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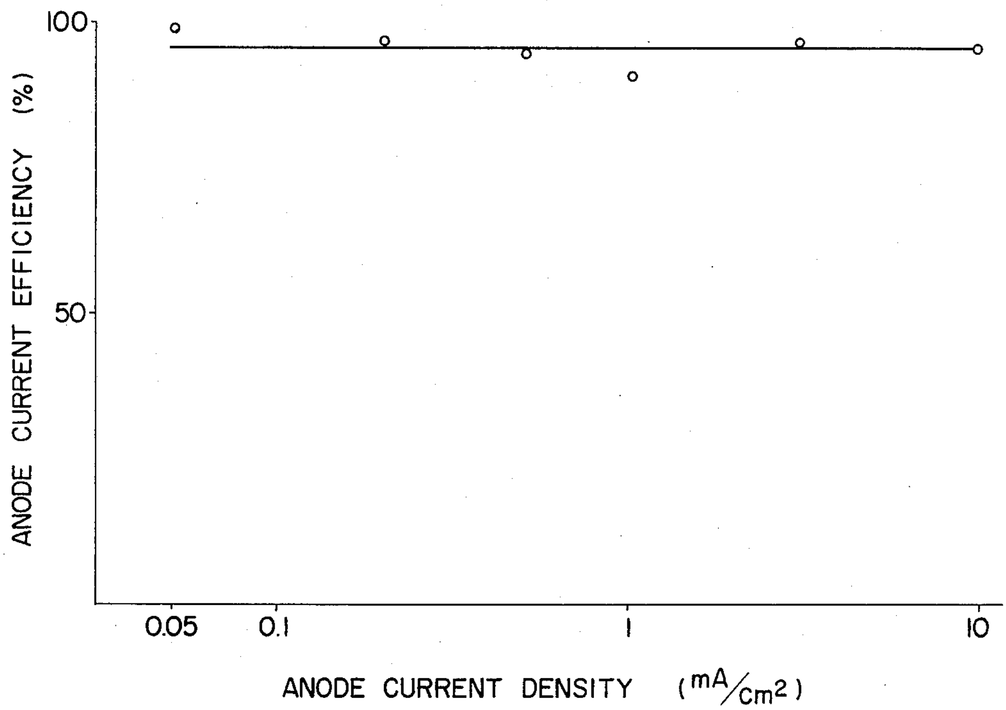

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ALUMINUM ALLOY FOR GALVANIC ANODE

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ABSTRACT OF THE DISCLOSURE

Aluminum alloy for galvanic anode having improved anode potential and anode current efficiency which consists of aluminum base and specific quantities of zinc, tin, bismuth, gallium capable of imparting to the base aluminum these required galvanic anode characteristics.

This invention relates to a metal alloy for use as the galvanic anode, and, more particularly, to an aluminum alloy for such galvanic anode having an improved galvanic, or anode current characteristics.

There have so far been known various aluminum alloys for the galvanic anode of different compositions, in which those elements capable of imparting to aluminum the required galvanic anode characteristics (a low electrode potential and high anode current efficiency) such as, for example, mercury, gallium, indium, tin, magnesium, zinc, etc. are added. (vide: "Material Protection," vol. 5 (1966), No. 12, pp. 15–18)

Of these alloys, the mercury-containing alloy anode not only requires particular caution in removing mercury vapor to be generated at the time of its production, but also is liable to contaminate the circumstances surrounding the place where the anode is used. Also, the magnesium-containing alloy is highly dangerous of causing inflammation due to impact or shock, hence the place for its use is naturally limited.

It is therefore the primary object of the present invention to provide an improved galvanic anode having a low anode potential and a high anode current efficiency, as well as exhibiting uniform dissolution at anode consumption.

It is another object of the present invention to provide

an improved galvanic anode which is easily produced by proper combination of those elements capable of imparting to the aluminum base the requisite galvanic anode characteristics, is not dangerous of inducing explosion, etc. at the time of use, and does not contaminate the surrounding circumstances.

It is other object of the present invention to provide an aluminum alloy for the galvanic anode of an improved properties, which consists of 0.5–10% zinc, 0.05–1.0% tin, 0.05–1.0% bismuth, and 0.005–1.0% gallium, and remainder of aluminum.

The foregoing objects as well as the details of this invention will be readily understood from the following description, when read in connection with the preferred examples thereof as well as the accompanying drawing.

In the drawing, single figure is a graphical representation showing a relationship between the anode current density and the galvanic (or anode) current efficiency of the galvanic anode made of the alloy according to the present invention.

The aluminum alloy for the galvanic anode according to the present invention is an improvement in the known alloy of this type and purpose.

For the known type of the aluminum alloys, there are various kinds such as shown in the following Table 1.

TABLE 1

	Composition (percent)						
	Ca	Cd	In	Sn	Li	Zn	Al
Alloy:							
1			either one or both: 0.1–1.0				Remainder.
2			in total			1–10	Do.
3			0.005–0.1			0.5–20	Do.
4		0.005–0.1	0.005–0.1			0.5–20	Do.
5	0.005–0.05		0.005–0.1			0.5–20	Do.
6			0.005–0.1		0.005–0.1	0.5–20	Do.

The present invention has succeeded in developing the aluminum alloy for the galvanic anode having further improved electrical properties by adding to the alloy consisting of aluminum, zinc, and tin particular elements capable of imparting galvanic anode characteristics such as, for example, bismuth, gallium, etc.

When 0.5 to 10% of zinc is added to the base aluminum, the resulting anode possesses a stabilized low anode potential and high galvanic current efficiency. The zinc content of below 0.5% does not result in any appreciable improvement in the anode (galvanic) current efficiency. On the other hand, the zinc content exceeding 10% does not yield so remarkable an effect as in the content of less than 10%. Addition of tin at a rate of below 0.05% increases the anode potential and lowers the anode current efficiency. Again, when the tin content exceeds 1.0%, the current efficiency also lowers. From this, the appropriate content of tin in the alloy is from 0.05 to 1.0%. From experimental results, the appropriate adding quantity of bismuth is found to be equal to or less than that of tin. If the adding quantity of bismuth exceeds 1.0%, adhesion of corrosion product to the anode surface increases, and the condition for elution (a state of galvanic dissolution of the anode) deteriorates. With the gallium content of below 0.005%, no current efficiency improves. However, within the range of from 0.005 to 0.3%, improvement in the current efficiency can be recognized. Further increase in the adding quantity of gallium lowers the current efficiency, while low anode potential which is one of the characteristics of this invention is resulted. However, addition of large amount of gallium causes irregularity in dissolution on the anode surface, which brings about undesirable slimming phenomenon at the dissolved portion, accompanying impairment of economic value of the alloy product, hence the quantity exceeding 1.0% is not recommendable.

In order to enable skilled persons in the art to readily reduce this invention into practice, the following preferred example is presented.

EXAMPLE

An aluminum base metal (containing 0.12% of iron, 0.08% of silicon, 0.003% of copper, and remainder of aluminum) was dissolved in a graphite crucible, and, at a temperature of 680° C., zinc, tin, bismuth, and gallium are simultaneously added to the molten base metal, sufficiently agitated, and cast into an ingot of the alloy composition as shown in the following Table 2.

For the purpose of comparison, various kinds of alloy sample were cast in the same manner as in the preceding.

These sample alloys were subjected to tests for their anode potential and current efficiency by causing anode current to flow through artificial brine at an anodic current density of 1 ma./cm.^{2}, the results of which are as shown in Table 2 below.

TABLE 2

Sample No.	Composition (percent)					Anode potential after 240 hours of galvanic action (v.)	Anode current efficiency (percent)
	Zn	Sn	Bi	Ga	Al		
Inventive alloys:							
1	6.0	0.05	0.1	0.01	Remainder	−0.99	95
2	0.5	0.1	0 1	0.01	do	−1.03	91
3	6.0	0.05	0.05	0.005	do	−1.10	96
4	6.0	0.1	0.1	0.01	do	−1.09	91
5	6.0	0.1	0.05	0.01	do	−1.11	95
6	6.0	1.0	0.1	0.06	do	−1.05	96
7	6.0	1.0	1.0	0.1	do	−1.02	91
8	10.0	0.1	0.1	0.01	do	−1.11	96
9	10.0	1.0	1.0	0.1	do	−1.01	97
10	2.0	0.5	0.5	0.3	do	−1.41	78
11	6.0	0.5	0.5	0.3	do	−1.40	68
12	6.0	1.0	1.0	0.3	do	−1.46	64
13	2.0	1.0	1.0	0.5	do	−1.52	76
14	6.0	1.0	1.0	0.5	do	−1.53	75
Comparative alloys:							
15	5.0	0.1			do	−1.02	55
16		0.2			do	−0.94	81
17			0.05		do	−0.69	86
18			1.0		do	−0.69	88
19				0.005	do	−0.67	85
20				0.2	do	−0.81	81
21				1.0	do	−1.29	64

Note.—Electric potentials indicated in this table are the values of the electrode referred to as "saturated calomel electrode."

The comparative alloy samples are of the known alloy composition as well as those produced by adding to the aluminum base any one of the above-mentioned alloying components.

As seen from the above table, no satisfactory results in the anode potential or current efficiency can be obtained with the comparative alloy samples. In contrast to this, the alloys of the present invention, in which all of the alloying components are properly combined and added to the base aluminum, exhibit the current efficiency of higher than 90% at the anode potential of from −1.0 v. to −1.1 v., and 70% or so at about −1.5 v.

The measured results of the alloy composition according to the present invention as shown in Sample No. 4 of Table 2 above (6.0% Zn, 0.1% Su, 0.1% Bi, 0.01% Ga, and remainder of Al) for its anode current density

and anode current efficiency are as shown in the figure, from which it will be noted that the anode of this alloy maintains its high performance even at a low current density, and, while its conditions for elution may be local at the initial stage, the dissolution of the anode surface proceeds with lapse of time until the entire surface thereof dissolves with the consequence that there is no possibility of adhesion of corrosion products, and the anode can be successfully used at a high specific resistance, which greatly contributes to the corrosion engineering.

What we claim is:

1. Aluminum alloy for galvanic anode which consists of 0.5–10% zinc, 0.05–1.0% tin, 0.05–1.0% bismuth, 0.005–1.0% gallium, and remainder of aluminum.

2. Alloy of claim **1** consisting of 6.0% zinc, 0.05% tin, 0.1% bismuth, 0.01% gallium, and remainder of aluminum.

3. Alloy of claim **1** consisting of 0.5% zinc, 0.1% tin, 0.1% bismuth, 0.01% gallium, and remainder of aluminum.

4. Alloy of claim **1** consisting of 6.0% zinc, 0.05% tin, 0.05% bismuth, 0.005% gallium, and remainder of aluminum.

5. Alloy of claim **1** consisting of 6.0% zinc, 0.1% tin, 0.1% bismuth, 0.01% gallium, and remainder of aluminum.

6. Alloy of claim **1** consisting of 6.0% zinc, 0.1% tin, 0.05% bismuth, 0.01% gallium, and remainder of aluminum.

7. Alloy of claim **1** consisting of 6.0% zinc, 1.0% tin, 0.1% bismuth, 0.06% gallium, and remainder of aluminum.

8. Alloy of claim **1** consisting of 6.0% zinc, 1.0% tin, 1.0% bismuth, 0.1% gallium, and remainder of aluminum.

9. Alloy of claim **1** consisting of 10.0% zinc, 0.1% tin, 0.1% bismuth, 0.01% gallium, and remainder of aluminum.

10. Alloy of claim **1** consisting of 10.0% zinc, 1.0% tin, 1.0% bismuth, 0.1% gallium, and remainder of aluminum.

11. Alloy of claim **1** consisting of 2.0% zinc, 0.5% tin, 0.5% bismuth, 0.3% gallium, and remainder of aluminum.

12. Alloy of claim **1** consisting of 6.0% zinc, 0.5% tin, 0.5% bismuth, 0.3% gallium, and remainder of aluminum.

13. Alloy of claim 1 consisting of 6.0% zinc, 1.0% tin, 1.0% bismuth, 0.3% gallium, and remainder of aluminum.

14. Alloy of claim 1 consisting of 2.0% zinc, 1.0% tin, 1.0% bismuth, 0.5% gallium, and remainder of aluminum.

15. Alloy of claim 1 consisting of 6.0% zinc, 1.0% tin, 1.0% bismuth, 0.5% gallium, and remainder of aluminum.

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RICHARD O. DEAN, Primary Examiner

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