

[54] ELECTROPLATING ALUMINUM

[75] Inventors: **Guido A. Capuano**, Boucherville, Quebec; **William G. Davenport**, St. Lambert, Quebec, both of Canada

[73] Assignee: **Canadian Patents and Development Limited**, Ottawa, Ontario, Canada

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[58] Field of Search 204/14 N, 39, 14 R

[56] References Cited

UNITED STATES PATENTS

2,170,375	8/1939	Mathers	204/14 N
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Electrodeposition of Aluminum From Non-Aqueous

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Electrodeposition of Aluminum Alloys by R. D. Blue & F. C. Mathers, Electrochemical Society Preprint 69-23 April 27, 1936 pgs. 267-271

Primary Examiner—T. Tufariello

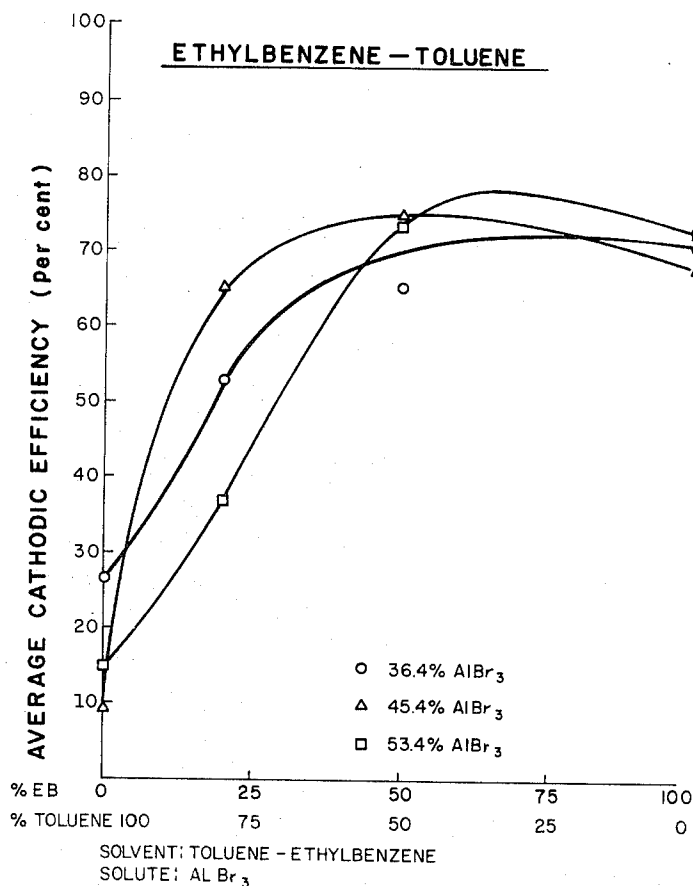
Attorney—Stevens, Davis, Miller & Mosher

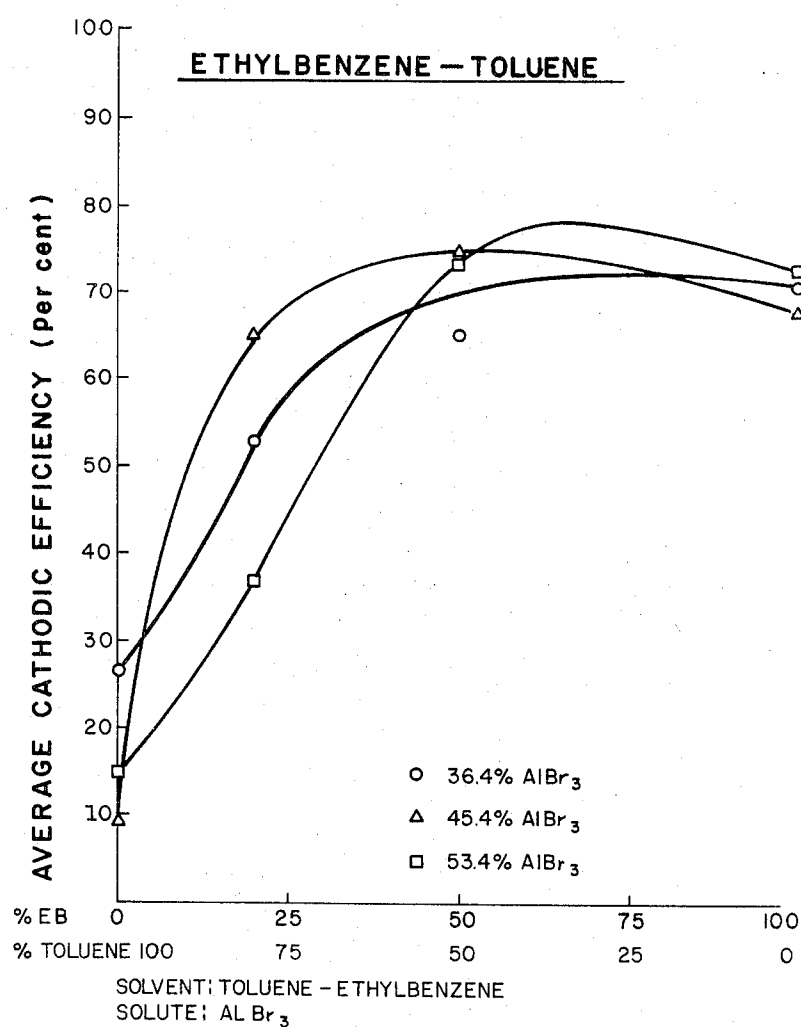
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ABSTRACT

An improved electrolyte for use in the electrodeposition of aluminum or an alloy thereof as a coating on an electrically conducting preferably metallic substrate which electrolyte comprises an aluminum halide, in particular aluminum bromide, in solution in an organic solvent consisting of certain alkyl benzenes usually having at least two carbon atoms in the alkyl groups, alone, in admixture with each other or in admixture with other alkyl benzenes, benzene or halo-benzenes.

33 Claims, 3 Drawing Figures



**FIG. 1**

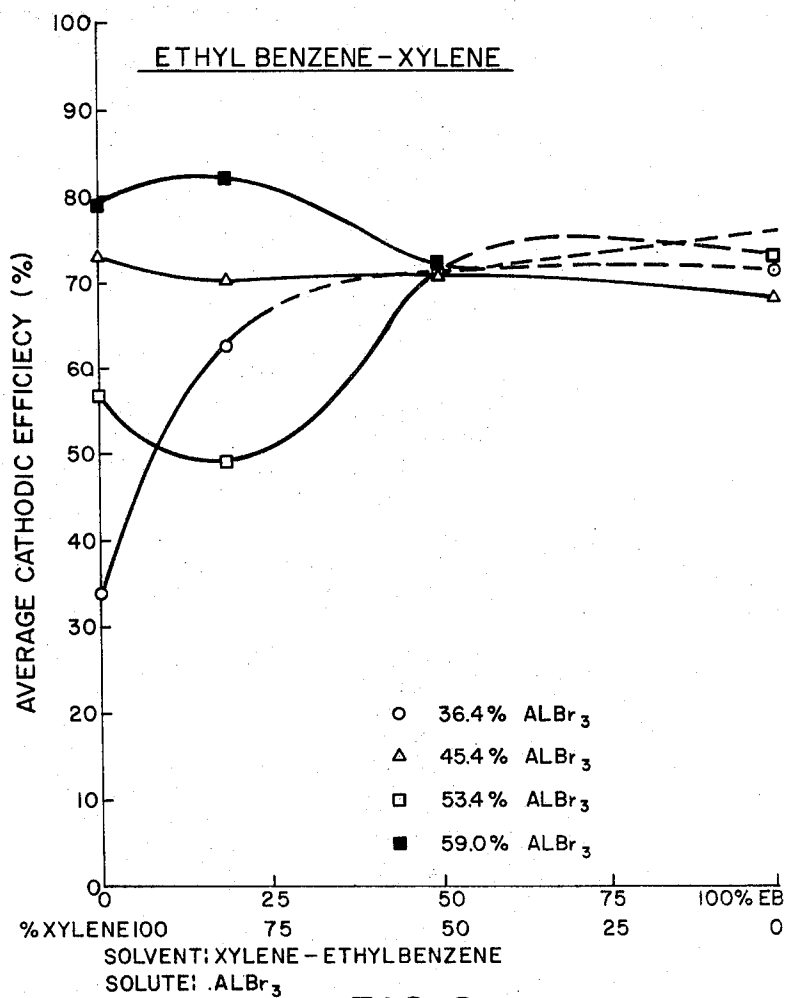
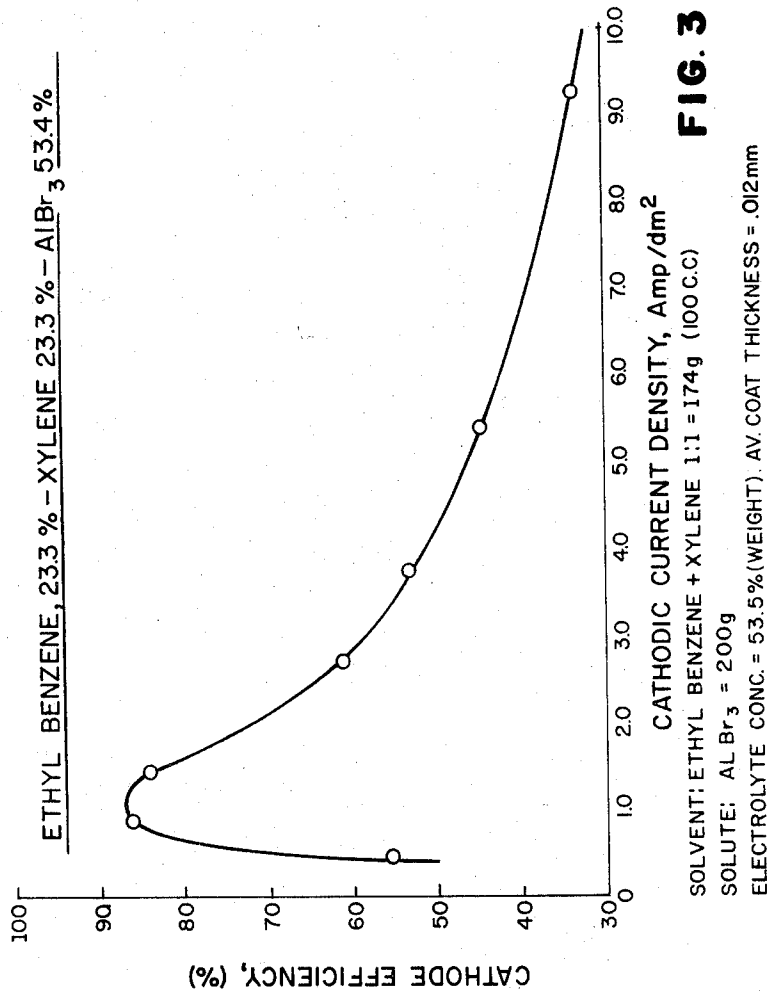


FIG. 2



ELECTROPLATING ALUMINUM

The present invention relates to the electrodeposition of aluminum and alloys of aluminum with other metals such as copper, zinc, cadmium, silver, tin, nickel, lead and mercury onto a metallic substrate such as a copper, brass, steel and platinum substrate or other electrically conducting substrate. In particular the present invention relates to a novel electrolyte for use in such an electrolytic process which produces on the substrate a bright, smooth, coherent, adherent coating of said aluminum or alloy thereof.

It has long been recognized that aluminum cannot be electrodeposited successfully from aqueous solutions of its salts as such electrolysis merely results in the decomposition of the water present in the electrolyte since the potential necessary for the deposition of aluminum is much in excess of that necessary for the liberation of hydrogen.

Heretofore therefore commercially aluminum has been subjected to electrowinning, electrorefining and electroplating from fused inorganic aluminum salt baths. However, such processes are subject to the serious disadvantage that the baths must be operated at high temperature with consequent serious corrosion and control problems.

Attempts have been made to electrodeposit aluminum from a bath containing aluminum compounds in organic solutions such processes being disclosed for example in U.S. Pat. No. 2,170,375 issued Aug. 22, 1939 to Mathers et al., U.S. Pat. No. 2,763,605 issued Sept. 18, 1956 to Miller et al., U.S. Pat. No. 3,355,368 issued Nov. 28, 1967 to Smith et al., U.S. Pat. No. 2,651,608 issued Sept. 8, 1953 to Brenner et al as well as an article entitled "Electrolytic Precipitation of Aluminum from Solutions of Aluminum Bromide in Xylene" by A. Levinskene and L. Simanavichyus, in Scientific Works of the Universities of the Lithuanian SSR Chemistry and Chemical Technology VII, 1965. However, such processes have not achieved commercial success as the electrolytic baths have normally been unstable, often contain inflammable or possibly explosive organic materials and are in addition usually toxic, complex and relatively expensive to formulate. In particular such baths because of their organic nature are not particularly conductive and as it has been found necessary with such baths usually to employ either a volatile solvent such as ether or a compound which evolves copious quantities of a poisonous gas such as hydrogen bromide, such baths are hazardous to work with. Further the aluminum coating obtained from electrodeposition in these baths is not particularly desirable, being dull, brittle and not very adherent to the substrate on which it is electrodeposited.

For example electrodeposition of aluminum, in U.S. Pat. No. 2,170,375 is effected from a bath comprising an aluminum halide with an alkyl halide and benzene or a derivative thereof. The alkyl halide was a required ingredient of this bath as otherwise the bath was essentially non-conductive requiring 90 volts to pass 0.1 amps. The presence of alkyl halides in these electrolytes leads, on the other hand, to the copious evolution of HBr fumes during electrolysis and the aluminum plated on the substrate is a dull grey and somewhat brittle. Again as reported in the article "Electrolytic Precipitation of Aluminum from Solutions of Aluminum Bromide in Xylene," by A. Levinskene and L.

Simanavichyus referred to above aluminum plating may be effected from solutions of aluminum bromide in *o*-, *m*- and *p*-xylene and mixtures thereof. It was concluded in the article that satisfactory plating could be achieved with a solution containing about 25 mol per cent AlBr_3 in a technically obtainable isomeric mixture of *o*-, *m*- and *p*-xylene. Variation from the 25 mol per cent AlBr_3 generally results in a series reduction in cathode efficiency.

It has now been found that aluminum or an aluminum alloy with at least one other metal may be electrodeposited from a relatively inexpensive, conductive, stable organic electrolyte to produce a bright, adherent, ductile deposit of aluminum or said alloy on an electrically conducting metal substrate. The electrolyte of the present invention comprises a solution of an aluminum halide at least a portion of which is aluminum bromide dissolved in certain hydrous aromatic solvents. The aromatic solvents are of the following types:

a. ethylbenzene or a polyethylbenzene or mixtures thereof.

b. toluene, xylene, benzene, or a halobenzene or mixtures thereof in combination with ethylbenzene, diethylbenzene, mesitylene, isopropylbenzene or mixtures thereof.

c. toluene or a polymethylbenzene or mixtures thereof in combination with ethylbenzene or polyethylbenzene or mixtures thereof.

d. isopropylbenzene alone or in mixture with ethylbenzene, polyethylbenzene, methylbenzene, polymethylbenzene or mixtures thereof.

e. toluene in combination with a polymethylbenzene having at least 3 CH_3 groups or mixtures thereof.

According to the present invention therefore there is provided an electrolyte for electrodepositing aluminum or an alloy thereof consisting essentially of a hydrous solution of an aluminum halide comprising aluminum bromide in an organic solvent said solvent being selected from

a. an alkyl benzene or a mixture of alkylbenzenes, said solvent including at least one alkylbenzene selected from ethylbenzene, a polyethylbenzene, mesitylene, durene or cumene, and

b. at least one alkylbenzene selected from ethylbenzene, diethylbenzene, mesitylene and cumene in admixture with benzene or a halobenzene.

The present invention also provides in a process for electrodepositing aluminum or an alloy thereof onto an electrically conducting preferably metal substrate which comprises passing a current through an electrolytic bath having as cathode said substrate, as the anode said aluminum or aluminum alloy and as electrolyte an organic solution containing an aluminum-containing compound the improvement in which the electrolyte is as described above.

When it is desired to electrodeposit an alloy of aluminum with another metal such as copper, zinc, cadmium, silver, tin, nickel, lead or mercury besides the anode being formed of said alloy it is also desirable to include in the electrolyte a halide, suitably a bromide of said metal.

The solvents present in the electrolytes according to one embodiment of the present invention consist of a single alkylbenzene selected from ethylbenzene, mesitylene, durene, cumene and polyethylbenzenes in particular diethylbenzene and triethylbenzene.

In another embodiment of the present invention the solvent consists essentially of a mixture of the aforesaid alkyl benzenes.

In yet another embodiment of the present invention the solvent consists essentially of the aforesaid alkylbenzenes with methyl or polymethylbenzenes such as toluene and xylene. When the alkylbenzenes selected from ethylbenzene, diethylbenzene, triethylbenzene and cumene are in admixture with xylene or toluene the alkylbenzenes are desirably present in an amount of at least 5 wt. percent of the mixture. It has been found that the use of xylene or toluene or mixtures thereof as the sole components of the solvent i.e., in the absence of the aforesaid alkylbenzenes is not useful in that the aluminum coating obtained is black and unsightly and is difficult to obtain.

In still another embodiment of the present invention the solvent consists essentially of at least one alkylbenzene selected from ethylbenzene, diethylbenzene, mesitylene and cumene in admixture with benzene or halobenzene in particular bromobenzene. When the alkylbenzene is present in an admixture with bromobenzene or benzene it is desirably present in an amount of at least 2 wt. percent of the mixture. Again an electrolyte having benzene or bromobenzene as sole solvent and also an electrolyte in which the solvent is a mixture of durene and benzene or triethylbenzene and benzene does not produce a coating of aluminum by electrodeposition.

A particular solvent which may be mentioned which produces excellent coatings is a mixture of durene with 75 wt. percent toluene.

Further solvents which have produced excellent coatings when used in electrolytes for the electrodeposition of aluminum are listed below.

Ethylbenzene.

A mixture of substantially equal volumes of ethylbenzene with toluene, benzene, xylene, cumene or bromobenzene.

Diethylbenzene.

A mixture of substantially equal volumes of diethylbenzene with benzene.

Triethylbenzene.

Mesitylene.

A mixture of substantially equal volumes of mesitylene with benzene.

Durene.

A mixture of durene and toluene or benzene.

Cumene.

A mixture of substantially equal volumes of cumene with benzene or toluene.

The solvent of the solution must be hydrous as it is found that there is no significant electrodeposition with an anhydrous solution. Suitably the solution contains water in an amount of at least about 25 percent of, and preferably at least 33 percent of, the saturation point thereof dissolved in the solvent, and the solvent may conveniently be saturated with water. High purity materials are not required, technical grade materials being quite adequate. Further no precautions need be taken to eliminate water from the solvent. A particularly suitable solvent is that sold under the trademark "imperial solvent" which is a by-product of petroleum distillation and which contains approximately 18.3 percent ethylbenzene, 26.1 percent o-xylene, 38.6 percent m-xylene and 17.0 percent p-xylene. This particular solvent has the advantage that large quantities of technical grade

are available at a relatively low cost and no special compounding is required. This solvent normally contains water up to the solubility limit of water in the solvent. No special steps to remove any of this water need be taken.

The aluminum halide is preferably aluminum bromide alone due to its ready commercial availability, its ready solubility in the solvent and the improved attractive aluminum coatings which are applied to the metal substrates. The aluminum bromide is suitably present in an amount of from about 5 mol percent to saturation and preferably at least about 22 percent by weight of the solution. However the aluminum bromide may be in admixture with other aluminum halides such as aluminum chloride but less attractive deposits are achieved.

The electrolyte solutions of the present invention are relatively conductive, requiring only about 3-5 volts to pass 0.1 amps.

It has been found that the presence of ethylbenzene improves the cathode efficiency and plating capacity of the electrolytic cell in which the electrodeposition of aluminum is effected at any concentration, but, generally, as low ethylbenzene concentrations a "working up" period before plating occurs on the cathode. This "working up" period which may be as long as 8-10 hours is a time when the electrolyte takes more aluminum from the anode than is being plated on to the cathode, resulting in a build up of aluminum ions in solution, which may even persist after plating has started. In U.S. Pat. No. 2,170,375 it was found that periodic additions of ethyl bromide, which caused an evolution of noxious HBr fumes, were necessary, to overcome the accumulation of aluminum ions in solution.

We have found that the "working up" period can be substantially eliminated by employing an electrolyte which contains at least 10 wt. percent ethylbenzene. Other solvents which have been found suitable for this purpose are diethylbenzene, triethylbenzene, mesitylene, durene, and cumene.

We have further found that using ethylbenzene, ethylbenzene-toluene mixtures, ethylbenzene-bromobenzene mixtures, ethylbenzene-cumene mixtures, diethylbenzene, diethylbenzene-benzene mixtures, triethylbenzene, cumene, cumene-toluene mixtures, or cumene-benzene mixtures as solvents in the electrolyte, there is no gas evolution during electrolysis. The other solvents employed in the invention produce hydrogen at the cathode during electrolysis. Gas evolution is of course undesirable as it wastes current but hydrogen evolution is not a serious problem and the aluminum coatings obtained are excellent.

The invention will now be described in more detail with reference to the Examples and the drawings in which all concentrations are shown as weight percent and in which:

FIG. 1 is a graph showing cathode efficiency for varying concentrations of aluminum bromide in an ethylbenzene-toluene system.

FIG. 2 is a graph of cathode efficiency for varying concentrations of aluminum bromide in an ethylbenzene-xylene system.

FIG. 3 is a graph showing cathode efficiency vs current density in an ethylbenzene-xylene system.

EXAMPLE 1 SOLVENT: ETHYLBENZENE

A 180 ml PYREX (Trademark) electrolysis beaker

was deaerated with a current of dry argon, and 50 grams of AlBr_3 (technical grade) were added, followed immediately by 75 ml of ethylbenzene (technical grade). A TEFLON (Trademark) covered magnetic bar was placed into the beaker and a cover, carrying the electrodes described hereinafter, was placed over the beaker. The solution was stirred with a magnetic stirrer until the AlBr_3 dissolved, thus providing an electrolyte consisting of 23 mol percent AlBr_3 and 77 mol percent ethylbenzene.

No heating or cooling was necessary during the dissolution of the salt. The argon flow was stopped and the gas inlet and outlets were closed.

The electrodes in the beaker comprised a hollow cylindrical 1 mm thick aluminum anode 2 inches long with a 5 inch stem and 1.27 inches diameter provided with regularly spaced 0.5 cm holes at $\frac{1}{4}$ inch intervals, and a concentrically placed copper cathode 7 inches long, $\frac{1}{2}$ inch wide and 0.5 mm thick with 2 inches submerged. Oxide was removed from the cathode before electrolysis by immersing the cathode in a solution of 1/3 Nitric, 1/3 Acetic, and 1/3 Phosphoric acids.

Electrolysis was performed with gentle stirring at 5 volts d.c. and 1 amp/dm² for 1 hour.

An upper layer consisting of almost pure ethylbenzene was observed to form during the electrolysis thus providing a protective layer over the electrolyte. No gas evolution was produced at either electrode.

After the electrolysis the cover was removed and the electrodes were immersed in a water bath and then an acetone bath. The copper cathode was observed to be coated with a bright whitish gray fine grained adherent aluminum coating 0.0005 inch thick.

EXAMPLE 2 SOLVENT: ETHER

35 grams of AlBr_3 were placed in the electrolysis beaker of Example 1 and 100 ml of ether were slowly added. A violent reaction occurred in contrast to the ease of AlBr_3 dissolution in Example 1.

Electrolysis was conducted according to the process of Example 1 but the experiment was abandoned after 5 hours, at which time no aluminum had been deposited. This experiment was conducted to establish the parameters of the present invention and to evaluate the state of the prior art in which ether had often been proposed as a solvent for an AlBr_3 electrolyte.

EXAMPLE 3 SOLVENT: ETHYLBENZENE-TOLUENE SYSTEM

The procedure of Example 1 was repeated with 36.4 wt. percent AlBr_3 , 45.4 percent AlBr_3 and 53.4 percent AlBr_3 dissolved in ethylbenzene-toluene mixtures varying from 0 - 100 percent ethylbenzene. Plating quality was excellent at all levels of AlBr_3 concentration in the ethylbenzene-toluene mixtures and it was found that 1.0 amp/dm² produced the highest quality finish. The average cathode efficiency was measured for each electrolyte composition and the results are plotted as FIG. 1. It will be noted that for each level of AlBr_3 concentration the addition of ethylbenzene to the electrolyte progressively improves the cathode efficiency from between about 10 - 25 percent to a maximum of about 75 percent at a 1 : 1 ratio. It is normally considered that a cathode efficiency below about 30 percent is unsatisfactory in terms of electrical cost and quality of the deposit and it is preferred that the cathode efficiency should be at least 50 percent.

EXAMPLE 4 SOLVENT: ETHYLBENZENE-XYLENE SYSTEM

The procedure of Example 3 was repeated with an ethylbenzene-xylene system. The results are shown in FIG. 2. Ethylbenzene improves the cathode efficiency at all concentrations of AlBr_3 except the 53.4 percent level in which there is an initial fall in efficiency and then a subsequent increase up to the 1 : 1 ethylbenzene-xylene level. It should be noted that the xylene/ AlBr_3 system per se at the 25 mol percent AlBr_3 level only was studied by Levinskene and Simanavichyus (supra). It will be further noted that any decrease in AlBr_3 from the 25 mol percent (45.4 wt. percent) level results in a drastic decrease in cathode efficiency. Furthermore an increase in AlBr_3 from the 25 mol percent level to 31 mol percent (53.4 wt. percent) also results in a decrease in cathode efficiency. This problem can be eliminated by the addition of ethylbenzene at a 1 : 1 ratio level.

The plating quality achieved with all ethylbenzene-xylene mixtures was excellent at all levels of AlBr_3 concentration and all ethylbenzenexylene ratios, except that at the 59 percent AlBr_3 level some dark veins were noted in the deposit. In other respects the deposits were comparable to those produced in Example 1.

EXAMPLE 5 CATHODE EFFICIENCY AT VARIOUS CURRENT DENSITIES

The procedure of Example 4 was repeated at the 1 : 1 ratio of ethylbenzene-xylene and 53.4 percent AlBr_3 level, using different cathodic current densities. Plating at each current density was conducted in the same electrolyte with the electrolytic cell connected in series with a silver coulometer. A new cathode was used for each test and the electricity passed in each test was 0.15 ampere hours. The cathode efficiencies are plotted in FIG. 3. It will be noted that cathode efficiencies are somewhat high because they are instantaneous values taken under optimum conditions. It will be noted that cathode efficiency optimizes at about 1 amp/dm².

EXAMPLE 6 SOLVENT: "IMPERIAL SOLVENT"

43, 38, 31 and 22 wt. percent AlBr_3 was dissolved in successive quantities of "Imperial Solvent" (trademark of Imperial Oil Ltd.) (18.3 percent Ethylbenzene, 26.1 percent o-xylene, 38.6 percent m-xylene and 17.0 percent p-xylene) and electrolyzed according to the process of Example 1. Good quality electroplating was achieved at each concentration level. The 22 percent AlBr_3 solution demixed into two layers, the lower of which contained the usual brown aluminum complex present in the electrolytes having higher AlBr_3 concentrations. The upper layer was not, in fact, an electrolyte. Thus, although solutions containing less than about 22 percent AlBr_3 can be used there is little point in so doing as the volume of the lower layer available for plating also tends to decrease.

EXAMPLE 7 SOLUTE: AlCl_3

21.5 wt. percent AlBr_3 and 21.5 percent wt. percent AlCl_3 were dissolved in the "Imperial Solvent" of Example 8, and electrolyzed according to the process of Example 1. Plating was successfully achieved, but the appearance of the plating was, however, black. It was concluded that although plating from electrolytes containing a proportion of AlCl_3 can be achieved, it is ad-

visible to exclude AlCl_3 in those applications requiring an attractive deposit.

EXAMPLE 8 ELECTROWINNING USING PLATINUM ELECTRODES

100g AlBr_3 was dissolved in 150 ml ethylbenzene and electrolysed in a similar cell to that employed in Example 1, except that platinum electrodes were employed at 10 volts applied potential. Successful aluminum plating on the cathode was achieved, thereby demonstrating that electrowinning aluminum from solution is feasible.

EXAMPLE 9 CATHODE: PLAIN CARBON STEEL

43 wt. percent AlBr_3 was dissolved in the "Imperial Solvent" described in Example 6 and electrolysed in a similar cell to that employed in Example 1 except that a plain carbon steel cathode was employed. Good quality plating was obtained on the steel thereby demonstrating the feasibility of plating on different substrates.

EXAMPLE 10 PLATING OF A COPPER-ALUMINUM ALLOY

43 wt. percent AlBr_3 was dissolved in the "Imperial Solvent" described in Example 8 and electrolysed in a similar cell to that employed in Example 1, except that the anode was the copper electrode and the cathode was the hollow aluminum cylinder.

A beautiful golden adherent copper-aluminum alloy was deposited on the aluminum cathode thus demonstrating the usefulness of the electrolytes in electrodepositing alloys.

EXAMPLE 11 OTHER ELECTROLYTES

The process described in Example 1 was repeated for a series of electrolytes containing 45 wt. percent AlBr_3 plus the following solvents or solvent mixtures (1:1 volume): diethylbenzene, triethylbenzene, ethylbenzene-benzene, ethylbenzene-cumene, ethylbenzene-bromobenzene, diethylbenzene-benzene, mesitylene, mesitylene-benzene, durene-toluene, cumene, cumene-benzene, and cumene-toluene.

In each case plating was immediate and a coherent whitish grey deposit was obtained.

EXAMPLE 12 PLATING QUALITY TEST

The 0.5 mm aluminum plated copper cathode of Example 3 produced from the ethylbenzene-toluene 1:1 ratio at the 45.4 wt. percent AlBr_3 level was subjected to a bend test. The thickness of the aluminum plating was 0.013. The cathode was subjected to twenty 90° bends after which the copper fractured. There was no evidence of flaking, lack of adhesion or other disruption of the aluminum plating even after the copper fractured, indicating that the fine grained aluminum deposit was ductile and adherent.

The above examples demonstrate that aluminum can be successfully deposited from an electrolyte containing an aluminum halide, preferably aluminum bromide, and an aromatic solvent at least a portion of which is selected from ethylbenzene, a polyethylbenzene, a polymethylbenzene having at least 3 CH_3 groups, or a propylbenzene. Ethylbenzene, the polyethylbenzenes, and the propylbenzenes are the preferred solvents as they do not produce gas during electrolysis and the deposits produced therefrom are the most coherent and attractive.

The deposition of aluminum onto copper and steel substrates has been demonstrated and the process and electrolyte may be used to plate aluminum onto these and other metals for replacing such applications as tinning, galvanizing and chromium plating for the production of attractive corrosion resistant layers. The aluminum deposits may be anodized in certain instances where a highly polished or coloured surface is required.

It has also been shown that by slight modification of the process copper-aluminum alloys can be plated using the electrolytes of this invention.

It has further been demonstrated that the electrolyte may be used to electrowin aluminum from solution and it is also possible to electrorefine impure or scrap aluminum using the electrolytes of this invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An electrolyte for electrodepositing aluminum or an alloy thereof consisting essentially of a solution of an aluminum halide comprising aluminum bromide dissolved in a hydrous organic solvent, selected from
 - a. an alkylbenzene or a mixture of alkylbenzenes said solvent including at least one alkylbenzene selected from ethylbenzene, a polyethylbenzene, mesitylene, durene or cumene, or
 - b. at least one alkylbenzene selected from ethylbenzene, diethylbenzene, mesitylene and cumene in admixture with benzene or a halobenzene, said solution containing at least about 22% by weight aluminum bromide and dissolved water in the amount of at least 25 percent of the saturation amount for said solvent.
2. An electrolyte as claimed in claim 1 in which the aluminum halide consists of aluminum bromide.
3. An electrolyte as claimed in claim 1 in which the solvent consists essentially of ethylbenzene or a polyethylbenzene or mixtures thereof.
4. An electrolyte as claimed in claim 1 in which the solvent consists essentially of toluene, xylene, benzene, or a halobenzene or mixtures thereof in combination with ethylbenzene, diethylbenzene, mesitylene, isopropylbenzene or mixtures thereof.
5. An electrolyte as claimed in claim 1 in which the solvent consists essentially of toluene or a polymethylbenzene or mixtures thereof in combination with ethylbenzene or polyethylbenzene or mixtures thereof.
6. An electrolyte as claimed in claim 1 in which the solvent consists essentially of isopropylbenzene alone or in mixture with ethylbenzene, polyethylbenzene, methylbenzene, polymethylbenzene or mixtures thereof.
7. An electrolyte as claimed in claim 1 in which the solvent consists essentially of toluene in combination with a polymethylbenzene having at least 3 CH_3 groups or mixtures thereof.
8. An electrolyte as claimed in claim 1 in which the solvent consists essentially of an alkylbenzene or a mixture thereof said solvent including at least one alkylbenzene selected from ethylbenzene, a polyethylbenzene, mesitylene, durene and cumene.
9. An electrolyte as claimed in claim 1 in which the solvent consists essentially of at least one alkylbenzene selected from ethylbenzene, diethylbenzene, mesitylene and cumene in admixture with benzene or a halobenzene.
10. An electrolyte as claimed in claim 8 in which the

polyethylbenzene is diethylbenzene or triethylbenzene.

11. An electrolyte as claimed in claim 1 wherein the solvent is ethylbenzene, diethylbenzene, triethylbenzene, cumene or mixtures thereof.

12. An electrolyte as claimed in claim 1 wherein the solvent consists of toluene with at least 5 wt. percent ethylbenzene, diethylbenzene, triethylbenzene, cumene, durenene or mixtures thereof.

13. An electrolyte as claimed in claim 1 wherein the solvent consists of xylene with at least 5 wt. percent ethylbenzene, diethylbenzene, triethylbenzene, cumene or a mixture thereof.

14. An electrolyte as claimed in claim 1 wherein the solvent consists of benzene with at least 25 wt. percent ethylbenzene, diethylbenzene, cumene, mesitylene or a mixture thereof.

15. An electrolyte as claimed in claim 1 wherein the solvent comprises bromobenzene with at least 25 wt. percent ethylbenzene, diethylbenzene, triethylbenzene, cumene or a mixture thereof.

16. An electrolyte as claimed in claim 1 in which the solvent is ethylbenzene alone or in admixture with benzene, toluene, xylene, cumene or bromobenzene in substantially equal volumes.

17. An electrolyte as claimed in claim 1 in which the solvent is diethylbenzene alone or in admixture with benzene in substantially equal volumes.

18. An electrolyte as claimed in claim 1 in which the solvent is triethylbenzene.

19. An electrolyte as claimed in claim 1 in which the solvent is cumene alone or in admixture with benzene and toluene in substantially equal volumes.

20. An electrolyte as claimed in claim 1 in which the solvent is mesitylene alone or in admixture with benzene in substantially equal volumes.

21. An electrolyte as claimed in claim 1 in which the electrolyte is durenene.

22. An electrolyte for electrodepositing an alloy of aluminum with at least one other metal which consists of the solution as claimed in claim 1 having dissolved therein a halide salt of said other metal or metals.

23. In a process for electrodepositing aluminum or an alloy thereof onto an electrically conducting substrate which comprises passing a current through an electrolytic bath having as cathode said substrate, as the anode said aluminum or aluminum alloy, and as electrolyte an organic solution containing an aluminum and any alloying metal compound, the improvement in which said electrolyte is as claimed in claim 1.

24. A process as claimed in claim 23 in which the anode is formed from aluminum.

25. A process as claimed in claim 23 in which the anode is an alloy of aluminum with copper, zinc, cadmium, silver, tin, nickel, lead or mercury.

26. A process as claimed in claim 24 in which the bath is as claimed in claim 2.

27. A process as claimed in claim 24 in which the bath is as claimed in claim 3.

28. A process as claimed in claim 24 in which the bath is as claimed in claim 4.

29. A process as claimed in claim 24 in which the bath is as claimed in claim 5.

30. A process as claimed in claim 24 in which the bath is as claimed in claim 6.

31. A process as claimed in claim 24 in which the bath is as claimed in claim 7.

32. A process as claimed in claim 24 in which the bath is as claimed in claim 8.

33. A process as claimed in claim 23 for the electrodeposition of an alloy of aluminum with another metal in which the solution from said electrolyte contains a halide of said other metal.

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