**Santilli’s New Fuels as Sources of Clean Combustion**

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**Abstract.** Molecular combustion or nuclear fission is the conventional source of energy, which are not clean as they generate large amount of greenhouse gas or nuclear waste. Clean energy can be obtained by harnessing renewable energy sources like solar, wind, etc. However, each of these sources has their own limitations and is dependent on geographical locations. The modern day demand of clean, cheap and abundant energy gets fulfilled by the novel fuels that have been developed through hadronic mechanics/chemistry. In the present paper, a short review on such novel fuels like Hadronic energy of non-nuclear type (combustion of MagneGas) and nuclear type (intermediate controlled nuclear fusion and particle type like stimulated neutron decay) has been presented.

**Keywords:** Magneclus, intermediate controlled nuclear fusion, alternative energy sources, hadronic chemistry.

**PACS:** 21.10Dr, 33.15Fm, 25.60.Pj, 75.50.-y

**INTRODUCTION**

The technological advancement of the modern society has created a dearth for energy. The energy requirement has been fulfilled by the conventional source of energy i.e. molecular combustion of fossil fuels, hydrogen or nuclear fission. However, combustion of fossil fuel generates large amount of greenhouse gas like CO$_2$ and hydrogen combustion depletes atmospheric O$_2$ by forming H$_2$O. Similarly, nuclear fission generates large amount of nuclear waste risking ecosystem. These energy sources are supported by the 20$^{th}$ century sciences.

Clean energy can be obtained by harnessing renewable energy sources like solar, wind, geothermal, tidal, etc. Nevertheless, each of these sources has their own drawbacks and is generally dependent on geographical locations and the power generated cannot be stored efficiently due to insufficient growth of battery technology.

The modern day demand is clean energy source that is cheap and abundant. The fuels developed should be such that can be used in existing engines without any or major modifications. This requirement has been fulfilled by changing the approach from quantum mechanics to hadronic mechanics to hadronic chemistry. Italian-American physicist Santilli developed various new fuels characterized by hadronic mechanics/chemistry such as MagneGas [1-3], which shows better efficiency than existing fossil based fuels and the intermediate controlled nuclear fusion (ICNF) [3,4]. The present paper is a short review on Hadronic fuels.

**Hadronic Energy of Non-nuclear Type: Magnecular Combustion**

Magnecluses are novel chemical species having at least one magnecular bond. The atoms are held together by magnetic fields originating due to toroidal polarization of the atomic electron orbits. The rotation of the electrons within the toroid creates the magnetic field which is absent for the same atom with conventional spherical distribution of electron orbitals. When two such polarized atoms are sufficiently close to each other and in north-south north-south alignment, the resulting total force between the two atoms is attractive. The polarization is brought about by high magnetic field which is obtained as in the case of high voltage DC arc.

Magnecluses are of the following types-

- **Elementary** when composed only of two molecules, e.g.: {H – H} × {H – H}; and so on
  - where ‘−’ denotes conventional valence bond and ‘×’ denotes magnecular bond

- **Magneplexes** when entirely composed of several identical molecules
  - e.g.: \(\{H – O – H\} \times \{H – O – H\} \times \{H – O – H\} \times \{H – O – H\} \times \{H – O – H\} \times \ldots\); and so on

- **Magneclusters** when composed of several different molecules
  - e.g.: \(\{H – H\} \times \{C – O\} \times \{O – C – O\} \times \{C = O\} \times \{H – H\} \times \ldots\); and so on

Magnecules are also classified as-

i) **Isomagnecules** when having all single-valued characteristics and being reversible in time, namely, when they are characterized by isochemistry,

ii) **Genomagnecules** when having all single-valued characteristics and being irreversible in time, namely, when they are characterized by genochemistry; and

iii) **Hypermagnecules** when having at least one multi-valued characteristic and being irreversible in time, namely, when they are characterized by hyperchemistry.

Santilli magnecluses are characterized by-
i) Large atomic weights which are ten times or more than the conventional molecules.

ii) Large peaks in macroscopic percentages in mass spectra, which do not belong to conventional molecules.

iii) These peaks show same infra-red and ultra-violet signature as expected from the conventional molecules and/or dimers constituting the magnecule.

iv) Said infrared and ultraviolet signatures are generally altered with respect to the conventional versions.

v) Magnecules have an anomalous adhesion to other substances.

vi) They can break down into fragments under high energetic collisions, with subsequent recombination with other fragments and/or conventional molecules.

vii) They can build up or lose individual atoms, dimmers or molecules during collision.

viii) They have an anomalous penetration through other substances indicating a reduction of the average size of conventional molecules as expected under magnetic polarizations.

ix) Gas magnecules show an anomalous solubility in liquids due to new magnetic bonds between gas and liquid molecules caused by magnetic induction.

x) Magnecules can be formed by molecules of immiscible liquids.

xi) A gas with magnecular structure does not follow the perfect gas law.

xii) Substances with magnecular structure have anomalous physical characteristics, as compared to the conventional molecules.

xiii) Magnecules release more energy in thermochemical reactions than that released by the same reactions among unpolarized molecular constituents.

xiv) All the above characteristic features disappear when the magnecules are brought to a sufficiently high temperature (Curie Magnecular Temperature), which varies from species to species.

The property of magnecules to undergo magnecular combustion with high energy output which is attributed to weak magnecular bond [5]. This is exploited for the industrial development of novel clean fuels such as magnegas.

Consider the case of combustion of molecular hydrogen and oxygen to produce H$_2$O. The dissociation of H$_2$ and O$_2$ molecules consume 163.7 kcal/mol and thereafter the atom recombination to produce H$_2$O releases 221.25 kcal/mol hence the net release of energy is 57 kcal/mol [3]. However, in case of magnecular hydrogen {H × H} and atomic oxygen O combustion (even if on considering H × H bond dissociation energy to be zero) the energy output is predicted to be approximately three times the value predicted by molecular structures with the same atomic constituents and combustion temperature [3].

**MagneGas: MagneHydrogen™ and MagneOxygen™**

The simple principle of synthesizing magnecules is similar to the magnetization of a ferromagnet where the orbits of unbounded electrons are polarized. Thus, in principle any matter whether solid, liquid or gas can be converted to magnecules provided it is subjected to sufficiently strong external magnetic field.

Conventional H$_2$ and O$_2$ gases can be turned into their respective magnecular structure called MagneHydrogen™ (MH) and MagneOxygen™ (MO) by subjecting them to strong external magnetic field generally carried out in a Hadronic reactor. H$_2$ is diamagnetic and cannot acquire a total net magnetic polarity. However, the orbit of each H atom acquires a toroidal polarization under sufficiently strong external magnetic field. The opposite magnetic moments of the two H atoms explain the diamagnetic character of the hydrogen molecule. Also the intrinsic magnetic moments of nuclei and electrons of H$_2$ molecule are polarized which creates new chemical species having bigger specific weight due to formation of new bonds between pairs of individual H atoms.

The MO is formed comparatively easily as oxygen is paramagnetic, so electrons acquire an overall magnetic polarity. However, significant increase of the specific weight of the oxygen requires the toroidal polarization of at least some of the peripheral atomic electrons, along with total magnetic polarization.

**HHO: Magnecular Water**

HHO gas has distinctly different chemical composition than ‘Brown gas’, even though both gases have many similarities. HHO gas is magnecular water having {H × H – O} structure whereas Brown gas is mixture of conventional molecular hydrogen and oxygen in 2:1 ratio. Since HHO is a MagneGas it has all the characteristics of magnecules. It also does not require atmospheric oxygen unlike MH thereby overcoming the problem of depletion of atmospheric oxygen due to combustion. The oxygen present in HHO is sufficient to bring about complete combustion of the gas. The important aspect of this gas is its anomalous adsorption to liquids, solids and gases and widely varying thermal content.

The anomalous adsorption makes it a perfect additive to other fuels. The flash point of diesel was found to increase from 75°C to 79°C on purging the same with HHO [2]. This anomalous rise was not of just 4°C but of 42°C as addition of gas to liquid reduces its flash point by half. This could be attributed to the magnecular structure of the
HHO which influences to form magnecluster HHO and diesel molecules, thereby drastically increasing its flash point. If HHO existed as gas then the flash point would not have increased. The adsorption of the HHO to the diesel molecules is also expected to significantly reduce the harmful emission of the original fuel (due to inherent O content) and increases the thermal output of the fuel in case of combustion.

HHO exhibits a wide range of thermal output. It ranges from relatively cold flame in open air (150°C) to large releases of thermal energy depending on the substance to which the flame is applied (instantaneous melting of W or bricks requiring ~9000°C). This capability can be explained by the presence of polarized H-atom in the HHO gas. Instantaneous melting of bricks is only possible due to the polarized hydrogen contained in the HHO gas which rapidly penetrates into the deep layers of the brick. Besides due to smaller sectional area, penetration is fast. Polarized H-atoms induces polarization of the brick’s atomic orbitals, leading to attraction of the polarized H atoms. This leads to faster penetration within the solid lattice causing higher reactivity and consequently higher melting temperature.

**Efficiency of Hadronic Reactor**

The efficiency of Hadronic reactor is expressed in two ways namely scientific efficiency and commercial efficiency as shown by expressions 1 and 2.

\[
\text{Scientific Efficiency} = \frac{\text{total energy output}}{\text{electric energy + energy from carbon combustion}} < 1 \quad (1)
\]

\[
\text{Commercial Efficiency} = \frac{\text{total energy output}}{\text{electric energy only}} > 1 \quad (2)
\]

Notice that the scientific efficiency is always less than 1 as per the Carnot theorem. However, the Hadronic reactors do not produce energy sufficient for the entire regeneration of the used electric energy for various reasons, such as dispersion, very low efficiency of current electric generators, etc. Regardless of this limitation, the production of MagneGas (MH) in an electric power plant (to whom the cost of electricity is zilch) is very advantageous from an energy viewpoint because-

I] For every kW of used energy, they produce at least the equivalent of 3 kW of thermal energy in MagneGas (MH);

II] When MH is used as an additive to coal or petroleum combustion, the H-content of MagneGas can burn at least half of the combustible components in the plant exhaust that now constitute environmental problems; and

III] There are additional savings (of the order of several millions of dollars per year) in scrubbing and other means to clean the exhaust.

In summary, Magnegas Corporation has documented evidence that an electric power plant, by producing MagneGas locally and injecting it into the flame of the used fossil fuel, can increase the production of electricity by at least 30% with the same use of fossil fuel.

The credibility of this statement is evident and due to the fact that about 60% of the energy of fossil fuels is wasted due to formation of combustible CO, hydrocarbons and other contaminants in flue gas. These combustible exhausts are burnt off when combined with the H\(_2\) in MagneGas as is well known to chemists. Hence the indicated 30% gain in the production of electricity from a given fossil fuel volume is only \(\frac{1}{2}\) of the lost energy.

MH in fossil fuel decreases its volatility probably due to their anomalous adsorption, consequently attaining higher temperature which results in a cleaner combustion. Thus the consideration of commercial efficiency becomes evident for all practical purposes.

**Hadronic Energy of Nuclear Type**

Nuclear energy conventionally obtained by fission reaction is hazardous due to generation of high energy ionizing radiation and radioactive waste. The shielding from these radiations is cumbersome as well as expensive whereas disposal of the radioactive waste poses environmental risk. The fission reactions could be adequately explained by quantum mechanics by considering the fragments as point mass. However, the same theory could not explain nuclear fusion because considering the reacting nuclei as point mass was not possible. Hence the use of hadronic mechanics to explain nuclear fusion is necessary.

**Nuclear Fusion**

Harnessing energy through nuclear fusion reactions has been the Holy Grail. Low energy nuclear fusion or ‘cold fusion’ reported by Fleishmann, Pons and Hawkins in 1989 had been in the eye of controversy due to non-
reproductibility by various other laboratories. This could be due to insufficient energy required to expose the atomic nuclei from within the covering atomic electron cloud. On the other hand in case of high energy nuclear fusion or ‘hot fusion’ the atomic electron clouds are completely stripped off and the energy attained by the nuclei are generally higher than the fission barrier which results in fission reaction or nuclear decay as prominent exit channels rather than forming stable heavy nucleus (compound nucleus). The fission reaction thus initiated leads to formation radioactive wastes. Also the fusion reaction unlike fission reaction is not self sustaining. Thus, both the techniques prove to be insufficient in sustaining controlled nuclear fusion. In view of this Santilli proposed new form of nuclear energy without ionizing radiations and radioactive waste predicted using hadronic mechanics.

**Intermediate Controlled Nuclear Fusion (ICNF)**

In case of ICNF, proposed by Prof. Santilli is based on the following basic assumptions-

i) Nuclear force: Nuclear force can be partly represented with a Hamiltonian and partly is of non-potential type and cannot be represented with a Hamiltonian.

ii) Stable nuclei: According to Heisenberg-Santilli Lie-isotopic equations the sub-nuclear particles are in contact with each other without appreciable overlap of their wave-functions.

iii) Unstable nuclei and nuclear fusion: In case of Heisenberg-Santilli Lie-admissible equation

\[
i \frac{dA}{dt} = (A; H) = ARH - HSA
\]

if Hermitean, \( H \) represents non-conserved total energy and genotopic elements \( R \) and \( S \) represents non-potential interactions then irreversibility is assured. Lie-admissible branch of hadronic mechanics is ideally suited to represent the decay of unstable nuclei as well as nuclear fusions, since both are irreversible over time.

iv) Neutron synthesis: Neutron is assumed (originally conjectured by Rutherford) to be compressed hydrogen atom.

\[p^+ + a + e^- \rightarrow n\]

where ‘\( a \)’ is Santilli’s etherino (conventional Hilbert space)

v) Nuclear structure: Proton is the only stable particle and neutron is unstable comprising of proton and electron. Santilli assumed that nuclei are a collection of protons and neutrons, in first approximation, while at a deeper level a collection of mutated protons and electrons.

Controlled Nuclear Fusion (CNF) is systematic energy releasing nuclear fusion whose reaction rate is controllable via one or more mechanisms capable of performing the engineering optimization of the applicable laws.

The CNF is governed by Santilli’s laws for controlled nuclear fusions:

i) The orbitals of peripheral atomic electrons are controlled such that nuclei are systematically exposed.

ii) CNF occurs when nuclei spins are either in singlet planar coupling or triplet axial coupling.

iii) The most probable CNF are those occurring at threshold energies and without the release of massive particles.

iv) CNF requires trigger, an external mechanism that forces exposed nuclei to come in fm range.

Santilli’s magnecules have systematic and controlled exposure of nuclei which have singlet planar or triplet axial coupling. However, axial triplet coupling is considered to be the most efficient as nuclear fusion can be initiated by an external action (trigger (TR), DC arc) which pushes nuclei at one Fermi mutual distance where the strong attractive nuclear force is activated and fusion is unavoidable.

The ICNF proposed by Santilli are of the generic type

\[N_1 (A_1, Z_1, \frac{J_1^P}{1}, u_1) + N_2 (A_2, Z_2, \frac{J_2^P}{2}, u_2) + TR \rightarrow N_3 (A_3, Z_3, \frac{J_3^P}{3}, u_3) + \text{Heat}\]

where \( A_1 + A_2 = A_3 \); \( Z_1 + Z_2 = Z_3 \); \( J_1 + J_2 = J_3 \); \( P_1 + P_2 = P_3 \)

The symbols \( A, Z, J^P \) and \( u \) denote the atomic number, nuclear charge, nuclear angular momentum with parity and nuclear energy in amu units, respectively. TR represents trigger mechanism -- a high voltage DC arc in the case of hadronic reactor.

The most simple reaction studied in case of intermediate controlled nuclear fusion was synthesis of nitrogen from carbon and deuterium as was expected in nature due to lightning. The reaction is as shown below [4],

\[C (12, 6, 0, 12.0000) + H(2, 1, 1', 0.0041) + TR \rightarrow N(14, 7, 1', 14.0030) + \text{Heat}\]

The energy supplied is of threshold value just sufficient to expose the atomic nuclei from within the electron cloud. Since the energy is not very high, production of ionizing radiations or sub-nuclear particles are avoided. For example, the above reaction is carried out in sealed tanks called hadronic reactors [3,4]. This synthesis is of industrial importance because it yields \(10^{16} \) BTU of energy per hour.

The electric arc polarizes carbon and hydrogen atoms by forming the \( C \times H \times H \) magnecule, having triplet axial spin coupling. Under a suitable trigger, the magnecule \( C \times H \times H \) should yield a nucleus with \( A=14, Z=8, J^P=1'\)
however, that does not exist (since O(14, 8) has spin J = 0). So, the explanation adopted by Santilli is that the nature synthesizes a neutron from proton, electron and etherino as,

\[ C \times H \times H \rightarrow C(12, 6, 0) + 2 \times p + e + a \rightarrow C(12, 6, 0) + H(2, 1, 1) \rightarrow N(14, 8, 1) \]

The fusion process can also be explained by zero-point energy [6].

The fusion reaction taking place in hadronic reactor using deuterium as fuel have shown to yield clean energy without formation of any radioactive species or ionizing radiations.

**Particle Type Hadronic Energy: Stimulated Decay of the Neutron**

Photo-disintegration of \(^2_1H\) and \(^9_4Be\) nuclei due to 2.22 MeV and 2.62 MeV photons respectively are well-known due to their low binding energy. Similarly, stimulated decay of neutrons is also a well-known phenomenon aptly described by Fennyman. The prediction and its quantitative treatment can be done by hadronic mechanics.

According to Prof. Santilli, neutron is an unlimited source of energy because it decays releasing highly energetic electron and neutrino that can be easily trapped with a metal shield. It is well-known that an isolated neutron is unstable and has half life of ~15 minutes. However, as a constituent of nuclei, it shows high stability which has been attributed to a strong nuclear force of attraction [3].

The neutron shows stimulated decay as shown below,

\[ TR + n \rightarrow p^+ + \beta^- \]

where \(\beta^-\) has spin zero for the conservation law of the angular momentum. \(\beta^-\) also be considered either as an electron and a neutrino or as an electron and an antietherino with opposing spin 1/2. This difference is irrelevant for the stimulated decay of the neutron.

**ACKNOWLEDGMENTS**

The financial support for this work from The R. M. Santilli Foundation is gratefully acknowledged. The author expresses her deep gratitude to Professor R. M. Santilli, Professor C. Corda, Professor R. Anderson and Professor A. A. Bhalekar for encouragements and valuable guidance in preparing this paper.

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