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CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

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Published:

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(54) Title: METAL SURFACE TREATMENT METHOD

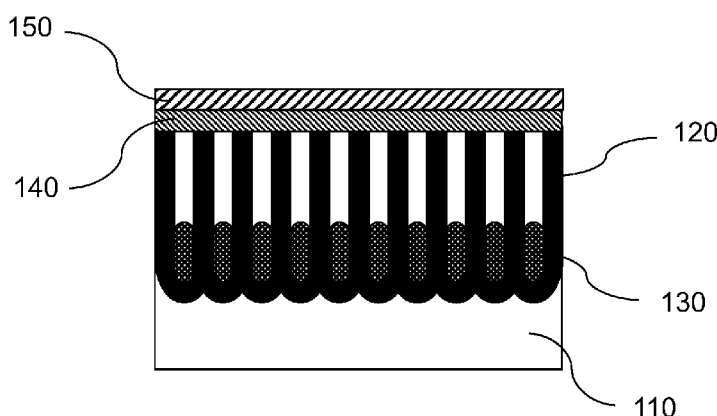


Figure 4

(57) Abstract: There is provided a method for treating the surface of a metallic material (110). The method comprises a sealing step. The sealing step comprises reacting the metallic material (110) with a first nickel free solution to form a sealing layer (140). The method comprises a coating step. The coating step comprises applying a second nickel free solution to the sealing layer (140) to form a coating (150).



Metal Surface Treatment Method

The present invention relates to a method for treating the surface of a metallic material. In particular, the present invention relates to a method for treating the surface of a metallic material including a sealing step and a coating step.

It is known to treat the surface of metals to modify the surface properties of the metal. For example, a metallic material may be surface treated to improve properties including the surface hardness, corrosion resistance, or aesthetics of the material. A common surface treatment is anodization.

Anodization may improve the abrasion and wear resistance of a metallic component. This may be due to the thick metal oxide layer which protects the metal from damage. Anodization may improve the corrosion resistance of a metallic component. In addition, it is known to use anodization to add colour to the surface of a metallic component. Anodization is particularly suitable for treating components formed from aluminium. Due to this ability to customise the colour, and to improve the durability of a product, anodization is often used to treat metallic components used in consumer products such as mobile phone cases.

The process of anodization involves producing a thick metal oxide layer on the metal surface. The metal oxide layer may be formed by incorporating the metallic component to be treated as the anode in an electrolytic cell. The anodizing process may use an acid as electrolyte. For example, the anodizing process may use at least one of chromic acid or sulphuric acid as an electrolyte.

The anodizing process may create a porous metal oxide structure on the surface of the metallic component. The pores may be elongate pores extending perpendicular from the surface of the metallic component. These pores may then be used to adsorb dye to colour the surface of the metallic component. However, these pores may also lead to corrosion. As a result, following the anodizing process, it is common to seal the anodized surface of the metallic component to close the pores in the metal oxide structure. Typically, the anodized metallic component is sealed by immersion in a solution of nickel acetate. The nickel acetate impregnates the pores and seals the metal oxide structure.

However, it has been found that sealing using nickel acetate does not always provide the surface durability required. In addition some consumers are known to experience allergic reactions when coming into contact with nickel. Furthermore, in some cases the extraction of nickel may have a negative environmental impact.

As a result, there is a need to provide a process which seals an anodized metallic component which provides a more durable finished component. In addition, the method needs to be cost effective and must be suitable for use with existing anodization processes.

According to the present disclosure, there is provided a method for treating the surface of a metallic material. The method may comprise a sealing step. The sealing step may comprise

reacting the metallic material with a first nickel free solution to form a sealing layer. The method may comprise a coating step. The coating step may comprise applying a second nickel free solution to the sealing layer to form a coating.

According to the present invention, there is provided a method for treating the surface of a metallic material. The method comprises a sealing step. The sealing step comprises reacting the metallic material with a first nickel free solution to form a sealing layer. The method comprises a coating step. The coating step comprises applying a second nickel free solution to the sealing layer to form a coating.

The inventors have identified that the multi-step process of the present invention provides several benefits compared to the single step sealing process of the prior art. In particular, the inventors have identified that the multi-step process of the present invention may advantageously provide a more resilient and durable surface treatment compared to the single step sealing process of the prior art. In addition, the multi-step process of the present invention may eliminate the need to use nickel acetate in a sealing process. This may advantageously reduce the likelihood of allergic reactions developing in users of the treated product. In addition, the reduced use of nickel may advantageously improve the sustainability of the sealing process.

The surface treating method of the present invention comprises at least a sealing step and a coating step. However, the surface treating method of the present invention may comprise one or more additional step. For example, the surface treating method of the present invention may comprise an additional one, two, three, four, or more additional steps.

The coating step may take place after the sealing step. The coating step may take place immediately after the sealing step.

As used herein with reference to the present invention, the term “nickel free solution” refers to a solution which does not comprise nickel metal or a compound comprising nickel.

The sealing step may comprise a hydration reaction in which the first nickel free solution is reacted with water to form a hydroxide.

The hydroxide may form a sealing layer which closes the pores of the metal oxide structure. This may advantageously prevent corrosion of the metal within the pores of the metal oxide structure.

As used herein with reference to the present invention, the term “hydration reaction” refers to a chemical reaction in which water is reacted with an unsaturated substrate. Typically, a hydration reaction involves reacting an alkene or an alkyne with water to yield an alcohol.

At least one of the first nickel free solution and the second nickel free solution may comprise a compound containing a metallic element. At least one of the first nickel free solution and the second nickel free solution may comprise a light metal. At least one of the first nickel free solution and the second nickel free solution may comprise one or more of lithium, beryllium, sodium, magnesium, potassium, calcium, or combinations or alloys thereof. At least one of the

first nickel free solution and the second nickel free solution may comprise at least one of iron or a compound containing iron.

The first nickel free solution may comprise a light metal. The second nickel free solution may comprise a light metal.

The first nickel free solution may comprise one or more of lithium, beryllium, sodium, magnesium, potassium, calcium, or combinations or alloys thereof. The second nickel free solution may comprise one or more of lithium, beryllium, sodium, magnesium, potassium, calcium, or combinations or alloys thereof.

The first nickel free solution may comprise at least one of iron or a compound containing iron. The second nickel free solution may comprise at least one of iron or a compound containing iron.

At least one of the first nickel free solution and the second nickel free solution may comprise a semi-organic compound.

As used herein with reference to the present invention, the term “semi-organic compound” refer to a hybrid material comprising both an organic compound and an inorganic compound.

The first nickel free solution may comprise a semi-organic compound. The second nickel free solution may comprise a semi-organic compound.

The first nickel free solution may comprise a polymeric material. The first nickel free solution may comprise a hybrid and polymeric material.

The second nickel free solution may comprise a paint.

The sealing step may comprise immersing the metallic material in the first nickel free solution.

The sealing step may comprise immersing the metallic material in the first nickel free solution for any length of time. The sealing step may comprise immersing the metallic material in the first nickel free solution for at least 1 minute, at least 2 minutes, or at least 5 minutes.

The sealing step may comprise immersing the metallic material in the first nickel free solution for no more than 20 minutes, no more than 15 minutes, or no more than 10 minutes.

For example, the sealing step may comprise immersing the metallic material in the first nickel free solution for between about 1 minute and about 20 minutes, between about 2 minutes and about 15 minutes, or between about 5 minutes and about 10 minutes.

The sealing step may comprise applying the first nickel free solution to the metallic material in any other way. For example, the sealing step may comprise spraying the metallic material with the first nickel free solution.

The sealing step may take place at any temperature.

The sealing step may comprise reacting the metallic material with the first nickel free solution at a temperature of at least 5 degrees Celsius, at least 10 degrees Celsius, or at least 20 degrees Celsius.

The sealing step may comprise reacting the metallic material with the first nickel free solution at a temperature of no more than 100 degrees Celsius, no more than 85 degrees Celsius, or no more than 70 degrees Celsius.

The sealing step may comprise reacting the metallic material with the first nickel free solution at a temperature of between about 5 degrees Celsius and about 100 degrees Celsius, between about 10 degrees Celsius and about 85 degrees Celsius, or between about 20 degrees Celsius and about 70 degrees Celsius.

The coating step may comprise immersing the metallic material in the second nickel free solution. The coating step may comprise an electrophoresis step.

The coating step may comprise applying the second nickel free solution to the metallic material for any length of time.

The coating step may comprise applying the second nickel free solution to the metallic material for at least 5 minutes, at least 10 minutes, or at least 15 minutes.

The coating step may comprise applying the second nickel free solution to the metallic material for no more than 50 minutes, no more than 30 minutes, or no more than 25 minutes.

For example, the coating step may comprise applying the second nickel free solution to the metallic material for between about 5 minutes and about 50 minutes, between about 10 minutes and about 30 minutes, or between about 15 minutes and about 25 minutes.

The coating step may take place at any temperature.

The coating step may comprise applying the second nickel free solution to the metallic material at a temperature of at least 70 degrees Celsius, at least 75 degrees Celsius, or at least 80 degrees Celsius.

The coating step may comprise applying the second nickel free solution to the metallic material at a temperature of no more than 110 degrees Celsius, no more than 100 degrees Celsius, or no more than 95 degrees Celsius.

The coating step may comprise applying the second nickel free solution to the metallic material at a temperature of between about 70 degrees Celsius and about 110 degrees Celsius, between about 75 degrees Celsius and about 100 degrees Celsius, or between about 80 degrees Celsius and about 95 degrees Celsius.

The method may further comprise at least one additional step. The at least one additional step may be performed before or after the sealing step and the coating step.

The method may further comprise a pre-sealing cleaning step in which debris and contamination is removed from the metallic material before the sealing step.

The pre-cleaning step may take place after an anodizing step. The pre-cleaning step may advantageously remove any debris and contamination originating from the anodizing step. The provision of a pre-cleaning step before the sealing step may advantageously make the sealing step more effective. For example, the pre-cleaning step may advantageously remove debris from

the porous metal oxide structure to prevent the debris from being sealed in the porous metal oxide structure.

The method may further comprise a post-coating cleaning step in which debris and contamination is removed from the metallic material after the coating step.

The post-cleaning step may advantageously remove any debris and contamination originating from the coating step.

At least one of the pre-sealing cleaning step and the post-coating cleaning step may comprise electrocleaning.

The pre-sealing cleaning step may comprise electrocleaning. The post-coating cleaning step may comprise electrocleaning.

As used herein with reference to the present invention, the term “electrocleaning” refers to a method for removing soil, scale, or corrosion products from a metallic component by using the metallic component as an electrode in an electrolytic cell.

At least one of the pre-sealing cleaning step and the post-coating cleaning step may comprise cleaning in pure water.

The pre-sealing cleaning step may comprise cleaning in pure water. The post-coating cleaning step may comprise cleaning in pure water.

The pure water may be distilled water. The pure water may be deionised water.

Cleaning the metallic material using pure water may advantageously remove debris and contamination. Cleaning in pure water may take place after the electrocleaning. This may advantageously remove any debris and contamination originating from the electrocleaning.

The method may further comprise a dyeing step in which a coloured pigment is applied to the metallic material, the dyeing step occurring before the a sealing step.

The provision of a dyeing step before the sealing step may advantageously allow the dye to penetrate into the porous metal oxide structure before the metal oxide is sealed by the sealing step.

The method may further comprise an anodizing step in which a metal oxide layer is formed on the surface of the metallic material, the anodizing step occurring before the sealing step. The anodizing step may occur before the dyeing step where a dyeing step is present.

The provision of an anodizing step may advantageously improve the corrosion resistance and durability of the metallic material.

The metallic material may be any metallic material. Suitable metallic materials include, but are not limited to titanium, aluminium, zinc, or alloys thereof.

Preferably, the metallic material comprises aluminium metal or an aluminium alloy.

Aluminium is particularly suitable for anodizing since it forms a hard oxide which increases the durability of the metal surface.

The metallic material may comprise any suitable metallic component. For example, the metallic material may be a metallic component of an aerosol-generating device. The aerosol-

generating device may be an electronic cigarette. The aerosol-generating device may be intended to be used in conjunction with an aerosol-generating article. For example, where the aerosol-generating article comprises an aerosol-generating substrate, the aerosol-generating article may be intended to be heated by the aerosol-generating device to generate an aerosol. Where this is the case, the aerosol-generating device may include a heater to heat the aerosol-generating article. The heater may be an electrical resistance heater. The heater may be an induction heater.

The metallic material may be any metallic component of an aerosol-generating device. The metallic material may comprise a portion of the outer casing of an aerosol-generating device. This may be advantageous since an anodizing process may be used to customise the colour of the outer casing of the aerosol-generating device to control the overall appearance of the device.

The invention is defined in the claims. However, below there is provided a non-exhaustive list of non-limiting examples. Any one or more of the features of these examples may be combined with any one or more features of another example, embodiment, or aspect described herein.

Example 1. A method for treating the surface of a metallic material, the method comprising: a sealing step comprising reacting the metallic material with a first nickel free solution to form a sealing layer, and a coating step comprising applying a second nickel free solution to the sealing layer to form a coating.

Example 2. A method according to Example 1, wherein the sealing step comprises a hydration reaction in which the first nickel free solution is reacted with water to form a hydroxide.

Example 3. A method according to claim Example 1 or Example 2, wherein at least one of the first nickel free solution and the second nickel free solution comprises at least one of iron or a compound containing iron.

Example 4. A method according to any preceding Example, wherein at least one of the first nickel free solution and the second nickel free solution comprises a semi-organic compound.

Example 5. A method according to any preceding Example, wherein the sealing step comprises immersing the metallic material in the first nickel free solution.

Example 6. A method according to Example 5, wherein the sealing step comprises immersing the metallic material in the first nickel free solution for at least 5 minutes.

Example 7. A method according to Example 5 or Example 6, wherein the sealing step comprises immersing the metallic material in the first nickel free solution for no more than 10 minutes.

Example 8. A method according to any preceding Example, wherein the sealing step comprises reacting the metallic material with the first nickel free solution at least 20 degrees Celsius.

Example 9. A method according to any preceding Example, wherein the sealing step comprises reacting the metallic material with the first nickel free solution at no more than 70 degrees Celsius.

Example 10. A method according to any preceding Example, wherein the coating step comprises applying the second nickel free solution to the metallic material for at least 15 minutes.

Example 11. A method according to any preceding Example, wherein the coating step comprises applying the second nickel free solution to the metallic material for no more than 25 minutes.

Example 12. A method according to any preceding Example, wherein the coating step comprises applying the second nickel free solution to the metallic material at least 80 degrees Celsius.

Example 13. A method according to any preceding Example, wherein the coating step comprises applying the second nickel free solution to the metallic material at no more than 95 degrees Celsius.

Example 14. A method according to any preceding Example, further comprising a pre-sealing cleaning step in which debris and contamination is removed from the metallic material before the sealing step.

Example 15. A method according to any preceding Example, further comprising a post-coating cleaning step in which debris and contamination is removed from the metallic material after the coating step.

Example 16. A method according to Example 14 or Example 15, wherein at least one of the pre-sealing cleaning step and the post-coating cleaning step comprises electrocleaning.

Example 17. A method according to any one of Examples 14 to 16, wherein at least one of the pre-sealing cleaning step and the post-coating cleaning step comprises cleaning in pure water.

Example 18. A method according to any preceding Example, further comprising a dyeing step in which a coloured pigment is applied to the metallic material, the dyeing step occurring before the a sealing step.

Example 19. A method according to any preceding Example, further comprising an anodizing step in which a metal oxide layer is formed on the surface of the metallic material, the anodizing step occurring before the sealing step.

Example 20. A method according to any preceding Example, wherein the metallic material comprises aluminium metal or an aluminium alloy.

Example 21. A method according to any preceding Example, wherein the metallic material comprises a portion of an aerosol-generating device.

In the following non-limiting examples, the invention will be further described with reference to the drawings of the accompanying Figures, in which:

Figure 1 shows a schematic representation of the cross sectional microstructure of a portion of anodized material,

Figure 2 shows a schematic representation of the cross sectional microstructure of a portion of anodized material which has undergone a dyeing step,

Figure 3 shows a schematic representation of the cross sectional microstructure of a portion of anodized material which has undergone a dyeing step and a sealing step according to the present invention, and

Figure 4 shows a schematic representation of the cross sectional microstructure of a portion of anodized material which has undergone a dyeing step, a sealing step according to the present invention, and a coating step according to the present invention.

There is provided a multistep process for treating the surface of a metallic material 110. The metallic material 110 in this example is a portion of the housing of an electronic aerosol-generating device formed from aluminium metal.

The metallic material 110 first undergoes an anodizing process by using the metallic material 110 as an anode in an electrolytic cell with a suitable electrolyte. This anodization process produces a thick layer of aluminium oxide 120 on the surface of the metallic material 110. The thick layer of aluminium oxide 120 includes a plurality of elongate pores which extend from, and are perpendicular to, the metallic material 110. This is shown in Figure 1.

The anodized metallic material 110 is then dyed in a dyeing step. This is achieved by applying a pigment to the surface of the anodized metallic material 110. This pigment 130 impregnates the porous structure of the aluminium oxide layer 120. This is shown in Figure 2.

The anodized and dyed metallic material 110 is then cleaned in a pre-sealing cleaning step. The pre-sealing cleaning step is intended to remove any residue or debris from the anodizing and dyeing steps. The pre-sealing cleaning step comprises electrocleaning. The pre-sealing cleaning step comprises cleaning in pure water.

The anodized, dyed, and pre-cleaned metallic material 110 is then subjected to a sealing step. In the sealing step, the metallic material 110 is reacted with a first nickel free solution to form a sealing layer 140. The sealing step is performed by immersing the metallic material 110 in the first nickel free solution for between 5 and 10 minutes at a temperature of about 25 degrees Celsius. The first nickel free solution is a semi-organic compound. The first nickel free solution comprises a polymeric material. The first nickel free solution comprises iron. The sealing step involves a hydration reaction. The sealed metallic material 110 is shown in Figure 3.

The anodized, dyed, pre-cleaned, and sealed metallic material 110 is then subjected to a coating step. In the coating step, a second nickel free solution is applied to the sealing layer 140 to form a coating layer 150. The coating step is performed by immersing the metallic material 110 in the second nickel free solution for between 15 and 25 minutes at a temperature of about 85 degrees Celsius. The second nickel free solution is a semi-organic compound. The coated metallic material 110 is shown in Figure 4.

The anodized, dyed, pre-cleaned, sealed, and coated metallic material 110 is then cleaned in a post-coating cleaning step. The post-coating cleaning step is intended to remove any residue or debris from the sealing and coating steps. The post-coating cleaning step comprises electrocleaning. The post-coating cleaning step comprises cleaning in pure water.

For the purpose of the present description and of the appended claims, except where otherwise indicated, all numbers expressing amounts, quantities, percentages, and so forth, are to be understood as being modified in all instances by the term "about". Also, all ranges include the maximum and minimum points disclosed and include any intermediate ranges therein, which may or may not be specifically enumerated herein. In this context, therefore, a number A is understood as $A \pm 10\%$ of A. Within this context, a number A may be considered to include numerical values that are within general standard error for the measurement of the property that the number A modifies. The number A, in some instances as used in the appended claims, may deviate by the percentages enumerated above provided that the amount by which A deviates does not materially affect the basic and novel characteristic(s) of the claimed invention. Also, all ranges include the maximum and minimum points disclosed and include any intermediate ranges therein, which may or may not be specifically enumerated herein.

While a number of example embodiments have been disclosed herein, it should be understood that other variations may be possible. Such variations are not to be regarded as a departure from the scope of the present disclosure, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims. It will be understood that features described above in relation to one aspect of the invention or disclosure are equally applicable to other aspects of the invention or disclosure.

CLAIMS

1. A method for treating the surface of a metallic material, the method comprising:
a sealing step comprising reacting the metallic material with a first nickel free solution to form a sealing layer, and
a coating step comprising applying a second nickel free solution to the sealing layer to form a coating.
2. A method according to claim 1, wherein the sealing step comprises a hydration reaction in which the first nickel free solution is reacted with water to form a hydroxide.
3. A method according to claim 1 or claim 2, wherein at least one of the first nickel free solution and the second nickel free solution comprises at least one of iron or a compound containing iron.
4. A method according to any preceding claim, wherein at least one of the first nickel free solution and the second nickel free solution comprises a semi-organic compound.
5. A method according to any preceding claim, wherein the sealing step comprises immersing the metallic material in the first nickel free solution.
6. A method according to claim 5, wherein the sealing step comprises immersing the metallic material in the first nickel free solution for at least 5 minutes.
7. A method according to claim 5 or claim 6, wherein the sealing step comprises immersing the metallic material in the first nickel free solution for no more than 10 minutes.
8. A method according to any preceding claim, wherein the sealing step comprises reacting the metallic material with the first nickel free solution at least 20 degrees Celsius.
9. A method according to any preceding claim, wherein the sealing step comprises reacting the metallic material with the first nickel free solution at no more than 70 degrees Celsius.
10. A method according to any preceding claim, wherein the coating step comprises applying the second nickel free solution to the metallic material for at least 15 minutes.
11. A method according to any preceding claim, wherein the coating step comprises applying the second nickel free solution to the metallic material for no more than 25 minutes.

12. A method according to any preceding claim, wherein the coating step comprises applying the second nickel free solution to the metallic material at least 80 degrees Celsius.
13. A method according to any preceding claim, wherein the coating step comprises applying the second nickel free solution to the metallic material at no more than 95 degrees Celsius.
14. A method according to any preceding claim, further comprising an anodizing step in which a metal oxide layer is formed on the surface of the metallic material, the anodizing step occurring before the sealing step.
15. A method according to any preceding claim, wherein the metallic material comprises a portion of an aerosol-generating device.

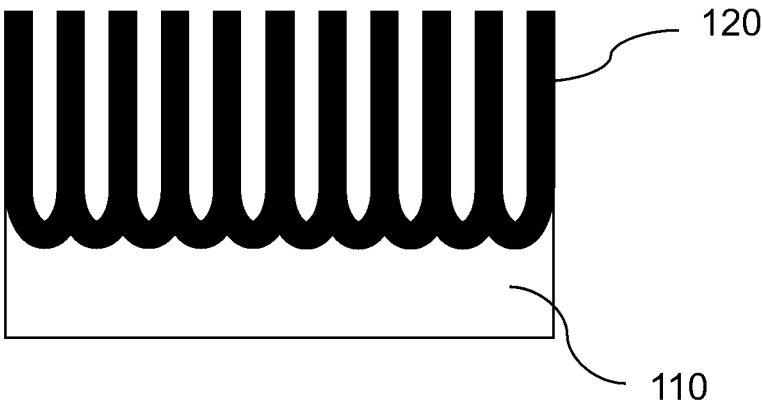


Figure 1

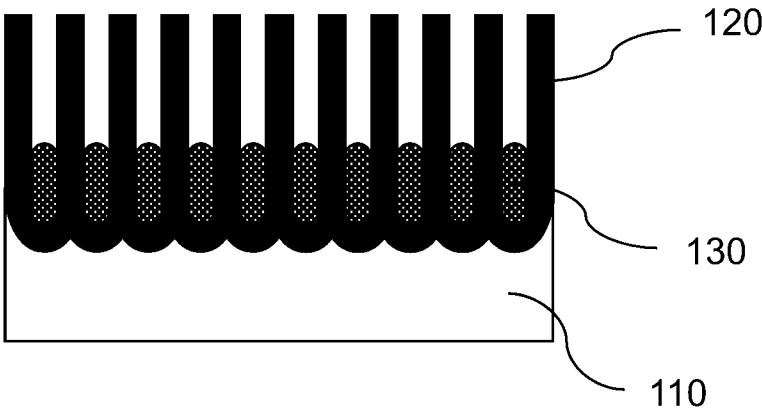


Figure 2

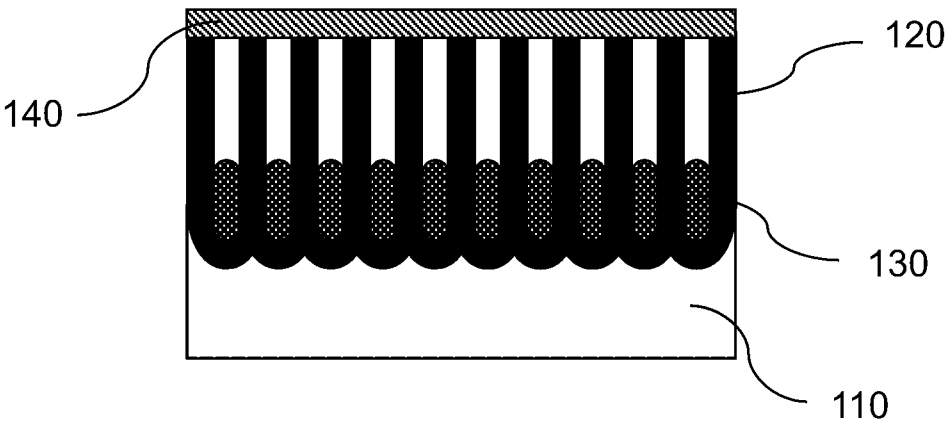


Figure 3

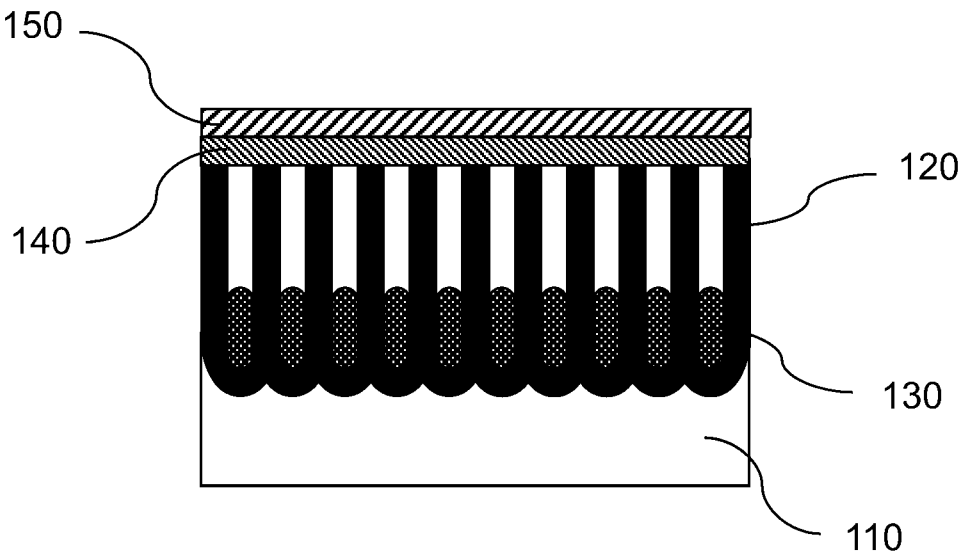


Figure 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/CN2023/139572

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	C25D11/24	C25D11/26
		C25D11/34
		A24F40/00
ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
C25D		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102 650 067 B (SUZUKI MOTOR CORP) 3 June 2015 (2015-06-03)	1,2,5-9, 14
Y	Description; claims 1-6	15

X	US 4 225 398 A (HASEGAWA MUTSUO ET AL) 30 September 1980 (1980-09-30)	1,2,5, 10-14
Y	claim 1 column 3, line 24 - line 32 column 5, line 63 - column 6, line 2	15

X	US 3 852 124 A (FASSELL W) 3 December 1974 (1974-12-03)	1,3,5-7, 14
Y	claims 1,4,5 table 1	15

- / - -		
☒ Further documents are listed in the continuation of Box C.		
☒ See patent family annex.		
* Special categories of cited documents :		
"A" document defining the general state of the art which is not considered to be of particular relevance		
"E" earlier application or patent but published on or after the international filing date		
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention		
"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone		
"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art		
"&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
28 August 2024		23/09/2024
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Le Hervet, Morgan

INTERNATIONAL SEARCH REPORT

International application No

PCT/CN2023/139572

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 26 32 626 A1 (ICI LTD) 10 February 1977 (1977-02-10)	1, 3, 5, 14
Y	example 1 -----	15
X	US 2021/363654 A1 (WU KUAN-TING [TW] ET AL) 25 November 2021 (2021-11-25)	1, 4, 14
Y	claims 1-3 -----	15
X	KR 102 006 759 B1 (TOYOTA MOTOR CO LTD [JP]) 5 August 2019 (2019-08-05)	1, 4, 5, 14
Y	claim 1 paragraph [0026] -----	15
Y	CN 115 399 506 A (ALD GROUP LTD) 29 November 2022 (2022-11-29) Description claims 1-8 -----	15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/139572

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims;; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/CN2023/139572

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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 2, 14 (completely); 1 (partially)

A method for treating the surface of a metallic material, the method comprising: a sealing step comprising reacting the metallic material with a first nickel free solution to form a sealing layer, and a coating step comprising applying a second nickel free solution to the sealing layer to form a coating, wherein the sealing step comprises a hydration reaction in which the first nickel free solution is reacted with water to form a hydroxide, and/or comprising an anodizing step in which a metal oxide layer is formed on the surface of the metallic material, the anodizing step occurring before the sealing step.

2. claims: 3 (completely); 1 (partially)

A method for treating the surface of a metallic material, the method comprising: a sealing step comprising reacting the metallic material with a first nickel free solution to form a sealing layer, and a coating step comprising applying a second nickel free solution to the sealing layer to form a coating, wherein at least one of the first nickel free solution and the second nickel free solution comprises at least one of iron or a compound containing iron.

3. claims: 4 (completely); 1 (partially)

A method for treating the surface of a metallic material, the method comprising: a sealing step comprising reacting the metallic material with a first nickel free solution to form a sealing layer, and a coating step comprising applying a second nickel free solution to the sealing layer to form a coating, wherein at least one of the first nickel free solution and the second nickel free solution comprises a semi-organic compound.

4. claims: 5-13 (completely); 1 (partially)

A method for treating the surface of a metallic material, the method comprising: a sealing step comprising reacting the metallic material with a first nickel free solution to form a sealing layer, and a coating step comprising applying a second nickel free solution to the sealing layer to form a coating, wherein the sealing step comprises immersing the metallic material in the first nickel free solution, and/or wherein the sealing step comprises reacting the metallic material with the first nickel free solution at at least 20 degrees Celsius and/or at no more than 70 degrees Celsius, and/or wherein the coating step comprises applying the

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

second nickel free solution to the metallic material for at least 15 minutes and/or for no more than 25 minutes, and/or wherein the coating step comprises applying the second nickel free solution to the metallic material at at least 80 degrees Celsius and/or at no more than 95 degrees Celsius.

5. claims: 15(completely); 1(partially)

A method for treating the surface of a metallic material, the method comprising: a sealing step comprising reacting the metallic material with a first nickel free solution to form a sealing layer, and a coating step comprising applying a second nickel free solution to the sealing layer to form a coating, wherein the metallic material comprises a portion of an aerosol-generating device.
