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IN REPLY REFER TO:

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METHOD TO ACCELERATE WETTING OF AN ION EXCHANGE MEMBRANE IN A SEMI-FUEL CELL

TO ALL WHOM IT MAY CONCERN

BE IT KNOWN THAT (1) LOUIS G. CARREIRO, (2) CHARLES J. PATRISSI, AND (3) STEVEN P. TUCKER, employees of the United States Government, citizens of the United States of America, and residents of (1) Westport, County of Bristol, Commonwealth of Massachusetts, (2) Newport, County of Newport, State of Rhode Island and (3) Portsmouth, County of Newport, State of Rhode Island, have invented certain new and useful improvements entitled as set forth above of which the following is a specification:

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STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefore.

CROSS REFERENCE TO OTHER RELATED APPLICATIONS

This patent application is co-pending with a related patent application entitled HIGH EFFICIENCY SEMI-FUEL CELL INCORPORATING AN ION EXCHANGE MEMBRANE (Navy Case No. 82737), by, Maria G. Medeiros, Eric G. Dow, employees of the United States government, Russell R. Bessette, Susan G. Yan, and Dwayne W. Dischert.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to semi-fuel cells, and more specifically to a new treatment for ion exchange membranes that accelerates the wetting of the membranes by aqueous electrolyte solutions, thus reducing the start up time for metal/hydrogen peroxide-based semi-fuel cells.

(2) Description of the Prior Art

A semi-fuel cell is essentially a hybrid of fuel cells and batteries. Combining the refillable cathode or catholyte oxidizer of fuel cells with the consumable anode fuel of batteries. Semi-fuel cells are currently under investigation as electrochemical power sources for unmanned undersea vehicles. In a semi-fuel cell, a metal anode, such as magnesium or aluminum along with a liquid catholyte, typically a strong oxidizer like hydrogen peroxide, are consumed to produce energy. The electrochemical reaction is given below for magnesium with hydrogen peroxide in acid media.

Anode:	$Mg \rightarrow Mg^{2+} + 2e^-$		2.37 v
Cathode:	$H_2O_2 + 2H^+ + 2e^-$	$2\ H_2O$	1.77 v
Cell Reaction:	$Mg + H_2O_2 + 2H^+$	$Mg^{2+} + 2\ H_2O$	4.14v

In addition to the primary electrochemical reaction, several parasitic reactions can also take place.

Decomposition: $2\ H_2O_2 \rightarrow 2H_2O + O_2$

Direct Reaction: $Mg + H_2O_2 + OH^- \rightarrow Mg^{2+} + 3\ OH^-$

Corrosion: $Mg + 2H_2O \rightarrow Mg^{2+} + 2\ OH^- + H_2$

Of the three parasitic reactions listed above, the direct reaction is the most detrimental to the operation of the semi-fuel cell since both magnesium and hydrogen peroxide are consumed in a single step. Whereas magnesium corrosion can be suppressed by pH adjustment and hydrogen peroxide decomposition minimized by careful temperature control, prevention of the direct reaction requires that the magnesium anode and hydrogen peroxide catholyte be physically separated from each other. To accomplish this, a semi-permeable membrane capable of ion exchange is placed between the anode and cathode compartments of the semi-fuel cell in order to isolate the anolyte and catholyte solutions.

In order for ionic transport to occur across a membrane, the membrane must first absorb the electrolyte solution. The membrane's rate of absorption determines how quickly the semi-fuel cell reaches its operating voltage. In most applications, semi-fuel cells are stored "dry" to prevent corrosion of the magnesium anode. When electrical energy is needed, the semi-fuel cell's anode and cathode compartments are flooded with electrolyte so that power generation can begin. The membrane must then wet immediately upon contact with the electrolyte, so that the semi-fuel cell can begin to supply power. In the situation where the semi-fuel cell is being used with an unmanned underwater vehicle, the requirement for power generation is within seconds of the vehicle's deployment. Ion exchange membranes, such as Nafion®, require a long pre-soak period (at least 12 hours) in aqueous electrolyte solution in order to be fully wet and therefore fully functional in a semi-fuel cell. A method to accelerate the wetting of the membrane is needed.

Several prior art methods exist for treating a Nafion® membrane to make its performance more consistent and reproducible. However, these techniques are designed to remove impurities from the manufacturing process and/or exposure to the environment rather than enhance the membrane's ability to absorb liquid. Typical treatments involve boiling the membrane in dilute acid followed by rinsing in boiling distilled water. After treatment, the membrane must remain wet prior to use.

What is needed is a method that will allow an ion exchange membrane such as a Nafion® membrane in a semi-fuel cell to be stored dry and then to wet immediately when the semi-fuel cell is activated.

SUMMARY OF THE INVENTION

It is a general purpose and object of the present invention to provide a method to increase the rate of absorption of electrolyte solution by a Nafion® membrane.

This object is accomplished with the present invention by providing a treatment method whereby a Nafion® membrane is treated with glycerin (glycerol) to enhance its rate of absorption of electrolyte solution

BRIEF DESCRIPTION OF THE DRAWINGS

None.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The following is a detailed description of the treatment method of the present invention. In the preferred embodiment a membrane made of Nafion®, is used as the separating membrane in a semi-fuel cell, however, other perfluorinated ionomer membranes such as Felmion® and Aciplex-XR® could also be used. In the preferred embodiment, the treatment method is applied to Nafion® membranes NE-112, NE-1135, N-115 and N-117. Initially the membrane is immersed in 1.5 M H_2SO_4 for 48 hours. The membrane is then removed from the H_2SO_4 and rinsed in distilled and or deionized H_2O. The membrane is then soaked in distilled and or deionized H_2O for 24 hours. The membrane is then removed from the H_2O and then again rinsed in more distilled and or deionized H_2O. The membrane is then immersed in a polyhdric alcohol for 48 hours. In the preferred embodiment of the method the polyhdric alcohol is glycerin. After 48 hours the membrane is removed from the glycerin and once again rinsed in distilled and or deionized H_2O. Finally the membrane is dried in air for at least 48 hours prior to use.

Once treated in this manner, the Nafion® membrane may be installed in the semi-fuel cell in the dry state and is ready to instantaneously absorb electrolyte when the semi-fuel cell's anode and cathode compartments are flooded with electrolyte, thus allowing power generation to occur immediately.

The advantages of the present invention over the prior art are that the present invention allows a Nafion® ion exchange membrane to be stored dry within a semi-fuel cell module. This is critical since the magnesium anode of a semi-fuel cell must also be stored dry to prevent its corrosion. Upon activation of the semi-fuel cell, the Nafion® membrane treated according to the method of the present invention instantly allows ionic transport to readily take place between the anode and cathode compartments. The semi-fuel cell is then able to generate and maintain sufficient voltage. In the situation where a semi-fuel cell is used to power an unmanned underwater vehicle, the present invention will reduce the vehicle's dependence on standby/auxiliary batteries.

What has thus been described is a new treatment method for ion exchange membranes used in semi-fuel cells that accelerates the wetting of the membranes by aqueous electrolyte solutions, thus reducing the start up time for metal/hydrogen peroxide-based semi-fuel cells.

Obviously many modifications and variations of the present invention may become apparent in light of the above teachings. For example different types of ion exchange membranes may be used. Different polyhydric alcohols may be used.

In light of the above, it is therefore understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

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ABSTRACT OF THE DISCLOSURE

A new treatment method for ion exchange membranes used in semi-fuel cells that accelerates the wetting of the membranes by aqueous electrolyte solutions, thus reducing the start up time for metal/hydrogen peroxide-based semi-fuel cells. Specifically, a Nafion® membrane that is intended for dry storage in a semi-fuel cell is treated with glycerin (glycerol) to enhance its rate of absorption of electrolyte solution when the semi-fuel cell is activated.