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METHOD AND COMPOSITION FOR TREATING ALUMINUM AND ALUMINUM ALLOYS

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This invention relates to the brightening of aluminum and aluminum alloys. More particularly, the invention relates to a composition and method for chemical brightening of aluminum and its alloys.

Although aluminum is ordinarily considered a bright metal, it often presents a dull or matte-like finish due to the oxide films formed on its surfaces during processing. Many aluminum and aluminum alloy products are fabricated from mill finished sheet having such a characteristic dully appearance, which leads to a demand by fabricators for means to impart a bright, lustrous finish to their products. One widely used method of polishing aluminum and its alloys is by mechanical buffing with a suitable abrasive. However, this mechanical polishing is expensive and is not easily adaptable to articles having intricate shapes and inaccessible surfaces. Other methods known as electropolishing and electrobrightening involve subjecting the aluminum article to an electrolytic treatment and produce desirable lustrous finishes. However, these methods are both slow and expensive.

It is, therefore, a primary object and purpose of the invention to provide a composition and method for the chemical brightening or polishing of aluminum. A further object is to provide a chemical solution or bright dip composition for aluminum and aluminum alloys which is characterized by its economy in use, short immersion time required to obtain the desired effect, and ease of application. Another object is to produce on aluminum and aluminum alloy articles polished or brightened surfaces by means of a chemical bright dip composition and process which effectively removes the dulling oxide films from the metallic surfaces and imparts thereto a high luster.

Chemical brightening of aluminum has previously been accomplished using a combination of nitric and hydrofluoric acids. The hydrofluoric acid readily dissolves any oxide film and attacks the metal. The nitric acid, which is essentially inactive toward aluminum, serves to dissolve any metallic smut which might deposit out of solution onto the metal surface being treated. However, the etching or pitting action of the HF proved extremely difficult to control

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regardless of the concentration or temperature employed and uniform results could not be consistently obtained at a favorable rate of reaction.

It has been discovered according to the present invention that uniform and superior chemical brightening of aluminum and aluminum alloys is obtained with a bright dip composition comprising an aqueous acid solution containing in addition to hydrogen, nitrate and fluoride ions, chromate and ammonium ions.

The term "chromate" as used in the specification and claims generically designates bivalent anions containing chromium and includes dichromate ($Cr_2O_7^=$) ions, as well as other polychromates or complexes which may form from the ion $CrO_4^=$ in acid solution.

The presence of the chromate and ammonium ions appear to exert a modifying influence on the action of the acid bath containing fluoride ions. Previously, the hydrofluoric acid, although effective in removing the dulling oxide film, caused pitting or uneven etching of the metallic surfaces which prevented the production of the desired specular-like bright finish. Reduction in concentration of the hydrofluoric acid merely resulted in a decrease in the pitting effect, but at the same time it appreciably lowered the rate of reaction of the solution, thus increasing immersion time. It was found that by the introduction of chromate ions and ammonium ions the concentration of hydrofluoric acid could be maintained sufficiently high to give optimum rate of action while overetching or pitting was completely eliminated. Furthermore, the presence of chromate ions prevented formation of any smut on the metal surface being treated, and a brighter surface was produced.

The proper hydrogen ion concentration for the acid solution is preferably maintained by the use of nitric acid in an amount of from about .5 to 5% by weight of the solution. When using 70% HNO_3, this amount corresponds to a volume concentration of from about 5 to 50 cc. per liter.

The fluoride ion is preferably introduced in the form of hydrofluoric acid, although an equivalent amount of any soluble salt of the acid which forms hydrofluoric acid in situ in the solution in the presence of nitric acid may be employed. Ammonium fluoride may advantageously be used, in which case a proportion-

ately smaller amount of the compound supplying the ammonium ion is employed in order to maintain the NH_4^+ concentration within the prescribed limits.

It has been found that the fluoride ion concentration should be maintained at a value corresponding to that produced by hydrofluoric acid within the range of from about .01 to about 0.5% by weight of solution. When using 48% HF, this corresponds to a volume concentration of from about .2 to 9 cc. per liter.

The chromate ion in the solution is preferably formed by adding chromic anhydride, CrO_3, although it may be introduced by addition of equivalent amounts of a soluble chromate salt, for example, ammcnium chromate or dichromate. Where ammonium chromate is used it may supply all of the ammoniun ion required or an additional amount of an ammonium compound may be added depending upon the relative concentrations of chromate and ammonium ions desired. The amount of chromate preferred corresponds to that produced by addition of from about .01 to about 1% of chromic acid (calculated as CrO_3).

A part or all of the ammonium ion content of the solution, as above indicated, may be supplied in conjunction with the chromate ion, or even the fluoride ion. However, where these ions are present in the lower range of the recommended concentrations, it is necessary to add additional ammonium ion. Thus, all of the NH_4^+ ion or the balance required may be introduced in the form of another ammonium compound, such as the hydroxide or nitrate. Ammonium hydroxide is preferably employed. The preferred amount of the ammonium constituent or of the solution is equivalent to about .01 to about 0.5% ammonia by weight of the solution.

Thus, the bright dip composition of the present invention comprises an aqueous acid solution containing from about .5 to 5% nitric acid by weight, fluoride, chromate and ammonium ions in amount corresponding to that produced by a solution containing from about .01 to .5% hydrofluoric acid, about .01 to 1% chromic acid anhydride, and from about .01 to 0.5% ammonia.

Excellent brightening results are obtained when the hydrogen, fluoride, chromate and ammonium ion concentrations are maintained at any combination of values corresponding to that produced in a solution prepared from nitric acid, hydrofluoric acid, chromic, and ammonia in any combination of amounts within the ranges above stated or any combination of equivalent substances which will produce a solution of substantially the same chemical composition.

It is to be noted that a satisfactory degree of brightening is obtained when using any of the constituents in smaller or larger amounts than indicated above. However, the desired effect is more readily obtained by operating within the stated ranges.

The chemical bath may be operated at temperatures of from about 100° F. to the boiling point. The desired brightening is accomplished with a shorter immersion time at the higher temperatures of from about 190° F. to boiling, and accordingly, this range is preferred. The time of immersion of the articles being treated in the bath should be sufficient to produce the desired brightening, yet insufficient to cause any undue etching of the metal. It is, of course, dependent primarily on solution temperatures and concentrations and may be widely varied. An

immersion time of from about one-half to about ten minutes is recommended.

As a specific example, not intended to limit the invention, maximum brightness was obtained with aluminum and aluminum alloys treated by a five minute immersion in a solution (at a temperature of 190° F. to boiling) prepared by addition of the indicated compounds.

Example

Constituent	Volume Concentration cc./liter	Weight Concentration g./liter	Percent Weight of Solution
HNO_3	30 (70% HNO_3)		3
HF	5 (48% HF)		.3
NH_4OH	12 (28% NH_3)		.3
CrO_3		2	.2
Water, Balance			

The procedure followed in treating the aluminum or alloy articles with the bright dip is merely to immerse the article in the heated solution for the required time. The article is thoroughly water rinsed and dried. However, it is advantageous that prior to immersion the metal be cleaned or degreased by the use of a mild, inhibited alkaline cleaner, for example, Kelite Aviation Cleaner (KDL#1). This is preferably accomplished by immersion in a heated solution of the cleaner for a few minutes, for example, two minutes in solution at 180–200° F., followed by a thorough rinsing prior to introduction into the bright dip solution.

Agitation of the bath is not essential, but is recommended since it produces more uniform results and tends to decrease the required immersion time. Mechanical or air agitation may be used, but the former is preferable since it does not cool the solution as does air agitation.

The process may be operated on a continuous or semi-continuous basis, or it may be conducted as a batch process. In case of the former, the components are gradually depleted and calculated additions of the compounds supplying these ions are periodically added to maintain proper concentrations.

The chemical polishing treatment may be conducted in any suitable tank or other apparatus provided with a lining impervious to the corrosive action of the nitric and hydrofluoric acids at the operating temperatures. Glass lined equipment is satisfactory. A particularly useful lining is Karbate—a treated carbon product resistant to attack by all chemicals except those which are highly oxidizing. Karbate is manufactured in molded slabs, blocks and other shapes.

The heating of the solution may be accomplished by the use of Karbate tubes or heat exchangers, or, if electrical heating is desired Karbate shielded immersion heaters may be employed.

The results obtained with the chemical bright dip of the present invention do not produce a surface smoothing effect in comparison to mechanical buffing or electropolishing. However, the surface luster or brightness compares very favorably with that produced by electrobrightening, while the chemical bright dip requires only a short immersion time and no electric current. In short, the improved chemical bath produces the desired result much more economically.

I claim:

1. A composition for the chemical brightening of aluminum and aluminum alloys comprising

an acid aqueous solution containing hydrogen, nitrate, fluoride, ammonium, and chromate ions in concentration corresponding to that produced by a solution containing from about .5 to 5% nitric acid, about .01 to .5% hydrofluoric acid, about .01 to 0.5% ammonia and about .01 to 1% chromic acid (calculated as CrO_3) by weight of the solution.

2. A composition for the chemical brightening of aluminum and aluminum alloys comprising an aqueous solution containing by weight from about .5 to 5% nitric acid, about .01 to 0.5% hydrofluoric acid, about .01 to 0.5% ammonia, and from about .01 to 1% chromic acid (calculated as CrO_3).

3. A composition according to claim 1 in which the said chromate is chromic acid.

4. An aqueous solution for chemically brightening aluminum and aluminum alloys consisting essentially of about .5 to 5% nitric acid, about .01 to 0.5% hydrofluoric acid, about .01 to 0.5% ammonia, about .01 to 1% chromic acid (calculated as CrO_3), by weight.

5. A process for the chemical brightening of aluminum and aluminum alloys which comprises treating the metal in an aqueous acid bath containing hydrogen, nitrate, fluoride ammonium and chromate ions in concentration corresponding to that produced by a solution containing from about .5 to 5% nitric acid, about .01 to 0.5% hydrofluric acid, about .01 to 0.5% ammonia and about .01 to 1% chromic acid (calculated as CrO_3), and maintaining the solution at a temperature of about 100° F. to the boiling point.

6. A process for the chemical brightening of aluminum and aluminum alloys which comprises immersing the metal in a heated aqueous bath containing about .5 to 5% nitric acid, about .01 to 0.5% hydrofluoric acid, about .01 to 0.5% ammonia, and from about .01 to 1% chromic acid (calculated as CrO_3), by weight for a time sufficient to brighten the metals but insufficient to cause overetching thereof, maintaining the bath at a temperature of from about 190° F. to the boiling point, withdrawing the treated metal and removing adhering solution.

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