The present disclosure provides for hydrogen generation via an acid-reactive, hydrogen-producing alloy composition and method for manufacturing which provide hydrogen generation rates that are particularly customizable and adjustable for intended uses and time-spans.
Provide Container 105

Supply Initial Components 110

Supply Continuous Flow of Gas 125

Liquefy Initial Components 130

Provide Heat 115

Stir Continuously 120

Supply Additional Components 135

Reach Target Temperature 140

Introduce into Mold 145

FIG. 1
Place Alloy Composition into Container 210
Provide Acidic Fluid into Container 215
Reaction Occurs Providing Hydrogen 220

FIG. 2
HYDROGEN GENERATION UTILIZING ALLOYS AND ACIDS AND ASSOCIATED MANUFACTURING METHODS

RELATED APPLICATIONS

[0001] This application claims the benefit of and priority to U.S. Provisional Application Ser. No. 60/624,961, filed on Nov. 3, 2004, the contents of which are incorporated by reference herein in its entirety.

BACKGROUND

[0002] 1. Field

[0003] The present disclosure relates to a composition and associated methods for producing hydrogen and more generally to a hydrogen generation utilizing an alloy composition exposed to an acidic medium.

[0004] 2. General Background

[0005] Hydrogen production and uses as a potential fuel have been areas of intense research in recent years. Hydrogen is particularly attractive as a fuel because of the lack of resultant production of polluting substances such as sulfur oxides and nitrogen oxides that are typically associated with the combustion of various petroleum based/derived fuels.

[0006] Various methods for producing hydrogen are known, including various reactions that provide for electrolysis of water. As a further method of producing hydrogen, the reaction between magnesium and water is known. This reaction is illustrated by the following chemical equation:

\[ \text{Mg} + \text{H}_2\text{O} \rightarrow \text{Mg(OH)}_2 + \text{H}_2. \]

[0007] However, a common problem associated with such prior art methods and systems is that once magnesium hydroxide is formed on the surface of the magnesium, the magnesium hydroxide prevents further contact of magnesium with the surrounding water. The reaction is stopped and therefore the generation of hydrogen slows down or stops altogether. The formation of oxides onto the surface of alloys and metal that have been utilized to generate hydrogen has been a problem area that has plagued this field of endeavor for many years.

[0008] Furthermore, the formation of reaction-limiting oxides/scum, uncontrollability of hydrogen production and production of hazardous waste material are areas of concern in the hydrogen production field.

SUMMARY

[0009] The present disclosure provides for the use and formation of an acid-reactive hydrogen-producing alloy composition that provides for an efficient, and controllable method of obtaining hydrogen upon exposure of the acid-reactive hydrogen-producing alloy composition to an acidic medium. It is noted that the term alloy composition comprises both compositions of purely metallic elements and compositions which comprise both metallic and non-metallic elements. Thus, the term alloy composition should not be limited to compositions only comprising metallic elements.

[0010] In one aspect of the disclosure, a particularly useful acid-reactive hydrogen-producing alloy composition and method for making same is provided, which can be formed and shaped in accordance with particular applications. For example, the alloy composition can be formed to produce hydrogen for use in a hydrogen fuel cell or internal combustion engines. Various purities of the elements are utilized to produce hydrogen for a particular purpose.

[0011] In particular implementations, an alloy composition for generating hydrogen upon exposure to an acidic medium is disclosed, which is comprised of magnesium, zinc, calcium and iron. In other implementations, the magnesium is present in about 30 to 40% by weight, the zinc is present in about 40 to 55% by weight, the iron is present in about 2 to 5% by weight, and calcium is present in about 4 to 12% by weight.

[0012] In one implementation, a method for forming an alloy composition for hydrogen generation upon exposure of said alloy composition to an acidic medium comprises supplying an amount of magnesium and zinc into a container, heating the container to a predetermined temperature; supplying a stream on inert gas into said container; and stirring the contents of said container. In one implementation, iron and zinc are added to the liquefied magnesium and zinc to form an alloy composition. In particular implementations, the alloy composition is introduced into a mold.

[0013] In particular implementations, the acid-reactive hydrogen-producing alloy composition of the present disclosure can be spherical or multifaceted. In other implementations, the alloy composition is shaped into a columnar or cylindrical rod. In other implementations, the allow may be shaped into its final shape in another forming step wherein the alloy is formed into the predetermined shape that is chosen in accordance with an end use of the alloy.

[0014] In one aspect of the disclosure, a method for forming an acid-reactive hydrogen-producing alloy is disclosed that can be executed in a particular manner to obtain a hydrogen-producing alloy composition that generates hydrogen, upon exposure to acid, at particular rates.

[0015] In particular implementations, a ratio of magnesium, zinc, iron and calcium are provided and combined together is such a manner as to provide an alloy composition which, upon exposure to acid, produces hydrogen at a desired rate over desired time.

[0016] In one implementation, a method for generating hydrogen is also provided, comprising providing an alloy composition; supplying a container to hold acidic fluid and the alloy composition; allowing the acid fluid and alloy composition to come into contact; and generating hydrogen from the reaction of the acidic fluid and the alloy composition.

[0017] In particular implementations, the pH of the acidic fluid is monitored utilizing a pH sensor. When the pH of the fluid reaches a set point, a delivery stream will provide more acidic fluid to the container.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The foregoing aspects and advantages of this disclosure will become more readily apparent and understood with reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:
FIG. 1 is a block flow diagram illustrating an exemplary method of producing the alloy composition;

FIG. 2 is a block flow diagram illustrating an exemplary method of producing hydrogen from the alloy composition; and

FIG. 3 is a block flow diagram illustrating an exemplary process control system to maintain the desired pH to optimize the reaction.

DETAILED DESCRIPTION

In one implementation of the present disclosure, various components are combined together in order to form an alloy composition that, when exposed to an acidic medium, generates hydrogen. Exemplary components of such an alloy composition comprise magnesium, zinc, iron, and calcium. These components are provided and heated at desired temperatures to form useful alloy compositions that generate hydrogen in accordance with the teachings provided herein.

It is contemplated that the components comprising the hydrogen-producing alloy composition may have various forms, different percentages by weight, various purities, and many combinations thereof.

In one implementation, the components of the hydrogen-producing alloy composition are available in a variety of forms. In one exemplary implementation, the components are available in the form of 1 lb magnesium plates, 1 lb zinc spheres, iron powder, and calcium pellets. These configurations are only exemplary and the various components may be provided in any useful combination of forms (e.g., plates, powders, flakes, pellets, spheres, rods, etc.). Another exemplary implementation of various component forms is listed in the table below.

<table>
<thead>
<tr>
<th>Component</th>
<th>Shape/Size</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium (Mg)</td>
<td>Plates</td>
<td>1 lb.</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Spheres</td>
<td>1 lb.</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>Powder</td>
<td>30 Mesh</td>
</tr>
<tr>
<td>Ca (Ca)</td>
<td>Pellets</td>
<td>¼ inch</td>
</tr>
</tbody>
</table>

As depicted in the table above, each component of the alloy composition is associated with a particular ratio. In this exemplary implementation, Magnesium has a ratio by weight of 30-40%, Zinc has a ratio by weight of 40-55%, Iron (Fe) has a ratio by weight of 2-5%, and Calcium has a ratio by weight of 4-12%. Of course it is contemplated that the alloy composition can comprise components each having any number of ratio by weight.

In another implementation, the purity of each component comprising the alloy composition may be varied. In one implementation, for hydrogen generated for particular uses (for example, in a fuel cell or an internal combustion engine [ICE]) it has been found that particular purities of various metallic components, such as the Magnesium, Zinc, Iron, and Calcium, provide optimal hydrogen generation characteristics. In an exemplary implementation, an exemplary list of components and their respective percentage of purity is provided below.

<table>
<thead>
<tr>
<th>Component</th>
<th>Purity (ICE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium (Mg)</td>
<td>85%</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>90%</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>80%</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>90%</td>
</tr>
</tbody>
</table>

As depicted in the table above, in one implementation, in the application of an internal combustion engine (ICE) the components of an alloy composition have a particular purity. Specifically, Magnesium has a 85% purity, Zinc has a 90% purity, Iron has 80% purity, and Calcium has 90% purity.

Of course, the percentage of purity may be varied according to the desired application of the alloy composition. Another exemplary implementation of the associated purities for each component of an alloy composition for a fuel cell application is depicted in the table below.

<table>
<thead>
<tr>
<th>Component</th>
<th>Purity (fuel cell)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium (Mg)</td>
<td>99%</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>99%</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>80%</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>90%</td>
</tr>
</tbody>
</table>

As depicted in the table above, in one implementation, in the application of a fuel cell the components of an alloy composition have a particular purity. Specifically,
Magnesium has a 99% purity, Zinc has a 99% purity, Iron has 80% purity, and Calcium has 90% purity.

In some implementations (described in further detail herein), the components that comprise the acid-reactive hydrogen-producing alloy composition are combined with heat to create an alloy composition that will react with acidic fluids. Exemplary acids that are useful, in accordance with the teachings provided herein, comprise citric and/or acetic acids. In one implementation, the acid or acids are added to a volume of fluid to drop the pH to the desired pH range of about 2 to about 3. Of course alternate types of acids capable of reducing the pH to the 2 to 3 range are contemplated. In other implementations, other acids are also contemplated, however appropriate handling and waste concerns may be associated with the use of other acids.

In one implementation, regardless of its components, an acid-reactive hydrogen-producing alloy composition can be provided in any desired shape. In one implementation, an exemplary shape comprises a rod, having a columnar or cylindrical shape, although any desired shape may be utilized in accordance with an end use of the alloy composition. In one implementation, the overall dimensions of the alloy composition(s) is in accordance with internal volumes/spaces of a reaction vessel that will contain acidic fluids and the acid-reactive hydrogen-producing alloy composition(s). Thus, in one implementation wherein the alloy composition is in the shape of a rod, the rods can be spaced in a desired pattern/configuration in a small or large container.

In one implementation, an exemplary container can be the size of an 8D battery box. Such battery boxes may have exemplary dimensions of about 10-13 inches high, about 13-18 inches long and about 10-12 inches wide and carries over about 500 rods that react to an acidic fluid and create liters per hour of hydrogen gas for days. Other useful exemplary dimension run from about 10x12x18 inches to about 24x28x42 inches.

If a container is in a seldom used machine application, then the hydrogen generating reaction can be fast for partial use, such as back-up power. For such cases, in one implementation, acid-reactive hydrogen-producing alloy compositions would be formulated to provide a higher rate of hydrogen production by increasing the percentages of Calcium and Zinc and a lowering the content of Magnesium and Iron. Calcium enhances the rate at which hydrogen is produced. In one exemplary implementation, the Magnesium content does not go below a certain weight ratio to the Zinc content. An exemplary ratio is about one to two, Zinc to Magnesium, weight mix as the lower limit, that is, for every one unit of Zinc, two units of Magnesium are utilized. In another implementation, the reaction speed and amount of hydrogen output can be varied to the service cycle of the machinery operated.

Various methods for creating the acid-reactive hydrogen alloy composition are disclosed herein. One implementation of a method for creating an acid-reactive hydrogen alloy composition is depicted in FIG. 1. In one implementation, the process for creating the alloy composition may be characterized as a bonding process that bonds all the components to form the acid-reactive hydrogen alloy composition.

As depicted in FIG. 1, first, a container is provided 105 in which to heat the components of the alloy composition. In one implementation, the container may comprise a clean crucible provided in an oven or heating chamber that does not expose the metals to be combined to an open heat source. An exemplary oven that can be utilized is a magnaflux heating oven. In another example, a particularly useful type of furnace is an electro magnetically inductive furnace (i.e., strong electrical currents are utilized to generate heat) and in which the materials are spun during mixing/melting.

Turning back to FIG. 1, once the container is provided, the some or all of the initial components are supplied 110. For example, in one implementation, Zinc and Magnesium are placed at the bottom of the container (in one implementation, a crucible). Next, the container is heated 115 and components begin to liquify once sufficient heat is applied. For example, the Zinc and Magnesium will begin to liquify upon providing heat. In one implementation, during the heat up cycle 115, a blanket of gas may be sprayed 125 into the crucible to retard any flash or ignition of the materials while heating up to the target temperature. In one implementation, Argon can be sprayed in a pattern to keep all oxygen out of the container opening while adding components and bringing the heat up to the target mixing temperature.

In further implementations, during the heating of components, the oven may be slowly heated with two or three cool down cycles. Heating of the components may cause some fly of particulates if pieces of heated metal separated from, for example, Magnesium plates or Zinc balls. Thus, prevention of chipping the material should be taken.

Once the materials begin to liquify 130, they should be stirred 120 to continue the process. In one implementation, the stirring is continuous. After all of the components provided are liquified, additional components may be then added 135. In one implementation, exemplary additional components comprise Iron and Calcium. In other implementations, additional components are not added. In one implementation, the added Iron particles do not melt at the temperatures utilized to mix the components of the present disclosure, but rather are stirred/mixed into the molten alloy composition in order to evenly disperse the particles throughout the formed alloy composition. The stirring rods are utilized to help mix the components of the alloy composition when mixed in the container, making sure that any pieces or globules that may stick to sides are pushed into the mix to properly homogenize the components with on another.

In one implementation, the stirring rod should be clean and not removed from the container during heating and mixing. If the stirring rod is removed, caution as to the flash and flaring of magnesium must be taken (exposure to air). In further implementations, multiple stirring rods are used in the process. Thus several safety precautions such as providing a safety sand box is located proximate to the stirring location, wearing proper eye protection in order to not burn one’s retina while viewing the white hot magnesium, and special fire extinguishers should be available, such as those extinguishers capable of dealing with/utilizes to put out Magnesium fires. Further, no water or moisture should be near the area of melting.

Next, the target temperature for the particular mixture of components is reached 140 (in one implementation,
within minutes of adding the last element). In one implementation, the target temperature is dependent on the particular range of weights of each component used. For example, in one implementation, the more Zinc, the lower the temperature tolerance to flash to gas. For example, with a balance of 40% Mg, 53% Zinc, 2% Iron and 5% Calcium the temperature will max out at around 1357 degrees Fahrenheit. In another exemplary implementation, for a mix of 45% Magnesium, 45% Zinc, 5% Iron and 7% Calcium the temperature will max out at 1557 degrees Fahrenheit. Thus, by varying the target temperature for the reaction, the hardness of the resulting alloy composition is modified. Consequently, in a further implementation, the rate to produce hydrogen will increase as more zinc is added and the hardness of the alloy composition is decreased.

[0044] In one implementation, the hardness of the resultant alloy composition is directly related to the overall ratio of Magnesium utilized and the temperature. If you maximize the temperature (in one implementation, to about 1557 Fahrenheit) and the ratio of the Magnesium, the hardness will increase and thus the life-span of a reaction between the alloy composition and the acid will lengthen.

[0045] Once the target temperature is reached 135, the resultant molten metal may be poured 145 directly into a provided mold. In one implementation, the mold design can include extra materials at the bottom of each cast form due to extreme heat generated by the exposure to oxygen during the pouring process. Exemplary materials comprise epoxy plasters and additional ceramic materials that are utilized to thicken the walls of standard, commercially available mold shapes.

[0046] Various shaping techniques can be utilized to mold/form the acid-reactive, hydrogen-producing alloy composition of the present disclosure into a desire shape. In one implementation, an exemplary casting technique comprises the lost wax method. In one implementation, the lost wax method utilizes a mold which is made of plaster and a wax form, having the desired shape of the acid-reactive hydrogen-producing alloy composition, which is burned out of the mold. Plaster mold formation and wax formation of the desired shape of the cast alloy composition, spruing/venting and gate formation are all standard, well-known aspects of casting utilizing the lost wax method and will not be elaborated here. The plaster mold is perfectly dry and warm before the liquid alloy composition metal, comprising the components disclosed above, is poured into the mold. The plaster molds are preferably kept preheated and dry until used.

[0047] In other implementations, other casting methods can also be utilized, such as investment casting. Such casting utilizes exemplary steps such as wax injection into a mold, assembly of multiple wax forms (if casting a plurality of forms at once) onto a central sprue or wax stick to form a casting assembly or cluster, formation of a shell of plaster, dewaxing or burning out/melting the wax, pouring in molten acid-reactive hydrogen-producing alloy composition, allowing it to harden and then knocking off the shell and finishing (e.g. cutting shaping, etc. . . . ) the final cast alloy composition form.

[0048] In further implementations, additional casting and molding methods known in the art may be used to form the alloy composition into the desired form.

[0049] In one implementation, once the formed acid-reactive, hydrogen-producing alloy composition is provided, hydrogen generation can commence by exposing the acid-reactive hydrogen-producing alloy composition to an acidic fluid. In one implementation, the acidic fluid is created by use of citric acid added to tap water. An exemplary pH range of acidity is between about 2 and 3. The maintenance of the pH of the fluid is automated in a container including acid-reactive hydrogen-producing alloy composition and the acidic fluid. Naturally, the as the hydrogen-producing reactions proceed, the acidity of the fluid will decrease over time.

In another implementation, an exemplary acidic fluid comprises water mixed with an acid. In one exemplary implementation, a ratio of about 4 parts water to 1 part acid is utilized, depending on the buffer of acid and what is required to maintain the pH level at the desired level. In one implementation, if a container has no citric acid being added during the hydrogen output, the volume of water will increase and thus move toward neutral or an alkaline pH. Thus, in one implementation, the target acidity is maintained by automated assistance, for example, by automated addition of more acid in accordance with a pH sensor, as described in further detail herein.

[0050] FIG. 2 depicts a representative flow diagram for an implementation of the hydrogen generation process using an acid-reactive hydrogen alloy composition. As depicted in FIG. 2, an acid-reactive alloy composition is produced 205 using any of the methods as described herein. For example, the acid-reactive alloy composition may be produced according to the method depicted in FIG. 1. However, the acid-reactive alloy composition may be produced according to various other methods disclosed herein and obvious modifications thereof. Turning back to FIG. 2, the acid-reactive alloy composition is placed 210 into a container. Next, an acidic fluid is placed 215 into the container. Then, the acid fluid comes into contact with the alloy composition and a reaction occurs, producing hydrogen 220.

[0051] In one implementation, in order to control the rate of hydrogen generation, a feedback system is provided in order for the acid (in one implementation, citric acid) to retain the acidity targeted for a particular desired rate of reaction. FIG. 3 depicts an exemplary implementation of a feedback system used to control the rate of hydrogen produced by monitoring the pH. As depicted in FIG. 3, the reaction container 310 is attached to an acid reservoir 305, via a delivery stream 315. The reaction container 310 comprises a pH sensor 320 for deterring the pH level within the reaction container 310. In other implementations, the pH sensor may be a separate, attached component with respect to the reaction container. In one implementation, the pH sensor 320 determines if the pH has reached a certain set point. If the pH has reached the predetermined set point, the delivery stream 315 will be initiated and will provide acid from the acid reservoir 305 to the reaction container 310. If the pH has not reached the set point, the delivery stream 315 will be terminated and the pH will be maintained in the reaction container 310.

[0052] In particular implementations, an exemplary feed system comprises a screw fed container that contains citric acid (powder form) in a hopper or closed container. The system also includes a pH sensor that monitors the pH of the acidic fluid as it reacts with the hydrogen-producing acid-reactive alloy composition of the present disclosure. As the
pH sensor detects the pH of the acidic fluid rising past a certain set point, for example pH 3, as a result of the reaction of the alloy composition with the acidic fluid, a switch turns on a screw conveyor nozzle or any other delivery device, and adds an amount of citric acid to the acidic solution to lower the pH back to the desired optimum reaction range, for example back to between a pH of about 2 to about 3.

Various methods can be utilized to provide for faster or slower rates of hydrogen generation. For example, in one implementation, in particular metal content of the alloy composition and increasing of acidity will cause a faster reaction and higher output of hydrogen. In one exemplary implementation, increased hydrogen production is observed with increasing the content of Zinc and/or Calcium in the alloy composition. The hydrogen-producing reaction increases as pH is lowered, that is, hydrogen is produced at a higher rate when utilizing an acidic fluid having a pH of 2 than utilizing an acidic fluid having a pH of 3.

In further implementations, salt has proved a slight buffer toward removal of any scum formed in the oxidation of the materials. In one implementation, Ethylene-diaminetetraacetate (EDTA) containing compositions may also be added in order to reduce the formation of scum, including oxides, off of the metals.

Furthermore, waste management issues are contemplated. In one implementation, the iron content of the alloy composition may create iron oxide upon exposure to the acidic fluid, which is disposed of in an approved manner, either by an in situ or ex situ plan. In one exemplary implementation, methods utilized for iron clean-up comprise bioremediation, air sparging, soil flushing, etc. It is contemplated that the other components do not create any hazard known at this time and that all other components can go directly into a liquid waste system or into land.

While the above description contains many particulars, these should not be considered limitations on the scope of the present disclosure, but rather a demonstration of implementations thereof. The alloy composition, method for making and uses disclosed herein include any combination of the different species or implementations disclosed. Accordingly, it is not intended that the scope of the present disclosure in any way be limited by the above description. The various elements of the claims and claims themselves may be combined any combination, in accordance with the teachings of the present disclosure, which includes the claims.

What is claimed is:

1.) An acid-reactive alloy composition for hydrogen generation comprising:
- magnesium in about 30% to 40% by weight;
- zinc present in about 40% to about 55% by weight;
- iron present in about 2% to about 5% in weight;
- and calcium present in about 4% to about 12% by weight.
2.) A method for producing an acid-reactive alloy composition for hydrogen generation, comprising the steps of:
- supplying an amount of magnesium and zinc;
- placing said provided magnesium and zinc into a container;
- heating up said container;
- supplying a stream of an inert gas into said container during said heating step;
- continuing said heating of said container up to a predetermined temperature at which said magnesium and zinc liquefy;
- stirring said magnesium and zinc as they begin to liquefy;
- adding an amount of iron to liquefied magnesium and zinc;
- adding an amount of calcium to liquefied magnesium and zinc to form an alloy composition which includes magnesium, zinc, calcium and iron;
- providing continuous stirring once magnesium and zinc begin to liquefy;
- reaching a target temperature once said magnesium, zinc, iron and calcium are mixed with each other; and
- introducing a resultant alloy composition into a mold.

3.) The method in claim 2 wherein the magnesium is present in about 30% to about 40% by weight, the zinc is present in about 40% to about 55% by weight, the iron is present in about 2% to about 5% in weight, and the calcium is present in about 4% to about 12% by weight.

4.) The method in claim 2 wherein the inert gas comprises argon.

5.) The method in claim 2 wherein the acid-reactive alloy composition is formed with the mold in accordance with the end use of the acid-reactive alloy composition.

6.) The method in claim 5 wherein the mold is in the shape of a columnar rod.

7.) The method in claim 2 wherein the mold is shaped using a lost wax method.

8.) The method in claim 2 wherein the mold is shaped using investment casing.

9.) A method for generating hydrogen, comprising the steps of:
- producing an acid-reactive alloy composition;
- supplying a container capable of containing the acid-reactive alloy composition and an acidic fluid;
- allowing the acidic fluid and the alloy composition to come into contact;
- and generating an amount of hydrogen upon the acidic fluid contacting with the alloy composition.

10.) The method of claim 9 wherein the acidic fluid comprises water and an acid.

11.) The method of claim 10 wherein the acidic fluid is in the ratio of 4 parts water to one part acid.

12.) The method of claim 10 wherein the acid is citric acid.

13.) The method of claim 10 wherein the acid is acetic acid.

14.) The method of claim 9 wherein the acidic fluid has a pH of about 2 to about 3.

15.) The method of claim 9 wherein the pH of the acidic fluid is monitored using a pH sensor.

16.) The method of claim 15 wherein the pH sensor will trigger a delivery stream to provide acid to the container when the pH reaches a set point.
17.) The method in claim 9 wherein the acid-reactive alloy composition comprises magnesium, zinc, iron, and calcium.

18.) The method in claim 9 wherein the magnesium is present in about 30% to 40% by weight, the zinc is present in about 40% to about 55% by weight, the iron is present in about 2% to about 5% in weight, and the calcium is present in about 4% to about 12% by weight.

19.) The method in claim 9 wherein the acid-reactive alloy composition is formed with a mold in accordance with the end use of the acid-reactive alloy composition.

20.) The method in claim 19 wherein the mold is in the shape of a columnar rod.

21.) The method in claim 10 wherein the acidic fluid further comprises a salt.

22.) The method in claim 21 wherein the salt comprises sea salt.

23.) The method in claim 21 wherein the salt is selected from the group consisting of potassium chloride, sodium chloride, calcium chloride, magnesium chloride, or magnesium bromide.

24.) A method for generating hydrogen, comprising the steps of:

- supplying a specified amount of magnesium, zinc, calcium, and iron;
- melting and mixing the supplied magnesium, zinc, calcium, and iron to form an acid-reactive alloy composition;
- forming the acid-reactive alloy composition with a mold into a desired shape of alloy composition;
- supplying a container cable of containing the shape of alloy composition and an acidic fluid;
- allowing the acidic fluid and the shape of alloy composition to come in contact; and
- generating an amount of hydrogen upon said contact of the acidic fluid with the alloy composition.

25.) The method of claim 24 wherein the acidic fluid comprises water and an acid.

26.) The method of claim 24 wherein the acid comprises citric acid.

27.) The method of claim 24 wherein the acid comprises acetic acid.

28.) The method of claim 24 wherein the acidic fluid has a pH of about 2 to about 3.

29.) The method in claim 24 wherein the acid-reactive alloy composition comprises magnesium, zinc, iron, and calcium.

30.) The method in claim 24 wherein the magnesium is present in about 30% to 40% by weight, the zinc is present in about 40% to about 55% by weight, the iron is present in about 2% to about 5% in weight, and the calcium is present in about 4% to about 12% by weight.

31.) The method in claim 24 wherein the acid-reactive alloy composition is formed with the mold in accordance with the end use of the acid-reactive alloy composition.

32.) The method in claim 24 wherein the mold is in the shape of a columnar rod.

33.) The method in claim 24 wherein a plurality of acid-reactive alloy compositions are placed into the container and allowed to contact the acidic fluid.

34.) The method in claim 24 wherein the dimensions of the container are about 10x12x18 inches to about 24x28x42 inches.

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