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METHOD OF ELECTROPOLISHING DENTAL APPLIANCES

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1

The present invention relates to a novel electrolyte bath for use in the electropolishing of corrosion-resistant metals, and more particularly to a bath for the electropolishing of irregularly-shaped dental appliances of stainless alloys particularly high cobalt alloys, such as cobalt-chromium-molybdenum alloy in which the preponderant metal is cobalt, and of high nickel alloys, such as nickel-chromium-beryllium alloy, in which the preponderant metal is nickel. The invention also relates to a novel process of polishing such articles involving the use of the novel bath.

The polishing of metal structures, particularly of the complex and irregular shapes of dental appliances, such as cast plate fittings, fixed and removable bridge fittings, inlays, crowns, and the like, has presented many difficulties. In the first place, because of the crevices, rugae, and other irregularities in the surface and shape of such structures, it is practically impossible to completely polish the entire surface by ordinary mechanical means. Moreover, because of the possibility of distortion so frequently caused by mechanical polishing, such means of polishing is not satisfactory for metal articles, particularly dental appliances, which must possess precise accuracy and which must constitute a definite reproduction of the impression made by the dentist. With respect to electrolytic polishing of such articles, the methods available in the past have not been satisfactory, particularly in the polishing of dental appliances, due to their failure to provide uniform polishing, to their tendency to cause etching of the metal or to their tendency to cause undue dissolution of the metal which latter factor cannot be tolerated in view of the precise accuracy and definite reproduction required. These difficulties are particularly pronounced with dental appliances made from high cobalt alloy, such as cobalt-chromium-molybdenum alloy in which the preponderant metal is cobalt, or from high nickel alloy, such as nickel-chromium-beryllium alloy in which the preponderant metal is nickel.

It is an object of the present invention to provide a method for electropolishing irregularly-shaped corrosion - resistant metal structures wherein the difficulties of the prior art are eliminated.

Another object of the invention is to provide a bath for the electropolishing of corrosion-resistant metal structures wherein a uniform highly polished surface, regardless of the complexity or irregularity in shape and surface of the article, is readily provided.

Still another object of the present invention is to provide a method for electropolishing dental

2

appliances made of stainless alloys, particularly of cobalt-chromium-molybdenum alloy in which the preponderant metal is cobalt, or of nickel-chromium-beryllium alloy in which the preponderant metal is nickel, by which a high uniform polish is provided without danger of etching or of undue dissolution of metal.

Still another object of the invention is to provide a novel electrolyte bath by which such stainless alloy dental appliances, particularly of the stated cobalt-chromium-molybdenum alloy or of the stated nickel-chromium-beryllium alloy, may be readily provided with a uniform high polish without danger of etching or of undue dissolution of the metal.

Other objects will be apparent from the consideration of the following specification and claims.

In accordance with the present invention, the novel electrolyte bath employed in electropolishing consists of essentially of between about 5% and about 22%, by weight, of H_2SO_4, between about 0.25% and about 5%, by weight, of HCl, and between about 70% and about 84%, by weight, of ethylene glycol. The amount of water in the bath will be maintained below a maximum amount generally below about 8%, by weight, this being the maximum amount of water which would normally be associated with the acids and with the ethylene glycol as obtained in commerce. The metal article is immersed in the described bath, as anode, a cathode also being provided, and an electric current is applied until the desired polish is obtained.

By the present invention corrosion-resistant metal articles may be readily provided with a high uniform polish without danger of etching or undue dissolution of the metal. The uniform high polish is obtained regardless of the complexity of the shape and irregularities in the surface of the metal articles treated. This feature is of particular importance in connection with dental appliances which are delicate and extremely complex and irregular in shape and surface, and which must possess precise accuracy and provide a definite reproduction of the dentist's impressions.

Although the present invention is applicable to all corrosion-resistant metals, including metal alloys, such as nickel, copper, chromium, brass, the stainless steels, and the like, it is particularly applicable for the treatment of structures of high cobalt alloys, specifically cobalt-chromium-molybdenum alloy in which the preponderant metal is cobalt, and of high nickel alloys, specifically nickel-chromium-beryllium alloy in which the preponderant metal is nickel. These particular alloys are those generally employed in the

manufacture of dental appliances. Of these latter-named alloys, the stated cobalt-chromium-molybdenum alloy is most generally employed in the dental appliance field, and the electropolishing of dental appliances made of such alloy represents the preferred embodiment of the present invention. In this alloy the cobalt generally ranges between about 60 and about 65%, by weight, the chromium between about 27 and about 32%, by weight, and the molybdenum between about 2 and about 6%, by weight. Such alloy also generally contains traces of other elements such as nickel, iron, carbon, vanadium, silicon, manganese, aluminum, wolfram, and the like. Typical specific examples of such alloy are as follows:

	No. 1	No. 2	No. 3
Ni	.07	.67	1.09
Cr	29.61	27.95	29.28
Mn	.08	.10	1.32
Si	1.30	.45	.44
C	.52	.22	.41
Co	63.05	63.07	61.07
Mo	5.44	4.27	5.62
W	.10	1.04	1.10
Al	.22	.15	.44
Fe	1.24	1.03	.96

With respect to the nickel-chromium-beryllium alloy mentioned above, such alloy generally contains between about 75% and about 77%, by weight, of nickel, between about 18% and about 25%, by weight, of chromium, and between about 3% and about 5%, by weight, of beryllium, with traces of other elements as is the case with the cobalt-chromium-molybdenum alloy.

Since, as stated, the present invention is particularly applicable to the treatment of dental appliances, in which field the invention represents a particularly marked improvement over prior polishing procedures, the invention will be described with particular emphasis on such articles.

The novel electrolyte bath employed in accordance with the present invention, as will be noted from the above, consists essentially of sulfuric acid and hydrochloric acid dissolved in ethylene glycol. The amount of water in the bath must be maintained at a minimum, water in excess of that which would normally be associated with the acid and with the ethylene glycol being detrimental. Thus, the total amount of water in the bath should be less than about 8%, more generally less than about 5%, by weight, and preferably by the use of the acids in concentrated form, the amount of water is maintained below about 2%, by weight, of the bath. As stated, the H_2SO_4 and the HCl will generally be present in the bath in amounts between about 5% and about 22% and between about 0.25% and about 5%, respectively, substantially the entire balance of the bath (with the exception of the small amount of water that may be present), that is, between about 70% and about 84%, by weight, of the bath, being made up of the ethylene glycol. While amounts of H_2SO_4 below about 10% are satisfactory, the speed of the process is increased with amounts of H_2SO_4 between about 10% and about 20%. Likewise, while amounts of HCl in excess of about 1% are satisfactory from the standpoint of electropolishing such amounts offer no advantage over the use of lesser amounts such as between about 0.3% and about 1%, aand the fumes of the excess HCl may be objectionable to operators. For most practical purposes the amount of ethylene glycol will be between about 72% and about 83%. Preferably the bath consists essentially of between about 16% and about 19%, by weight, H_2SO_4, between about 0.4% and about 0.6%, by weight, of HCl, less than about 2%, of water, and between about 79% and about 82%, by weight, of ethylene glycol.

The term "consists essentially" as used herein and in the claims, is not intended to exclude the accidental or deliberate inclusion of traces of other materials or of such minor amounts of other materials as do not alter materially the advantageous properties of the described bath. For example, it has been found that a very small amount, for example, from 1 to 2% of phosphoric acid can be incorporated in the bath without critically affecting the properties thereof. Larger amounts of phosphoric acid, for example, from about 5% to about 12%, by weight thereof, destroy the ability of the bath to polish deep cavities or crevices in the article, but may be tolerated where smooth surfaces only are being treated.

With respect to the temperature of the bath during the process, it has been found that moderately elevated temperatures facilitate the electropolishing operation. Thus, while electropolishing takes place when the bath is at a temperature in the neighborhood of normal room temperature, the process is relatively slow. On the other hand, relatively high temperatures are not only difficult to maintain but may be detrimental. Thus, the temperature of the bath is generally maintained between about 130° and about 170° F. The provision of these temperatures will offer no difficulty to those skilled in the art; but it should be noted that, in certain situations, particularly when relatively large pieces are being treated in a relatively small volume of bath, the heat developed is not readily dissipated and this exothermic heat may serve to maintain the temperature of the bath in the desired range.

In conducting the process, the metal article to be treated is immersed as anode in the described bath. A cathode or cathodes will be provided. The cathode may be any suitable material and shape; for example, a particularly advantageous cathode has been found to a copper ring which, when submerged in the electrolyte bath, surrounds the article undergoing treatment. The anode, i. e., the article undergoing treatment, and the cathode are connected to a suitable source of direct current. The current may be supplied from batteries or from a conventional alternating current source, the alternating current being converted to direct current in a rectifier. The electrical conditions employed will, of course, depend upon many factors including the size of the pieces undergoing treatment, the number thereof, the particular material undergoing treatment, and other considerations well known to those skilled in the electropolishing art. In general, however, it has been found that with the average dental appliances, current densities ranging from about 0.5 and about 5 amp./sq. in. are satisfactory, with current densities ranging from 0.7 to about 1.5 amp./sq. in. being particularly satisfactory.

The article being treated is left immersed in the electrolyte bath, as anode, until the desired polish has been obtained This point may readily be determined visually. The exact time in any particular case will vary depending upon many factors, including the size, shape and number of articles undergoing treatment, the elec-

trical conditions employed, the temperature of the bath, as well as other considerations well known to those skilled in the art. The time required, however, is normally on the order of minutes, times of treatment ranging from about 5 minutes to about 35 minutes having been used in particular situations.

Following the electropolishing treatment the article may be removed from the bath and washed with water. It will be found to possess a very high permanent polish and this polish will be uniform in the deep crevices as well as on the raised surfaces. Likewise, this high polish will be found to be uniform on all sides of the article.

The novel bath of the present invention and the method of electropolishing employing the bath will be more readily understood from a consideration of the following specific example which is given for the purpose of illustration and is not intended to limit the scope of the invention in any way.

EXAMPLE

Into a cell consisting of an agate jar 5¼" inside diameter by 5¾" deep, is placed an electrolyte consisting of 1500 cc. ethylene glycol, 200 cc. of concentrated sulfuric acid (about 98% H_2SO_4), and 20 cc. of concentrated hydrochloric acid (about 38% HCl). This provides a calculated theoretical analysis in percent by weight as follows:

	Percent
Ethylene glycol	80.97
H_2SO_4	16.80
HCl	0.42
Water	1.81

The mixture was heated with agitation to about 150° F.

As the cathode, a sheet of copper 5" wide and long enough to make a ring fitting against the inner circumference of the cell, was placed in the jar. This copper sheet is connected to one lead of a rectifier which in turn was connected to a 110 volt alternating current source. The output of the rectifier is about ten volts, and the circuit is equipped with an ammeter and a voltmeter. The article undergoing treatment is connected to the other lead of the rectifier.

The described bath and apparatus are used to polish several different articles as follows: sheets of nickel possessing areas of 2, 4, 6, and 8 square inches, respectively, and 2 dentures. The dentures were composed of the stated cobalt-chromium-molybdenum alloy having a composition corresponding to alloy No. 1 in the table hereinabove set forth.

The conditions of temperature and time as well as of amperage employed with each specimen which provided a uniform high polish, are set forth below in the table.

Table

Specimen	Temp. of Bath	Amps.	Time, minutes
2 sq. in. (nickel)	140° F./138° F.	2.8/3.0	11
4 sq. in. (nickel)	138° F./130° F.	4.0/4.4	16
6 sq. in. (nickel)	130° F.	5.0/5.6	20
8 sq. in. (nickel)	135° F./140° F.	5.5/6.0	31
Denture #1	135° F.	4.7/5.1	15
Denture #2	135° F.	4.3/4.7	12

Considerable modification is possible in the selection of the particular ingredients and amounts thereof, in the selection of the particular metal articles to be treated and in the selection of the particular technique employed during the process, without departing from the scope of the present invention.

I claim:

1. The method of electropolishing a dental appliance comprising an alloy having the following composition: between about 60 and about 65%, by weight, of cobalt, between about 27% and about 32%, by weight, of chromium, and between about 2% and about 6%, by weight, of molybdenum, which comprises immersing, as anode, said dental appliance in an electrolyte bath consisting essentially of between about 5% and about 22% of H_2SO_4, between about 0.25% and about 5% of HCl, between about 70% and about 84% of ethylene glycol and less than about 8% water; and producing an electric current flow between said dental appliance and an associated cathode.

2. The method of electropolishing a dental appliance comprising an alloy having the following composition: between about 75% and about 77%, by weight, of nickel, between about 18% and about 25%, by weight, of chromium, and between about 3% and about 5%, by weight, of beryllium, which comprises immersing, as anode, said metal article in an electrolyte bath consisting essentially of between about 5% and about 22% of H_2SO_4, between about 0.25% and about 5% HCl, between about 70% and about 84% of ethylene glycol and less than about 8% water; and producing an electric current flow between said dental appliance and associated cathode.

3. The method of claim 1 wherein said electrolyte bath consists essentially of between about 10% and about 20% of H_2SO_4, between about 0.3% and about 1% of HCl, between about 72% and about 83% of ethylene glycol and less than about 5% of water.

4. The method of claim 1 wherein said electrolyte bath consists essentially of between about 16% and about 19% of H_2SO_4, between about 0.4% and about 0.6% of HCl, between about 79% and about 82% of ethylene glycol and less than about 2% of water.

5. The method of claim 2 wherein said electrolyte bath consists essentially of between about 10% and about 20% of H_2SO_4, between about 0.3% and about 1% of HCl, between about 72% and about 83% of ethylene glycol and less than about 5% of water.

6. The method of claim 3 wherein the temperature of the bath is between about 130° F. and about 170° F.

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