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(54) **ELECTROPLATED PRODUCT AND METHOD FOR PREPARING SUCH PRODUCTS WITH A HIGH TEMPERATURE TREATMENT**

(57) The present invention refers to a method for preparing an electroplated product by applying different steps, i.a. a heat treatment step, to obtain a product that

is resistant to the white haze effect. Moreover, the invention refers to such electroplated products.

Fig. 1



Description

[0001] The present invention refers to a method for preparing an electroplated product by applying different steps, i.a. a heat treatment step, to obtain a product that is resistant to the white haze effect. Moreover, the invention refers to such electroplated products.

[0002] Zinc and zinc alloys are common materials used for plating in many applications. They offer a good corrosion resistance especially for the zinc alloy with a competitive price.

[0003] To enhance the properties of this first metal layer, it is common to use a conversion layer (i.e. a passivation layer) on top of the zinc or zinc alloy. Among those conversion, chromium salts are widely used in the industry for conversion layers. Hexavalent chromium salts were historically used for conversion layers on zinc or zinc alloys but this substance is under regulatory pressure due to its toxic nature. In consequence, trivalent chromium conversion layers have gained more and more popularity. The colour of the chromating layers can be varied by composition of the solutions and by the working parameters in the treatment. A black trivalent chromium conversion layer can be obtained. Those types of passivation layers are widely used in the automotive industry and especially for screws and other fasteners.

[0004] Unfortunately, black pigmented passivation layers do not bear the same corrosion protection as it is found in non-pigmented, so called clear or iridescent conversion layers. The black pigments do not contribute to corrosion protection and to some extent may interfere with the barrier functionality.

[0005] The black passivation layers are in particular prone to a phenomenon called white haze. This is in particular true in a corrosive environment resulting in a white grey layer appearing on the passivation layer. It poses a problem since this change of appearance makes the detection of white rust quite difficult. Hence, there is a need for a process to obtain a better resistance to white haze.

[0006] US9567453B2 discloses a water-soluble finishing agent for a trivalent chromium chemical conversion coating film, which has low insulation, no problems with tightening properties, outstanding gloss and high corrosion resistance, and can obtain a trivalent chromium chemical conversion coating film, in particular a black trivalent chromium chemical conversion coating film, having few scratches and flaws.

[0007] JP2008255408A discloses a chemical conversion coating on zinc or zinc alloy that is composed of an aqueous solution of pH 3 to 9 containing a heated reaction product in an amount of 0.1 to 10 g/L in terms of a chromium metal amount, the heated reaction product being obtained by bringing at least one kind of carboxylic acids selected from a group consisting of carboxylic acid, the ammonium salt of carboxylic acid and the acid adduct salt of amino carboxylic acid, and a trivalent chromium compound.

[0008] WO2015036124 discloses a treatment solution for a method for producing an anti-corrosion coating layer on a metal surface, wherein the surface to be treated is brought in contact with a treatment solution, which contains a chromium(III) ion source, a phosphate source, a zinc ion source, and a citrate source, wherein the amount-of-substance ratio of chromium(III) ions to zinc ions is 1 to at least 1.65 and the amount-of-substance ratio of chromium(III) ions to citrate is 1 to at least 1.4 and the treatment solution is substantially free of polymers that can be obtained by reacting one or more alkoxysilanes of the formula: $R_4-xSi(OR_1)_x$.

[0009] US9499700B2 discloses a finishing agent satisfying a condition that (A) the ratio of the chromium equivalent molar concentration of a water-soluble trivalent chromium-containing substance contained in the finishing agent relative to the phosphorus equivalent molar concentration of a water-soluble phosphoric acid-based compound contained in the finishing agent is at least 0.5, or a condition that (B) a water-soluble aluminum-containing substance and/or a water-soluble zirconium-containing substance are contained in the finishing agent.

[0010] WO201100969A1 discloses a method for producing an anti-corrosive cover layer, a surface to be treated being brought into contact with an aqueous treatment solution containing chromium(III) ions and at least one phosphate compound and an organosol. The method improves the anti-corrosion protection of metal, in particular zinc-containing surfaces and zinc-containing surfaces provided with conversion layers. This produces or improves the decorative and functional properties of the surfaces.

[0011] None of those prior art documents has focused on the improvement of the resistance to white haze for trivalent chromium passivation.

[0012] When starting from this prior art, there are many different trivalent chromium layers with a finishing agent to enhance the properties of the compound, in particular regarding corrosion resistance. However, it is known that such layers are temperature sensitive since thermal treatments have the drawback to lower the corrosion resistance by generating cracks in the passivation layer. In consequence, according to the prior art, only drying steps with moderate temperatures around 80-120°C for a short period of time around 10 minutes have been performed up to now.

[0013] It was therefore an object of the present invention to provide electroplated products having a trivalent chromium passivation layer without showing any white haze.

[0014] This problem is solved by the method for preparing an electroplated product with the features of claim 1 and the electroplated product with the features of claim 13. The further dependent claims mention preferred embodiments.

[0015] According to the present invention a method for preparing an electroplated product by electroplating a substrate

is provided comprising the following steps:

- a) Electroplating a substrate with a first metal layer comprising or consisting of zinc or a zinc alloy with an electrolyte comprising at least one source of zinc ions,
- b) Depositing a black passivation layer on the first metal layer wherein the black passivation layer comprises trivalent chromium ions,
- c) Depositing a finishing agent layer on the black passivation layer,
- d) Drying of the layers at temperatures from 60 to 120 °C for 1 minutes to 20 minutes.

[0016] The trivalent chromium ions of the passivation layer are especially present in the form of at least one trivalent chromium compound.

[0017] In a preferred embodiment, after the heating in step d), in a further step e), a heating of the layers at temperatures from 150°C to 250°C for 20 minutes to 15 hours is conducted.

[0018] Surprisingly, it has been found that a thermal treatment for a longer duration with a higher temperature (at least 150°C) increased the resistance to white haze if it was done after the deposition of the finishing agent layer. It is also possible to add an additional top coating if dedicated surface properties like friction, wear resistance etc. are required.

[0019] In a preferred embodiment, the zinc alloy of the first metal layer is selected from the group consisting of zinc nickel alloys, zinc iron alloys and zinc nickel iron alloys.

[0020] In a more preferred embodiment, the first metal layer comprises a zinc nickel alloy with from 10 wt.-% to 20 wt.-% of nickel, preferably from 11 wt.-% to 18 wt.-% of nickel, more preferably from 12 wt.-% to 15 wt.-% of nickel, or consists thereof.

[0021] In a more preferred embodiment, the first metal layer comprises a zinc iron alloy with from 2 wt.-% to 18 wt.-% of iron, preferably 7 wt.-% to 16 wt.-% of iron, more preferably 8wt.-% to 16 wt.-% of iron, or consists thereof.

[0022] It is preferred that the heating in step e) is conducted at temperatures from 160 to 240°C, preferably from 175 to 220°C.

[0023] In a preferred embodiment the heating in step e) is conducted for 1 hour to 15 hours, preferably 2 hours to 10 hours, more preferably 3 hours to 9 hours.

[0024] Preferably, after the heating in step e), or the drying in step d), in a further step f), a top coat layer is deposited on the finishing agent layer, wherein the top coat layer preferably comprises a polymer and/or a colloidal corrosion inhibitor and/or a wax.

[0025] In a preferred embodiment, the passivation layer and/or the finishing agent layer is free of cobalt. The presence of cobalt ion in the bath is a source of health issue.

[0026] In a preferred embodiment, the passivation layer and/or the finishing agent layer comprise(s) cobalt.

[0027] In a preferred embodiment, the finishing agent layer comprises a wax or a non-wax friction adjuster, preferably a substance selected from the group consisting of polyethylene (PE), polypropylene (PP), polytetrafluoroethylene (PTFE), ethylenetetrafluoroethylene (ETFE), perfluorinated polyethers (PFPE), polyvinylidene fluoride (PVDF), tetrafluoroethylene / hexafluoroethylene copolymer (FEP), perfluoroalkoxy copolymer (PFA), polysulfones, MoS₂, WS₂, TiS₂, BN graphite, polyvinylchloride (PVC), polystyrene (PS), metacrylate resin, polycarbonate (PC), polyamide (PA), polyimide (PI), polyacetal, fluororesin, urea resin, phenol resin, unsaturated polyester resin, polyurethane, alkyd resin, epoxy resin, melamine resin, paraffin, carnauba wax and combinations thereof.

[0028] The above mentioned substances advantageously increase the wear resistance of surfaces and allow obtaining advantageous sliding properties such as a low coefficient of friction.

[0029] It is preferred that the finishing agent layer comprises trivalent chromium ions and/or phosphate ions and/or zinc ions and/or citrate ions. The finishing agent layer can comprise (trivalent) chromium compounds and/or zinc compounds.

[0030] The first metal layer has preferably a thickness from 1 μm to 20 μm. The black passivation layer has preferably a thickness from 0.05 μm to 1 μm. The finishing agent layer has preferably a thickness from 0.1 μm to 1 μm. The top coat layer has preferably a thickness from 0.1 μm to 2 μm. Regarding the effect of the white haze, a higher thickness of the passivation layer and the finishing agent layer results in an improved appearance of the electroplated products.

[0031] In a preferred embodiment, the drying step d) is conducted at temperatures of 60 to 100°C, preferably at temperatures of 70 to 90°C. The drying step is conducted preferably for 5 to 15 minutes.

[0032] It is preferred that the inventive method provides electroplated products being able to pass the Neutral Salt Spray (NSS) test according ISO 9227 according to the VW standard TL 244 requirements and/or RNES - B - 0059 Renault Nissan requirements up to 168 hours without any optical change of aspect of the electroplated product.

[0033] Moreover, also an electroplated product is provided comprising

- a) a first metal layer comprising or consisting of a zinc or a zinc alloy,
- b) a black passivation layer comprising chromium (i.e. trivalent chromium ions), and
- 5 c) a finishing agent layer.

[0034] The black passivation layer according to the present invention has an L value lower than 40 and the electroplated product passes NSS test according ISO 9227 according to the VW standard TL 244 requirements and/or RNES - B - 0059 Renault Nissan requirements up to 168 hours without any optical change of aspect of the electroplated product.

[0035] It is preferred that the black passivation layer has an L value lower than 30, preferably lower than 25.

[0036] The first metal layer has preferably a thickness from 1 μm to 20 μm . The black passivation layer has preferably a thickness from 0.05 μm to 1 μm . The finishing agent layer has preferably a thickness from 0.1 μm to 1 μm . The top coat layer has preferably a thickness from 0.1 μm to 2 μm .

[0037] It is preferred, that the finishing agent layer comprises chromium ions and/or phosphate ions and/or zinc ions and/or citrate ions. The finishing agent layer can comprise (trivalent) chromium compounds and/or zinc compounds.

[0038] In a preferred embodiment, the finishing agent layer comprises a wax or a non-wax friction adjuster, preferably a substance selected from the group consisting of polyethylene (PE), polypropylene (PP), polytetrafluoroethylene (PTFE), ethylenetetrafluoroethylene (ETFE), perfluorinated polyethers (PFPE), polyvinylidene fluoride (PVDF), tetrafluoroethylene / hexafluoroethylene copolymer (FEP), perfluoroalkoxy copolymer (PFA), polysulfones, MoS_2 , WS_2 , TiS_2 , BN graphite, polyvinylchloride (PVC), polystyrene (PS), metacrylate resin, polycarbonate (PC), polyamide (PA), polyimide (PI), polyacetal, fluororesin, urea resin, phenol resin, unsaturated polyester resin, polyurethane, alkyd resin, epoxy resin, melamine resin, paraffin, carnauba wax, polymers of the esters of acrylic acid and combinations thereof.

[0039] In a preferred embodiment, a top coat layer is deposited on the finishing agent layer as a finish, wherein the top coat layer preferably comprises a polymer and/or a colloidal corrosion inhibitor and/or a wax or a non-wax friction adjuster.

[0040] In a more preferred embodiment, the top coat layer allowed that the coefficient of friction can be adjusted between 0.09 to 0.15 or 0.12 to 0.18.

[0041] It is preferred that the wax comprised in the top coat are polyethylene waxes (in the form of an emulsion). Waxes advantageously increase the wear resistance of surfaces and allow obtaining advantageous sliding properties such as a low coefficient of friction.

[0042] It is preferred that the polymer comprised in the top coat are the acrylic copolymers of the type methacrylic or vinylic resins. These are polymers of the esters of acrylic acid or methacrylic acid and may have as alcohol component an unsubstituted alkyl group or substituted by functional groups, for example methyl, ethyl, propyl, isopropyl, n-butyl, isobutyl, tert-butyl, pentyl and hexyl and their isomers and higher homologues, 2-ethylhexyl acrylate, phenoxyethyl, hydroxyethyl, 2-hydroxypropyl, caprolactone hydroxyethyl or dimethylaminoethyl.

[0043] It is preferred that the colloidal corrosion inhibitor comprised in the top coat is silicon dioxide.

[0044] With reference to the following figures and examples, the subject-matter according to the present invention is intended to be explained in more detail without wishing to restrict said subject-matter to the specific embodiments shown here.

Fig.1 shows a photo of samples 1 to 4 after a NSS test of 912h.

Fig.2 shows a photo of samples 5 to 8 after a NSS test of 912h.

Fig.3 shows a photo of sample 4 after a NSS test of 240h.

Fig.4 shows a photo of samples 9, 10, 4, 11, 12 and 2 after a NSS test of 1008h.

Fig.5 shows a photo of samples 13 to 15 after a NSS test of 240h.

Fig.6 shows a photo of sample 16 after a NSS test of 240h.

Fig.7 shows a photo of sample 17 after a NSS test of 240h.

Fig. 8 shows a comparison of the coefficient of friction for samples 12 (on the left) , 19 (in the middle) and 20 (on the right)

Fig. 9 shows a photo of sample 20 after a NSS test of 240h.

Examples

Samples preparation:

[0045] The plating is conducted on a steel substrate screw or steel plate.

[0046] The first metal layer is composed of zinc nickel alloy with a nickel content of 12 to 15 weight% and a thickness of 8 to 10 μm on the head of the screw or is composed of a zinc iron alloy with an iron content of 12 to 14 weight%. As an alternative to the examples of this experiment, the iron content could be chosen to be in the range of 8 to 14 weight%. As an option, an activation with a 0.1% HCl solution is conducted subsequently. More detail protocol on the plating bath can be found in the examples of the patent WO2005073438A1.

[0047] The conversion layer is deposited by dipping the screw or panel plated in step 1 during 60 seconds in a trivalent chromium cobalt-free solution at a pH of 2.0 and a temperature around 25°C followed by a rinsing step with water.

[0048] The finishing agent layer is deposited for 15 seconds with a solution at a pH of 4.3 and a temperature around 25°C followed by a drying step for 10 minutes at 80°C in a centrifuge. After the deposition of the finishing agent layer no further rinsing step is necessary.

[0049] For samples 18, 19 and 20, the finishing agent layer comprised of cobalt, for the other samples there were cobalt free.

[0050] For samples 19 and 20, a solution of 50ml/L of wax was added during the deposition of the finishing agent layer.

[0051] Optionally, the deposition of a top-coat layer is conducted by dipping in a polymer, colloidal corrosion inhibitor, and a wax solution followed by a drying step for 10 minutes at 80°C in a centrifuge.

[0052] The thermal treatment (TTH) step of the samples has been conducted in an oven at different steps of the process with different temperatures and durations.

[0053] Colour coordinates have been determined according to UNI EN ISO 8654:2018 on a Minolta CM-503i spectrophotometer. As illuminant daylight D65 (6500K) with an included reflective component (sci) has been used. The observer was set at standard (10°) and the measurements were conducted in the colour space CIE L*a*b*. The instrument has been calibrated before the measurement with a black (L = 0) and with a white (L = 100) standard. For the different samples a L value from 25 to 29 was obtained.

[0054] Coefficient of friction were measured according to ISO 16047 (DIN EN ISO 16047).

[0055] The samples prepared according to different methods are presented on the Table 1 below.

Table 1 (Sample preparation)

Sample	ZnNi/ ZnFe	Activation with HCl	Top coat	TTH	Thermal shock before NSST
1	ZnNi	No	No	No	No
2	ZnNi	No	No	Yes After Post Dip 8h 200°C	No
3	ZnNi	No	Yes	No	No
4	ZnNi	No	Yes	Yes After Post Dip Before Top Coat 8h 200°C	No
5	ZnNi	No	No	No	Yes 2h 120°C
6	ZnNi	No	No	Yes After Post Dip 8h 200°C	Yes 2h 120°C
7	ZnNi	No	Yes	No	Yes 2h 120°C
8	ZnNi	No	Yes	Yes After Post Dip Before Top Coat 8h 200°C	Yes 2h 120°C
9	ZnNi	No	Yes	Yes After ZnNi before Passivation 8h 200°C	No
10	ZnNi	No	Yes	Yes After Passivation Before Finishing agent 8h 200°C	No
11	ZnNi	No	No	Yes After ZnNi Before Passivation 8h 200°C	No
12	ZnNi	No	No	Yes After Passivation Before Finishing agent 8h 200°C	No

(continued)

Sample	ZnNi/ ZnFe	Activation with HCl	Top coat	TTH	Thermal shock before NSST
13	ZnNi	No	Yes	Yes After Post Dip Before Top Coat 4h 120°C	No
14	ZnNi	No	Yes	Yes After Post Dip Before Top Coat 4h 200°C	No
15	ZnNi	No	Yes	Yes After Post Dip Before Top Coat 8h 120°C	No
16	ZnFe	No	No	No	No
17	ZnFe	No	No	Yes After Post Dip 8h 200°C	No
18	ZnNi	No	No	Yes After Passivation Before Finishing agent 8h 200°C	No
19	ZnNi	No	No	Yes After Passivation Before Finishing agent 8h 200°C	No
20	ZnNi	No	No	Yes After Passivation Before Finishing agent 8h 200°C	No

White haze resistance

[0056] The white haze resistance was evaluated by the resistance to the Neutral Salt Spray (NSS) Test. Those experiments were conducted with a Braive 2000L corrosion chamber following the norm ISO 9227.

[0057] The different samples were submitted to different durations according to the NSS to evaluate their corrosion resistance.

[0058] The first test were set to be in line with the VW standard TL 244 requirements and/or RNES - B - 0059 Renault Nissan. So, the duration was set around 200 hours. To assess the white haze resistance, we observed the samples and noted the severity of white haze (WH).

[0059] The results from those tests are presented on Table 2 below and also on the Fig. 3, 5, 6 and 7.

Table 2 (NSS Test results)

Sample	Duration of the NSS test (in hours)	WH
4	240	No
13	240	Medium
14	240	No
15	240	Medium
16	240	Important
17	240	No

[0060] It was observed that the best results regarding WH resistance were realised for the examples in which the TTH step was performed after the deposition of the finishing agent layer.

[0061] It was further investigated to lower the time and temperature of the TTH step (samples 13, 14 and 15). It was observed that the duration of the TTH step can be reduced, but when reducing the temperature of the TTH step, an obvious WH was observed. The best results were observed at a temperature of approx. 200°C.

[0062] With those results, further tests were conducted to assess the WH resistance with longer time in the NSS test chamber.

[0063] The results from those tests are presented in Table 3 below and also in the Figs. 1, 2 and 4.

Table 3 (NSS Test results)

Sample number	Duration of the NSS test (in hours)	WH
1	912	Important
2	912	No
3	912	Important
4	912	No
5	912	Important
6	912	Slight
7	912	Important
8	912	No
9	1008	Important
10	1008	Slight
4	1008	No
11	1008	Medium
12	1008	Slight
2	1008	No
18	1008	No

[0064] It has been observed that a drying step before the TTH does not improve the appearance significantly. Moreover, the addition of a top coat does not change the WH resistance. Also after 1008 hours in the NSS no WH occurred.

[0065] Finally, an increase of WH resistance after the TTH work for a first metal layer of ZnNi and ZnFe, so it seems that the alloy of the first layer does not impact the WH resistance.

Wax influence on coefficient of friction with and without heat treatment

[0066] The coefficient of friction is a value that is essential for certain piece of equipment especially for screws. A way to modulate this value is by adding wax to the finishing agent layer and/or topcoat.

[0067] It is interesting to see if the modulation of the coefficient of friction is maintained with the heat treatment and if the addition of wax change something to the white haze resistance effect of the invention.

[0068] It shows on Fig.8 the measure of coefficient of friction for 12, 19 and 20, we can see that there is a decrease in the coefficient of friction with the addition of wax as expected. With the heat treatment, there is still an increase of the coefficient of friction, but it stays below the value of the reference.

[0069] On Fig.9 it is shown that for sample 20 after 240 hours of the NSS test that there is no white haze. So we can see that the addition of the wax in the finishing layer does not affect the white haze resistance.

Claims

1. Method for preparing an electroplated product having the following steps:

- Electroplating a substrate with a first metal layer comprising or consisting of zinc or a zinc alloy with an electrolyte comprising at least one source of zinc ions,
- Depositing a black passivation layer on the first metal layer wherein the black passivation layer comprises trivalent chromium ions,
- Depositing a finishing agent layer on the black passivation layer,
- Drying of the layers at temperatures from 60 to 120 °C for 1 minutes to 20 minutes.

2. Method of claim 1, **characterised in that** the zinc alloy is selected from the group consisting of zinc nickel alloys, zinc iron alloys and zinc nickel iron alloys.

3. Method according to claim 1 or 2, **characterised in that**, after the heating in step d), in a further step e), a heating of the layers at temperatures from 150°C to 250°C for 20 minutes to 15 hours is conducted.
- 5 4. Method according to claim 3, **characterised in that** the heating in step e) is conducted at temperatures from 160 to 240°C, preferably from 175 to 220°C.
5. Method according to any one of claims 3 or 4, **characterised in that** the heating in step e) is conducted for 1 hour to 15 hours, preferably 2 hours to 10 hours, more preferably 3 hours to 9 hours.
- 10 6. Method according to any one of claims 1 to 5, **characterised in that**, after the heating in step e), or the drying in step d), in a further step f), a top coat layer is deposited on the finishing agent layer, wherein the top coat layer preferably comprises a polymer and/or a colloidal corrosion inhibitor and/or a wax.
- 15 7. Method according to any one of claims 1 to 6, **characterised in that** the black passivation layer and/or the finishing agent layer is free of cobalt.
8. Method according to any one of claims 1 to 6, **characterised in that** the black passivation layer and/or the finishing agent layer comprise(s) cobalt.
- 20 9. Method according to any one of claims 1 to 8, **characterised in that** the finishing agent layer comprises chromium ions and/or phosphate ions and/or zinc ions and/or citrates ions.
10. Method according to any one of claims 1 to 9, **characterised in that** the drying in step d) is conducted at temperatures from 60°C to 100°C.
- 25 11. Method according to any one of claims 1 to 10, **characterised in that** the drying in step d) is conducted for 5 to 15 minutes.
- 30 12. Method according to any one of claims 1 to 11, **characterised in that** the finishing agent layer comprises a wax or a non-wax friction adjuster, preferably a substance selected from the group consisting of polyethylene (PE), polypropylene (PP), polytetrafluoroethylene (PTFE), ethylenetetrafluoroethylene (ETFE), perfluorinated polyethers (PFPE), polyvinylidene fluoride (PVDF), tetrafluoroethylene / hexafluoroethylene copolymer (FEP), perfluoroalkoxy copolymer (PFA), polysulfones, MoS₂, WS₂, TiS₂, BN graphite, polyvinylchloride (PVC), polystyrene (PS), metacrylate resin, polycarbonate (PC), polyamide (PA), polyimide (PI), polyacetal, fluororesin, urea resin, phenol resin, unsaturated polyester resin, polyurethane, alkyd resin, epoxy resin, melamine resin, paraffin, carnauba wax and combinations thereof.
- 35 13. Electroplated product comprising
 - 40 a) a first metal layer comprising or consisting of a zinc or a zinc alloy,
 - b) a black passivation layer comprising chromium, and
 - c) a finishing agent layer,wherein the black passivation layer has an L value lower than 40 and the electroplated product passes NSS test according ISO 9227 according to the VW standard TL 244 requirements and/or RNES - B - 0059 Renault Nissan requirements up to 168 hours without any optical change of aspect of the electroplated product.
- 45 14. Electroplated product according to claim 13, **characterised in that** the black passivation layer has an L value lower than 30, preferably lower than 25.
- 50 15. Electroplated product according to any one of claims 13 to 14, **characterised in that** the first metal layer has a thickness from 1 µm to 20 µm.
- 55 16. Electroplated product according to any one of claims 13 to 15, **characterised in that** the finishing agent layer comprises chromium ions and/or phosphate ions and/or zinc ions and/or citrates ions.
17. Electroplated product according to any one of claims 13 to 16, **characterised in that** a top coat layer is deposited on the finishing agent layer as a finish, wherein the top coat layer preferably comprises a polymer and/or a colloidal

corrosion inhibitor and/or a wax.

- 5 18. Electroplated product according to any one of claims 13 to 18, **characterised in that** the finishing agent layer comprises a wax or a non-wax friction adjuster, preferably a substance selected from the group consisting of polyethylene (PE), polypropylene (PP), polytetrafluoroethylene (PTFE), ethylenetetrafluoroethylene (ETFE), perfluorinated polyethers (PFPE), polyvinylidene fluoride (PVDF), tetrafluoroethylene / hexafluoroethylene copolymer (FEP), perfluoroalkoxy copolymer (PFA), polysulfones, MoS₂, WS₂, TiS₂, BN graphite, polyvinylchloride (PVC), polystyrene (PS), metacrylate resin, polycarbonate (PC), polyamide (PA), polyimide (PI), polyacetal, fluororesin, urea resin, phenol resin, unsaturated polyester resin, polyurethane, alkyd resin, epoxy resin, melamine resin, paraffin, carnauba wax and combinations thereof.
- 10
- 15
- 20
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- 45
- 50
- 55

Fig. 1

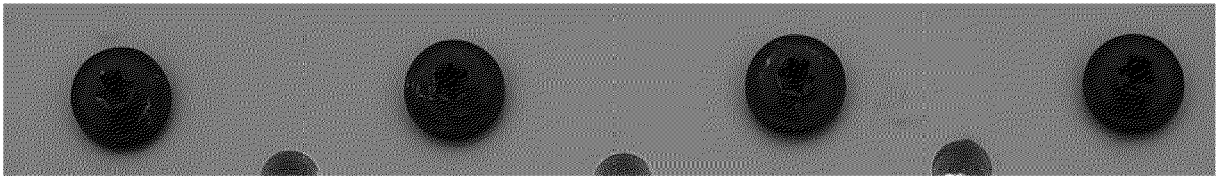


Fig. 2

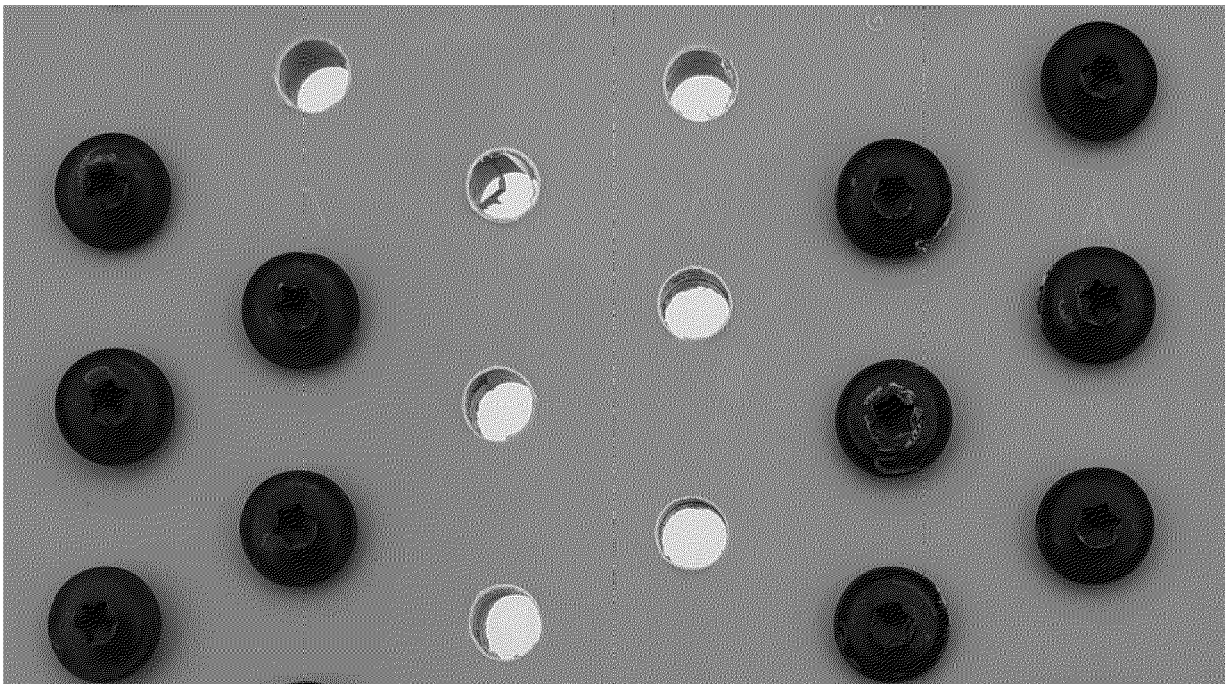


Fig. 3

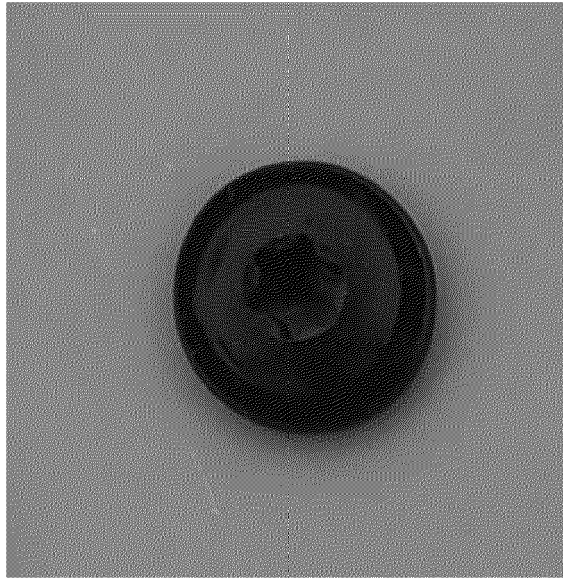


Fig. 4

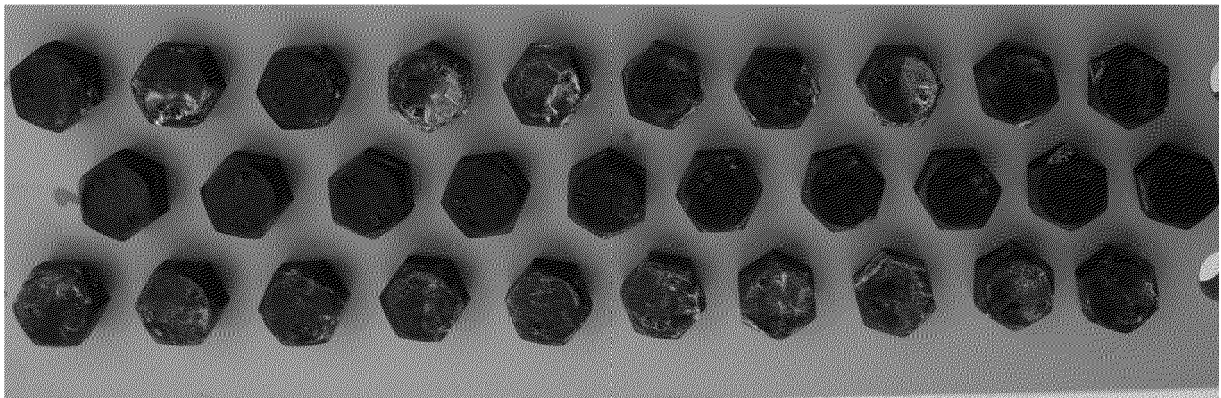


Fig. 5

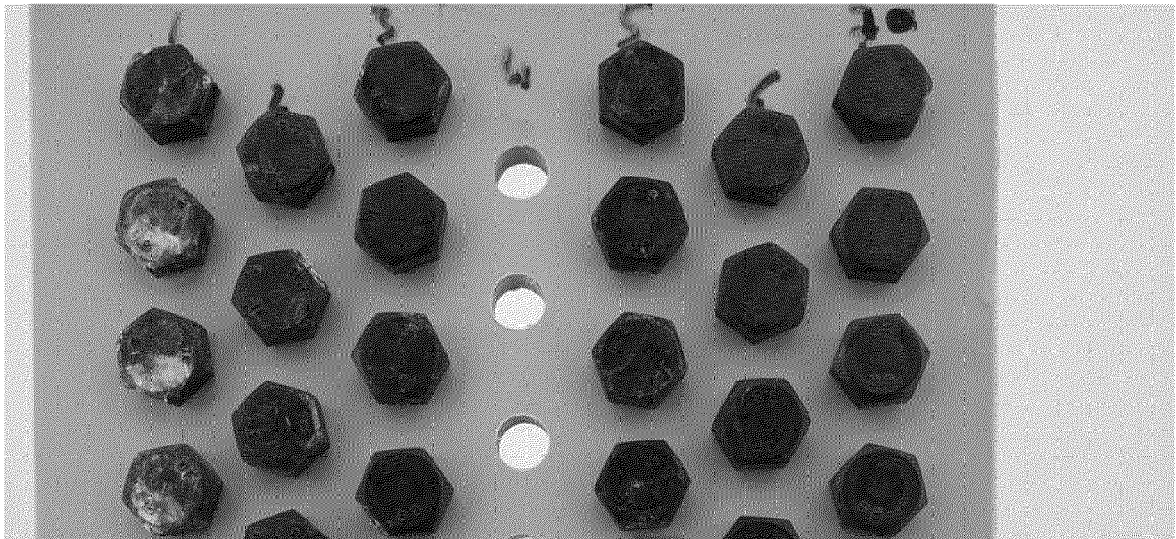


Fig. 6

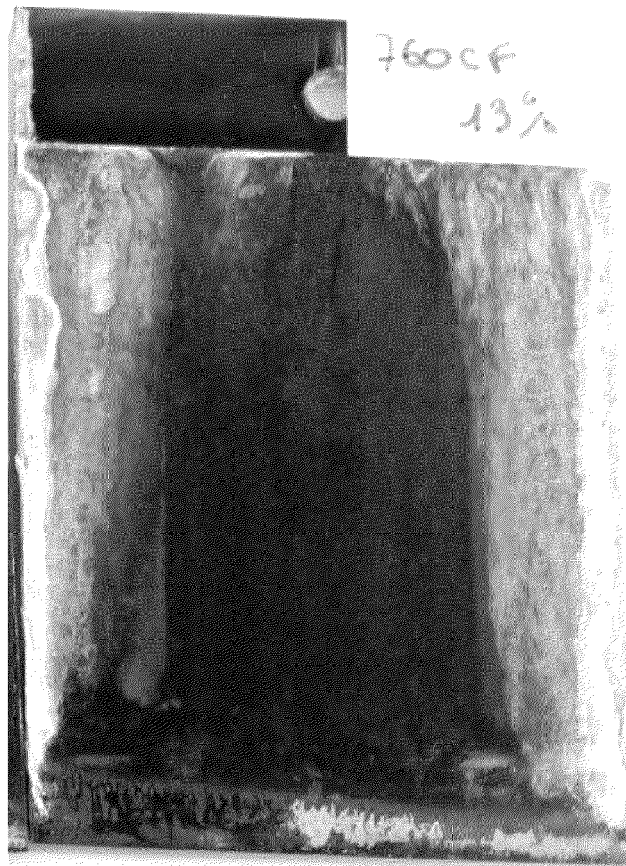


Fig. 7



Fig. 8

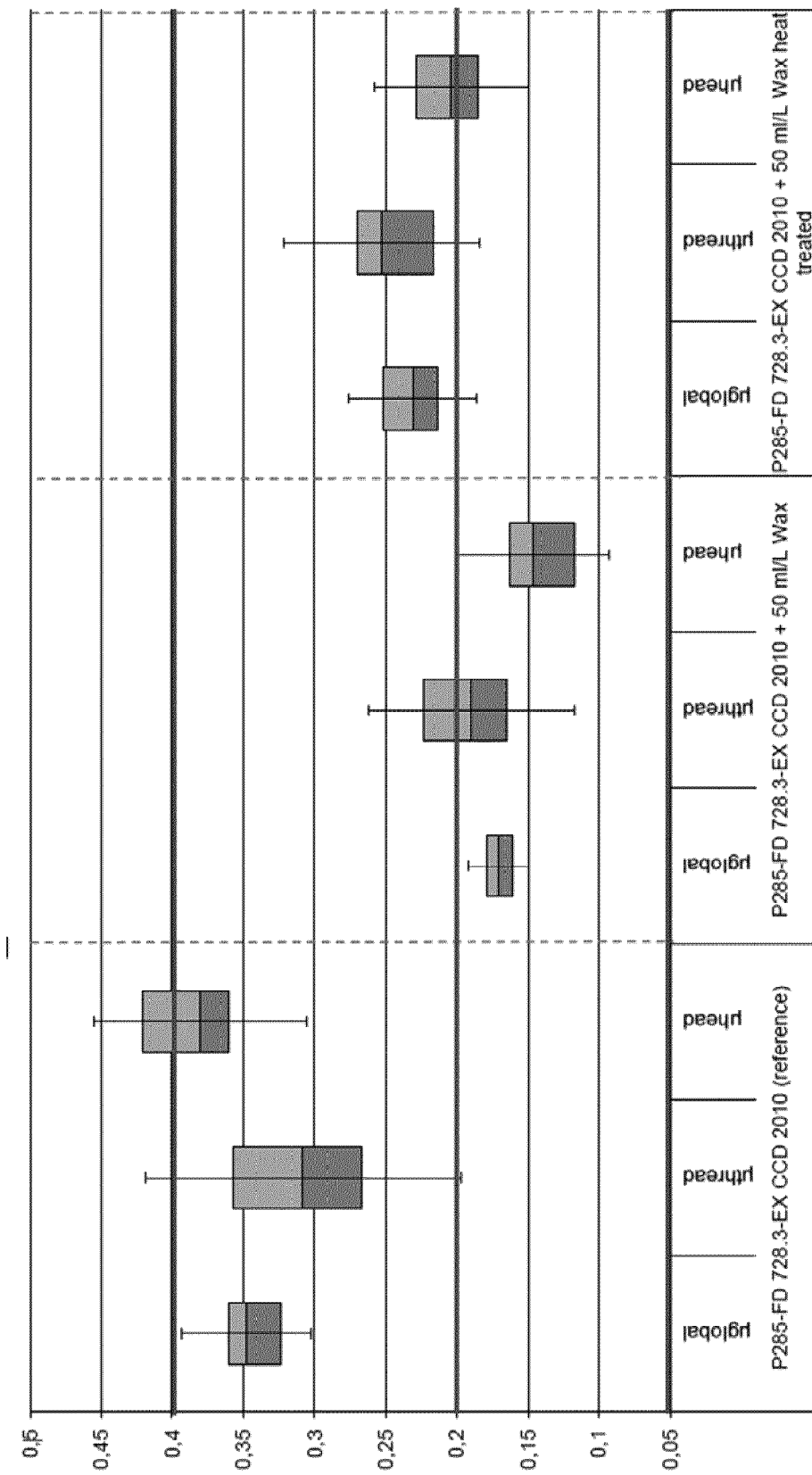
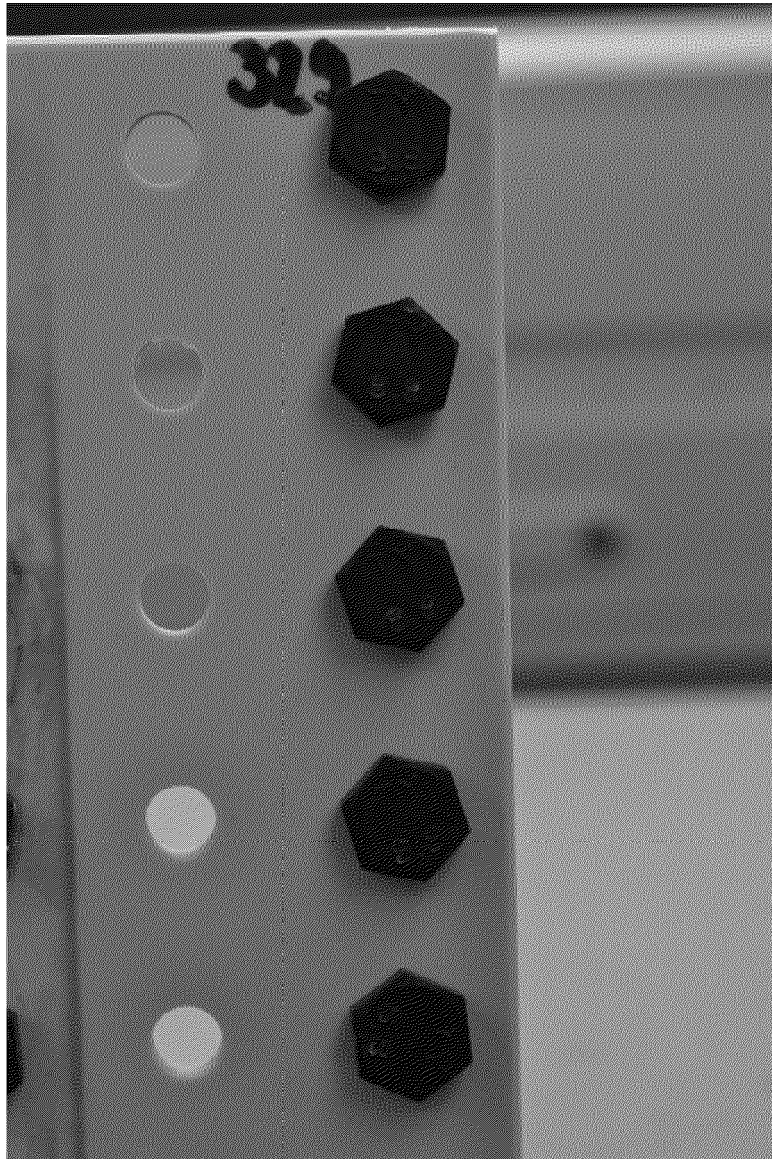


Fig. 9





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