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CHROMIUM PLATING PROCESS

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This invention relates to an improved process for producing a chromium plate on a solid platable substrate, and in particular, is concerned with an improvement in chromium plating processes based upon the catalyzed thermal decomposition of a bis(arene) chromium compound to produce said chromium plate.

Heretofore, it was known that a chromium plate could be produced on a solid platable substrate by contacting the substrate with a bis(arene) chromium compound at a temperature at or above the thermal decomposition temperature of the bis(arene) chromium compound. While various embodiments of this process are operable, they all have at least one important characteristic in common. Namely, they entail the use of a plating, i.e., contact, temperature of at least about 300° C., and preferably at least about 350° C., in order to effect the thermal decomposition of the bis(arene) chromium compound.

Unfortunately, however, the necessity for utilizing such elevated plating temperatures limits the selection of substrates which can be plated in accordance with the process. Thus, for instance, the use of many synthetic resins, such as polyethylene and poly(vinyl chloride), etc., which decompose when heated to temperatures of about 300° C. and higher, is precluded in this regard. In addition, the use of such elevated temperatures may damage the temper of many steel products, particularly tempered spring steel, on which a chromium plate is often desirable. Further, the use of such elevated temperatures may be a hazard in plating large glass objects which are ordinarily subject to strain unless heating and cooling operations are slow, the latter, in turn, being an undesirable feature from a commercial point of view. Finally such elevated temperatures are often above the stability range of common gasketing materials, such as polytetrafluoroethylene, neoprene and rubber, etc., thereby limiting the type of apparatus employed in the plating operation, or complicating the construction of such apparatus.

Advantageously, it has now been found that upon contacting a platable solid substrate in an inert atmosphere with a bis(arene) chromium compound in mutual contact with a halogen-containing catalyst, the thermal decomposition of the bis(arene) chromium compound, producing a substantially pure chromium plate on the substrate, can be carried out at a temperature materially lower than that heretofore believed to be minimally required in the plating process, i.e., a temperature as low as about 150° C., or slightly lower. In this manner, substrates such as large glass objects, many synthetic resins, and tempered steels, etc., which are not thermally stable at the elevated temperatures employed in accordance with prior art plating techniques as indicated above, can now be plated satisfactorily through the practice of the improved process of this invention. At the same time, through the use of lower plating temperatures, a more convenient and economical plating process is made possible.

The plating process of this invention is predicated in important part upon the unexpected finding that the thermal decomposition of the bis(arene) chromium compound is catalyzed by certain halogen-containing materials which lower the thermal decomposition temperature of the bis(arene) chromium compound when in contact therewith. The halogen-containing catalysts contemplated

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in this regard are those containing as the halogen moiety, at least one element having an atomic number of from 17 to 53, i.e., bromine, chlorine and/or iodine, and include these halogens in elemental form, as well as the following:

- 5 halogen-substituted cyclic and acyclic saturated and unsaturated aliphatic and aromatic hydrocarbons containing from 1 to about 20 carbon atoms, and preferably from 1 to about 12 carbon atoms, such as carbon tetrachloride, bromoform, dichloriodomethane, butyl chloride, 1-chloro-2-ethylhexane, 1,2-dichlorononane, dodecyl chloride, octadecyl chloride, vinyl chloride, allyl bromide, isobutenyl chloride, propargyl bromide, cyclohexyl iodide, phenyl bromide, ortho-dichlorobenzene, hexachlorobenzene, naphthyl chloride, various dichloroxylenes, benzyl chloride, and the like; the halogen-substituted
- 10 cyclic and acyclic saturated and unsaturated aliphatic hydrocarbon ethers consisting only of carbon, hydrogen, oxygen and halogen atoms, and containing from 2 to 12 carbon atoms, and preferably from 2 to 6 carbon
- 20 atoms, such as 2,2'-dichloroethyl ether, 1-chloromethyl octyl ether, 6,6'-dichlorohexyl ether, vinyl 2-chloroethyl ether, 2,3-dichloro-1,4-dioxane, and the like; the tetraalkyl ammonium halides containing from 1 to 12 carbon atoms, and preferably from 1 to 6 carbon atoms in each
- 25 alkyl radical, such as tetramethyl ammonium moniodide, tetramethyl ammonium triiodide, tetramethyl ammonium heptaoidide, tetrahexyl ammonium chloride, tetradecyl ammonium chloride, tributyl ethyl ammonium bromide, and the like; the hydrogen halides, such as anhydrous hydrogen bromide, chloride, and iodide; the ammonium halides, such as ammonium bromide, chloride, and iodide; interhalogens, such as iodine monochloride, bromine monochloride, iodine bromide, iodine trichloride, and the like; and metal halides, especially the alkali
- 30 metal halides, such as potassium iodide, potassium tetrachloroiodate, sodium chloride, lithium bromide, cesium iodide, rubidium chloride, and the like. The selection of catalyst for optimum results depends to a certain extent upon the particular plating technique employed, as indicated below.

The bis(arene) chromium compounds contemplated by this invention are organometallic compounds in which the arene groups are uncharged aromatic hydrocarbons containing either an isolated benzene ring or an aryl-substituted benzene structure. As employed herein, the term "isolated benzene ring" is intended to define a benzene ring as contained in benzene itself, or in a fused ring polycyclic aromatic hydrocarbon containing a benzene ring, wherein, by the Kekule formulation, any

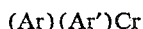
- 50 double bond in a ring fused to such benzene ring is removed from the benzene ring carbon atom nearest to it by at least two carbon atoms. The term "isolated benzene ring" is also intended to define a benzene ring as contained in a monocyclic aromatic hydrocarbon having one or more aliphatic substituents on a benzene ring, wherein any double bond external to the benzene carbon ring is removed from the benzene ring carbon atom nearest to it by at least two carbon atoms. Thus, benzene, indane, tetrahydronaphthalene, 9,10-dihydroanthracene, 9,10-dihydrophenanthrene, alkyl-substituted benzenes such as toluene, ethylbenzene, butylbenzene, octylbenzene, etc., and alkenyl-substituted benzenes in which double bonds external to the benzene ring are separated therefrom by at least two carbon atoms, such as allylbenzene, etc., are
- 65 examples of aromatic hydrocarbons containing an isolated benzene ring. By contrast, naphthalene, indene, anthracene, phenanthrene and styrene are examples of aromatic hydrocarbons which do not contain an isolated benzene ring.

As also mentioned above, a class of aromatic hydrocarbons which do not contain an isolated benzene ring,

namely aryl-substituted benzenes, also form bis(arene) chromium compounds which are useful in the plating process of this invention. Examples of such aryl-substituted benzenes are polyphenyls, alkyl-substituted polyphenyls, such as p-isopropylidiphenyl and p,p'-dimethyldiphenyl, phenylanthracene and phenylphenanthrene.

The bis(arene) chromium compounds contemplated by this invention may, from the point of view of their organic moiety, be characterized as addition compounds in contrast to organometallic substitution compounds, wherein hydrogen or another substituent of the organic nucleus is substituted or removed in forming the organometallic compound. Thus, the bis(arene) chromium compounds are to be distinguished from the organometallic compounds formed by the chemical bonding of a cyclopentadienyl radical with an element (Fischer and Pfab, *Zeit. für Naturforschung*, 7b, page 377 (1952)), and from phenyl mercury compounds, e.g., phenyl mercuric acetate (U.S. Patent 2,502,222). Formation of such substitution compounds, it is to be noted, involves elimination of hydrogen from the cyclopentadiene or benzene nucleus. In the case of the bis(arene) chromium compounds of the present invention, the chemical union of the metal with the aromatic hydrocarbon does not involve the elimination of hydrogen or any other substituent of the organic nucleus. The bis(arene) chromium compounds may, therefore, be regarded as the addition products of chromium with aromatic hydrocarbons.

The bis(arene) chromium compounds contemplated by this invention can be represented more clearly by the formula $(Ar)_2Cr$, wherein Ar designates either an aromatic hydrocarbon containing an isolated benzene ring, or an aryl-substituted benzene, as hereinabove described. The bis(arene) chromium compounds can also have mixed Ar substituents, as more specifically represented by the formula



wherein Ar and Ar' independently designate members of the same class of aromatic hydrocarbons. The exact nature of the bond between the aromatic hydrocarbon moiety and the metal is unknown. However, it is known that the isolated benzene ring or the benzene ring of the aryl-substituted benzene is complexed to the metal.

The bis(arene) chromium compounds contemplated by this invention include, by way of illustration,

bis(benzene)chromium,
bis(tetrahydronaphthalene)chromium,
bis(toluene)chromium,
bis(mesitylene)chromium,
bis(hexamethylbenzene)chromium,
bis(orthoxylene)chromium,
bis(meta-xylene)chromium,
bis(para-xylene)chromium,
bis(octylbenzene)chromium,
(benzene) (tetrahydronaphthalene)chromium,
bis(diphenyl)chromium,
bis(cumene)chromium, and the like.

The preferred bis(arene) chromium compounds are those in which the arene moiety is either benzene or a lower alkyl-substituted benzene in which the lower alkyl-substituent(s) contain from 1 to about 8, and preferably from 1 to about 4 carbon atoms.

The bis(arene) chromium compounds can be prepared by reacting an anhydrous chromium salt, such as a chromium halide, with an aromatic hydrocarbon containing at least one isolated benzene ring, or with an aryl-substituted benzene, in the presence of an anhydrous aluminum halide and a reducing agent. More particularly, the bis(arene) chromium compounds and methods for their production are described more fully in U.S. 2,953,586 and in copending application Serial No. 676,389, filed August 5, 1957, such descriptions being incorporated herein by reference.

The plating process of this invention, as hereinabove described, entails contacting a suitable substrate over the area to be plated with the bis(arene) chromium compound in mutual contact with a catalytic amount of halogen-containing catalyst, and heating the bis(arene) chromium compound and halogen-containing catalyst in contact with the substrate at a temperature of at least the decomposition temperature of the bis(arene) chromium compound when in contact with the catalyst. A substantially pure, ordinarily uniform chromium plate is thereby produced on the substrate. In addition, it is essential that the process of this invention be carried out in an inert atmosphere, i.e., in the absence of oxygen or oxygen-containing substances which react with the bis(arene) chromium compound, or with the resulting chromium plate itself, to form metal oxides which contaminate the plate.

The function of the halogen-containing material employed in accordance with this invention being that of a catalyst, any amount thereof sufficient to catalyze the thermal decomposition of the bis(arene) chromium compound, resulting in the lowering of the decomposition temperature, can be utilized with satisfactory effect. Such amounts will vary to a certain extent depending upon the particular catalyst employed and the plating rate desired, and can readily be determined by one skilled in the art in light of this disclosure. Moreover, particularly good results can be obtained, for instance, employing the halogen-containing catalyst in an amount varying in the range of from about 0.1 to about 5 weight percent, and preferably from about 0.2 to about 3 weight percent, based upon the amount of bis(arene) chromium compound employed. Within this range, an increase in the amount of catalyst ordinarily engenders a more rapid rate of plating. Greater amounts of catalyst can also be employed, although little additional advantage may accrue. It is to be noted further that certain of the halogen-containing catalysts, particularly the elemental halogens, may react with a minor amount of the bis(arene) chromium compound employed. Under such circumstances, the resulting product, produced using a catalytically efficient amount of the halogen-containing catalyst, has also been found to have catalytic activity within the contemplation of this invention as hereinabove described.

The plating temperature to be employed will vary to a certain extent, depending upon the particular bis(arene) chromium compound and catalyst employed, as well as upon the desired rate of plating. In general, however, satisfactory results can be obtained at a plating temperature of at least about 150° C., and preferably in the range of about 150° C. to about 250° C., with more rapid plating occurring as the plating temperature is increased. Plating temperatures of 300° C. and higher can also be employed, although the use of such higher temperatures may limit the type of substrate which can be plated, for reasons such as those described above in connection with the prior art. The maximum plating temperature is, for practical purposes, determined by the decomposition (cracking) temperature of the arene moiety of the bis(arene) chromium compound.

The heating period can also be varied broadly. Commercially acceptable plates can be obtained, for instance, by heating for a contact period of from about 10 minutes to about 3 hours, although somewhat shorter, as well as longer heating periods can also be employed. In general, thicker plates are ordinarily produced as the heating period is extended.

Any platable solid substrate which is thermally stable at the temperature encountered can be used in the plating process of this invention in a variety of shapes or forms. By way of illustration, suitable substrates include glass, metals such as aluminum and iron, etc., thermoplastic and thermoset polymers such as poly(vinyl chloride), polyethylene, poly(ethylene terephthalate), the polyimide of isophthalic acid and meta-phenylene diamine, polytetrafluoroethylene, polytrifluorochloroeth-

ylene, acrolein-pentaerythritol resins, etc., and the like. Moreover, the substrate can be in the form of single sheets, laminates, fibers, films, molded or shaped articles, etc.

The plating process of this invention can be carried out by various means without limiting the invention. In one embodiment of the invention, for instance, the bis(arene) chromium compound and halogen-containing catalyst are admixed in any convenient manner, such as by physical admixture, or by saturating the bi(arene) chromium compound with the halogen-containing catalyst, the latter preferably being in vapor phase. The resulting mixture is then vaporized, and the vapors are passed over and contacted with the substrate at a plating temperature as hereinabove described. Conventional vapor-phase plating techniques can be employed in this regard. In this embodiment, particularly good results have been achieved using elemental iodine and carbon tetrachloride as catalysts.

In another embodiment of this invention, the substrate is initially contacted with the halogen-containing catalyst, and the bis(arene) chromium compound is subsequently vaporized so that the resulting vapors are passed over and contacted with the substrate and catalyst at a plating temperature. Here again, conventional vapor-phase plating techniques can be employed. The initial treatment of the substrate with the halogen-containing catalyst can be effected, for instance, in any convenient manner, such as by dipping the substrate into a solution of the catalyst in an inert diluent or solvent such as ethanol, and subsequently evaporating the solvent, leaving the catalyst in contact with the substrate. In this embodiment, particularly good results have been achieved using ammonium iodide and bromoform as catalysts.

In still another embodiment of this invention, the bis(arene) chromium compound is initially dissolved in an inert diluent such as paraffin oil, tetralin, etc., and the resulting solution is subsequently brought into contact with the substrate at a plating temperature. Contact can be effected by conventional dip-plating techniques, or in any other convenient manner. In this embodiment, particularly good results have been achieved using elemental iodine and ortho-dichlorobenzene as catalysts.

Other means for bringing the substrate, bis(arene) chromium compound and halogen-containing catalyst into mutual contact at a plating temperature so as to produce or deposit a chromium plate on the substrate will occur to those skilled in the art in light of this disclosure and can be employed within the contemplation of this invention.

The invention can be illustrated further by the following specific examples of its practice.

EXAMPLE I

Two glass microscope slides were introduced into a 30 mm. x 25 cm. glass tube. The tube was purged with nitrogen and 10 drops (approximately 0.3 gram) of dicumene chromium were introduced into the tube from a hypodermic syringe. A small crystal of iodine was then inserted in the tube by use of a spatula. The tube was partially evacuated, leaving $\frac{3}{4}$ of an atmosphere of nitrogen, and sealed. The sealed tube was placed in an electrically heated, thermostatically controlled oven, at a temperature of 250° C., for a period of 0.5 hour. At the end of this period, the tube was removed from the furnace, cooled, opened, and the microscope slides found to be chromium plated. In like manner, glass slides are chromium plated independently using ammonium chloride, ortho-dichlorobenzene, hexachlorobenzene, 2,3-dichloro-1,4-dioxane, allyl chloride, propargyl chloride, 2,2-dichloroethyl ether, cyclohexyl chloride, and bromoform as catalysts. However, similar efforts to chromium plate the slides omitting the use of a halogen-containing catalyst, were unsuccessful at temperatures of about 250° C. and evidence of plating was not observed under such

conditions until the plating temperature reached 300° C., and then only after heating periods of several hours.

EXAMPLE II

A glass tube, as described in Example I, was charged with two glass microscope slides, purged with nitrogen, and two drops of dicumene chromium were introduced into the tube. The drops of dicumene chromium were moved around in the tube to expose as much liquid surface as possible. Chlorine gas was then passed through the tube for fifteen minutes at room temperature, thereby saturating the dicumene chromium. The tube was purged again with nitrogen, after which an additional twenty drops of dicumene chromium were introduced into the tube. Finally, the tube was evacuated, sealed, and placed in an oven at a temperature of 157° C. After a period of six hours at this temperature, the tube was removed from the oven, and a thin chromium plate was found to be deposited on the slides. The tube was returned to the oven and heating was continued at the same temperature. After an additional twelve-hour heating period, the tube and the slides were uniformly coated with a shiny and adherent chromium plate. In similar manner, glass slides are chromium plated, in one instance, using dibenzene chromium as the plating agent, and in another instance, using anhydrous hydrogen chloride as the catalyst.

EXAMPLE III

A piece of coronized glass cloth (6" x 10") was dipped in a solution containing 0.4 weight percent of ammonium iodide in ethanol. The cloth was removed from the solution, drained and the ethanol was allowed to evaporate from the cloth. The cloth, thereby impregnated with ammonium iodide, was then placed in a one-gallon stainless steel vessel, under a nitrogen atmosphere, and twenty cubic centimeters of dicumene chromium were introduced into the vessel. The vessel was heated to a temperature of 250° C. for a period of one hour. At the end of this period, a uniform chromium plate was found to be deposited on the cloth. In similar manner, glass cloth is chromium plated, in one instance, using an isomeric mixture of dixylene chromium as the plating agent, and in other instances, independently using potassium iodide and elemental iodine as catalysts.

In addition, a series of experiments were conducted in similar manner using ethanol solutions containing varying amounts of ammonium iodide to treat or impregnate the glass cloth prior to plating. The results are tabulated below in Table A. In the table, the proportion of ethanol to ammonium iodide indicates the volume of ethanol in cubic centimeters which contains 0.2 gram of ammonium iodide, the solution being used to treat the cloth prior to plating.

Table A

Run	Ethanol/NH ₄ I (cc./0.2 g.)	Temp. (° C.)	Time (Hr.)	Result
1.....	25	250	0.5	Heavy plate.
2.....	50	250	0.5	Do.
3.....	100	250	0.5	Do.
4.....	200	250	0.5	Do.
5.....	400	250	0.5	Thin plate.

Thus a sixteen-fold dilution of the catalyst solution resulted in reaching a catalyst concentration at which a light plate was produced on the cloth.

EXAMPLE IV

Six feet of commercially available polyethylene terephthalate tape were washed in ethanol, wound on a metal rack, and the rack was inserted in a two-liter glass flask gasketed with silicone rubber and fitted with a stainless steel lid with connection for evacuation. The flask was purged with nitrogen and chlorine gas was passed through the flask for a period of ten minutes at room temperature, thereby saturating the tape. The chlorine gas was

evacuated, and the flask was again purged with nitrogen. Five cubic centimeters of dicumene chromium were then introduced into the flask and the flask was evacuated to 29.5 inches of mercury at room temperature. Finally, the flask was heated to a temperature of 225° C. for a period of 0.5 hour. At the end of this period, the tape was removed from the flask and was found to be uniformly coated with a thin chromium plate.

EXAMPLE V

A three-liter glass flask was equipped with a mechanical stirrer, a thermometer, an inlet tube below the eventual liquid surface, and a vent consisting of a water-cooled reflux condenser and a bubble bottle. The flask was purged with nitrogen and 2000 cubic centimeters of mineral oil, 0.2 gram of iodine, and 10 cubic centimeters of dicumene chromium were introduced into the flask. The resulting solution was heated to a temperature of 200° C. for a period of 2.5 hours, while a slow stream of nitrogen was passed through the flask. At the end of this period the flask was found to be coated with a thin chromium plate, and upon cooling and removing the residual solution from the flask, the thermometer, inductor tube, and stirrer were also found to be coated with a thin chromium plate over those parts which were immersed in the treating solution. A similar experiment was also performed in which a copper strip (1" x 2.5") and a sample of black-plate strip-steel of the same area were suspended in the treating solution by means of nichrome wires. After a period of 2.5 hours at a temperature of 200° C., the metal strips were found to be uniformly chromium plated. In addition, the plated strip-steel withstood immersion for thirty seconds in a copper nitrate solution without appearance of the copper discoloration otherwise denoting pores in the plating. In similar manner, a chromium plate is deposited on the substrates independently using potassium tetrachloroiodate, tetramethyl ammonium monoiodide, tetramethyl ammonium triiodide and tetramethyl ammonium hepta-iodide as the catalysts.

What is claimed is:

1. The process for producing a chromium plate on a platable solid substrate in an inert atmosphere, which process comprises: contacting said substrate over the area to be plated with (a) a bis(arene) chromium compound of the formula $(Ar)_2Cr$ wherein Ar designates an organic hydrocarbon selected from the group consisting of aromatic hydrocarbons containing an isolated benzene ring and aryl-substituted benzenes, in mutual contact with (b) a catalytic amount of a halogen-containing catalyst selected from the group consisting of the elemental halogens, the halogen-substituted aliphatic and aromatic hydrocarbons containing from 1 to 20 carbon atoms, the halogen-substituted aliphatic hydrocarbon ethers consisting of carbon, hydrogen, oxygen, and halogen atoms and containing from 2 to 12 carbon atoms, the tetraalkyl ammonium halides containing from 1 to 12 carbon atoms in each alkyl radical, the ammonium halides, the interhalogens, the hydrogen halides, and the alkali metal halides, the halogen moiety of said catalyst having an atomic number of from 17 to 53, said catalyst being present in an amount sufficient to catalytically lower the thermal decomposition of said bis(arene) chromium compound to below about 300° C.; and heating said bis(arene) chromium compound and said catalyst in contact with said substrate at a temperature of at least the decomposition temperature of said bis(arene) chromium compound in contact with said catalyst and below about 300° C.; thereby producing a chromium plate on said substrate.

2. The process for producing a chromium plate on a platable solid substrate in an inert atmosphere, which process comprises: contacting said substrate over the area to be plated with dicumene chromium in mutual contact with a catalytic amount of a halogen-substituted saturated aliphatic hydrocarbon catalyst containing from 1 to 12

carbon atoms, the halogen moiety of said catalyst having an atomic number of from 17 to 53; said catalyst being present in an amount sufficient to catalytically lower the thermal decomposition of said dicumene chromium; and heating said dicumene chromium and said catalyst in contact with said substrate at a temperature from about 150° C. to about 250° C.; thereby producing a chromium plate on said substrate.

3. The process according to claim 2 wherein said catalyst is carbon tetrachloride.

4. The process according to claim 2 wherein said catalyst is bromoform.

5. The process for producing a chromium plate on a platable solid substrate in an inert atmosphere, which process comprises: contacting said substrate over the area to be plated with dicumene chromium in mutual contact with a catalytic amount of a halogen-substituted aromatic hydrocarbon catalyst containing from 1 to 12 carbon atoms, the halogen moiety of said catalyst having an atomic number of from 17 to 53; said catalyst being present in an amount sufficient to catalytically lower the thermal decomposition of said dicumene chromium; and heating said dicumene chromium and said catalyst in contact with said substrate at a temperature from about 150° C. to about 250° C.; thereby producing a chromium plate on said substrate.

6. The process according to claim 5 wherein said catalyst is ortho-dichlorobenzene.

7. The process according to claim 5 wherein said catalyst is hexachlorobenzene.

8. The process for producing a chromium plate on a platable solid substrate in an inert atmosphere, which process comprises: contacting said substrate over the area to be plated with dicumene chromium in mutual contact with a catalytic amount of an elemental halogen catalyst having an atomic number of from 17 to 53; said catalyst being present in an amount sufficient to catalytically lower the thermal decomposition of said dicumene chromium; and heating said dicumene chromium and said catalyst in contact with said substrate at a temperature from about 150° C. to about 250° C.; thereby producing a chromium plate on said substrate.

9. The process according to claim 8 wherein said catalyst is iodine.

10. The process according to claim 8 wherein said catalyst is chlorine.

11. The process for producing a chromium plate on a platable solid substrate in an inert atmosphere, which process comprises: contacting said substrate over the area to be plated with dicumene chromium in mutual contact with a catalytic amount of an ammonium halide catalyst, the halogen moiety of said catalyst having an atomic number of from 17 to 53; said catalyst being present in an amount sufficient to catalytically lower the thermal decomposition of said dicumene chromium; and heating said dicumene chromium and said catalyst in contact with said substrate at a temperature from about 150° C. to about 250° C.; thereby producing a chromium plate on said substrate.

12. The process according to claim 11 wherein said catalyst is ammonium iodide.

13. The process according to claim 11 wherein said catalyst is ammonium chloride.

14. The process for producing a chromium plate on a platable solid substrate in an inert atmosphere, which process comprises: contacting said substrate over the area to be plated with dicumene chromium in mutual contact with a catalytic amount of an alkali metal halide catalyst, the halogen moiety of said catalyst having an atomic number of from 17 to 53; said catalyst being present in an amount sufficient to catalytically lower the thermal decomposition of said dicumene chromium; and heating said dicumene chromium and said catalyst in contact with said substrate at a temperature from about 150° C. to

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about 250° C.; thereby producing a chromium plate on said substrate.

15. The process according to claim 14 wherein said catalyst is potassium iodide.

16. The process for producing a chromium plate on a platable solid substrate in an inert atmosphere, which process comprises: contacting said substrate over the area to be plated with dicumene chromium in mutual contact with a catalytic amount of a tetraalkyl ammonium halide catalyst containing from 1 to 6 carbon atoms in each alkyl radical, the halogen moiety of said catalyst having an atomic number of from 17 to 53; said catalyst being present in an amount sufficient to catalytically lower the thermal decomposition of said dicumene chromium; and heating said dicumene chromium and said catalyst in contact with said substrate at a temperature from about

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150° C. to about 250° C.; thereby producing a chromium plate on said substrate.

17. The process according to claim 16 wherein said catalyst is tetramethyl ammonium monoiodide.

18. The process according to claim 16 wherein said catalyst is tetramethyl ammonium triiodide.

19. The process according to claim 16 wherein said catalyst is tetramethyl ammonium heptaoidide.

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