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METHOD OF COMPLETELY IMPREGNATING A MEDIUM HARD ANODIZED SURFACE WITH MOLTEN STRAIGHT-CHAIN SATURATED ALIPHATIC COMPOUNDS AND THE PRODUCT THEREOF

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ABSTRACT OF THE DISCLOSURE

A method of completely impregnating a medium hard anodized coating with a molten straight-chain saturated aliphatic compound having at least 5 carbon atoms per molecule, and each molecule having a terminal polar group of either an acidic, alcoholic or aminoic nature and the product formed by this process.

The present application is a continuation-in-part of United States application Ser. No. 242,080 filed on Dec. 4, 1962 and now abandoned.

This invention relates to a novel method for providing effectively new characteristics in metals and, in particular, for enormously increasing the resistance to fatigue, corrosion and the like of structural metals, particularly of aluminum and aluminum-base alloys.

Reports in the literature concerning the results of fatigue studies on structural metals such as steel, stainless steel, copper alloys and aluminum alloys, have indicated that fatigue strength or fatigue life of a given metal or alloy depends upon such factors as the previous processing of the metal, and the influence of various types of media and external environments to which the metal has been exposed. These studies had led to the belief that fatigue strength was affected mainly by environmental influences such as air, oxygen, corrosive liquids and gases, and that if the metal surfaces were protected by the application of suitable protective media, fatigue strength could be improved, or at least maintained. In an article by H. E. Frankel et al. National Bureau of Standards Journal of Research, Volume 64C, No. 2, April-June, 1960, pages 147–150, it was reported that the fatigue strength of a low-alloy steel, a magnesium alloy, and a copper-beryllium alloy were increased by coating specimens with, or immersing them in certain polar organic compounds, particularly compounds having a carbon chain between 12 and 18 carbon atoms, for example, dodecyl alcohol, dodecylamine, and octadecylamine. These compounds were characterized by the authors as oleophobic materials, that is, long chain aliphatic molecules having a polar group at one end. They were brought directly in contact with the metal surface and their action was thought to be due to their ability to present a barrier to water and oxygen molecules. The improvement produced in the steel, magnesium and copper alloys with respect to fatigue life was of the order of two to five times. The effect on stainless steel was slight, and no improvement was observed with aluminum and titanium alloys.

Elsewhere, it has been taught that the effect of anodization on metals, e.g., on aluminum and anodizable alloys of aluminum, is, if anything, to decrease the resistance of said metals to fatigue. While it is known and widely appreciated that anodically produced coatings can improve somewhat the corrosion resistance of aluminum while at the same time the attractive metallic appearance of the base metal is retained, the improvement in corrosion resistance attained by virtue of said coatings and the customary sealing techniques applied thereto is small. Anodic coatings on aluminum and alloys thereof, known to the trade as "hard" coatings such as can be produced by anodizing in a dilute sulfuric acid bath at temperatures below about 50° F., give good to excellent corrosion protection to the base metal. However, such "hard" coatings carry with them a severe penalty in loss of fatigue resistance and a loss in metallic appearance. As far as we are aware, there has not been available heretofore a process, much less a commercially operable process, whereby one can provide an anodized metal structure having a combination of excellent resistance to corrosion, an attractive metallic appearance, and resistance to fatigue at least equal to, if not highly superior to, the resistance to fatigue of the metal per se.

It is an object of the present invention to provide a novel metal treatment process.

It is another object of the present invention to provide a novel metal structure.

A further object of the present invention is the provision of a novel metallic-appearing metal structure as employed under conditions where corrosion and/or fatigue detrimentally affect the performance of said structure.

Other objects and advantages of the present invention will become apparent from the following description.

In accordance with the present invention, it has been found, surprisingly and unexpectedly, that a very large increase in the fatigue life of anodizable metals and metal alloys can be obtained by first forming a specially controlled anodic coating on the surface of the metal or alloy and then specially impregnating the anodic coating with terminally substituted, aliphatic compound from a specially restricted group, said aliphatic compound containing a polar group and being capable of forming something more than an absorbent layer, or mere physical coating, possibly a metal soap, or an alcoholate. For example, freshly and specially anodized aluminum when immersed in molten stearic acid, and removed therefrom, provided an impregnation, or coating, which could not be removed by known solvents for the stearic acid even when the coated aluminum was immersed in the solvent at boiling temperatures.

The novel process of the invention will be illustrated by its application to the improvement of the fatigue life of aluminum and aluminum-base alloys, but it will be understood that it is also applicable to other anodizable metals. When the term "aluminum" is used in this specification and accompanying claims it is to be understood that it includes not only aluminum metal itself but also those alloys which are anodizable and which contain aluminum as the predominant alloying ingredient.

The improvement in fatigue life of aluminum obtainable by the method of the invention goes far beyond, in order of magnitude, anything heretofore obtainable by the application to metal surfaces of oleophobic materials, amounting to increases up to 100 fold and more. This indicates that while restricted access to the metal surface of air and oxygen may play a part, as it has in prior art methods, a much more novel and fundamental principle has been discovered and applied in the present invention.

The first step in the novel process of the invention is the formation of an anodic or oxide coating on the outer surface of the aluminum or other anodizable metal. This is performed by conventional methods well known in the anodizing art, employing as an anodizing electrolyte an aqueous solution of sulfuric acid or other electrolyte which will provide anodic coatings similar to those produced on aluminum in sulfuric acid solutions. When employing sulfuric acid, which is highly advantageous for the purposes of the invention, the conditions can be varied within wide limits. Thus, while anode current densities are advantageously, about 12 to 15

amperes per square foot, (a.s.f.), the anode current density can vary within much wider limits depending, among other factors, upon anode to cathode spacing, electrolyte composition, temperature, driving voltage and cell geometry. Sulfuric acid concentrations can be about 5 to 60 percent by weight; bath temperatures can be from about 65° F. to about 80° F.; and anodizing times can be from about 15 to about 60 minutes. Other electrolytes and additives can be employed in conjunction with sulfuric acid as long as the result of anodizing is an anodic film as described hereinafter and similar in characteristics to an anodic film produced as described above.

The character of the anodized coating is important in the present invention. First, the coating must have an effective thickness, e.g., in excess of about 0.3 mil. It has been found that the advantages of the invention are not normally achieved with coatings 0.15 mil thick produced in an aqueous sulfuric acid bath. With coatings of about 0.5 mil thickness, it is possible to achieve both extraordinary resistance to corrosion and extraordinary resistance to fatigue. Thus, it is important that the thickness of the anodic coating be in excess of about 0.2 or even 0.3 mil. For best combinations of fatigue and corrosion resistance characteristics, it is advantageous to maintain a maximum coating thickness of about 0.6 or 0.7 mil. In view of these requirements as to thickness, it is necessary to interrelate the anodizing parameters to assure the production of the proper thickness coating. Typical coatings of highly advantageous thicknesses are achieved by anodizing an aluminum alloy such as the alloy generally designated as 7075–T6 in an aqueous bath within the ranges set forth in Table I.

TABLE I

H_2SO_4 concentration—[1] 12%–17%
Anode current density—12–17 a.s.f.
Temperature—70° F.–75° F.
Time—30–50 minutes
Voltage—15 volts

[1] H_2SO_4 concentration is in percent by weight.

Since the anodizing characteristics of anodizable aluminum alloys can vary somewhat, it is not possible, as a practical matter, to specify exactly the optimum anodizing conditions for each specific alloy. However, whatever aluminum alloy is used, the anodizing conditions within the aforementioned ranges will vary so that as anode current density decreases, time of anodizing will increase, so that as temperature decreases, acid concentration will increase and vice versa.

The micromorphology of the anodized rooting is highly important. Generally, the required anodized coating consists of a dense oxidic barrier layer up to about 200 angstrom units thick immediately adjacent the metal and an oxidic layer of increasing porosity extending outwardly therefrom. As is evident from the maximum thickness of the barrier layer, the thickness of the porous layer constitutes a preponderant proportion of the thickness of coatings found to be advantageous in the invention. When employing sulfuric acid baths containing about 15% sulfuric acid by weight, satisfactory barrier layer thicknesses can be attained by immersing aluminum articles to be anodized in the bath and applying voltage smoothly thereto so that the maximum voltage of about 15 volts is attained after about one minute.

The physical characteristics of the anodized coating are also highly important. The coatings cannot be too hard. For example, hard anodic coatings formed by anodizing in an oxalate bath or by low-temperature, i.e., less than about 50° F., anodizing in a sulfate bath are unsatisfactory for purposes of the present invention. Likewise, very soft anodic coatings which exhibit chalking tendencies and which can be produced by anodizing in a sulfate bath at temperatures in excess of about 90° F. are also unsatisfactory for purposes of the present invention. Thus the anodized coating must be of medium hardness.

After anodizing, the anodized metal should be washed to remove adhering amounts of anodizing electrolyte. It has been found that washing for about 5 to 30 minutes in running water at a temperature of about 100° F. provides satisfactory results. On the other hand, washing can also be conducted for very short periods of time using ultrasonic vibrations or other means of violent agitation.

Following washing, the anodized objects are advantageously dried in air at ambient temperatures until the moisture content of the anodized layer is less than about a total of 100 milligrams of water per square foot per mil. Both the absorbed water and the water of hydration should be less than 50 milligrams per square foot per mil (mg./mil/sq.ft.). Immediately after drying, or at least prior to about 8 hours after anodizing under ordinary conditions, the anodic coating is impregnated with a saturated aliphatic compound containing at least one terminal polar group and capable of forming an impregnation, or coating, chemically bonded within the pores of the anodic coating to the aluminum. Advantageously, aliphatic compounds of this class are terminally substituted compounds having at least 16 carbon atoms per molecule and containing at least one end polar group, such as a carboxyl, hydroxyl, or amino group, and which are capable of forming something more than a physical coating which may be said to be chemisorbed.

Impregnating is advantageously accomplished by the use of an essentially undiluted compound of the class set forth hereinbefore. More advantageously, the impregnant is an essentially undiluted, terminally substituted, aliphatic carboxylic acid having a straight or branched chain and at least about 16 carbon atoms per molecule and the impregnation is carried out at a temperature of at least about 200° F.

It is important that impregnation be accomplished at a temperature at which the aliphatic acid has a viscosity and a surface tension such that positive capillarity is exhibited when anodized and dried metal is brought in contact with the saturated aliphatic acid. When, as stated before, the impregnant is an "essentially (or substantially) undiluted compound," it is not intended to exclude thereby mixtures of operable compounds such as would be encountered in commercial grades of saturated aliphatic acids or even mixtures of such commercial grades. Further, the term "essentially undiluted" is not intended to exclude the use of small amounts of agents such as viscosity modifiers, surface tension modifiers, biocides, antioxidants, radiation-filters and the like which do not interfere with the operability of the invention and which can enhance the effectiveness thereof.

The foregoing types of saturated aliphatic compounds, when applied to anodically coated anodizable metals, produce remarkable increases in fatigue strength. Applicants are not certain of the nature of the action which occurs when these substances come into contact with the anodized metals, and do not wish to be bound by any particular theory. It is known, as described hereinbefore, that the coating on anodized metals such as aluminum consists of an outer, relatively porous oxide layer, surmounting an intermediate, relatively thin, dense barrier layer of oxide which lies immediately adjacent the metal. Metal ions in an active state are liberated by the action of the anodizing current, and ultimately migrate to form the outer layer. It is believed that the aliphatic compounds of the invention are absorbed in the porous layer and penetrate through the pores of the anodic coating and, upon reaching the barrier layer or the metal surface itself, encounter and react with metal ions to form small amounts of metal derivatives or chemical reaction products. These aliphatic compounds are adsorbed in the form of chemically bonded

films on freshly exposed metal surfaces, particularly at high energy sites of the slip bands or slip lines, which form during plastic deformation a process which is characterized herein as chemisorption. When the metal is subjected to plastic deformation, as in the course of flexure testing, the presence of dislocations facilitates the formation of chemisorbed substances, and indeed the aliphatic substance penetrates or migrates onto newly created surfaces and reacts to form a chemiadsorbed compound, thus greatly increasing the fatigue life of the metal. When the aliphatic compound is a carboxylic acid, it is believed that metal soaps are formed in minute amounts. Where the aliphatic compound is an alcohol, the metal derivative may be a metal alcoholate, or where the compound is an amine, the substance formed may be a metal amide soap. It will be understood, however, that these represent hypotheses concerning the causes of the unpredictable action of the process of the invention in prolonging metal fatigue life, and do not constitute limitations as to the scope of the invention.

Regardless of the mechanism or mechanisms underlying the present invention, it is imperative to the operability of the invention that impregnation of the freshly formed porous anodized coating take place under conditions whereby the aliphatic impregnant can penetrate throughout the pores of said coating and especially to the bottom thereof. Under the usual conditions of impregnation employed in accordance with the most advantageous aspects of the present invention, i.e., impregnation with a normally solid, saturated, aliphatic fatty acid containing at least about 16 carbon atoms per molecule at a temperature of about 250° F., the impregnant exhibits a sufficiently low surface tension and viscosity to penetrate essentially completely through the pores of the anodically produced coating and impinge and/or abut upon and react with materials at the barrier layer described hereinbefore in a reasonable time, e.g., about 20 minutes. This penetration is important in order to achieve the advantages of the present invention both as to resistance to corrosion and resistance to fatigue.

In accordance with the preferred embodiment of the invention, the anodized metal is subjected to treatment with a saturated, aliphatic, carboxylic acid capable of forming a chemisorbed layer. Advantageously, the carboxylic acid is an aliphatic carboxylic acid containing at least 16 and up to 22 or more carbon atoms per molecule.

Examples of aliphatic carboxylic acids which can be used with advantage in accordance with the present invention include hexadecanoic (palmitic), octadecanoic (stearic) and docosanoic (behenic) acids or mixtures thereof.

The procedure in accordance with the most advantageous aspect of the invention as described hereinbefore is to produce an anodic film on aluminum or an aluminum-base alloy, preferably in a sulfuric acid bath, containing less than about 25% by weight H_2SO_4, balance essentially water, rinse thoroughly with water, air-dry the specimen, and then apply to the anodized specimen or article a molten bath of the carboxylic acid. The anodic film can be of any desired thickness in the range of about 0.3 mil to about 0.8 mil. A film thickness of about 0.5 mil is most suitable. It is important, however, that the anodic film be porous. Experience has indicated that a greater degree of improvement in fatigue life occurs with thicker and more porous anodic films. The maximum time of exposure to the impregnating carboxylic acid is not critical, and may range, for example, up to about 80 minutes. As explained hereinbefore, sufficient time, e.g., a minimum of about 5 minutes, should be allowed for impregnation to assure penetration of the impregnant throughout the pores of the anodic coating.

The anodic coating should be freshly, and recently, formed. For instance, upon coating, or impregnating, anodized aluminum with stearic acid, four days after anodizing had been effected, only a very small increase in the fatigue life of the aluminum was obtained.

The process of the invention is applicable to aluminum and to a wide variety of anodizable aluminum base alloys, including for example, the following aluminum Association designations: 7075–T6, 2014–T6, 2014–T6–Alclad, 6061–T6, and 5456–11343.

A highly advantageous anodizing bath is an aqueous solution of 15% sulfuric acid, with anodizing carried out at a current density of 15 amperes per square foot, temperature of bath 74° F., anodizing time 40 minutes.

The temperature of the aliphatic carboxylic acid treatment will depend upon the melting temperature of the particular acid, and is not critical except insofar as discussed hereinbefore. It can range from just above the melting temperature of the carboxylic acids to about 350° F. It is advantageous to impregnate at as low a temperature as is practical. The impregnating acids are subject to some decomposition and/or oxidation at elevated temperatures. Keeping the impregnating temperature as low as possible assists in enhancing the useful life of the impregnating bath.

The flexture fatigue tests may be carried out by any suitable apparatus, for example, a mechanical oscillating testing machine applying pure bending moments to the test section, operating at 1800 c.p.m. Tests are carried out at various stress levels and measurements are expressed in number of cycles to failure.

The application of this aspect of the invention to the fatigue improvement of an aluminum base alloy using the fatigue test set out above is illustrated by the following examples:

EXAMPLE 1

Aluminum alloy 7075–T6 sheet material was machined into standard flexure fatigue specimens (3" x 10" x 0.2"). These specimens were anodized in a 15% sulfuric acid bath at a temperature of 74° F. and a current density of 15 amperes per sq. ft. for 40 minutes, and were rinsed in cold water and dried in air. The specimens were immersed in a bath of valeric acid for a period of 20 minutes at a temperature of about 250° F. On removal from the treating bath the specimens were wiped with clean cloths to remove excess valeric acid, and were subjected to flexure tests in comparison with test specimens of the untreated alloy, and of the alloy anodized in the same way, but sealed with hot water and not further treated.

The results of the flexure tests were as follows:

Test specimen	Stress level, p.s.i.	Average No. of cycles to failure
Untreated alloy	26,000	312,000
Alloy anodized and hot water sealed	26,000	125,000
Alloy anodized and treated with valeric acid	26,000	15,300,000

The foregoing results demonstrate in striking fashion the enormous increase in fatigue life obtained by the treatment of the anodized alloy with an aliphatic carboxylic acid (valeric acid), the increase being in excess of 10,000%.

The results of flexure fatigue tests carried out on several aluminum base alloys at various stress levels, in comparison with specimens of the alloy anodized and hot water sealed but not otherwise treated, are summarized in Table II. All the anodized alloys were treated in the same manner, using 15% sulfuric acid, 75° F. bath temperature, 15 amp./sq. ft. current density, time 40 minutes. From 2 to 3 test pieces were tested for each alloy and each treating carboxylic acid. The anodized test pieces were impregnated with saturated aliphatic acids

containing at least 5 carbon atoms per molecule as set out above.

TABLE II

[Unit: Millions of cycles to failure at stress level noted]

Treated Material Stress Level	2014–T6, 23,000 p.s.i.	2014–T6–Alc., 20,000 p.s.i.	6061–T6, 20,000 p.s.i.	7075–T6, 26,000 p.s.i.
Hot water 180° F.	0.2	0.2	0.6	0.1
Acid:				
Valeric				15.3
Caproic				9.2
Octanoic	11.7	1.3		12.3
Decanoic	1.0	1.3	2.9	7.5
Lauric	16.9	1.1		8.6
Myristic	10.8	2.3		11.6
Palmitic		2.5	2.7	7.3
Stearic	13.7	1.5	1.6	8.7
Docosanoic	18.2	2.0	3.3	6.1
Sebacic				13.7

The foregoing table clearly demonstrates the great increase in fatigue life of anodized aluminum alloys with aliphatic carboxylic acids.

In the case of another alloy, 5456–H343 treated with lauric acid, at a stress level of 26,000 p.s.i., 30 million cycles were achieved with no failure, whereas in comparison with anodized and water sealed specimens the average fatigue life was 57,000 cycles.

EXAMPLE II

Structures in accordance with the present invention such as structures made from aluminum alloy 2014–T6 which have been treated with aliphatic acids such as stearic acid and for docosanoic acid exhibit not only excellent resistance to fatigue as shown in Table II but also exhibit excellent resistance to corrosion. Test panels subjected to salt spray as described in the test designated Federal Test Method Standard 151 Method No. 811 show no signs of corrosion after 6552 hours. In contrast, similar specimens of alloy 2014–T6 which were anodized and sealed in the conventional manner with hot water at 180° F. and which exhibited a sensitivity to fatigue as shown in Table II also exhibited signs of severe corrosion after only 264 hours when similarly exposed to salt spray.

In accordance with another aspect of the invention, anodized aluminum alloys are subjected to treatment with aliphatic alcohols in a manner similar to that disclosed with aliphatic carboxylic acids. Alcohols which have proved most suitable for this purpose have been those containing from 8 to 18 carbon atoms, such as, for example, octyl, dodecyl and octadecyl alcohol.

EXAMPLE III

Flexure fatigue tests on alloy 2014–T6 carried out in the manner described in connection with Table I, showed 15.7 million cycles to failure in the case of octyl alcohol and 16.3 million cycles in the case of dodecyl alcohol.

EXAMPLE IV

In accordance with still another aspect of the invention, aluminum alloys are anodized and then treated with aliphatic amines, which may be primary monoamines or primary diamines, such as, for example, dodecylamine or hexanediamine. Flexure tests on alloy 2014–T6 in the case of dodecylamine showed 5.6 million cycles to failure and in the case of hexanediamine, 11.8 million cycles.

Other anodizable metals and alloys, such as, for example, magnesium and titanium, can be anodized to form a porous anodic coating thereon and then treated with an aliphatic compound containing a polar group capable of forming a chemisorbed layer to improve their resistance to fatigue in the same manner. The process of the present invention is of particular value in the manufacture of aircraft structures wherein metal fatigue is a problem, thus enhancing the safety of flight. The present invention is also highly useful with regard to structures to be employed under corrosive conditions where fatigue considerations are secondary. The bright metallic appearance and corrosion resistance of articles made in accordance with the most advantageous aspects of the present invention give rise to areas of utility in the field of decorative trim for automotive and other industrial and home usage.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention.

What is claimed is:

1. A process for metal treatment comprising forming an effectively thick, porous, anodic, oxidic coating of medium hardness on the surface of an anodizable metal, said oxidic coating having characteristics essentially similar to the characteristics of an oxidic coating produced on aluminum by anodizing in an aqueous sulfuric acid bath containing about 15% by weight of sulfuric acid at a temperature of about 65° F. to 80° F. at an anodic current density of about 12 to about 15 amperes per square foot for about 5 to about 60 minutes, and impregnating said coating with a substantially undiluted, molten, saturated, aliphatic compound selected from the group consisting of acids, alcohols and amines having at least 5 carbon atoms per molecule and having the polar group from the group of acidic, alcoholic and aminoic groups positioned on a terminal carbon atom; while said coating is freshly formed for a time sufficient to achieve penetration of said aliphatic compound throughout the pores of said coating.

2. A process for metal treatment comprising forming a porous, anodic, oxidic coating of medium hardness, at least about 0.2 mil thick on an aluminum surface, said oxidic coating having characteristics essentially similar to the characteristics of an oxidic coating produced on aluminum by anodizing in an aqueous sulfuric acid bath containing about 15% by weight of sulfuric acid at a temperature of about 65° F. to 80° F. at an anodic current density of about 12 to about 15 amperes per square foot, and impregnating said coating with a substantially undiluted, molten, saturated, aliphatic compound selected from the group consisting of straight-chain acids, alcohols and amines ahving at least 5 carbon atoms per molecule and having the polar group from the group of acidic, alcoholic and aminoic groups positioned on a terminal carbon atom; within about eight hours of the formation of said coating for a time sufficient to achieve penetration of said aliphatic compound throughout the pores of said coating.

3. A process for metal treatment comprising forming porous, anodic, oxidic coating of medium hardness at least about 0.3 mil thick on an aluminum surface, said oxidic coating having characteristics essentially similar to the characteristics of an oxidic coating produced on aluminum by anodizing in an aqueous sulfuric acid bath containing about 15% by weight of sulfuric acid at a temperature of about 65° F. to 80° F. at an anodic current density of about 12 to about 15 amperes per square foot, and impregnating said coating with a substantially undiluted, molten, straight-chain, saturated, aliphatic acid having at least about 16 carbon atoms per molecule with the acidic group being positioned on a terminal carbon atom; while said coating is freshly formed for a time sufficient to achieve penetration of said aliphatic acid throughout the pores of said coating.

4. A process for metal treatment comprising forming a porous, anodic, oxidic coating of medium hardness about 0.3 to about 0.7 mil thick on an aluminum surface by anodizing said surface in an aqueous sulfuric acid bath at a temperature of about 60° F. to about 85° F. for about 15 to about 60 minutes, washing and drying the thus produced coating and, promptly thereafter, impregnating the dried coating with a substantially undiluted, molten,

straight-chain, saturated, aliphatic acid having at least about 16 carbon atoms per molecule with the acidic group being positioned on a terminal carbon atom at a temperature in excess of the melting point of said acid and up to about 350° F. for at least about 5 minutes to achieve penetration of said aliphatic acid throughout the pores of said coating.

5. A process as in claim 4 wherein the aqueous sulfuric acid anodizing bath contains about 15% sulfuric acid by weight.

6. A process as in claim 4 wherein the impregnation step is conducted at a temperature in excess of about 200° F.

7. A process as in claim 4 wherein the anodized coating is washed for up to 30 minutes prior to drying and impregnation.

8. A process as in claim 4 wherein the straight-chain acid is essentially behenic acid.

9. A process as in claim 4 wherein the anodized aluminum is dried to a moisture content of less than 100 mg./sq. ft./mil total absorbed water and water of hydration in the anodized coating prior to impregnation.

10. A treated metal structure comprising a base of anodizable metal having a porous anodic coating of medium hardness thereon, said porous anodic coating being at least about 0.2 mil thick and having characteristics essentially similar to the characteristics of an oxidic coating produced on aluminum by anodizing in an aqueous sulfuric acid bath containing about 15% by weight of sulfuric acid at a temperature of about 65° F. to about 80° F. at an anodic current density of about 12 to about 15 amperes per square foot for about 5 to about 60 minutes, and the pores of said anodic coating being substantially completely impregnated with a straight-chain, saturated, aliphatic compound having at least 5 carbon atoms per molecule and selected from the group consisting of acids, alcohols and amines having the polar group selected from the group consisting of acidic, alcoholic and aminoic groups positioned on a terminal carbon atom.

11. A medium-hard anodized and treated aluminum structure comprising a base of aluminum, an inner, substantially impervious, dense oxidic layer up to about 200 Angstrom units thick superimposed directly thereon and an oxidic layer of increasing porosity extending outwardly therefrom, said oxidic layers being in total at least about 0.2 mil thick and having characteristics essentially similar to the characteristics of an oxidic coating produced on aluminum by anodizing in an aqueous sulfuric acid bath containing about 15% by weight of sulfuric acid at a temperature of about 65° F. to about 80° F. at an anodic current density of about 12 to about 15 amperes per square foot for about 5 to about 60 minutes, and the pores of the outer layer being substantially completely impregnated with a straight-chain aliphatic compound having at least about 5 carbon atoms per molecule and being selected from the group consisting of acids, alcohols and amines having the polar group selected from the group consisting of acidic, alcoholic and aminoic groups positioned on a terminal carbon atom.

12. An aluminum structure as in claim 11 wherein the impregnant is a straight-chain aliphatic carboxylic acid containing at least about 16 carbon atoms per molecule and the total thickness of the oxidic layers is at least about 0.3 mil.

13. An aluminum structure as in claim 12 wherein the total thickness of the oxidic layers is about 0.3 to about 0.7 mil.

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