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ELECTRODEPOSITION OF ALUMINUM

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This invention relates to the electrodeposition of aluminum, and particularly to a process involving the deposition of aluminum on a suitable cathode from an electrolyte comprising a fused or liquid mixture of a suitable aluminum salt with an N-alkyl pyridinium halide.

It has long been recognized that aluminum possesses many unique properties particularly with respect to corrosion resistance. However, the low tensile strength and especially the low elastic limit of pure aluminum render it rather unsatisfactory as a structural material for many purposes. Therefore the possibility of electroplating aluminum on steel and on other common metals promises a wider range of mechanical substances, particularly in chemical construction work. The appearance of many articles would also be improved if they could be plated with aluminum.

It is in general the broad object of the present invention to provide a process enabling aluminum to be electroplated on various dissimilar common metals.

A further object of the present invention is to provide a novel electroplating bath which can be successfully employed for electrodeposition of aluminum.

A still further object of the present invention is to provide a bath for the electrodeposition of aluminum which has a relatively high electrical conductivity, a low voltage requirement, and in which high electrode efficiencies are obtained.

In my process for the electroplating with aluminum of dissimilar metals such as iron, copper, brass, bronze, lead and tin, I employ a bath composed essentially of a fused or liquid mixture of an N-alkyl pyridinium halide and an anhydrous aluminum halide, preferably aluminum chloride. I have successfully employed solutions of anhydrous aluminum chloride in various anhydrous fused pyridinium compounds, particularly ethyl pyridinium bromide, ethyl pyridinium chloride, ethylene dipyridinium dibromide, and ethylene dipyridinium dichloride.

The bath is prepared by mixing the aluminum salt and the pyridinium compound together, melting the mixture by heating, if desired. The addition of the aluminum chloride causes a considerable amount of heat to be generated, and in some instances no additional heating is necessary. Generally the bath composition should be such that the pyridinium cation is not reduced at the cathode. The aluminum salt concentration must be sufficiently high, having regard to the actual conditions of electrolysis in each instance,

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that this does not occur. I have found that one should employ a bath containing approximately two mols of aluminum chloride (taken as $AlCl_3$ herein and in the claims) to one mol of halide or nitrogen (taken as N) in the pyridinium salt. With ethyl pyridinium bromide this approximate value represents an eutectic composition corresponding to a 2 to 1 mol ratio of aluminum chloride to ethyl pyridinium bromide. The ethyl pyridinium bromide content can, however, vary between about 46 mol per cent and 30 mol per cent. In any case, if the aluminum chloride concentration is too low, the aforementioned reduction of the pyridinium cation occurs at the cathode, while if the aluminum chloride concentration is too high, the plate will contain what appears to be occluded aluminum chloride.

In operation, the electrolyte is maintained at a sufficiently high temperature so that it is in a fused condition, and, more especially, at a temperature at which good plates are obtained. With ethyl pyridinium bromide, temperatures in the range from 40° C. to 150° C. depending on the composition of the bath, have been found useful for plating. The preferred temperature for the aforementioned eutectic mixture is approximately 125° C. Too low a temperature results in low conductivity and produces spongy deposits. At higher temperatures aluminum chloride will distill from the bath and decomposition of the electrolyte can occur. With other pyridinium compounds different temperatures are required, generally above 100° C.

As a container for the bath a cell of glass, porcelain, or other inert material may be used; or the container may be made of aluminum and can then serve as the anode. If the cell is made of other metals, any moisture which is present may result in corrosion of the metal by moist hydrogen halide. This can carry the metal halide into solution and may result in the formation of a plate consisting of an aluminum alloy. Under certain conditions these alloy plates may not be disadvantageous and accordingly the term aluminum as used here and in the claims is to be considered as including such alloys in which aluminum forms the major constituent.

The anode employed consists, of course, of aluminum; the cathode is the article to be plated. A zinc article should not be employed inasmuch as zinc reacts with the bath.

In removing the plated object from the bath, care must be taken to remove the adhering liquid before absorption of moisture from the atmosphere can occur, for this will generate hy-

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drogen chloride which will attack the aluminum plate. One method of achieving this is to rinse the plate in a solvent miscible with the bath, such as benzene, immediately after removal.

It is a feature of the present invention that relatively low voltages can be employed. In fact, relatively low voltages are essential to successful operation, for too high a voltage can produce organic decomposition at the electrodes. In cells in which the anode and cathode were about 1½ inches apart, two to three volts was employed; in cells of other design, lower voltages were successfully used.

The optimum cathode current density for baths of this type is approximately 0.5 amp./dm.². Variation in the current density affects the type of plate produced. For example, those obtained at current densities much lower than 0.5 amp./dm.² were usually white and dull, whereas at current densities somewhat higher than this value they were usually gray and dull. At the preferred current density bright and shiny plates were usually obtained. If the current density becomes too high, a black deposit appears at the cathode.

To obtain the proper conditions of current density and voltage, a suitably designed cell must be employed. In general, the anode should be as large as or larger than the cathode object, and the electrodes should be so arranged in the cell that the resistance of the cell is not too high and the current distribution on the cathode is uniform.

The following specific operating example is set forth by way of further illustrating the invention and not by way of limitation.

A plating mixture containing 63.0 mol per cent of aluminum chloride (taken as AlCl₃) and 37.0 mol per cent of ethyl pyridinium chloride was prepared by adding the aluminum chloride to the molten pyridinium salt. The mixture was transferred to an aluminum pot which served both as the container and the anode. This was fitted with a suitably designed top to prevent absorption of moisture by the bath. The cathodes, which could be inserted through the top, consisted of suitably cleaned sheets of steel and other metals, 5 cm. wide and 14 cm. long with a depth of immersion in the plating liquid of 3.5 cm. The temperature of the plating bath was maintained at 125° C. by immersing the aluminum pot in a large oil bath.

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Plating tests of several different sorts were made with this bath, using steel cathodes. In one set of tests using voltages ranging from 0.2 to 0.6 volt, the following results were obtained at different current densities, when the total quantity of electricity was held constant:

1. 1.00 amp./dm.²—uniform gray plate, somewhat granular
2. 0.90 amp./dm.²—less uniform, granular in spots
3. 0.63 amp./dm.²—uniform plate, white in color
4. 0.46 amp./dm.²—shiny, adherent plate
5. 0.30 amp./dm.²—partly shiny, partly dull plate

Plates on brass and bronze cathodes were also obtained using this bath.

I claim:

1. A process of electroplating that comprises electrodepositing aluminum as a bright, adherent deposit on a metal from the group consisting of iron, copper, brass, bronze, lead and tin from a cell containing a liquid nonaqueous electrolyte consisting essentially of a fused mixture of (1) about 2 mols of aluminum chloride and (2) 1 mol of ethyl pyridinium chloride.
2. A nonaqueous electrolyte for use in the electro-deposition of aluminum as a bright, adherent deposit that consists essentially of a fused mixture of (1) about 2 mols of aluminum chloride and (2) 1 mol of ethyl pyridinium chloride.

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