuel combustion} = 2.8875 \times 10^7 \text{ metric tons } O_2 \text{ depleted/day},
\]

which would imply the termination of any life on Earth within a few months.

Predictably, the above feature of hydrogen combustion has alarmed environmental groups, labor unions, and other concerned people. As an illustration, calculations show that, in the event all fuels in Manhattan were replaced by hydrogen, the local oxygen depletion would cause heart failures, with evident large financial liabilities and legal implications for hydrogen suppliers. An inspection of fuel cells reveals essentially the same scenario. If hydrogen is used as fuel we have the above indicated oxygen depletion. If, instead, we use fossil fuels in fuel cells, we are back to essentially the original problems caused by fossil fuel combustions. The main open issue created by the above scenario is: since pure hydrogen is potentially catastrophic on a large scale use whether as direct fuel or in fuel cells, how can hydrogen be upgraded to a form avoiding the oxygen depletion? It is easy to see that this question does not admit an industrially and environmentally acceptable answer via the use of conventional gases. For instance, the addition of CO to H$_2$ in a 50-50 mixture would leave the oxygen depletion unchanged. In fact, each of the two reactions, \( H_2 + (1/2) O_2 \rightarrow H_2O \) and \( CO + (1/2) O_2 \rightarrow CO_2 \), requires 1/2 mole of O$_2$. Therefore, the 50-50 mixture of H$_2$ and CO would also require
1/2 mole of O$_2$, exactly as it is the case for the pure H$_2$.

After studying the above problems for years, the only answer known to this author is that of upgrading hydrogen into a new combustible gas, called magnegas$^\text{TM}$ [1] (international patents pending), which is produced as a by-product in the recycling of liquid waste (such as automotive antifreeze and oil waste, city and farm sewage, etc.) or the processing of carbon-rich liquids (such as crude oil, etc.). The new technology, called PlasmaArcFlow$^\text{TM}$ (international patents pending), is essentially based on flowing liquids through a submerged electric arc with at least one carbon electrode. The arc essentially decomposes the liquid molecules into a plasma at 7,000$^\circ$ F composed of mostly ionized H, O and C atoms, plus solid precipitates. The technology then controls the recombination of H, O and C into a combustible gas with a new chemical species, tentatively called magnecules$^\text{TM}$ [2], which is currently under study.

A first peculiarity of magnegas$^\text{TM}$ nonexistent in other gases, is that, following numerous tests in analytic laboratories, its chemical structure cannot be identified via conventional Gas Chromatographic Mass Spectrometric (GC-MS) measurements, since it results to be constituted by large clusters (all the way to 1,000 a.m.u. in molecular weight) which remain completely unidentified by the MS. The chemical structure of magnegas is equally unidentifiable via InfraRed Detectors (IRD), because the new clusters composing magnegas$^\text{TM}$ have no IR signature at all, thus suggesting a bond of non-valence type (because these large clusters cannot possibly be all symmetric). Moreover, the IR signature of conventional molecules such as CO and CO$_2$ result to be mutated with the appearance of new peaks, which evidently indicate new internal bonds. These features establish that magnegas has an energy content considerably bigger than that predicted by quantum chemistry, since it can store energy in three different levels: magnecules, molecules, and new internal molecular bonds. As a result, the combustion of conventional fuels can be conceived as a singlet rocket firing, while the combustion of magnegas can be referred to the burning of a multi-stage rocket, with intriguing new features. In vies of the above occurrences, quantitative scientific studies of magnegas are, therefore, beyond the capabilities of quantum chemistry. A broader theory suitable for scientific studies of the new chemical species and the combustion of the new gas has been developed by R. M. Santilli and D. D. Shillady under the name of hadronic chemistry [3, 4] (see also papers [5]).
Scans of the same sample of magnegas at different times shows different magnecules, a phenomenon called magnecule mutation. The effect is expected to be due to collisions among magnecules, resulting fragmentations due to their large size, and their subsequent recombinations with other fragments. This results in macroscopic changes of the MS peaks for the same gas under the same GC-MS test, only conducted at different times. These mutations have identified the presence in the clusters of individual atoms of H, O and C, plus ordinary molecules H\(_2\), CO, and O\(_2\) [2, 3]. The estimated conventional composition of magnegas consists of about 40%-45% hydrogen, 55%-60% carbon monoxide, the rest being composed by traces of oxygen and carbon dioxide. Evidently, small traces of light HC are possible in ppm, but no heavy HC is possible in magnegas since the gas is created at 7,000° F of the electric arc, as confirmed by the lack of activation of catalytic converters during the combustion. As a working hypothesis in the absence of a more accurate knowledge, it is conjectured that the very intense magnetic fields in the microscopic vicinity of 1,000-3,000 DC Amps of the submerged electric arc (which can be as high at 10\(^{14}\) Gauss at distances of 10\(^{-8}\) cm) cause a polarization of the orbits of at least the valence electrons from a spherical into a toroidal configuration, resulting in strong magnetic fields estimated to be 1,415 times nuclear magnetic fields [2, 5a]. It is then expected that strongly polarized individual atoms and molecules bond together like little magnets, resulting in clusters which are stable at ordinary conditions. Since the new bonds do not appear to be of valence type (or any of its variations), they can only be of electric, magnetic, or electromagnetic nature. The new clusters are called magnecules because of the dominance of magnetic over other effects in their creation, while electric effects are generally unstable, and often repulsive (as it is the case of ions).

Besides direct calculations [2, 5a], the magnetic polarization of the atoms and molecules constituting magnegas is further supported by a number of indirect effects, such as the capability of magnegas\(^\text{TM}\) to stick to instruments walls, called magnecule adhesion. As an illustration, following the removal of magnegas from a GC-MS and its conventional flushing, the background preserves all the anomalous peaks of magnegas. This occurrence can only be interpreted numerically via adhesion due to induced magnetic polarization, and not via electrostatic, coordination, and other effects. Mutatis mutandae, stable clusters can only exist under a sufficiently strong attractive force, which must be numerically identified for a model to have sufficient depth.
Among all possible non-valence bonds, the magnetic attraction among polarized valence orbits is the only model available at this writing with a concrete attractive bond, while all other models lack such an identification (as it is the case for electric effects, coordination effects, co-valence, etc.). Due to the implications here at stake, the study of alternative structure of the new clusters in magnegas is warmly recommended, provided that, again, the attractive force creating the clusters is specifically and numerically identified, and models based on pure nomenclatures are avoided.

Even though the chemical structure of magnegas escapes current quantum chemical knowledge, its combustion exhaust has a conventional chemical structure, because the exhaust temperature is beyond the Curie point of magnecules. As a result, all magnecules and other anomalies are removed by the combustion. Following numerous tests, including various conversions of automobiles to run on magnegas, we have the following combustion exhaust of magnegas measured before the catalytic converter, in percentages:

|                           | 65%-70%       |
|----------------------------|---------------|
| Water vapor                | 9.5%-10.5%    |
| Oxygen                     | 6%-8%         |
| Hydrocarbons               | 0.00%-0.01%   |
| Rest atmospheric           | minus 2 to minus 5 ppm |

As one can see, the upgrading of hydrogen into magnegas: 1) turns the oxygen depletion caused by hydrogen combustion into a positive oxygen balance (more oxygen in the exhaust than that used for the combustion) 2) emits no carcinogenic or toxic substance in the exhaust; and 3) implies a significant reduction of carbon dioxide emission over fossil fuels. In particular, magnegas exhaust meets the most stringent governmental requirements without a catalytic converter while having a positive oxygen balance. Preliminary magnegas exhaust measurements have been recently conducted at the EPA Certified, Vehicle Certification Laboratory Liphardt & Associates of Long Island, New York, via the Varied Test Procedure (VTP) as per Regulation 40-CFR, Part 86 on a Honda Civic Natural Gas Vehicle VIN number 1HGEN1649WL000160, produced in 1998 (and purchased new in 1999) to
operate with Compressed Natural Gas (CNG). This car was converted by US-Magnegas, Inc., Largo, Florida, to operate on Compressed Magnegas (CMG) via: 1) the replacement of CNG with CMG; 2) the disabling of the oxygen sensor (because magnegas has 20 times more oxygen in the exhaust than natural gas); and 3) installing a multiple spark system (to improve combustion); while leaving the rest of the car unchanged, including its computer.

The tests consisted of the conventional EPA routine for Regulation 40-CFR, Part 89, consisting of three separate and sequential tests conducted on a computerized dynamometer, the first and the third tests using the car at its maximal possible capability to simulate an up-hill travel at 60 mph, while the second test consists in simulating normal city driving of the car. Three corresponding bags with the exhaust residues are collected, jointly with a fourth bag containing atmospheric contaminants. The final measurements expressed in grams/mile are given by the average of the measurements on the three EPA test bags, less the measurements of atmospheric pollutants in the fourth bag. The results of the above preliminary tests on magnegas exhaust are:

|                      |                     |                    |
|----------------------|---------------------|--------------------|
| **Hydrocarbons:**    | 0.026 gram/mile = 93.6% reduction | of the EPA standard of 0.41 gram/mile |
| **Carbon monoxide:** | 0.262 grams/mile = 92.6% reduction | of the EPA standard of 3.40 grams/mile |
| **Nitrogen oxides:** | 0.281 gram/mile = 29.7% reduction | of the EPA standard of 0.4 gm/mile |
| **Carbon dioxide:**  | 235 grams/mile - there is no EPA standard | on CO₂ at this moment |
| **Oxygen:**          | not measured because not requested | in Regulation 40-CFR, Part 86 |

The following comments are important for an appraisal of the above results:
1) Magnegas does not contain heavy HC since it is created at 7,000° F. Therefore, the measured HC is expected to be due, at least in part, to combustion of oil, either originating from magnegas compression pumps (thus contaminating the gas), or from engine oil. New tests are under way in
which magnegas is filtered after compression, and all oils of fossil fuels origin are replaced with synthetic oils.

2) Carbon monoxide is fuel for magnegas (while being a combustion product for gasoline). Therefore, any presence of CO in the exhaust is evidence of insufficient combustion.

3) The great majority of measurements (6) originate from the first and third parts of the test at extreme performance, because, during ordinary city traffic, magnegas exhaust is essentially pollutant free, as shown in Figure 1.

4) Nitrogen oxides are not due, in general, to the fuel (whether magnegas or other fuel), but to the temperature of the engine, thus being an indication of the quality of its cooling system. Therefore, for each given fuel, including magnegas, NOx’s can be decreased by improving the cooling system and other means.

5) Measurements (6) do not refer to the best possible combustion of magnegas, but only to the combustion of magnegas in a vehicle whose carburetion was developed for natural gas. Alternatively, the test was primarily intended to prove the interchangeability of magnegas with natural gas without any major automotive changes, while keeping essentially the same performance and consumption. The measurements under combustion specifically conceived for magnegas are under way, and will be released in the near future. The main difference in the latter tests is a considerable reduction in the emission of carbon dioxide for certain technical reasons related to the magnegas combustion.

In Figure 1, the first three diagrams illustrate the very low combustion emission of magnegas in city driving, by keeping in mind that most of measurements (6) are due to the heavy duty, hill climbing part of the EPA test. Even though 29.7% of EPA standard, the fourth diagram on nitrogen oxides is an indication of insufficient cooling of the engine. The bottom diagram indicates the simulated speed of the car versus time, where flat tracts simulate idle portions at traffic lights. By keeping in mind: 1) the lack of (heavy) hydrocarbon in magnegas (because produced at 7,000° F of the electric arc); 2) the expectation of no appreciable carbon dioxide in the magnegas exhaust under proper combustion (because CO is fuel for magnegas); 3) the possible further reduction of carbon dioxide via disposable sponges placed in the exhaust systems; 4) the decrease of nitrogen oxides with a more efficient engine cooling and other improvements; and 5) the positive oxygen balance of magnegas (not measured in the test because not included in current EPA
Figure 1: An illustration of the city part of the EPA test according to Regulation 40-CFR, Part 86, conducted at the Vehicle Certification Laboratory Liphardt & Associates of Long Island, New York on a Honda Civic Natural Gas Vehicle converted to magnegas.
regulations); the measurements depicted in this diagram indicate that the achievement of a truly clean fuel is indeed within technological reach.

We should also indicate considerable research efforts under way to further reduce the CO₂ content via suitable cartridges of disposable chemical sponges placed in the exhaust system. Admittedly, these catalytic means generally implies the creation of acids harmful to the human skin, if released in the environment. However, the ongoing research aims at the chemical and/or technological resolution of these problems. Additional research is under way via liquefied magnegas obtained via catalytic or conventional liquefaction, which is expected to have an anomalous energy content with respect to other liquid fuels, and an expected, consequential decrease of pollutants. As a result of these efforts, the achievement of an exhaust essentially free of CO₂ appears to be within technological reach.

As a comparison for measurements (6), a similar (but different) Honda car running on indolene (a version of gasoline) without affecting performance was tested in the same laboratory with the same EPA procedure, resulting in the following data:

|                  | 0.234 gram/mile = 900% of magnegas emission |
|------------------|---------------------------------------------|
| Hydrocarbons     | 1.965 gram/mile = 750% of magnegas emission |
| Carbon monoxide  | 0.247 gram/mile = 86% of magnegas emission  |
| Nitrogen oxides  | 458.655 grams/mile = 195% of magnegas emission |

which illustrates the environmental superiority of magnegas over gasoline. The improvement of emission by magnegas over the above data are evident.

Other features favoring the upgrading of pure hydrogen into magnegas are (international patents pending):

1) magnegas is cost competitiveness with respect to fossil fuels (since it is produced as a byproduct of an income-producing recycling);

2) magnegas increases the energy content from about 300 BTU/cf for hydrogen to about 800-900 BTU/cf (due to the new means of energy storage);

3) magnegas is more readily availability anywhere desired (since easily transportable PlasmaArcFlow reactors as big as a desk produce up to 1,500 cf of magnegas per hour, i.e, a production in one hour sufficient for about three hours city travel by a compact car);
4) magnegas admits easier liquefaction, e.g., via Fischer-Tropsch catalytic synthesis or conventional liquefaction (due to attractions between magnecules);

5) magnegas has a better penetration through membranes (due to measured decreases of average molecular sizes of magnetically polarized conventional molecules);

6) magnegas can be used for any conventional fuel application, including metal cutting, cooking, automotive use, etc.

7) Magnegas can be used in fuel cells, by preserving its environmental advantages.

Above all, the magnegas™ technology appears to permit an ultimate merger of crude oil and hydrogen technologies. One of the best liquids usable in the PlasmaArcFlow™ reactors is crude oil, which is then turned into a fuel much cleaner than gasoline (plus usable heat and solid precipitates) at a cost visibly smaller than that that via huge refineries. The fuel produced by the above new processing of crude oil is 40%-45% hydrogen.

In conclusion, crude oil, hydrogen, and fuel cells remain indeed fully admissible in this new era of environmental concern, provided that they are treated via a basically new technology whose quantitative study requires a new chemistry, hadronic chemistry [1-5].

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