

1

3,423,226

PLATING OF NON-METALLIC BODIES

Darwin P. Jensen, Palos Verdes Estates, Calif., assignor to
McDonnell Douglas Corporation, Santa Monica, Calif.,
a corporation of Maryland

No Drawing. Filed June 28, 1965, Ser. No. 467,700

U.S. Cl. 117—47

10 Claims

Int. Cl. C23b 5/08; C23c 13/04

ABSTRACT OF THE DISCLOSURE

Process for producing a securely bonded layer of nickel on the surface of a plastic body, e.g., an ABS plastic, to provide a base for subsequent electroplating. The plastic body surface is first contacted with an aqueous phosphoric acid solution of a noble metal salt, e.g., palladium chloride, followed by treatment with an electroless nickel plating bath comprising an aqueous solution of a nickel salt, e.g., nickel sulfate, and a reducing agent, e.g., sodium hypophosphite.

This invention relates to electroless metal deposition or plating, and is more particularly concerned with the provision of procedure for the deposition of electroless nickel on nonmetallic bodies, and particularly on synthetic plastic bodies, and which is particularly suited as a base metal for subsequent electroplating, and to the provision of novel compositions employed in such procedure.

Electroless metal deposition refers to the chemical deposition of an adherent metal coating on a conductive, non-conductive, or semi-conductive substrate in the absence of an external electric source. This technique is employed to provide a metal base for subsequent electroplating. Thus, when it is desired to apply an electroplate to nonmetallic bodies such as plastics, since the plastic cannot be directly electroplated, it is the practice first to apply an electroless metal deposit such as a nickel deposit upon the nonmetallic or plastic body, and then use the electroless metal or electroless nickel as a base for electroplating a metal thereon. It will accordingly be seen that such an electroless metal or electroless nickel coating must be highly adherent and uniform over the entire surface of the nonmetallic, e.g., plastic body, in order to provide a strongly adherent, uniform electroplate to the surface of the body.

Conventional prior art procedure for providing the electroless metal coating on non-conductive or semi-conductive substrates comprises cleaning and abrading the substrate surface, contacting the surface with a solution containing stannous chloride, or other stannous salt, seeding or catalyzing to provide catalytic nucleating centers by treatment of such surface in an aqueous solution of a salt of a metal catalytic to the deposition of the desired metal coating, such as palladium, gold or platinum chloride, or silver nitrate, these metal ions being reduced to catalytic metal nucleating centers by the stannous ions adsorbed on the substrate and/or by reducing agents contained in the electroless metal bath, and thereafter treating the so-catalyzed surface with the electroless metal bath containing a salt of the desired metal, such as a copper or nickel salt, and a reducing agent therefor.

There are a number of serious disadvantages in the prior art procedure for depositing electroless metals such as nickel. In prior art procedures, such as that outlined

2

above, particularly in the case of electroless nickel, there is often insufficient adherence of the electroless nickel to the substrate, e.g., plastic surface, and resulting in unsatisfactory electroplating thereover. Further, according to prior art procedure, uniform coating of the electroless nickel deposit is often difficult to obtain and control, and there is relatively slow deposition of the electroless nickel on the substrate surface. Also, the prior art methods involve a relatively large number of processing steps. Further, prior art sensitizing and seeding baths of the types noted above are generally unstable, requiring frequent replacement or replenishment and providing inconsistent results due to their tendency to suddenly lose effectiveness.

Accordingly, one object of the invention is the provision of improved procedure and compositions for depositing electroless metal coatings, particularly electroless nickel.

Another object is the provision of a process for depositing electroless nickel on the surface of a nonmetallic substrate, particularly synthetic plastics, by simpler more reliable procedure as compared to the prior art, and which requires fewer processing steps than heretofore practiced.

Yet another object of the invention is the provision of an electroless nickel coating on various types of non-metallic solid bodies, particularly ABS (acrylonitrile-butadiene-styrene terpolymer) plastics, rapidly and uniformly to provide an even highly adherent nickel coating, which functions efficiently as a base for rapidly electroplating a metal such as copper or nickel thereon to obtain a highly adherent and lustrous electroplate.

A still further object of the invention is to provide novel seeding or activating compositions particularly designed for use in electroless metal, especially electroless nickel, deposition.

Other objects and advantages of the invention will appear hereinafter.

The above objects and advantages are achieved according to the invention, and a highly adherent uniform electroless metal, particularly electroless nickel, can be deposited on a substrate or body, which is preferably nonmetallic, and particularly on the surface of a synthetic plastic body, by treating or contacting said body with an aqueous chromic acid solution, then contacting said body with an aqueous phosphoric acid solution of a noble metal salt, e.g., palladium chloride, and then contacting said body with an electroless nickel plating bath comprising an aqueous solution of a nickel salt and a reducing agent. Although in preferred practice, the chromic acid solution is employed prior to treatment with the phosphoric acid solution, if desired, such chromic acid treatment step can be eliminated, but under these conditions, aging of the electroless nickel deposit is usually desirable, for example, for a period of 24 hours after application of such electroless nickel coating, in order to increase the adhesion of the electroless nickel plate to the surface of the nonmetallic, e.g., plastic body.

In addition to providing a rapid uniform coating of the electroless nickel which is highly adherent, the invention process has the advantage of reducing the number of procedural steps of the process and employs processing solutions which are readily prepared and remain stable and reliable. The electroless nickel coating thus produced provides an excellent base for rapidly applying a highly adherent and lustrous electroplate, e.g., of nickel or copper.

The invention procedure can be employed for provid-

ing an electroless nickel deposit or plate upon a variety of nonmetallic materials. Thus, for example, and without limiting the application of the invention thereto, the invention procedure can be applied to synthetic plastics such as epoxy resins as exemplified by the well known amine catalyzed bisphenol A-epichlorhydrin condensation product, bonized Teflon (polytetrafluoroethylene), ABS plastics, polypropylene resins, polystyrene, butyl rubber, and the like. The invention process has been found particularly applicable to the commercially important class of materials known as the ABS plastics, having the composition noted above.

According to one feature of the invention as applied to a plastic, e.g., an ABS plastic body, such plastic body is contacted as by immersing same, in an aqueous, preferably concentrated, solution of chromic acid (CrO_3). The concentration of chromic acid (CrO_3) in the solution can range from as low as about 20% up to saturation, generally from about 20% to about 70%, and preferably from about 50 to about 65%. The treatment in the chromic acid solution is preferably carried out at about room temperature and the time of treatment can range from as little as 30 seconds up to about 30 minutes or more, the period of treatment usually being of the order of about $1\frac{1}{2}$ to 5 minutes. Although such chromic acid treatment of the nonmetallic substrate is preferably carried out at room temperature in order to obtain an electroless plate having high adhesion, the adhesion of the electroless plate to the substrate is substantially the same even though temperature is varied above or below room temperature. The use of deionized or distilled water in the chromic acid solution is preferred as compared to ordinary tap water, since tap water often contains impurities which may affect adversely the adsorption of the noble metal salt on the surface of the nonmetallic, e.g., plastic substrate, as described in greater detail hereinafter.

The aqueous chromic acid solution functions to etch the surface of the nonmetallic, e.g., plastic body and provide a surface of greater area on which the noble metal salt employed for seeding, and provided by the subsequent treatment with the phosphoric acid seeding solution, can be efficiently adsorbed. Thus, the chromic acid treatment aids in the production of a highly adherent electroless nickel which deposits upon the noble metal salt or noble metal nuclei, e.g., palladium chloride or palladium nuclei, adsorbed on the substrate surface.

As previously noted, for applying an electroless nickel deposit to a nonmetallic substrate such as plastic, according to the invention, the chromic acid treatment can be omitted. However, under these conditions, the electroless nickel deposit which is freshly applied to the surface of the substrate does not have sufficiently high adherence thereto, and to improve the adhesion of the electroless nickel coating, it has been found desirable to age the fresh coating for a period of time, e.g., from about 20 to about 28 hours. In preferred practice, however, the chromic acid treatment step is included.

Following rinsing of the chromic acid-treated non-metallic or plastic body in water, preferably rinsing first in tap water at room temperature and then in deionized water, to remove all traces of chromic acid, as an important novel feature of the invention, the substrate is then contacted as by immersion, in a phosphoric acid solution of a noble metal salt, e.g., palladium chloride, the solution preferably being a concentrated phosphoric acid solution. This phosphoric acid solution containing noble metal salt can range in phosphoric acid concentration from about 30 to about 85% H_3PO_4 , and preferably is in the range of about 60 to about 85% H_3PO_4 .

The noble metal salt incorporated in the phosphoric acid solution generally can be any sufficiently soluble salt of palladium, platinum, gold or silver. Thus, the soluble halides, e.g., the chlorides or bromides, of palladium, platinum or gold can be employed, and the soluble ni-

trates of such metals, e.g., silver nitrate. Also, the soluble sulfates of such noble metals can be employed. The preferred noble metal salt according to the invention is palladium chloride. The concentration of noble metal salt employed in the phosphoric acid solution can range from about .01 to about 2%, preferably from about .03 to about 1%, by weight of the solution.

As in the case of the use of the chromic acid solution, although tap water can be employed in preparing the aqueous phosphoric acid solution of the noble metal salt, in preferred practice deionized water is employed for the reasons noted above with respect to preferred use of deionized water in the chromic acid solution, namely, avoidance of impurities present in tap water which may tend to adversely affect the adsorption of the noble metal salt onto the surface of the substrate.

During treatment of the nonmetallic, e.g., plastic, substrate in the phosphoric acid solution of the noble metal salt, such solution is generally maintained at elevated temperature, but generally not above about 95°C . when treating a plastic substrate such as ABS plastics, in order to avoid undue softening thereof. Usually, such solution is maintained at temperature ranging from about 65°C . to about 95°C . and is preferably maintained at about 70° to about 85°C . Time of treatment of the nonmetallic, e.g., plastic substrate, in such solution can range from about 30 seconds up to as much as 1 hour, and in preferred practice, time of treatment is of the order of about 1 to about 5 minutes.

The phosphoric acid solution of the noble metal salt, preferably palladium chloride, is readily adsorbed onto the surface of the non-metallic, e.g., plastic, body, particularly where such substrate has first been treated in the chromic acid etch bath. This adsorption of the noble metal salt, preferably palladium chloride, onto the surface of the non-metallic or plastic body appears to be particularly aided by the use of a phosphoric acid solution. The use of a phosphoric acid solution of the noble metal salt has been found from experience to be highly superior to the prior art hydrochloric acid solution of the noble metal salt in this respect, and provides a much more evenly distributed and more concentrated layer of catalyst nuclei in the nature of subsequently reduced noble metal, e.g., palladium, upon treatment with the electroless nickel solution containing a reducing agent. The result is that when employing the phosphoric acid solution of the noble metal salt, according to the invention, the electroless nickel is deposited much more evenly and more rapidly upon the noble metal nuclei than when employing the conventional prior art hydrochloric acid solution of the noble metal salt. In addition, the use of the novel phosphoric acid solution of the noble metal salt, according to the invention, to provide the activating or seeding solution, permits avoidance of the stannous chloride solution employed in the prior art procedure and required therein so as to aid in reducing the noble metal salt applied to the surface by the hydrochloric acid solution, and to provide the nuclei required for deposition thereon of the electroless nickel.

Following treatment of the non-metallic, e.g., plastic substrate, in the phosphoric acid solution of the noble metal salt such as palladium chloride, to adsorb palladium chloride or noble metal salt onto the surface of the non-metallic body, such body is first rinsed in tap water at about room temperature to remove excess phosphoric acid, and the so-treated non-metallic or plastic body is then contacted as by immersion, with an electroless nickel bath. Such electroless nickel baths are well known in the art and generally comprise an aqueous solution of a soluble nickel salt such as nickel chloride, nickel fluoride or nickel sulfate, and an alkali metal hypophosphite such as sodium or potassium hypophosphite. Other reducing agents such as sodium or potassium borohydride, hydrazine, and the like, can be employed in place of the hypophosphite, although the latter is the

preferred reducing agent. Such electroless nickel baths generally contain a concentration ranging from about 0.3 to about 5% by weight of nickel salt, such as NiSO_4 (which is generally present as the hexahydrate), and a concentration in the range of about 0.3 to about 5% by weight of the reducing agent, e.g., hypophosphite salt. Generally, the nickel salt is present in greater proportion than the reducing agent. Usually a buffer is also present in the electroless nickel solution, such buffers being, for example, a carboxylic acid such as formic acid, hydroxyacetic acid, propionic acid, citric acid, aminoacetic acid, succinic acid, or the like.

Treatment of the non-metallic or plastic body in the electroless nickel bath can be carried out at elevated temperature, e.g. ranging from about 40° C. to about 95° C., but is preferably carried out at about 60° C. to about 75° C., particularly on plastic bodies, such as ABS plastics, so as to obtain relatively rapid reaction without softening or otherwise affecting the physical characteristics of the plastic body. Time of treatment can range from as little as about 2 minutes when carrying out the treatment at the higher temperatures of about 95° C. and up to about 20 to 30 minutes at the lower temperatures. Preferably, time of treatment is of the order of about 3 to 5 minutes where the treatment is carried out at the preferred temperature of about 60° C. to about 75° C.

It is believed that when the electroless nickel solution is contacted with the surface of the non-metallic or plastic substrate having adsorbed thereon the noble metal salt, e.g., palladium chloride, the hypophosphite immediately and first functions to reduce such adsorbed palladium chloride or noble metal salt, to form nuclei or seeds for deposition of the nickel coating, and then the hypophosphite functions to reduce the nickel salt in the electroless nickel bath to metallic nickel which then deposits on the seeds or nuclei and grows thereon to form a uniform continuous coating of nickel on the non-metallic or plastic substrate. As previously noted, due to the use of the phosphoric acid solution of the noble metal salt, and particularly when the surface of the non-metallic or plastic body is first etched with the aqueous chromic acid solution as above described, the reduced nuclei of noble metal or palladium present on the surface of the substrate are highly adherent thereto, causing deposition of a highly adherent electroless nickel coating on said nuclei.

It is understood that the electroless nickel coating deposited from the electroless nickel solution when the reducing agent is a hypophosphite is not pure nickel, but a nickel alloy, e.g. a compound of nickel and nickel phosphide. However, for purposes of the invention and as generally termed in the prior art, such coatings are referred to in the specification and claims as a "nickel" coating or plate.

The non-metallic or plastic substrate on which is now deposited the highly adherent uniform and continuous coating of electroless nickel, can be subjected, either directly after formation of the electroless nickel coating or, after aging of the electroless nickel coating where the initial chromic acid treatment is omitted, as previously noted, to treatment in an electroplating bath for deposition of a plating of any desired metal over the electroless nickel by conventional electroplating procedure. Thus, for example, electroplating solutions for electroplating copper, nickel, chromium, nickel-chromium, silver, gold, or any other metal which can be electroplated upon the electroless nickel, can be employed. The superior adherence and conductivity of the electroless nickel produced according to the invention procedure, as compared to prior art electroless nickel coatings, permits rapid electroplating of the desired metal, particularly a copper or nickel electroplate, upon the electroless nickel, and results in high adhesion of the electroplate to the electroless nickel base coating and production of a uniform lustrous electroplate.

The following are examples of practice of the invention.

EXAMPLE 1

An ABS plastic body is first immersed in an etch solution for a period of about 2 minutes, maintained at approximately 20° C. and having the following composition:

	Grams
Chromic acid (CrO_3)	175
Deionized water	100

Following rinsing first in tap water and then in deionized water, the etched plastic body is then immersed in a sensitizer solution for about 2 minutes at approximately 80° C. and having the following composition:

Phosphoric acid (85% H_3PO_4)	grams	250
Deionized water	do	65
Palladium chloride	milligrams	150

Following rinsing, the sensitized or activated plastic body is then treated in an electroless nickel bath such as that marketed as Electroless Nickel No. 21, and including nickel sulfate and sodium hypophosphite, in the usual concentrations as noted above, and a carboxylic acid buffer of the type noted above.

The plastic body now containing a conductive highly adherent uniform electroless nickel coating is then subjected to treatment in a conventional copper electroplating bath containing copper sulfate and sulfuric acid in the following proportions:

	Ounces/gal.
Copper sulfate	28
Sulfuric acid	8

The copper electroplate is rapidly applied and forms a highly adherent, uniform copper plate.

EXAMPLE 2

The procedure of Example 1 is carried out except that the treatment with the chromic acid solution is omitted and the clean ABS plastic body is treated directly in the phosphoric acid solution of palladium chloride.

However, in this procedure, following formation of the nickel electroless coating, the latter is aged for about 24 hours and the resulting electroless nickel coating obtained is a highly adherent uniform and conductive coating.

Following this aging period, the plastic body containing the nickel electroless coating is subjected to treatment in a copper electroplating bath of the type described in Example 1 for rapid production of a highly adherent lustrous copper plate.

EXAMPLE 3

The procedure of Example 1 is substantially carried out except that in place of the phosphoric acid solution of palladium chloride employed in Example 1, the respective phosphoric acid solutions containing palladium chloride, platinum chloride, auric chloride and silver nitrate, set forth below are employed:

Phosphoric acid (85% H_3PO_4)	grams	100
Tap water	do	100
Palladium chloride	milligrams	150

Phosphoric acid (85% H_3PO_4)	grams	200
Deionized water	do	100
Platinum chloride	milligrams	200

Phosphoric acid (85% H_3PO_4)	grams	250
Tap water	do	100
Auric chloride	milligrams	100

Phosphoric acid (85% H_3PO_4)	grams	150
Deionized water	do	100
Silver nitrate	milligrams	250

In each case, a highly adherent uniform conductive electroless nickel coating is obtained, and the copper electroplate applied thereover is rapidly formed, with good adherence to the electroless nickel, and forming a lustrous electroplate.

EXAMPLE 4

The procedure of Example 1 is substantially carried out except that in place of treatment of the electroless nickel deposited on the plastic, with a copper electroplating bath, such substrate containing the electroless nickel coating is subjected to electroplating in a conventional nickel electroplating bath containing nickel sulfate, nickel chloride and boric acid in the following proportions:

	Ounces/gal.
Nickel sulfate ($\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$)	44
Nickel chloride	6
Boric acid	5

The nickel electroplate is rapidly formed on the electroless nickel base coating, and such electroplate is a lustrous uniform nickel plate of high adherence to the plastic substrate.

EXAMPLE 5

The procedure of Example 1 is substantially carried out except that in place of the specific aqueous chromic acid solution employed in Example 1, the following chromic acid solutions of varying chromic acid concentration are employed:

	Grams
Chromic acid (CrO_3)	100
Deionized water	100
Chromic acid (CrO_3)	50
Deionized water	100
Chromic acid (CrO_3)	140
Tap water	100

In each case, a highly adherent electroless nickel coating is obtained which is uniform and highly conductive, and the resulting copper electroplate is rapidly applied and is highly adherent and lustrous.

EXAMPLE 6

The procedure of Example 1 is substantially carried out except that in place of the electroless nickel bath employed in Example 1, there is employed an electroless nickel bath marketed as Electroless Nickel No. 24, and including nickel sulfate and sodium hypophosphite in the usual concentrations as noted above, and a buffer comprising carboxylic acids of the type noted above.

An electroless nickel coating of substantially the same characteristics as in Example 1 is produced, namely one having high adherence to the substrate, good uniformity and good conductivity. The resulting copper electroplate also is of the same high quality as that formed by the procedure of Example 1, and is of a uniform, adherent and lustrous nature.

EXAMPLE 7

The procedure of Example 1 is substantially carried out employing in place of the ABS plastic body, plastic bodies formed respectively of bondized Teflon, amine catalyzed epoxy resin in the form of the condensation product of bisphenol A and epichlorhydrin, polystyrene and butyl rubber.

In each case, a highly adherent electroless nickel coating is provided on the plastic substrate, such coating being rapidly applied and having the improved characteristics of the electroless nickel coating obtained in Example 1 with respect to high adherence to the substrate, good uniformity and good conductivity.

The resulting copper electroplate formed on the respective electroless nickel coatings of the respective plastic substrates noted above also is of high quality with respect to high adherence to the substrate, good uniformity and of lustrous nature.

From the foregoing, it is seen that the invention provides an improved procedure for depositing a nickel electroless coating on a non-metallic, e.g., plastic substrate, rapidly and with a minimum number of operational steps,

to form an improved highly adherent, uniform electroless nickel coating which is highly conductive and particularly suited as a base for rapid and efficient electroplating of metals thereon, e.g., a copper or nickel electroplate, resulting in an electroplate having good adherence to the substrate and of good lustrous quality. Such procedure employs highly stable aqueous chromic acid etching solutions, and a particularly important and novel seeding or activating bath in the form of a phosphoric acid solution of a noble metal salt, which is also a stable solution.

Although the invention principles are of particular advantage for the application of an electroless nickel deposit on non-metallic bodies, particularly plastics, the invention procedure and compositions employed therein can also be utilized to advantage for applying an electroless nickel deposit on semi-conductive or conductive bodies or surfaces composed of metaloids, metals and alloys, e.g., carbon, boron, corrosion-resistant steel alloys, nickel, nickel alloys, silica, and aluminum oxide.

While I have described particular embodiments of the invention for the purpose of illustration, it should be understood that various modifications and adaptations thereof may be made within the spirit of the invention, and within the scope of the appended claims.

I claim:

1. In the process of producing a securely bonded layer of nickel on the surface of a plastic body, the improvement which comprises contacting said plastic body with an aqueous phosphoric acid solution of a noble metal salt, wherein said solution contains about 30% to about 85% H_3PO_4 and about 0.01% to about 2% of said noble metal salt, prior to treatment of said plastic body with an electroless nickel plating bath comprising an aqueous solution of a nickel salt and a reducing agent.

2. In the process of producing a securely bonded layer of nickel on the surface of an acrylonitrile-butadiene-styrene plastic body, the improvement which comprises contacting said body with an aqueous phosphoric acid solution of a noble metal salt, wherein said solution contains about 30% to about 85% H_3PO_4 and about 0.01% to about 2% of said noble metal salt, prior to treatment of said body with an electroless nickel plating bath comprising an aqueous solution of a nickel salt and a reducing agent.

3. In the process of producing a securely bonded layer of nickel on the surface of a plastic body, the improvement which comprises contacting said body with an aqueous phosphoric acid solution of palladium chloride, wherein said solution contains about 30% to about 85% H_3PO_4 and about 0.01% to about 2% of palladium chloride, prior to treatment of said body with an electroless nickel plating bath comprising an aqueous solution of a nickel salt and a reducing agent.

4. The process of producing a securely bonded layer of nickel on the surface of a plastic body, which comprises contacting said body with an aqueous phosphoric acid solution of a noble metal salt, wherein said solution contains about 30% to about 85% H_3PO_4 and about 0.1% to about 2% of said noble metal salt, and then contacting said body with an electroless nickel plating bath comprising an aqueous solution of a nickel salt and a reducing agent.

5. The process of producing a securely bonded layer of nickel on the surface of a plastic body, which comprises contacting said body with an aqueous chromic acid solution containing about 20% to about 70% CrO_3 , then contacting said body with an aqueous phosphoric acid solution of a noble salt, wherein said solution contains about 30% to about 85% H_3PO_4 and about 0.01% to about 2% of said noble metal salt, and then contacting said body with an electroless nickel plating bath comprising an aqueous solution of a nickel salt and a reducing agent.

6. The process of producing a securely bonded layer of nickel on the surface of a plastic body, which com-

prises contacting said body with an aqueous phosphoric acid solution of palladium chloride, wherein said solution contains about 30% to about 85% H_3PO_4 and about 0.01% to about 2% of palladium chloride, and then contacting said body with an electroless nickel plating bath comprising an aqueous solution of a nickel salt and a hypophosphite.

7. The process of producing a securely bonded layer of nickel on the surface of a plastic body, which comprises contacting said body with an aqueous chromic acid solution containing about 20% to about 70% CrO_3 , then contacting said body with an aqueous phosphoric acid solution of palladium chloride, wherein said solution contains about 30% to about 85% H_3PO_4 and about 0.01% to about 2% of palladium chloride, and then contacting said body with an electroless nickel plating bath comprising an aqueous solution of a nickel salt and a reducing agent.

8. The process as defined in claim 7, wherein said aqueous chromic acid solution is employed in a concentration of about 50 to about 65% CrO_3 , and wherein said phosphoric acid solution contains about 60 to about 85% H_3PO_4 , and said palladium chloride is present in a concentration of about 0.03 to about 1%.

9. The process of producing a securely bonded continuous layer of electroless nickel plate on the surface of an acrylonitrile-butadiene-styrene plastic body, which comprises contacting said body with a concentrated aqueous solution of chromic acid containing about 20% to about 70% CrO_3 , to etch the surface of said plastic body, then contacting said body at elevated temperature with a concentrated solution of phosphoric acid containing pal-

ladium chloride, wherein said solution contains about 30% to about 85% H_3PO_4 and about 0.01% to about 2% of palladium chloride, to adsorb palladium chloride onto the surface of said plastic body, and then contacting said body with an aqueous solution of a nickel salt and a hypophosphite to reduce said adsorbed palladium chloride to metallic palladium so that particles of said metallic palladium are distributed uniformly over the etched surface of said body and secured thereto, and substantially simultaneously to reduce said nickel salt to metallic nickel and cause plating of said metallic nickel upon said metallic palladium particles and form a continuous nickel layer on the surface of said body.

10. The process as defined in claim 9, wherein said aqueous chromic acid solution is employed in a concentration of about 50 to about 65% CrO_3 , and wherein said phosphoric acid solution contains about 60 to about 85% H_3PO_4 , and said palladium chloride is present in a concentration of about 0.03 to about 1%.

References Cited

UNITED STATES PATENTS

2,027,358	1/1936	Powell et al.	204—47
2,410,844	11/1946	Signaigo et al.	106—1 X
2,978,390	4/1961	Atwater et al.	204—46
2,984,603	5/1961	Duva	204—47
3,035,944	5/1962	Sher	117—47 X

RALPH S. KENDALL, *Primary Examiner.*

U.S. Cl. X.R.

117—138.8, 160