Creating synthetic fuels

Breaking and remaking of chemical bonds to create free or excess energy, and an outline of how it can be done.

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Down to basics first:-

Bond Energy

If we pass a direct electric current through water containing enough ions to make it a good electrical conductor, it will break down into its constituents: hydrogen and oxygen. Both hydrogen and oxygen gas exist as diatomic molecules so the equation for this chemical reaction is

 $2H_2O \rightarrow 2H_2 + O_2$

The prefixes tell us that it takes 2 molecules of water to produce one molecule of oxygen and two molecules of hydrogen. If we decompose 36 grams of water (**2 moles**), we produce 2 moles of hydrogen gas (4 g) and one mole of oxygen gas (32 g).

In this reaction, covalent bonds between the hydrogen atoms and oxygen atom in water have been broken and new bonds, between the hydrogen atoms in H2 and the oxygen atoms in O2, have been formed. This reaction requires the input of energy (electrical in this case). This is because:

•it takes energy to break chemical bonds

•energy is released as chemical bonds form

•but in this case the energy released is less than the energy needed.

For any particular chemical bond, say the covalent bond between hydrogen and oxygen, the amount of energy it takes to break that bond is exactly the same as the amount of energy released when the bond is formed. This value is called the **bond energy**.

There are many forms of energy:

electricalmechanicalchemical

but all forms are ultimately converted into heat. So it is convenient to measure energy in units of heat. The unit we shall use most often is the **kilocalorie** (**kcal**): the amount of heat needed to warm 1 litre of water 1 degree Celsius.

It takes a net of 118 kcal to decompose 2 moles of H2O into its elements. Actually it takes more than 118 kcal to decompose the water into its atoms, but some of the energy is given back as the atoms immediately bond together to form molecules of hydrogen and oxygen.

Let's look at the numbers.

•The bond energy of the H-O bond is 110 kcal.

•The bond energy of H-H bonds is 103 kcal.

•The bond energy of the O=O bonds is 116 kcal.

•The decomposition of 2 molecules of water requires breaking 4 H-O bonds and thus the input of 440 kcal.

•The formation of 2 moles of hydrogen yields 206 kcal (2 x 103).

•The formation of 1 mole of oxygen yields 116 kcal.

•The difference between

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•the energy released (206 + 116 = 322 \text{ kcal}) and
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•the energy consumed $(4 \times 110 = 440 \text{ kcal})$

•gives the net energy consumed = 118 kcal.

Where has the energy gone?

It is now **chemical energy** stored in the bonds of the hydrogen and oxygen molecules. The energy stored in this reaction is called **free energy** because it is still available to do work. It is useful to have a symbol for free energy, and we shall use the letter *G* (in honor of **Josiah Willard Gibbs** who developed the concept of free energy).

What is free energy?

It is energy that can be harnessed to do work. The water stored behind a dam has free energy. When allowed to fall through a turbine, it can generate electricity (another form of free energy).

But the most interesting form of free energy is the energy stored in chemical bonds. It, too, can be harnessed to do work.

A change in free energy is depicted by the letter G preceded by the Greek Delta (Δ).

By convention, we indicate the storage of free energy with a plus sign. So, our reaction is expressed:

$2H_2O \rightarrow 2H_2 + O_2, \Delta G = +118$ kcal.

Igniting hydrogen and oxygen gives the equation for this chemical reaction, in reverse of the one above and is expressed as

As the explosion suggests, this time a release of energy occurs. In fact, the free energy change is once again 118 kcal. This is because it took only 322 kcal to break the H-H and O=O bonds, and 440 kcal were liberated by the 4 moles of H-O bonds that were formed. (The igniting spark provided the initial input of energy; the surplus from the reaction then provided what was needed to get all the other molecules to react.)

We express the fact that energy came out of the reacting system by putting a minus sign before ΔG .

$$2H_2 + O_2 \rightarrow 2H_2O, \Delta G = -118$$
 kcal.

There are several contributing factors that determine the magnitude of the bond energy for a particular bond, but usually the most important is the difference in the **electronegativity** of the two atoms bonding together. The energies of bonds between atoms of substantially different electronegativities tend to be high, e.g., the 110 kcal of the H-O bond. Another important example is the bonds between oxygen and carbon atoms in carbon dioxide, CO_2 . The carbon atom shares two

pairs of electrons with each of the oxygen atoms, and each of these **double bonds** has a bond energy of 187 kcal (or about 93 kcal for each shared pair of electrons). The larger the bond energy, the more energy is needed to break the bond. Thus bonds between atoms of differing electronegativities are apt to be very strong and stable.

On the other hand, the energies of bonds between atoms of similar electronegativity tend to be smaller. Of course, where the atoms are the same (e.g., O=O, C-C) there is no electronegativity difference and so have lower bond energy values. Each of the shared electron pairs in the oxygen molecule is worth 58 kcal for a total of 116 in each molecule, as we saw above. The bond energy of the C-C bond is 80 kcal. There is a slight difference in electronegativity between carbon and hydrogen, and a bond energy of 98 kcal. The bonds with smaller bond energies are easier to break, so these bonds are weaker and less stable.

We should also note that the energy needed to break a particular bond, e.g., between carbon and oxygen, may also be influenced by the nature of the other atoms attached to the ones we are interested in. Thus the C=O double bond in carbon dioxide (O=C=O) has a bond energy of 187 kcal, whereas when this bond is found as part of a larger molecule, the value is closer to 170 kcal. Because of these variations, we speak of **average bond energies**. This table gives average bond energies for some of the bonds that are always being broken and formed in biochemical processes.

Average bond energies, kcal/mole	
С-Н	98
О-Н	110
C-C	80
C-0	78
Н-Н	103
C-N	65
0=0	116 (2 x 58)
C=O	187* (2 x 93.5)
C=C	145 (2 x 72.5)
(* as found in CO ₂)	

Electronegativity

The electronegativity of an atom is a measure of its affinity for electrons The atoms of the various elements differ in their affinity for electrons.

Example 1: Sodium (Na) and Chlorine (Cl) = Ionic Bond

- •There is a large difference in electronegativity, so
- •the chlorine atom takes an electron from the sodium atom
- •converting the atoms into ions (Na⁺) and (Cl⁻).
- •These are held together by their opposite electrical charge forming ionic bonds.
- •Each sodium ion is held by 6 chloride ions while each chloride ion is, in turn, held by 6 sodium ions.

•Result: a crystal lattice (not molecules) of common table salt (NaCl).

Example 2: Carbon (C) and Hydrogen (H) = Covalent Bond

- •There is only a small difference in electronegativity, so
- •the two atoms share the electrons.
- •Result: a covalent bond (depicted as C:H or C-H).
- •The atoms are held together by their mutual affinity for their shared electrons.
- •An array of atoms held together by covalent bonds forms a true molecule.

Example 3: Hydrogen (H) and Oxygen (O) = Polar Covalent Bond

- •Here there is a moderate difference in electronegativity, causing
- •the oxygen atom to pull the electron of the hydrogen atom closer to itself.
- •Result: a polar covalent bond.
- •Oxygen does this with 2 hydrogen atoms to form a molecule of water.

Molecules, like water, with polar covalent bonds

•are themselves polar; that is, have partial electrical charges across the molecule;
•may be attracted to each other (as occurs with water molecules);
•are good solvents for polar and/or hydrophilic compounds;
•may form hydrogen bonds.

Hydrogen, oxygen, nitrogen and carbon are the four main building blocks of energy molecular structures. As can be seen above, combining these molecules to create these structures is not easy without using, what I call, brute force (lots of energy).

What forms of energy are normally used to do this? Extrem heat, high amounts of electrical power all consum large amounts of energy and as seen will not give you a net gain in energy, which is what we are looking for, the best we could achieve would be a stalemate.

Finding another way to create heat and energy

Through many years of work and reading others works on the subject, it was found that heat and energy for these chemical reactions could be done at the molecular scale, within the molecules themselves, without a large amount of energy input. This has now turned the table in our favour of creating energy from synthesised fuels, made using very little energy to start with.

Example of heat created by frequency (in hertz's)

An example of very high heat generated in a nano scale (possibly in atomic scale) would be sonoluminesence, where a bubble of air in lets say water, is bombarded with frequencies that vibrate the molecules inside that bubble to a point of generating thousands of degrees of heat, which expands that bubble until it bursts and contracts to a size smaller that what it was to start with. At that point of bursting that energy is condensed and forms a glow which we see and call sonoluminescence.

Is this what we are looking for? It could be if we could multiply the number of reactions taking place at the same time, an instant molecular furnace.

Example of energy in the form of high current (amperes)

An example of creating high current (measurement in amperes per cm2) is in creating an electron beam such as laser or plasma at ATP, atmospheric temperature and pressure, and not in a vacuum.

This can be achieved by using a 2DBD, two dielectric barrier discharge at ATP to create the electrons, and then accelerating these electrons up to near light speed to create a wide electron beam moving away from the electron source. The 2DBD requires very high "anode" voltage at frequency, but very low amperage and so consumes very low energy (watts). A second higher voltage "anode" close by is used to accelerate these electrons from the 2DBD surface area (which has become a virtual cathode on the surface of the dielectric), towards the higher voltage anode, we now have our high velocity electron beam @ATP.

An electron beam is a **none thermal** plasma or laser which being a discharge, has condensed the low amperage very high voltage into a discharge of now very high amperage (typical in tests was 50 amps per cm2) as it travels from the virtual cathode toward the higher voltage anode.

Is this what we are looking for? It could be if we can control the discharge over a wide work area.

The reality revealed

If you have thought well about the two examples above, then you will have realised that both these examples take place at the same time in the second example (heat and power) all for a low input cost, especially as both have taken place by using the same input (two for the price of one).

Now we are motoring along, but wait a minute, what reactions are going to happen when we pass a mixture of gases through this electron beam? Well this will partly depend on the **electronegativity** of those gases and if one of those gases was water vapour, then the ph of that water vapour will come into effect (ph is connected to electronegativity and pure water is 7).

How do we direct the chemical reactions that we want to take place? Part of the answer is in the above and part depends on what you put into the reactor in the first place. The rest of the answer is in general catalyst chemistry, and physical separation through membrane separation, of which I am not going to go into just yet.

Resonant frequency and how it plays a part.

I know many would want to ask if resonant frequency plays a part in all this, and the answer is yes. Resonance is used to vibrate the molecules which in turn creates the heat, as stated in the example of heat above. In the ideal world we would want to hit a molecule with it's resonant frequency, if we know it, and that can be difficult if the molecule is not pure (as in water). But we also have different molecules in the mixture and they all have different resonant frequencies. What do we do? Use different generators for different molecules? No, we create a very wide band of frequencies which contain all the spectrum of frequencies that we want (a big hammer to make sure you hit the head of the nail).

How is this done? Well we take two frequency generators running at two different frequencies. One is the driver for the DBD and the other is the driver for the other anode. These two frequencies combine inside the molecules of gas which is passing through the accelerated electron beam, and form through hetrodyning, a very wide band of frequencies. When tuned correctly by also tuning the duty cycle, two frequencies of say 6khz and 36khz, but do not have to be these exact frequencies, would generate a very wide band which would go up into the Ghz range and off into infinity, as can be seen on an oscilloscope and frequency analyser. The oscilloscope would have to have Ghz/sec sample rate to see this well, it will look like a sample of DNA, this is because the hetrodyning also takes place with the harmonics that are also generated.

Due to this RF aspect and high current within the reactor, good shielding needs to be used so as not to radiate beyond the containments of the reactor, this is very important from a contaminating point of view, and so for obtaining licence to manufacture and use this type of reactor.

Catalysts and the part they play

One of the catalysts I am going to mention is shown in example one above, yes common salt (NaCl). This is not a molecule, it is a crystal lattice formed by an **ion bond**, this is important, and the other thing that is important is that the **solvent** for this is **water**.

Pure water has a ph of 7, that meens that the positive and negative ions are in balance. If the ph rises above 7 then the H+ will bind with the unoccupied pairs of electrons such as in the N atom, but if the ph drops below 7 then the H+ will bind with COO- groups. Salt is used more in this world for chemical reactions than for any other use, which just shows how important this is.

So now you can see how we can direct chemical reactions within the reactor, depending on what the gases are that we are putting in and what we want out, (electronegativity).

My work has been devoted to the making of NH3 or CH4, a by product of the NH3 is also N2O a very powerful oxidising gas as many know in the car tuning business, and is also helpful along with NH3 to bring it to the equivalent enery on burning, as that of gasolene.

Without using a gas separating method on the output of the reactor there will be other gases mixed in with the main gas that we want. You will not get a pure gas, with the NH3 production, you will also get NOx gases as the nitrogen that you feed into the reactor will also look to join with oxygen in a form other than N2O, nothing is perfect without further separation. Will it burn? Yes it will and you can feed back the Nox gases from the exhaust, to create the N2 that you need to start the process.

Carbon dioxide is a problematic gas as we all know, we create hugh amounts, now we can reuse it to create energy again and again, and thus be environmentally friendly.

CO2, carbon dioxide; one carbon and two oxygen molecules are hard to break, look at their bond energy in the chart previously provided. It is a non-polar covalent bond, O - C - O. The oxygen atoms have a delta- charge, and the carbon a delta+ charge. Because the negative charges pull the electron cloud into different directions, it has no side which is more **electronegative** than the other. Therefore it is a non-polar **covalent bond**.

The Sabatier reaction

The Sabatier reaction involves carbon dioxide CO2 and hydrogen H2 and using a nickel or ruthenium catalyst we can produce methane CH4 and water H2O.

$\mathbf{CO2} + \mathbf{4H2} = \mathbf{CH4} + \mathbf{2H2O}$

Now the reaction needs to have heat applied and the input gases should be near stoichiometric, but high flow rates can be obtained. The problem here is two fold, the first being the hydrogen stock and the second, heating the catalyst chamber to around 400c which would both use considerable energy.

MNE-beam reactors

MNE-beam reactors, I say in plural, as each reactor can be configured to do a different job. In the past most electron beams were produced in a vacuum, I did this to start with, until I came up with an idea of creating a powerful electron beam at atmospheric pressure.

I am going to concentrate on the production of methane and oxygen as our final gases. As seen above we need four H2 molecules to one CO2 to produce one CH4. Our source of H2 will come from water.

Using an e-beam reactor in the right configuration we will split the water molecule using very little energy. The resulting hydrogen and oxygen are then separated by means of a hydrogen membrane, and this hydrogen is then fed into the second mne-beam/sabatier reactor, as I call it, configured for methane production.

As explained before, the e-beam reactor has three functions, it vibrates the molecules, it locally heats them and accelerates electron movement. This has increased the Sabatier reaction ten fold and using less energy than for the heat normally required.

Our output is methane and water, the water is sent back to the first reactor to be used again. Now this is where the cool part comes from, we need CO2 to start with, OK, but after when we burn the CH4 with the oxygen we have taken away in the first reactor, we get CO2 + H2O, it is all recycled back (apart from minor losses).

$\mathbf{CH4} + \mathbf{2O2} = \mathbf{2H2O} + \mathbf{CO2}$

There will not be sufficient oxygen from the first reactor, but the rest comes from the air intake of what ever engine we are running.

In practice the air to the engine intake passes through a nitrogen/oxygen separation membrane and so delivering pure oxygen, this makes the exhaust of the engine to give out CO2 and not nitrogen containing Nox gases. This makes recycling direct without poisoning the input with nitrogen, nitogen is another part to this, in the production of NH3.

Ammonia, NH3 + N2O production

There are many pèople that do not believe that ammonia as a fuel source is a viable gas, but used with a good oxidiser it is equivalent to petroleum. Most of the world's ammonia is made by the Harber Bosch process which is very energy consuming, apart from most of the hydrogen comes from reformed methane or petroleum in the first place.

As shown before the source of hydrogen in our case comes from water splitting in a low energy system **"mne-beam reactor"**. The heat required for molecular bonding also comes from the low energy input, vibration of the molecules. Our nitrogen is taken from the air by an oxygen/nitrogen membrane separator which does not consume energy. This separation gives us as well as the pure nitrogen for the NH3 production, separated oxygen and nitrogen for the N2O production.

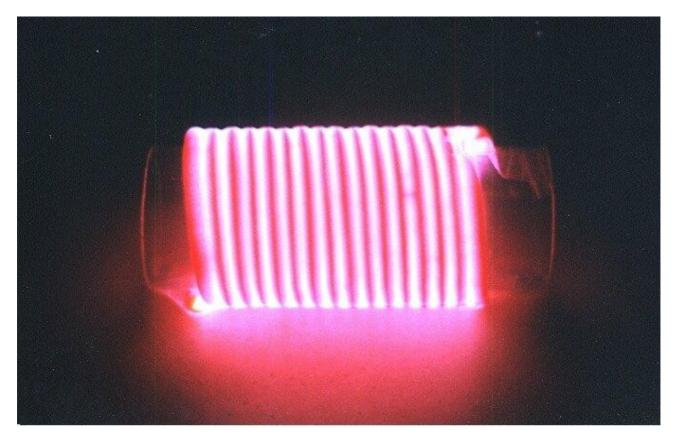
Gas flow volumetric regulators are used throughout all these systems to correct the stoichiometric requirements for molecular bonding and so ensure a more complete bonding as is required for the exiting gas. The following equations apply to the various sections of the system.

$2\mathrm{H2O} = 2\mathrm{H2} + \mathrm{O2}$

2N + 3H2 = 2NH3

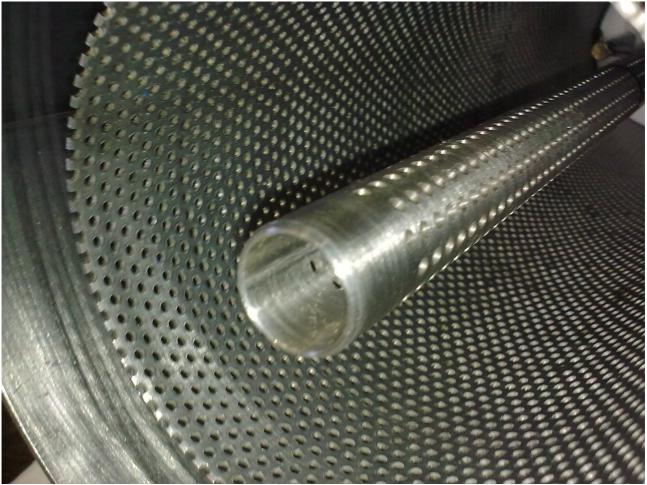
2N2 + O2 = 2N2O

combustion 2NH3 + 3N2O = 4N2 + 3H2O The last equation is from the combustion of the ammonia with the nitrous oxide, you will see that the ratio is **2:3** to give a nitrogen and water exhaust, but if the ratio is not obtained then certain NOx gases could be produced and therefore in practice these two gases could be mixed and stored at the correct ratio of **2:3** before being used.



Dielectric barrier discharge showing the electron discharge Plasma. In the e-beam reactor a third anode is used at a distance from the dielectric "vitual cathode". This anode is of higher potencial and the electrons accelerate towards it creating the electron beam. Each anode is running at a different frequency as explained in the part about frequency.





Part of the inside of the mne-beam reactor (no catalyst installed)

The initial energy required to run these systems is one of electric power. Due to the low power requirements of running these systems, the power could come from batteries which are charged from solar or wind power. By using such forms of electric generation, the power generated from the resulting gases would be 100% free energy. If the gases are used to run generating turbines, then some of the energy can be reused to power the reactors and give a net free energy gain.

For the sceptics, the energy gain comes from the energy stored in the chemical reactions as I have stated right at the beginning of this paper. This is like mixing chemicals to make TNT and then applying a match to the fuse to release the energy in those chemical bonds, the cost of the match is minimal, but the energy released is huge.

These reactors will be designed to work in parallel for large installations and can be linked to gas compressors for safe gas storage. These reactors could also be used for reprocessing CO2 emissions from coal fired power stations and the resulting CH4 pumped into the natural gas pipe lines for domestic use.

Other projects:-

STEAP : Space Time Energy Absorption Pump

Using the concept of molecular vibration and realinement of ferro magnetics for excess energy generation.

I thank my wife for supporting me on this project and also all those who have provided financial or technical help and building.

There is still a way to go on this project, to bring it to a final end, and financial support is always welcome and will help speed up the final production model.

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