United States Patent Office 3,475,167
Patented Oct. 28, 1969

3,475,167

ALUMINUM ALLOY FOR COLOR ANODIZING

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No Drawing. Continuation-in-part of application Ser. No. 506,396, Nov. 4, 1965. This application May 3, 1967, Ser. No. 635,685

Int. Cl. C22c 21/02

U.S. Cl. 75—147 3 Claims

ABSTRACT OF THE DISCLOSURE

An aluminum alloy suitable for producing extruded shapes and a process for forming a colored coating on such shapes. The alloy is a modification of 6063 aluminum alloy, including the addition of manganese, and the processs is direct current anodizing of the extruded shape in an aqueous electrolyte containing sulfate ion and aromatic sulfonic acid.

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of our copending application Ser. No. 506,396, filed Nov. 4, 1965, now Patent No. 3,370,943.

BACKGROUND OF THE INVENTION

This invention relates to a process for producing colored anodic oxide coatings on aluminum extrusions, and to an aluminum alloy adapted to receive such coatings.

It is now well known to color-anodize aluminum by processes that produce integrally colored coatings, as distinguished from colorless coatings that are later dyed or pigmented. For example, United States Patents Re. 25,566; 3,143,485 and 3,227,639 represent color-anodizing processes employing aqueous electrolytes containing sulfate ions and certain aromatic sulfonic acids that are substituted with hydroxyl or carboxyl groups or combinations of hydroxyl and carboxyl groups. When aluminum is employed as the anode in an electric circuit that includes the electrolyte, integrally colored anodic oxide coatings may be formed in colors ranging from light gold to black. The process may be applied to virtually any form of aluminum, but it is most often applied to sheets and extrusions, particularly sheets and extrusions employed for architectural purposes. This invention deals with such integrally colored coatings, and the term *color-anodized* or terms of similar import refer to integrally colored coatings.

Although it is easy, on a laboratory scale, to produce colored anodic oxide coatings, many difficulties arise when producing them for commerce. Among these difficulties are producing a series of color-anodized articles that "match." For example, it is difficult repeatedly to produce a number of color-anodized extrusions which have the same color, texture, and glossiness; in other words, the same appearance so that when used side by side they will match one another. Another problem is to create colors that are usable with one another even though the alloys employed are different. Typical of this problem is employing color-anodized sheets as curtain walls in conjunction with color-anodized extrusions employed as door frames, spandrels, lintels, column sheaths or similar members.

Metals suitable for extrusion usually have a different composition than metals suitable for rolling, and they respond differently to anodizing conditions. Even a series of articles made of the same metal may respond to anodizing differently due to different microstructures. A series

of extrusions may differ due to slight differences in the thermal treatment of the extrusion or the billet from which it is formed, and these differences in structure produce different appearing anodized extrusions even though the billets from which the extrusions were formed had identical composition.

Generally speaking, it is difficult to anodize to obtain darker colors on alloys that are constituted to be suitable for extrusion. For example, the alloy designated as 6063 alloy by the Aluminum Association is a widely used extrusion alloy and it is difficult to color-anodize with darker coatings such as those characterized by colors ranging from gray to black. The Aluminum Association composition limits for 6063 alloy are 0.20–0.6% silicon, up to 0.35% iron, up to 0.10% copper, up to 0.10% manganese, 0.45–0.9% magnesium, up to 0.10% zinc, up to 0.10% chromium, up to 0.10% titanium, other elements up to total of 0.15%, balance aluminum. Another difficulty is that the appearance of anodized 6063 alloy is extremely sensitive to the thermal treatments to which the alloy is subjected before and during extrusion. In this regard, it should be pointed out that control of thermal conditions is extremely difficult. Even such a well known heat treatment as homogenizing can create difficulties because ingots are generally homogenized in groups piled one upon another so that both the heating and the cooling rate of ingots in the interior of the pile is substantially slower than the heating and cooling rates of ingots on the exterior of the pile thereby producing a different internal structure which in turn produces a different response to color-anodizing.

SUMMARY OF THE INVENTION

This invention provides an alloy which is a modification of 6063 alloy and which is suitable for extrusion and for accepting a range of color-anodized coatings, particularly the darker colored coatings; and provides a process capable of producing colored coatings on extruded aluminum. Additionally it provides a process for reducing the effect that variations in thermal treatments have on the response an alloy has to an anodizing process. Stated differently, this invention provides a means for color-anodizing extruded products in such a way that the color of the product will depend almost entirely on the composition of the metal and the program employed to anodize it thereby giving close control over reproducibility of appearance, and in addition it provides an alloy having substantially the same extrudability as 6063 alloy.

DETAILED DESCRIPTION OF THE INVENTION

The object of this invention is accomplished by providing an extrusion alloy which is copper-free and consists essentially of from about 0.20 to about 0.6% silicon, up to 0.35% iron, from about 0.1 to about 0.6% manganese, from about 0.4 to about 0.8% magnesium, up to about 0.10% of each of chromium, zinc and titanium, other elements up to a total of 0.15%, balance aluminum. By the expression "copper-free" is meant that copper may be present as an impurity but the amount of copper present should not exceed 0.10%. A preferred alloy of this invention is one consisting essentially of from about 0.3 to about 0.4% silicon, from about 0.15 to about 0.25% iron, from about 0.1 to about 0.2% manganese, from about 0.45 to about 0.6% magnesium, up to about 0.10% of each of chromium, zinc, and titanium, other elements up to a total of 0.15%, balance aluminum. All compositions stated in this specification and the following claims are on a weight percent basis unless stated otherwise.

The above-specified alloy is homogenized and formed into an extruded shape. The extruded shape is immersed as the anode in an aqueous electrolyte which contains in solution from about 0.1% to 4% sulfuric acid or the equivalent amount of sulfate ion and from about 0.09 to about 0.7 gram mole per liter of an organic sulfonic acid substituted with hydroxyl, carboxyl or combinations of hydroxyl and carboxyl groups. Suitable organic acids include but are not limited to sulfosalicyclic acid, sulfophthalic acid, sulforesorcinol, and lignosulfonic acid.

Anodizing is effected at conditions now well known to the color-anodizing art. The temperature of the electrolyte may range from near its freezing point to 100° F. or substantially higher, the current density may range from about 10 to 100 amperes per square foot of surface being anodized, the voltage may range from about 30 to 130 volts and the time is that sufficient to produce the color and thickness of coating that is desired; usually less than 120 minutes.

Following are several examples presented to illustrate the present invention with typical embodiments of it. The examples are intended to be illustrative and they have been selected as typical examples to demonstrate the invention rather than to limit it.

Extrusions were made form several alloys that are useful as extrusion alloys and capable of being color-anodized. Prior to anodizing the alloys were subjected to two tempers that differed substantially from one another in order to compare the difference in color-anodizing response caused by varying thermal treatments of an alloy prior to extrusion. The alloys were also anodized by two different electrical programs which are both characteristic of those employed to color-anodize extrusions.

The temper designated —T4 is one of the well known and standard tempers used throughout the aluminum industry with heat treatable aluminum alloys. The —T4 temper is obtained by solution heat treating and rapidly cooling the alloy after which it is aged at room temperature to a stable condition. The temper designated as —T6 is also a standard temper well known to the aluminum industry for use with a heat treatable alloy. It is imparted by solution treating an alloy after which it is artifically aged to approximately maximum tensile properties thereby producing a very strong and stable alloy.

The alloy shown in Table 2 as 6063 alloy is a typical example of the 6063 alloy designated in the Aluminum Association classification of alloys. The specific alloy used contained 0.36% silicon, 0.2% iron, 0.005% copper, 0.004% manganese, 0.6% mangnesium, 0.005% chromium, 0.01% zinc, 0.004% titanium, and the remainder substantially aluminum containing normal amounts of impurities. The other alloys of the examples are the same 6063 composition with the specified amounts of additional elements. Thus, an alloy designated 6063 plus 0.2% manganese is the 6063 composition set forth above, but containing 0.2% manganese instead of 0.004% manganese.

In Table 1, two anodizing programs are set forth. The first anodizing program is employed in all cases in Example 1 and the second anodizing program is employed in all cases in Example 2. Examples 1 and 2 set forth the response to various anodizing treatments to the designated alloys in both the —T4 and the —T6 temper. The color reported for the —T4 temper is a subjective observation which is accomplished by comparing the colors obtained with previously established color standards. The colors obtained on the specimens with —T6 temper are comparative with respect to the colors on specimens with —T4 temper. Thus, if the —T4 temper produces a "bronze" color and the —T6 temper produces a "lighter bronze" color, the color produced on the —T6 temper is reported as lighter with respect to the color produced on the specimen with a —T4 temper.

The following Table 1 sets forth the anodizing conditions in each of Examples 1 and 2:

TABLE 1

	Example 1	Example 2
Sulfuric acid (grams/liter)	5	5
Sulfosalicylic acid (gram moles/liter)	0.45	0.45
Temperature (° F.)	75	75
Initial current density (amperes/sq. ft.)	24	27
Maximum volts	65	60
Anodizing time (minutes)	40	45
Total current quantity (amp. hrs/sq. ft.)	12.0	19

The results obtained in Examples 1 are set forth in Table 2:

TABLE 2

Alloy	—T4 Temper	—T6 Temper
6063	Bronze	Much lighter bronze.
6063 plus 0.2% Mn	Dark Bronze	Slightly lighter bronze.
6063 plus 0.4% Mn	Black	Very dark brown.

Example 1 above illustrates that the combined effect of the alloy of this invention and the color-anodizing process produces substantially darker color-anodized coatings and coatings that are far less sensitive to thermal treatments. Although the difference between the color produced in the —T4 temper and the —T6 temper in the manganese-containing alloys is noticeable, the amount of difference is very slight considering that the tempers employed were radically different from one another and that they were selected to exaggerate anodizing response differences resulting from thermal history.

The results of anodizing under conditions set forth for Example 2 produced anodized alloys as set forth in Table 3 below:

TABLE 3

Alloy	—T4 Temper	—T6 Temper
6063	Bronze	Much lighter bronze.
6063 plus 0.2% Mn	Dark Brown	Slightly lighter dark brown.
6063 plus 0.4% Mn	Black	Black.

Example 2 also ilustrates that the combination of the manganese-containing extrusion alloy and the color-anodizing process of this invention can produce darker colored anodized extrusions, and extrusions which are far less senistive to their thermal history with respect to color-anodizing response.

Having thus described this invention, what is claimed is:

1. An easily extrudable aluminum base alloy consisting essentially of 0.20–0.60% silicon; 0.15–0.25% iron; 0.10–0.60% manganese; from 0.40–0.80% magnesium; up to 0.10% each of copper, chromium, zinc and titanium; all other impurities up to a total of 0.15%; and the balance aluminum; and characterized by responding to a color-anodizing program in an electrolyte containing an aromatic sulfonic acid selected from the group consisting of sulfosalicylic acid, sulfophthalic acid, sulforesorcinol and lignosulfonic acid and a compound selected from the group consisting of metal sulfates and sulfuric acid and combinations thereof, to produce integrally colored oxide coatings ranging in color from grey to black.

2. An easily extrudable aluminum base alloy consisting essentially of about 0.36% silicon; 0.2% iron, 0.4% manganese, 0.6% magnesium and the balance aluminum with other normal impurities associated therewith.

3. An easily extrudable aluminum base alloy consisting essentially of 0.20–0.60% silicon; about 0.35% iron; from 0.10–0.60% manganese; from 0.40–0.80% magnesium; up to 0.10% each of copper, chromium, zinc and titanium; all other impurities up to a total of 0.15% and the balance aluminum; and characterized by responding to a color anodizing program in an electrolyte containing an aromatic sulfonic acid selected from the group consisting of sulfosalicylic acid, sulfophthalic acid, sulforesorcinol, and lignosulfonic acid and a compound selected from the group consisting of metal sulfates and sulfuric acid and

combination thereof to produce integrally colored anodic oxide coatings ranging in color from grey to black.

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U.S. Cl. X.R.

75—148; 204—58