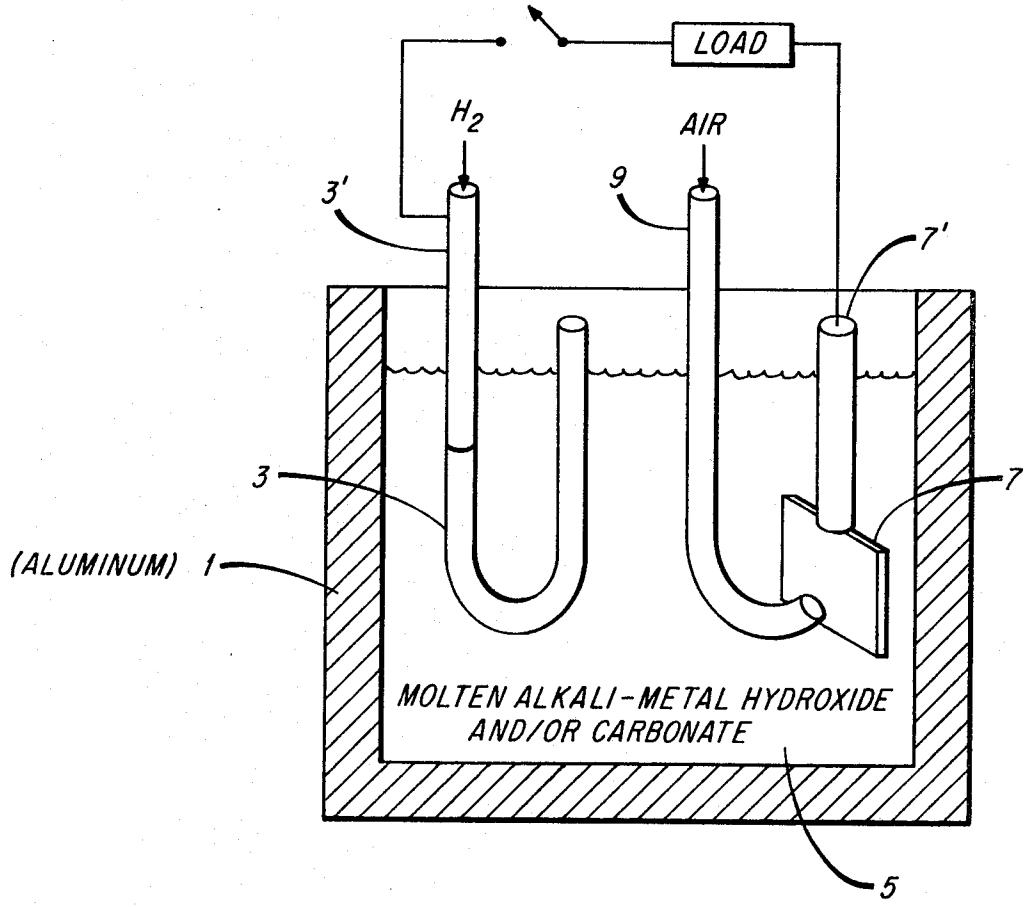
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METHOD OF MAINTAINING ALUMINUM IN CONTACT WITH MOLTEN ALKALI-METAL HYDROXIDES AND CARBONATES

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METHOD OF MAINTAINING ALUMINUM IN CONTACT WITH MOLTEN ALKALI-METAL HYDROXIDES AND CARBONATES

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ABSTRACT OF THE DISCLOSURE

This disclosure deals with the discovery that aluminum can be maintained in continuous contact with molten alkali-metal hydroxide and carbonate media without corrosive attack, by appropriate initial preparation of and maintenance of the molten media in a substantially anhydrous state, while insuring such contact only in such state.

This application is a continuation of application 376,917 filed June 22, 1964, now abandoned.

The present invention relates to methods of and apparatus for containing alkali-metal hydroxides and carbonates, being more specifically directed to a discovery that enables the utilization of aluminum for such purposes without the corrosive attack thereof.

It has long been accepted that aluminum is readily attacked in aqueous alkali-metal hydroxide solutions, forming a precipitate of aluminum hydroxide or forming aluminates. Similarly, the ready dissolution of aluminum in hot concentrated solutions of alkali-metal carbonates, such as sodium carbonate, has long been known. As a result, the art has considered aluminum a most unsatisfactory metal for use in systems in which it must come into contact with alkali-metal hydroxides or carbonates. In the alkali electrolyte fuel cell field, for example, it has even been reported that aluminum cannot stand up to such electrolyte, particularly at elevated temperatures.

In accordance with the present invention, however, a discovery has been made that, under certain very critical conditions, aluminum may not only withstand attack from alkali-metal hydroxides and carbonates, but it may be beneficially used even as a container for such hydroxides and carbonates and even at elevated temperatures.

An object of the present invention, therefore, is to provide a new and improved aluminum container and/or contacting element for alkali-metal hydroxides and carbonates and a new and improved method of rendering aluminum resistant to corrosive attack by such hydroxides and carbonates at elevated temperatures.

Other and further objects, including applications to novel fuel cells and the like, will be explained hereinafter and will be more particularly pointed out in connection with the appended claims.

The invention will now be described in connection with the accompanying drawing, the single figure of which illustrates a preferred use of aluminum in a molten alkali-metal hydroxide or carbonate fuel cell or the like.

It has been discovered that if molten alkali-metal hydroxides and carbonates are maintained at temperatures between about 300° C. and 500° C., more or less, and the water content thereof is allowed to decrease until it approaches substantial equilibrium with the moisture in the air or other medium surrounding the melt, aluminum, preferably substantially pure (although aluminum with some impurities and alloys thereof have been found to exhibit some of the resistant characteristics herein described), can be placed in direct and continuous contact with the molten alkali-metal hydroxides and carbonates without suffering any appreciable corrosion.

While it is not desired to predicate the invention upon a theory or hypothesis of operation, it being sufficient to describe the invention as it has been found to work in practice, it appears that the clue to rendering aluminum resistive to alkali-metal hydroxides and carbonates resides in the temperature elevation to the point of driving off the water therein sufficiently to attain the substantial equilibrium above-discussed, and the maintenance of the molten alkali-metal hydroxide and/or carbonate in the molten state. Physically, such molten hydroxide and carbonate assumes a substantially clear form when this region of substantial equilibrium is reached. It is this substantially anhydrous molten alkali hydroxide or carbonate that apparently no longer attacks the base metal of the aluminum with whatever oxide coating may be formed thereupon.

Thus, in the embodiment of the drawing, an aluminum cup is shown at 1, used for a purpose heretofore considered impossible; namely, as a container for a molten alkali-metal hydroxide or carbonate medium 5 comprising the electrolytic medium of a fuel cell. In this embodiment, a tubular Ag-Pd anode 3 is shown disposed in contact with the electrolytic medium 5 for passing, for example, hydrogen fuel into the cell; and a nickel or other cathode electrode 7 is shown disposed in the electrolytic medium 5, in this case operable with the oxidant provided by the apparent conversion of molten hydroxide, for example, into peroxide or superoxide in the region of the cathode 7. It is, of course, to be understood that other types of cathodes, including porous cathodes through which oxidant may be introduced from an external source, may be employed, as may other anodes. In the case of the utilization of non-porous nickel, iron or similar cathode electrodes 7, however, operating with the peroxide or superoxide oxidant, it is in some cases desirable to introduce agitation in the region of the cathode, as by blowing air therein. This is illustrated as effected with an inexpensive aluminum tube 9, which, by operation of the cell 5 in the before-described temperature region to a degree such that the water within the medium 5 is decreased until it approaches equilibrium where the water content in the air at the top of the medium 5 (i.e. substantially anhydrous), is rendered resistant to attack by the medium 5.

The support 7′ for the cathode electrode may also, if desired, be of aluminum, as may the tubular support 3′ for the anode 3. In connection with the latter, this is most unusual since aluminum is one of the few metals which is not active as a cathode in peroxide-containing melts and can thus be used at the anode.

As an example of actual experimental results, an aluminum cup 1, 2½ inches in diameter by about 4 inches deep, has been successfully operated for several months as the container for a potassium hydroxide molten electrolytic medium 5 maintained at a temperature in the before-mentioned temperature range, and intermittently operated as a fuel cell in accordance with the construction illustrated in the drawing; all with no noticeable attack upon the aluminum with its oxide coating. Similar results have also been obtained by immersing aluminum in molten lithium, potassium and sodium carbonates maintained at the above-mentioned temperatures to provide the said substantial equilibrium and anhydrous condition. Other alkali-metal molten hydroxides, including sodium, have also been so used with aluminum, all with successful resistance of the aluminum to the molten baths.

Clearly, the invention is not restricted to application in the important fuel cell field, but it is widely applicable

wherever it is desired to contact aluminum with such molten alkali-metal hydroxides and carbonates.

Further modifications will occur to those skilled in the art, and all such are considered to fall within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A method of maintaining an aluminum member in contact with an electrolytic medium consisting essentially of at least one of the group constituted by alkali-metal hydroxides and carbonates, said medium being normally corrosive to said member, and of preventing corrosive attack upon said member by said medium during the utilization of said member, which comprises elevating the temperature of said medium to a temperature sufficient to render the same molten, maintaining said medium at such elevated temperature for a time sufficient to cause the molten medium to become anhydrous, and continuously maintaining the anhydrous condition of said medium during the utilization of said member and while said member is maintained in contact with said medium.

2. A method as claimed in claim **1** and in which the temperature of said medium is raised to the range substantially 300 degrees to 500 degrees C.

3. A method of operating an electrochemical cell including the following elements: a cell container, a cell electrode, a support for a cell electrode, and an element for introducing gas into the cell, at least one of said elements being an aluminum member, and of preventing corrosive attack upon said member by a normally corrosive electrolytic medium which contacts said member, said medium consisting essentially of at least one of the group constituted by alkali-metal hydroxides and carbonates, which comprises elevating the temperature of said medium to a temperature sufficient to render the same molten, maintaining said medium at such elevated temperature for a time sufficient to cause the molten medium to become anhydrous, and continuously maintaining the anhydrous condition of said medium during the utilization of said member and while said member is in contact with said medium.

4. A method as claimed in claim **3** and in which a fuel and an oxidant are introduced into said medium at fuel and oxidant electrodes therein, respectively, an output current is drawn in a circuit connected to said fuel and oxidant electrodes, and said corrosive attack is prevented during the drawing of said current.

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