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INDIUM-GALLIUM-ALUMINUM ALLOYS AND GALVANIC ANODES MADE THEREFROM

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4 Claims. (Cl. 204—293)

ABSTRACT OF THE DISCLOSURE

An aluminum alloy having a high oxidation potential and comprising small, controlled quantities of indium and gallium alloyed with aluminum and a cast aluminum based sacrificial anode prepared from the alloy are disclosed.

BACKGROUND OF THE INVENTION

The present application is a continuation-in-part of application Ser. No. 384,796, filed July 23, 1964, and now abandoned.

This invention relates to sacrificial galvanic anodes and more particularly is concerned with a novel aluminum based alloy exhibiting high oxidation potential and a useful electrical output per unit mass of metal; i.e. an electrochemical equivalent which is suitable for use in such galvanic anodes.

Theoretically, aluminum should be expected to perform satisfactorily as a galvanic anode because the element aluminum fulfills the two primary requirements for anodes; (1) a high theoretical oxidation potential (1.80 volts versus calomel reference) and (2) a high theoretical electrical output per unit mass of metal consumed (2.98 amp-hours per gram). In actual practice, however, aluminum has not proved to be satisfactory for use in such applications since it does not exhibit these favorable theoretical properties when used as a sacrificial galvanic anode. The presence of the normally passive oxide surface film on the aluminum apparently presents a barrier to the oxidation of the aluminum metal thereby reducing the effective oxidation potential to about 0.7 volt (as measured in closed circuit at either 250 or 1000 milliamperes/square foot in a synthetic seawater electrolyte with a standard saturated KCl calomel cell as reference). At such low operating voltages, no cathodic protection is given to ferrous based structures, for example; therefore the anode exhibits no useful electrical output. By comparison, the actual working potential of magnesium is about 1.5 volt and of zinc is about 1 volt.

It is known in the art to add certain elements such as gallium or indium to aluminum in an attempt to provide an aluminum anode of commercial utility. Such additions result in some moderate increase of the working electropotential of aluminum.

Now, unexpectedly it has been found in the present invention that specific ratios and concentrations of a mixture of gallium and indium when alloyed with aluminum provide a novel alloy composition exhibiting markedly increased electropotential over that shown by what could be predicted from the potential exhibited by aluminum-gallium or aluminum-indium binary alloys.

It is a principal object of the present invention to provide an aluminum based galvanic anode which exhibits an unexpectedly high operating oxidation potential and a useful ampere-hour output.

It is another object of the present invention to provide a novel aluminum alloy particularly suitable for use as a sacrificial galvanic anode.

These and other objects and advantages readily will become apparent from the detailed description of the invention presented hereinafter.

SUMMARY

The present invention comprises a novel aluminum based alloy composition having alloyed therewith a small amount of a mixture of gallium and indium.

More particularly the present composition comprises aluminum having alloyed therewith from about 0.01 to about 0.5 weight percent indium and from about 0.01 to about 0.2 weight percent gallium.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferably the alloy comprises aluminum having alloyed therewith from about 0.02 to about 0.3 weight percent indium and from about 0.02 to about 0.08 weight percent gallium.

All weight percents are based on the total composition weight.

Unexpectedly, the present novel compositions when employed as sacrificial galvanic anodes exhibit a satisfactory corrosion pattern, a high operating oxidation potential and a satisfactory electrical output per unit mass of metal consumed.

Galvanic anodes can be prepared from the novel compositions by use of alloying and casting or fabricating techniques ordinarily employed in the aluminum art. No special metal handling or fabricating operations are required.

Aluminum for use in preparing the present novel alloy compositions should preferably be a relatively high purity metal (at least about 99.9% Al) but can be of a lower grade metal (e.g. 99.5% Al) having normal production introduced impurities associated therewith. With aluminum of 99.9% purity, gallium and indium minimum concentrations of about 0.02 weight percent are used for optimum oxidation potentials. With higher purity aluminum, e.g. 99.99%, potentials of greater than 1.4 volts in seawater (versus saturated KCl calomel cell) are realized using as low as 0.01 weight percent of the indium and gallium alloying ingredients. With lower purity commercial aluminum correspondingly larger quantities of the alloying components are used to achieve the desired high operating potentials. The alloying elements also can be of high purity or of commercial grade.

The resulting alloy product is not detrimentally degraded by storage in normal atmospheres through air oxidation.

The following example will serve to further illustrate the present invention but is not meant to limit it thereto.

Example.—A number of anodes of the present invention were prepared by melting commercial 99.9% or 99.99% purity aluminum ingot in a graphite crucible positioned within an electric furnace. Requisite amounts of gallium and indium were introduced into the molten aluminum and the resulting mixture stirred to effect dispersion of the alloying ingredients throughout the melt. The resulting alloy was cast in a graphite mold into cylindrical specimens about 5½ inches long and about 5/16 inch in diameter. The cooling and solidification rate of the castings were controlled such that these similated the cooling rate experienced in production of commercial, field-sized cast anodes.

The performance of the alloys was evaluated by positioning each cast cylindrical specimen (as anode) in a schedule 40 steel can 3 inches in diameter and 6 inches tall (as cathode). Synthetic seawater was used as an electrolyte with about 4 inches of each specimen being immersed. The cells were complete with respect to electrical

circuitry, a rectifier being employed to maintain a constant current through a group of cells connected in series.

The results of a number of runs comparing the performance of the novel aluminum alloy anodes of the composition of the present invention with commercial and high purity aluminum used as a base metal for these alloys and binary alloys of aluminum-gallium and aluminum-indium anodes as controls are summarized in Table I.

TABLE I

Run No.	Aluminum (Percent Purity)	Alloying Metal (Percent by weight)		Potential (Volts)*
		Indium	Gallium	
1	99.9	(Control)	—	0.71
2	99.99	(Control)	—	0.72
3	99.9	—	0.17 (Control)	0.72
4	99.99	—	0.17 (Control)	1.13
5	99.9	0.05	— (Control)	1.07
6	99.99	0.21	— (Control)	1.10
7	99.9	0.083	0.013	1.15
8	99.99	0.01	0.013	1.48
9	99.9	0.03	0.027	1.50
10	99.9	0.10	0.10	1.62
11	99.9	0.028	0.11	1.58
12	99.99	0.12	0.022	1.51
13	99.9	0.23	0.052	1.49
14	99.99	0.35	0.19	1.63
15	99.9	0.43	0.10	1.63
16	99.9	0.40	0.05	1.50

*Versus standard saturated KCl calomel cell as reference and measured in closed circuit at either 250 or 1,000 milliampere/square foot.

These results clearly show the superiority of the present novel aluminum based gallium and indium containing ternary alloys with respect to oxidation potential as compared to aluminum, aluminum-gallium and aluminum-indium binary alloys.

These alloys exhibit a high oxidation potential which makes them suitable for use as sacrificial anodes for applications such as galvanic pigments in paint films, galvanic anode materials for primary batteries, sacrificial galvanic coatings for sheet steel and other metals cathodic to aluminum and sacrificial anodes for cathodic protection. Additionally when in particulate form these compositions find utility as an active ingredient in flares, for use in chemical reductions and in the preparation of aluminum alkyls.

Various modifications can be made in the present invention without departing from the spirit or scope thereof for it is understood that we limit ourselves only as defined in the appended claims.

We claim:

1. An aluminum alloy having a high oxidation potential, said alloy comprising;
from about 0.01 to about 0.5 weight percent indium,
from about 0.01 to about 0.2 weight percent gallium,
and balance aluminum, said alloy being further characterized as containing at least about 0.02 weight percent each of said indium and said gallium when said aluminum has a purity of less than about 99.99 percent aluminum.

2. An aluminum alloy having a high oxidation potential, said alloy comprising;
from about 0.02 to about 0.3 weight percent indium,
from about 0.02 to about 0.08 weight percent gallium,
and
balance aluminum.

3. An aluminum based sacrificial galvanic anode having a minimum useful oxidation potential of about 1.4 volts in sea water as measured versus standard saturated KCl calomel, which comprises;
a cast anode structure, said structure comprising;
from about 0.01 to about 0.5 weight percent indium,
from about 0.01 to about 0.2 weight percent gallium,
and balance aluminum, said alloy being further characterized as containing at least about 0.02 weight percent each of said indium and said gallium when said aluminum has a purity of less than about 99.99 percent aluminum.

4. An aluminum based sacrificial galvanic anode having a minimum high useful oxidation potential of about 1.4 volts in sea water as measured versus standard saturated KCl calomel, which comprises;
a cast anode structure, said structure comprising;
from about 0.02 to about 0.3 weight percent indium,
from about 0.02 to about 0.08 weight percent gallium,
and
balance aluminum.

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