Control Global Warming by Reducing Atmospheric CO2 to Carbon and Producing Energy

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Abstract: A multipurpose plant setup is discussed using the concept of House Process and various other techniques to achieve objectives like reducing atmospheric CO2 to carbon and thus reduce global warming, production of hydrogen gas, to produce electricity, to provide energy feedback for improved efficiency. These objectives are obtained by a six stage process. In the 1st stage atmospheric CO2 is absorbed using an improvised version of House Process. In the 2nd stage, CO2 is produced by heating NaHCO3, a by-product of House Process. In the 3rd stage, reaction of the produced CO2 with Mg occurs, to get Magnesium Oxide and Carbon. The 4th stage consists of recovery of Mg from its oxide by using a modified House Process and consequent electrolysis of MgCl2.The 5th stage, energy produced by the exothermic reactions is used to produce steam and produce electrical energy by rotating a turbine. Finally, hydrogen gas is produced by the reaction of steam and magnesium. Thus the various objectives are achieved.

Key words: House Process, modified house process, fuel cell, multipurpose plant, electric energy production, hydrogen production, capturing atmospheric CO2.

Introduction

Concern about anthropogenic climatic change has stimulated research and investment into technologies that limit CO_2 emission from combustion of fossil fuel and other sources and also that remove carbon dioxide directly from atmosphere. If the cost of absorbing CO_2 from atmosphere is reduced by various means like inventing low cost methods, lowering the cost of establishment, it would prove to be more convenient and beneficial for various countries. We have discussed such a method where we adopt a set of processes. The multipurpose setup discussed below is a two-in-one setup, which includes both environment and energy benefits. Considering the monetary as well as the environmental benefits such as reducing global warming, the input is well justified and useful by-products are also obtained. The entire process has low carbon dioxide foot print.

Materials and Methods

Absorption of Atmosperic CO_2 and Production of $NaHCO_3$

In this process, modified House Process is used to absorb atmospheric CO_2 and produce $NaHCO_3$. First we need to understand the House Process—a process where CO_2 capture and storage from the atmosphere that involves enhancing the solubility of CO_2 in the ocean by a process equivalent to the natural silicate weathering reaction. This is achieved by increasing the alkalinity of sea water by removing HCl electrochemically and neutralized by the reaction with silicate rock. It is a four step process.

Step 1

The first step of the process involves the removal of chlorine ions from high purity artificial salt solution:

$NaCl\ (aq) + H_2O\ (l) \rightarrow NaOH\ (aq) + (1/2)\ Cl_2\ (g) + (1/2)\ H_2\ (g)$ $\Delta G = +212 KJ/mol\ NaOH$

Step 2

HCl is recovered from Cl_2 (g) and H_2 (g) produced in step1. Cl_2 and H_2 combine in fuel cell to produce HCl:

$(1/2)Cl_2\ (g) + (1/2)\ H_2 \rightarrow HCl\ (aq)$

$\Delta G = -131 KJ/mol\ NaOH$

Step 3

HCl is neutralized by various silicate rocks. The reaction is exothermic and spontaneous:

$HCl\ (aq) + (1/2)\ MgSiO_3(s) \rightarrow (1/2)\ MgCl_2\ (aq) + (1/2)\ SiO_2(s) + (1/2)\ H2O$

$\Delta H = -58 KJ/mol\ NaOH$

Step 4

The final step of the process involves capturing and storing of CO_2 gas:

$CO_2\ (g) + NaOH\ (aq) \rightarrow NaHCO_3\ (aq)$

$\Delta H = -70 KJ/mol\ NaOH$

Therefore the net reaction is given as:

$1/2\ H_2O\ (l) + 1/2 MgSiO_3(s) + CO_2\ (g) \rightarrow 1/2 Mg + 1/2 SiO_2(s) + HCO_3$

$\Delta Gnet = -4 kJ/mol$ $\Delta Hnet = -310.5 kJ/mol$

Modified House Process

In the modified House Process Steps 1, 2, 4 are same as House Process. The modification is made in Step 3, which involves use of magnesium oxide for neutralization of HCl which is by-product of stage 3 and stage 6 which also helps in recovery of magnesium. HCl is neutralized with help of MgO, the reaction of HCl and MgO is exothermic and spontaneous. This reaction also gives $MgCl_2$:

$MgO(s) + 2HCl\ (aq) \rightarrow MgCl_2\ (aq) + H_2O\ (l)$

$\Delta H = -146 kJ/mol$

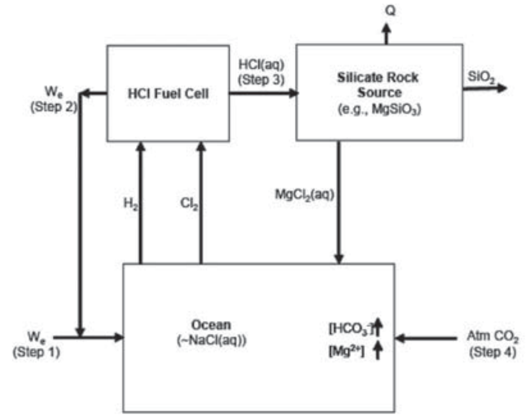

Figure 1. Diagram Showing Carbon Dioxide Sequestration via the Removal and Neutralization of Hydrochloric Acid from the Ocean. Magnesium has been Used to Represent Any Metal Found in Silicate Rocks. W_e Represents Electrical Work and Q Represents Heat.

Thus we produce $NaHCO_3$, $MgCl_2$ which is used in later process and comparatively more energy is released. The net reaction of the modified House Process is:

$$2NaCl + 2CO_2 + H_2O + MgO \rightarrow 2NaHCO_3 + MgCl_2 \quad \Delta H_{net} = -398.9\ KJ/mol$$

Production of CO_2 by Heating $NaHCO_3$

This stage involves the heating of $NaHCO_3$ to produce CO_2. Above 70 ° C, sodium bicarbonate gradually decomposes into sodium carbonate, water and carbon dioxide. This conversion is fast at 250 degree centigrade: $2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$.

Further heating converts the carbonate into oxide at around 1000 degree centigrade: $Na_2CO_3\ (aq) \rightarrow Na_2O + CO_2\ (g)$. Thus, the carbon dioxide gotten in this reaction is collected and transported for stage 3 process and the other by-product of the stage is Na_2O or Na_2CO_3 which can be also used for some other purpose.

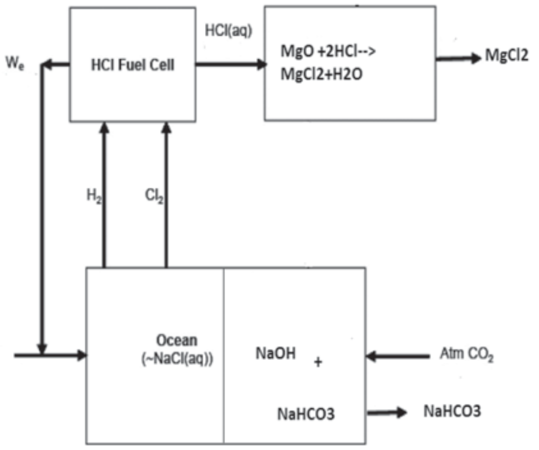

Figure 2. Modified Process

Production of Carbon and Magnesium Oxide

In the stage 3 process, the reaction of magnesium and carbon dioxide takes place in the absence of oxygen. The reaction is initiated by burning of magnesium. Magnesium reacts with carbon dioxide to form magnesium oxide and carbon:

$$2Mg(s) + CO_2\ (l) \rightarrow 2MgO(s) + C(s) \quad \Delta H = -810KJ/mol$$

The reaction can take place only if oxygen is absent, so one of the important conditions is absence of oxygen. A specially designed reactor is build in order to carry out the process. The reactor is similar to a simplified two reaction zone of magnesium reacting with carbon dioxide. This reaction releases a large amount of free energy almost equal to methane (-818kJ/mol). As a by-product of this reaction we get magnesium oxide and carbon in solid form. This carbon can be stored and used in future if necessary. As mentioned earlier, the magnesium oxide is used in modified House Process and recovery of msagnesium.

Recovery of Magnesium

Recovery of magnesium from magnesium oxide is a stage 4 process. The magnesium oxide obtained as a by-product and hydrogen neutralize HCl to produce $MgCl_2$ which is a part of modified House Process. This $MgCl_2$ is electrolysed to produce magnesium. At cathode Mg^{2+} ions is reduced by two electrons to magnesium metal:

$$Mg^{2+} + 2e^- \rightarrow Mg$$

At anode, each pair of Cl^- ions is oxidised to chlorine gas, releasing two electrons to complete the circuit:

$$2Cl^- \rightarrow Cl_2\ (g) + 2e^-$$

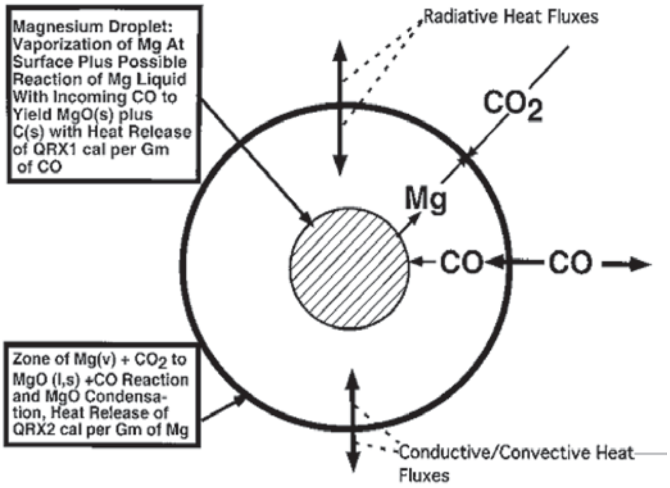

Figure 3. A Simplified Two-Reaction Zone Model of Magnesium Combustion in Carbon Dioxide.

Production of Electric Energy

In the stage 5 process, we use all the heat energy produced by various exothermic reactions to vaporize water into high pressure stream. Similar to the thermal power plant, the prime mover steam spins a steam turbine which drives electrical generator to produce electric energy. This electric energy can be used commercially.

Production of Hydrogen Gas

Hydrogen gas is produced in stage 6. Magnesium is capable of reducing water to highly flammable hydrogen gas. Magnesium reacts slowly with cold water and faster with steam:

$$Mg\ (s) + H_2O\ (g) \rightarrow MgO\ (s) + H_2\ (g) \quad \Delta H = -360 KJ/mol$$

So we use the low pressure steam that we get after rotating the turbine to react with the recovered magnesium from stage 4 to get magnesium oxide and hydrogen as by-product. This hydrogen gas is collected, stored and distributed for commercial purposes. The magnesium oxide can be used for the recovery of magnesium. This reaction being exothermic gives out heat energy.

Conclusion and Discussion

The rise in carbon dioxide in the atmosphere, which eventually leads to global warming and concern about energy crisis—the two important problems that the world faces today. The process discussed above considers both points and interlinks both to solve our problem. In the provided setup, atmospheric carbon dioxide is reduced to carbon form which leads to reduction in global warming. Also, all the by-products produced by the setup are useful and can be used practically.

This process causes very low air and water pollution. The carbon dioxide that is obtained in solid form can be stored and used if any energy crisis arises in the future; it can also be considered to replace limestone in many processes where limestone is used.

The enthalpy of formation of the overall reaction is more than -1568kJ/mol which can be effectively utilized in the production of electrical energy commercially.

Hydrogen gas which is a green fuel and causes no pollution, can be produced in a large scale and used as a substitute for fossil fuel and thus provides a solution for the current energy crisis problem.

We also get other by-products like chlorine, sodium oxide which can be used for commercial purposes.

The initial cost of setup of such a huge process might be high, but considering global warming, the energy produced and the profit, the cost is well justified. Thus this process gives a complete solution for reducing global warming and the energy problems

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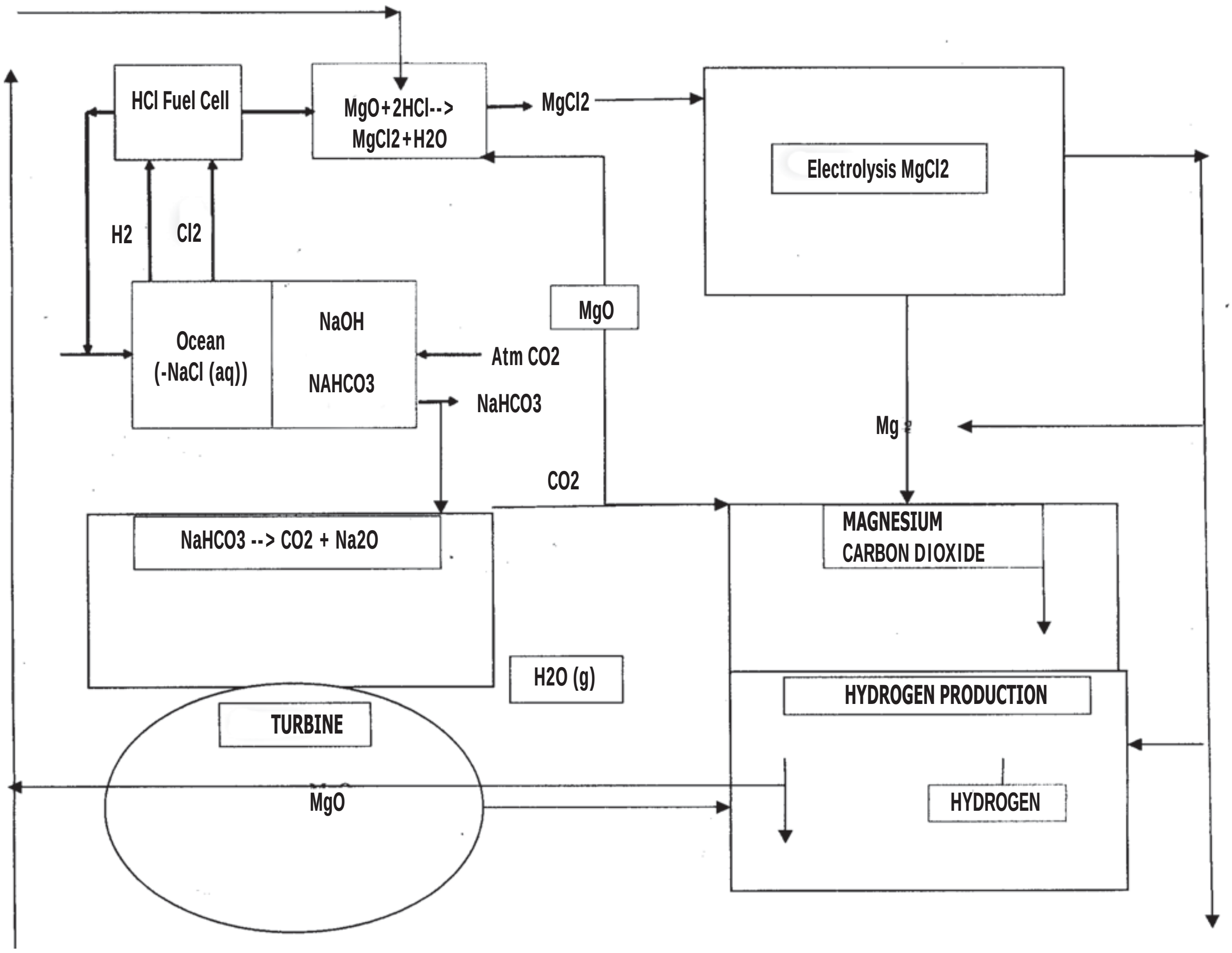

Figure 4. Flow Chart for the Total Process.

give innovative ideas.
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18 January- 7 May 2010: Integrated Water Resource Management Course. Location: Kenya. More Info: www.itc.nl/education/courses/course_descriptions/_pdf/C10-WREM-SC-01.pdf www.itc.nl/education/courses.aspx

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24-26 March 2010: HydroVision Russia, Location: Moscow, Russia, More info: www.hydrovision-russia.com

29-30 March 2010: Third International Conference on Water Resources and Renewable Energy development. Location: Sarawak, Malaysia. More Info: www.hydropower-dams.com

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27-30 July 2010: HydroVision International. Location: Charlotte Convention Center – Charlotte, NC, USA. More Info: www.hydroevent.com/index.html

> ***No cases relating to irrigation disputes would be heard in courts (to be resolved in the local community).***
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> -King Ram Shah, Gorkha (Nepal, 1603-33)