The present invention relates to a process for treatment of the surface of a workpiece of aluminum or of an aluminum alloy, which is characterized in that the workpiece is brightened in an aqueous electrolyte by application of an electric d.c. voltage, the electrolyte having the following composition per liter of water:

<table>
<thead>
<tr>
<th>Component</th>
<th>Concentration (g/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂SO₄ (sulfuric acid)</td>
<td>85 to 340</td>
</tr>
<tr>
<td>H₃PO₄ (phosphoric acid)</td>
<td>850 to 1360</td>
</tr>
<tr>
<td>Al (aluminum)</td>
<td>8.5 to 43</td>
</tr>
</tbody>
</table>

**ABSTRACT**

The present invention relates to a process for treatment of the surface of a workpiece of aluminum or of an aluminum alloy, which is characterized in that the workpiece is brightened in an aqueous electrolyte by application of an electric d.c. voltage, the electrolyte having the following composition per liter of water:
PROCESS FOR BRIGHTENING ALUMINUM, AND USE OF SAME

FIELD OF THE INVENTION
[0001] The present invention was made in the art of surface finishing of workpieces of aluminum and aluminum alloys and relates to an electrobrightening process.

BACKGROUND OF THE INVENTION
[0002] The machining of surfaces of aluminum and its alloys by electrobrightening is known. The workpiece to be brightened is immersed in an aqueous electrolyte, which is usually contained in a steel vessel. This workpiece is connected to the positive terminal of a voltage source. If the vessel is electrically conductive for the electrolyte, it is frequently connected to the negative terminal of the voltage source. Alternatively, copper or carbon cathodes are dipped into the electrolytes. At the surface of the workpiece, electrochemical reactions are induced by the electric current, thus causing aluminum and its alloys to pass into solution. Because of development of a poorly conductive, viscous liquid layer with high aluminum salt concentration, mainly the peaks, humps and irregularities of the surface are attacked by the electric current and stripped away by dissolution. This stripping of the raised structures results on the whole in smoothing of the surface, accompanied by an improvement of the reflectivity and gloss characteristics of the workpiece.

[0003] Usually three processes are used for electrobrightening of aluminum—the Bryal process, the Alzak process and the phosphoric acid/sulfuric acid process (see, for example, Hubner and Speiser, “Practice of anodic oxidation of aluminum”, Aluminium-Verlag, Düsseldorf, 4th Edition, 1988).

[0004] In the Bryal process, which is suitable mainly for treatment of objects of very high-purity aluminum, a solution of Na₂CO₃ (calcined soda) and Na₃PO₄ (trisodium phosphate) in demineralized water is used as electrolyte. The conductance can be increased by adding NaOH (caustic soda) to the electrolyte. Typical current densities used for treatment range from 3.5 to 8 A/dm². Depending on alloy and desired effect, the treatment temperature ranges from 70 to 95°C. The treatment time ranges between 1 and 12 minutes and is usually 6 minutes. This process is employed mostly for small reflectors and jewelry.

[0005] In the Alzak process, which is also suitable for treatment of aluminum of lower purity, a solution of hydrofluoric acid in distilled or demineralized water is used as electrolyte. Versions in which there is used a solution of chromic acid or sulfuric acid and hydrofluoric acid in water have less practical importance. The current density used for the treatment usually ranges from 1.1 to 2.1 A/dm². The treatment temperature ranges from 26 to 35°C. The treatment time ranges between 5 and 15 minutes. This process is employed mostly for small and large reflectors and for jewelry.

[0006] Finally, the phosphoric acid/sulfuric acid process is a universally usable brightening process, since very good to satisfactory gloss effects can be achieved even for aluminum of poorer quality and for most alloys. Furthermore, this process is economically preferable to the other processes. In this case a solution of concentrated H₂SO₄ (sulfuric acid), concentrated H₃PO₄ (phosphoric acid) and HNO₃ (nitric acid) is used as electrolyte. Furthermore, small quantities of Al (aluminum) are added to the electrolyte. Typically there is used an electrolyte containing 70 vol % of H₂SO₄, 15 vol % of H₃PO₄, 0.5 to 10 vol % of HNO₃ and 15 vol % of water. The current density for the treatment generally ranges between 10 and 15 A/dm². The treatment temperature is typically 75 to 85°C. The treatment time typically ranges between 2 and 15 minutes. This phosphoric acid/sulfuric acid process is not suitable, however, for specular surfaces.

[0007] Starting from the brightening processes known in the prior art, it would therefore be desirable to have a brightening process that is as universally usable as possible for aluminum and aluminum alloys and that can be achieved with high gloss, especially for production of specular surfaces. It should also be possible to perform such a process economically.

DESCRIPTION OF THE INVENTION
[0008] The object of the present invention is to overcome the disadvantages mentioned hereinabove for brightening processes known in the prior art. This object is achieved according to the invention by a process for treatment of the surface of a workpiece of aluminum or of an aluminum alloy, wherein the workpiece is brightened in an aqueous electrolyte by application of an electric d.c. voltage, the electrolyte having the following composition per liter of water:

<table>
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<th>Component</th>
<th>Concentration</th>
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<tr>
<td>H₂SO₄ (sulfuric)</td>
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</tr>
<tr>
<td>Al (aluminum)</td>
<td>8.5 to 43 g/l</td>
</tr>
</tbody>
</table>

[0009] Surprisingly, it has been found that an increase in gloss by about 20 to 30% can be achieved for aluminum and its alloys by the inventive process in comparison with the conventional sulfuric acid/phosphoric acid method. The achieved gloss advantageously approaches the very high gloss of chromium, but without the serious problems that the toxic vapors and environmentally polluting wastewater associated with chromium cause for manufacturing technology and the ecology.

[0010] Furthermore, high-gloss aluminum and aluminum alloys are protected from further uncontrolled oxidation in air by the artificially produced oxide layer, and therefore are much easier to maintain than chromium. A further advantage is that additional brightening agents such as alcohols, nitritus and fluorides no longer need to be used to achieve high gloss on aluminum and its alloys. Thus health-endangering gases containing nitrogen oxides, which would otherwise be formed, are not produced during brightening.

[0011] In contrast to the electrolyte of the sulfuric acid/phosphoric acid process used in the prior art, the electrolyte of the inventive process has a much lower concentration of sulfuric acid, aluminum and water as well as a much higher concentration of phosphoric acid. Nitric acid is not used at all. The formation of health-endangering gases containing nitrogen oxides can be advantageously avoided by omitting the nitric acid. Because of the inventive composition of the
electrolyte, the aggressiveness of the brightening bath is diminished. Thus surface unevennesses, especially grain boundaries, are attacked less intensively; at the same time, however, substantially better gloss is achieved.

[0012] The concentration of \( \text{H}_2\text{SO}_4 \) (sulfuric acid) in water preferably ranges from 85 to 253 g/l and particularly preferably is approximately 170 g/l. The concentration of \( \text{H}_3\text{PO}_4 \) (phosphoric acid) in water preferably ranges from 1020 to 1360 g/l and particularly preferably is approximately 1090 g/l. Furthermore, the concentration of \( \text{Al} \) (aluminum) preferably ranges from 17 to 43 g/l.

[0013] As in the sulfuric acid/phosphoric acid brightening process known in the prior art, a sludge of aluminum sulfate is formed by the stripped aluminum in the inventive brightening process when the solubility product of sulfuric acid and aluminum has been exceeded. The precipitated aluminum compound can greatly impair the treatment of brightening of the workpiece, however, and must therefore be removed if its relative proportion becomes too high. This can be accomplished, for example, by filtering or decanting. Removal of the sludge leads to higher costs and possibly also to loss of time. Thus precipitation of the aluminum sulfate sludge must be prevented in any case.

[0014] Yet another effect, however, is also important: the dissolved aluminum reduces the aggressiveness of the brightening bath, but the consequence is that this effect is suddenly lost when the dissolved aluminum precipitates as sludge. Unfortunately, the suddenly increased aggressiveness of the brightening bath that ensues can lead to “gritiness” of the material because of the associated increased removal of material at the grain boundaries. For this reason also, therefore, it is necessary to ensure that as little aluminum sulfate as possible precipitates as sludge from the electrolyte solution.

[0015] As tests of the Applicant have shown, sludge precipitation can be expected if the concentration product of sulfuric acid and aluminum, which is proportional to the solubility product and is defined as the product of the concentrations of sulfate ions and aluminum ions divided by the square of the concentration of water and multiplied by 100, reaches a value higher than about 14.5. The concentration of sulfuric acid and aluminum in the electrolyte must therefore be chosen such that the said concentration product does not exceed this value if at all possible during the time of treatment of the workpiece. On the other hand, if the limit chosen for this concentration product is too low, optical impairment of the brightened workpiece in the form of “blue clouds” can be expected. These are formed when the viscous film, which causes the brightening bath to attack the raised structures of the surface, cannot be formed sufficiently at the metal-electrolyte interface. For this reason a compromise must be found between the said two effects.

[0016] A very advantageous embodiment of the invention therefore provides that the product of the concentrations of sulfate ions and aluminum ions divided by the square of the concentration of water and multiplied by 100 ranges from 8 to 15. Furthermore, this value preferably ranges from 9 to 12 and particularly preferably is approximately 9.4.

[0017] During the treatment of the workpiece of aluminum or of an aluminum alloy, the temperature of the aqueous electrolyte can range from 60 to 80\(^\circ\) C. and preferably ranges from 62 to 75\(^\circ\) C.

[0018] For electrobrightening of the workpiece, there is preferably applied a d.c. voltage of 12 to 45 V and in particular a d.c. voltage of 25 to 40 V. Typically 30 to 38 V is applied. In the stationary phase, the current density is estimated on the basis of material removal ranges from 1 to 5 A/dm\(^2\), and particularly preferably it is about 2.5 A/dm\(^2\). The initial current densities are usually much higher, however, and on the order of, for example, about 10 A/dm\(^2\).

[0019] For brightening of the workpiece of aluminum or aluminum alloy, the treatment time preferably ranges from 3 to 20 minutes. Depending on the aggressiveness of the electrolyte used for brightening, the actual time is determined by a compromise between, on the one hand, sufficient removal of material from the surface and, on the other hand, suppression of chemical attack at the grain boundaries and of the associated potential surface “gritiness”. A typical treatment time is on the order of about 10 minutes.

[0020] To achieve high gloss, the workpiece surfaces to be brightened are preferably mechanically polished before electrobrightening, in order to smooth out the surface roughnesses. Conventional polishing disks and polishing pastes can be used for this purpose. Since mechanical polishing leads to contamination, however, it should be followed by chemical cleaning of the polished surfaces of the workpiece.

[0021] Chemical cleaning can be accomplished by, for example, dipping the workpiece in a dip bath containing a mixture of phosphoric acid and surfactant in water, the phosphoric acid concentration preferably ranging from 30 to 50 g/l and the surfactant concentration from 2 to 6 g/l. The surfactant may be a mixture of anionic and nonionic surfactants. The dip bath preferably has a temperature of 60 to 67\(^\circ\) C. The treatment time normally ranges from 8 to 30 minutes and typically is about 10 minutes.

[0022] Chemical cleaning is used not only to remove the smut produced by mechanical polishing but also for completely degreasing the workpiece. A grease film on a surface to be brightened increases the electrical resistance and thus can make the surface locally inaccessible to the electric current at least temporarily. The consequence can be surface inhomogeneities of the brightened workpiece.

[0023] In general, the remaining traces of the chemical cleaning solution must be removed after chemical cleaning of the surfaces to be brightened. This is accomplished by, for example, rinsing with water. Preferably the workpiece is sprayed twice with water for this purpose: first with well water and then with demineralized water, to ensure that foreign ions are not entrained into the electrolytes of the brightening bath. Thereafter the workpiece pretreated in this way is transferred into the brightening bath and electrobrightened.

[0024] The electrobrightened surfaces of the workpiece must usually be subjected to a treatment to increase corrosion resistance. This is all the more important if the workpiece will be exposed without protection to weathering after being mounted. Corrosion resistance of the brightened surfaces can be imparted by anodizing.

[0025] For this purpose the brightened surfaces of the workpiece are first pickled and passivated after electrobrightening, and then are anodized and finally sealed.

[0026] Before pickling of the brightened surfaces is performed, the workpiece is usually rinsed with water, in order
in particular to prevent entrainment of phosphoric acid. Entrainment of phosphoric acid can adversely influence the subsequent anodizing process, where phosphate concentrations as low as the ppm level already cause considerable interference. After the brightened surfaces have been rinsed with water, several times if necessary, they are pickled, preferably by dipping the workpiece in a dip bath containing a solution of caustic soda (NaOH) and if necessary aluminum (Al) in water. In the pickling solution, the sodium hydroxide (NaOH) concentration preferably ranges from 30 to 40 g/l and the aluminum (Al) concentration preferably ranges from 0 to 15 g/l. This pickling solution typically has a temperature of about 60°C. The immersion time is typically about 15 to 20 seconds. The purpose of pickling is to remove the thin oxide film formed during brightening of the surfaces in preparation for subsequent anodizing. After pickling, the workpiece is rinsed with water once again to remove the traces of pickling solution. Well water can be used for this purpose.

After pickling, the brightened surfaces are passivated by, for example, dipping the workpiece in a passivating bath. The passivating bath can be a solution of nitric acid in water. The nitric acid concentration therein preferably ranges from 160 to 190 g/l. Instead of nitric acid, it is also possible to use sulfuric acid. This is additionally mixed with strong oxidizing agents, such as hydrogen peroxide. After passivation, the workpiece is rinsed with water once again, several times if necessary, to remove the remaining traces of the passivating solution.

Thereafter the brightened surfaces of the workpiece are anodized by dipping the workpiece in an aqueous electrolyte containing sulfuric acid (H₂SO₄) and aluminum (Al). The sulfuric acid concentration in the anodizing bath ranges from 100 to 200 g/l and preferably from 160 to 200 g/l, and particularly preferably is 180 g/l. The aluminum concentration in the anodizing bath ranges from 7 to 15 g/l and preferably from 9 to 13 g/l, and particularly preferably is 10 g/l. During anodizing, the aqueous electrolyte advantageously has a temperature of 5 to 25°C, particularly preferably about 18 to 19°C.

The anodic current density during anodizing ranges from 0.5 to 2.5 A/dm². The rate of growth of the anodized aluminum layer increases with current density. As tests of the Applicant have shown, the image definition of the brightened and anodized surfaces depends sensitively on the current density used: at high current density the image definition deteriorates greatly, and so low current densities are preferred according to the invention. A particularly preferred current density for anodizing is about 0.6 A/dm².

Depending on the thickness of the desired anodized aluminum layer, the workpiece is anodized for a period of 5 to 90 minutes, particularly preferably 5 to 25 minutes. As tests of the Applicant have shown, the density of the anodized aluminum layer also has a substantial influence on the image definition of the polished and anodized surfaces: the image definition deteriorates at large thicknesses of the anodized aluminum layer, and so the preferred thickness of the produced anodized aluminum layer advantageously ranges from 3 to 15 μm. If the purpose of the anodized aluminum layer is exclusively to impart corrosion protection to the brightened surface, a thickness on the order of about 5 μm is sufficient. If the anodized aluminum layer is to be colored, however, its thickness should be greater than 5 μm. A particularly preferred thickness of the anodized aluminum layer therefore ranges from 3 to 10 μm.

After the treatment time has elapsed, the workpiece is removed from the anodizing bath and is rinsed at room temperature with water, several times if necessary. The purpose in particular is to remove acid still present in the pores of the anodized aluminum layer.

Thereafter the anodized surfaces are sealed, preferably by cold impregnation and hot-water compaction in two successive steps. For cold impregnation the workpiece is immersed in a bath which typically contains an aqueous solution of nickel fluoride (NiF-) in a concentration of about 2 to 6 g/l. At this time the bath preferably has a temperature of about 30°C. The immersion time is at most 4 minutes. After removal from this bath, the workpiece is rinsed with water, several times if necessary. During subsequent hot-water compaction, the workpiece is usually immersed for a period of 20 to 40 minutes in a bath containing demineralized water at a temperature of at least 95°C. Usually coating-inhibiting agents are also added to the hot-water compaction bath. These agents can comprise, for example, a mixture of different anionic and nonionic surfactants and amorphous aluminum hydroxide or aluminum oxide in different mixing ratios.

A preferred embodiment of the invention provides that the brightened surfaces of the workpiece be colored after anodizing. Conventional techniques can be used for coloring, especially electrolytic coloring techniques, absorptive coloring techniques and hydrolytic coloring techniques.

In the electrolytic coloring techniques, pigments are electrolytically generated from metal salts in the anodized aluminum layer. Suitable metal salts are in particular sulfates of tin(II), nickel, cobalt, copper, manganese, silver and selenium. Usually sulfuric acid and organic stabilizers are additionally introduced into the electrolytes, in order to ensure stable conductance of the electrolytes while preventing oxidation of the metal salts and achieving a homogeneous current distribution. Depending on the desired shade of color, the residence time in the dip bath usually ranges between 30 seconds and 10 minutes; the temperature of the dip bath is maintained at room temperature.

In the adsorptive coloring techniques, organic dyes are sprayed in the form of a dye solution onto the brightened surfaces or the workpiece is immersed in the dye solution. Depending on the desired shade of color, the residence time in the dip bath usually ranges between 1 and 20 minutes. The maximum temperature of the dip bath is 60°C.

Finally, in the hydrolytic coloring technique, the workpiece is immersed in, for example, a solution of sodium or ammonium ferrioxalate. Depending on the desired shade of color, the residence time in the dip bath usually ranges between 30 seconds and 20 minutes. The maximum temperature of the dip bath is 60°C.

After coloring, the workpiece is rinsed with water, several times if necessary, and then sealed by cold impregnation and hot-water compaction, as described hereinabove.

An alternative embodiment of the invention provides for application of a clear lacquer instead of anodizing...
the surfaces in order to impart corrosion resistance to the brightened surfaces. For this purpose the brightened surfaces of the workpiece are directly coated with a highly transparent clear lacquer immediately after electrobrightening. Similarly, it is possible to pickle and passivate the brightened surfaces of the workpiece. In this case, however, after passivation and before lacquering, the brightened surfaces of the workpiece must first be provided with an adhesion promoter, especially in the form of a compound based on chromium (Cr).

[0040] The individual process steps of the versions of the invention described hereinabove will be presented once again in the following overviews:

[0041] Version 1)

[0042] mechanical polishing→chemical cleaning→brightening→pickling→passivating→anodizing→scaling

[0043] Version 2)

[0044] mechanical polishing→chemical cleaning→brightening→pickling→passivating→anodizing→coloring→scaling

[0045] Version 2) corresponds to version 1), with the exception that a coloring step is additionally inserted after anodizing.

[0046] Version 3)

[0047] mechanical polishing→chemical cleaning→brightening→applying clear lacquer

[0048] In contrast to versions 1) and 2), in version 3) a clear varnish is applied onto the workpiece directly after brightening.

[0049] Version 4)

[0050] mechanical polishing→chemical cleaning→brightening→pickling→passivating→applying adhesion promoter→applying clear lacquer

[0051] Version 4) corresponds to version 3), with the exception that pickling and passivating are performed after brightening and, in addition, an adhesion promoter is applied on the workpiece.

[0052] For clarity, the rinsing processes were not mentioned in any of the versions.

[0053] The invention will now be described on the basis of several examples with reference to the attached diagram (FIG. 1). In all examples, the workpieces were treated according to version 1) of the invention.

[0054] FIG. 1 shows a diagram of the dependence of image definition (A) of the surfaces of an aluminum workpiece brightened according to the invention on layer thickness (s) of the anodized aluminum layer and on the current density applied during anodizing, the image definitions of a workpiece brightened by a brightening process known in the prior art (curve 4) and of chromium (curve 1) being illustrated for comparison.

EXAMPLE 1

[0055] In this example, a brightening bath employed herefore by the Applicant for brightening the surfaces of aluminum workpieces was used for the purposes of comparison with the inventive process. The aqueous electrolyte of the brightening bath had the following composition relative to 1 liter of water:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HSO₄ (sulfuric acid)</td>
<td>about 408 g/l</td>
</tr>
<tr>
<td>H₃PO₄ (phosphoric acid)</td>
<td>about 697 g/l</td>
</tr>
<tr>
<td>Al (aluminum)</td>
<td>about 37.4 g/l</td>
</tr>
</tbody>
</table>

[0056] The workpieces functioned as the anode in this case. A d.c. voltage of about 30 V was applied for brightening. The brightening time was about 10 minutes; the temperature of the brightening bath was adjusted to about 62°C.

[0057] Before brightening, the aluminum workpiece was mechanically polished and then chemically cleaned, in order to remove, from the surface to be brightened, the smut and other contaminants, including grease, caused by polishing. For chemical cleaning the workpiece was immersed in a dip bath containing an aqueous solution of a mixture of phosphoric acid and surfactant. The workpiece was then sprayed twice with water, using well water first and then demineralized water.

[0058] After brightening, the aluminum workpiece was anodized in an aqueous electrolyte of the following composition relative to 1 liter of water:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂SO₄ (sulfuric acid)</td>
<td>about 100 g/l</td>
</tr>
<tr>
<td>Al (aluminum)</td>
<td>about 11 g/l</td>
</tr>
</tbody>
</table>

[0059] The thickness of the anodized aluminum layer of the anodized workpieces varied depending on treatment time. For an anodized aluminum layer with a thickness of about 10 µm, a treatment time of about 35 minutes was necessary. The current density for anodizing was 0.7 A/dm² and the temperature of the electrolyte was 18°C.

[0060] After anodizing, the image definitions of the polished and anodized surfaces of the workpieces were determined photometrically. The results of these measurements are presented as curve 4 in FIG. 1.

[0061] As is evident from curve 4 in FIG. 1, the image definition of an aluminum workpiece brightened by a brightening process used in the prior art was about 73% without an anodized aluminum layer. This image definition decreased to about 65% after application of an anodized aluminum layer having a thickness of about 10 µm.

EXAMPLE 2

[0062] In Example 2, an aluminum workpiece was treated as in Example 1, with the difference that, in accordance with the invention, there was used for brightening an aqueous electrolyte that had the following composition relative to 1 liter of water:
### [0063] The temperature of the brightening bath was about 69°C. The brightened workpiece was then anodized for different times at a current density of about 0.6 A/dm². The treatment times for anodizing were 17 and 35 minutes respectively. All other parameters and process steps correspond to those of Example 1. The results of the photometric measurement of the image definition of the brightened surfaces are presented in curve 2 of FIG. 1.

### [0064] As is evident from curve 2 in FIG. 1, the image definition of an aluminum workpiece brightened according to the invention was about 96% without an anodized aluminum layer. This image definition decreased to about 90% after application of an anodized aluminum layer having a thickness of about 3 µm and to about 88% after application of an anodized aluminum layer having a thickness of about 7 µm.

### EXAMPLE 3

### [0065] Same as Example 2, with the difference that, in accordance with the invention, there was used an aqueous electrolyte that had the following composition relative to 1 liter of water:

<table>
<thead>
<tr>
<th>H₂SO₄ (sulfuric acid)</th>
<th>about 182 g/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₃PO₄ (phosphoric acid)</td>
<td>about 1156 g/l</td>
</tr>
<tr>
<td>Al (aluminum)</td>
<td>about 21.6 g/l</td>
</tr>
</tbody>
</table>

### [0066] In contrast to Example 2, the temperature of the brightening bath was about 62°C. The brightened workpiece was then anodized for different times at a current density of about 0.6 A/dm². The treatment times for anodizing were 9 and 46 minutes respectively. The results of the photometric measurement of the image definition of the brightened surfaces are presented in curve 3 of FIG. 1.

### [0067] As is evident from curve 3 in FIG. 1, the image definition of an aluminum workpiece brightened according to the invention was about 93% after application of an anodized aluminum layer having a thickness of about 2 µm, decreasing to about 86% after application of an anodized aluminum layer having a thickness of about 9 µm.

### EXAMPLE 4

### [0068] Same as Example 3, with the difference that the brightened workpiece was anodized for different times at a current density of about 2.0 A/dm². The treatment times for anodizing were 6 and 15 minutes respectively. The results of the photometric measurement of the image definition of the brightened surfaces are presented in curve 5 of FIG. 1.

### [0069] As is evident from curve 5 in FIG. 1, the image definition of an aluminum workpiece brightened according to the invention was about 74% after application of an anodized aluminum layer having a thickness of about 5 µm, decreasing to about 55% after application of an anodized aluminum layer having a thickness of about 10 µm, when anodizing was performed with a high current density of 2.0 A/dm².

[0070] As the result of the tests performed in the foregoing examples, it can be observed firstly that the image definitions of the workpieces brightened in Examples 1, 2, 3 and 4 depend on the thickness of the produced anodized aluminum layer as well as on the anodic current density used for anodizing. From Examples 2, 3 and 4 it is evident that an image definition very close to that of chromium can be achieved by employing the inventive process in combination with subsequent anodizing at low current density (about 0.6 A/dm² in this case) to apply an anodized aluminum layer in a thickness up to about 10 µm. For comparison with these results, the image definition of chromium (about 99%), which does not have an anodized aluminum layer, is illustrated as curve 1 in FIG. 1.

[0071] When the surface of a workpiece of aluminum or of an aluminum alloy has been brightened and anodized according to the invention, meaning that it is also corrosion resistant, the workpiece can practically no longer be distinguished with the naked eye from a corresponding workpiece of chromium. This is true in particular for a layer thickness of about 5 µm, which is regarded in the automobile industry as the minimum layer thickness for external applications.

[0072] A preferred use of the inventive process for treatment of surfaces of workpieces of aluminum or aluminum alloys is in the production of reflecting surfaces for lighting equipment, such as headlight reflectors, louvered lights and the like.

[0073] A further preferred use of the inventive process for treatment of surfaces of workpieces of aluminum or aluminum alloys lies in the manufacture of high-gloss workpieces in the automobile industry. In particular, decorative trim formerly made from chrome can now be replaced by decorative trim of aluminum and aluminum alloys, brightened according to the invention.

We claim:

1. A process for treatment of the surface of a workpiece of aluminum or of an aluminum alloy, comprising the steps of brightening the workpiece in an aqueous electrolyte by applying an electric d.c. voltage, the electrolyte having the following composition per liter of water:

<table>
<thead>
<tr>
<th>H₂SO₄ (sulfuric acid)</th>
<th>85 to 340 g/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₃PO₄ (phosphoric acid)</td>
<td>850 to 1360 g/l</td>
</tr>
<tr>
<td>Al (aluminum)</td>
<td>8.5 to 43 g/l</td>
</tr>
</tbody>
</table>

2. A process according to claim 1, wherein the concentration of H₂SO₄ (sulfuric acid) in the electrolyte ranges from 85 to 255 g/l.

3. A process according to claim 1, wherein the concentration of H₃PO₄ (phosphoric acid) ranges from 1020 to 1360 g/l in the electrolyte.

4. A process according to claim 1, wherein the concentration of Al (aluminum) ranges from 17 to 43 g/l in the electrolyte.

5. A process according to claim 1, wherein the product of the concentrations of sulfate ions and aluminum ions divided...
by the square of the concentration of water and multiplied by 100 has a value of between 8 and 15.

6. A process according to claim 5, wherein the product of the concentrations of sulfate ions and aluminum ions divided by the square of the concentration of water and multiplied by 100 has a value of between 9 and 12.

7. A process according to claim 1, wherein the temperature of the aqueous electrolyte during brightening of the workpiece ranges from 60 to 80°C.

8. A process according to claim 1, wherein the d.c. voltage for electrobrightening of the workpiece ranges from 12 to 45 V.

9. A process according to claim 1, wherein the treatment time for electrobrightening of the workpiece ranges from 3 to 20 minutes.

10. A process according to claim 1, wherein the workpiece surfaces to be brightened are mechanically polished and then chemically cleaned before electrobrightening.

11. A process according to claim 10, wherein the workpiece surfaces to be brightened are chemically cleaned in a bath containing an aqueous solution of a mixture of phosphoric acid and surfactant.

12. A process according to claim 1, wherein the brightened surfaces of the workpiece are pickled, passivated, anodized and then sealed after electrobrightening.

13. A process according to claim 12, wherein the brightened surfaces of the workpiece are pickled in a solution of caustic soda (NaOH) and if necessary aluminum (Al) in water.

14. A process according to claim 13, wherein the sodium hydroxide (NaOH) concentration ranges from 30 to 40 g/l and the aluminum (Al) concentration ranges from 0 to 15 g/l in the pickling solution.

15. A process according to claim 12, wherein the pickled surfaces of the workpiece are passivated in a solution of nitric acid in water.

16. A process according to claim 15, wherein the nitric acid concentration ranges from 160 to 190 g/l.

17. A process according to claim 12, wherein the brightened surfaces of the workpiece are anodized in an aqueous electrolyte containing sulfuric acid (H₂SO₄) and aluminum (Al).

18. A process according to claim 17, wherein the sulfuric acid concentration ranges from 100 to 400 g/l and the aluminum concentration ranges from 7 to 15 g/l.

19. A process according to claim 12, wherein during anodizing, the aqueous electrolyte has a temperature of 5 to 25°C.

20. A process according to claim 12, wherein the anodic current density during anodizing ranges from 0.5 to 2.5 A/dm².

21. A process according to claim 12, wherein the workpiece is anodized for a period of 5 to 90 minutes.

22. A process according to claim 12, wherein the thickness of the anodized aluminum layer ranges from 3 to 15 μm.

23. A process according to claim 12, wherein the anodized surfaces of the workpiece are sealed by cold impregnation and hot-water compaction.

24. A process according to claim 12, wherein the brightened surfaces of the workpiece are colored after anodizing.

25. A process according to claim 1, wherein the brightened surfaces of the workpiece are coated directly with a clear lacquer after electrobrightening.

26. A process according to claim 1, wherein the brightened surfaces of the workpiece are pickled, passivated, provided with an adhesion promoter and then coated with a clear lacquer after electrobrightening.

27. A process according to claim 1, wherein the concentration of H₃PO₄ (phosphoric acid) is approximately 170 g/l.

28. A process according to claim 1, wherein the concentration of H₂SO₄ (sulfuric acid) is approximately 1088 g/l in the electrolyte.

29. A process according to claim 5, wherein the product of the concentrations of sulfate ions and aluminum ions divided by the square of the concentration of water and multiplied by 100 has a value of approximately 9.4.

30. A process according to claim 1, wherein the temperature of the aqueous electrolyte during brightening of the workpiece ranges from 62 to 75°C.

31. A process according to claim 1, wherein the d.c. voltage for electrobrightening of the workpiece ranges from 25 to 40 V.

32. A process according to claim 1, wherein the d.c. voltage for electrobrightening of the workpiece ranges from 30 to 38 V.

33. A process according to claim 1, wherein the treatment time for electrobrightening of the workpiece is about 10 minutes.

34. A process according to claim 17, wherein the sulfuric acid concentration ranges from 160 to 200 g/l, and the aluminum concentration ranges from 9 to 13 g/l.

35. A process according to claim 17, wherein the sulfuric acid concentration is 180 g/l and the aluminum concentration is 10 g/l.

36. A process according to claim 12, wherein during anodizing, the aqueous electrolyte has a temperature of about 18 to 19°C.

37. A process according to claim 12, wherein the anodic current density during anodizing is about 0.6 A/dm².

38. A process according to claim 12, wherein the workpiece is anodized for a period of 5 to 25 minutes.

39. A process according to claim 12, wherein the thickness of the anodized aluminum layer ranges from 5 to 10 μm.

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