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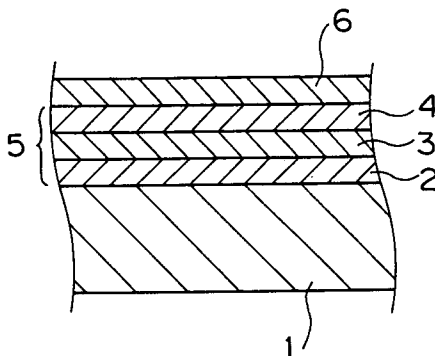
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(54) **Electrostatic powder coating method.**

(57) An electrostatic powder coating method of forming an undercoating film having a volume specific resistivity of not more than $10^{13} \Omega \cdot \text{cm}$ and a thickness of not more than $200 \mu\text{m}$ on a metal surface and forming an overcoating layer on the undercoating film by electrostatic powder coating.

Fig. 1

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BACKGROUND OF THE INVENTION

Field of the Invention

5 The present invention relates to a method of electrostatically powder-coating an undercoating film which is formed on a metal surface, and more particularly, it relates to an electrostatic powder coating method which can improve the amount of transfer by electrostatic powder coating.

Description of the Background Art

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In general, electrostatic coating of a metal surface is generally carried out by spraying a solvent type coating. While the metal surface may be directly electrostatically coated, an undercoating film is generally formed on the metal surface so that an overcoating layer is formed on this film by electrostatic coating, in order to improve corrosion resistance, smoothness and the like.

15 However, employment of such a solvent type coating is unpreferable in consideration of sanitation and environmental conservation, due to volatilization of the solvent. To this end, electrostatic powder coating of electrostatically coating the target with a powder coating is studied.

20 When an undercoating film which is formed on a metal surface is electrostatically coated with a powder coating, however, the transfer efficiency is extremely reduced as compared with a case of electrostatically coating the same with a solvent type coating. The transfer efficiency, which is not much reduced when the metal surface is directly coated with the powder coating, is extremely reduced when an undercoating film is formed on the metal surface and electrostatically coated with the powder coating.

SUMMARY OF THE INVENTION

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An object of the present invention is to provide an electrostatic powder coating method of electrostatically coating an undercoating film formed on a metal surface, which can improve the transfer efficiency.

30 The electrostatic powder coating method according to the present invention comprises the steps of forming an undercoating film having a volume specific resistivity of not more than $10^{13} \Omega \cdot \text{cm}$ and a thickness of not more than $200 \mu\text{m}$ on a metal surface, and forming an overcoating layer on the undercoating film by electrostatic powder coating.

35 According to the present invention, it is not necessary to extremely reduce the volume specific resistivity of the undercoating film, which is not more than $10^{13} \Omega \cdot \text{cm}$. In consideration of economy and practicality, the volume specific resistivity is preferably in the range of 10^8 to $10^{13} \Omega \cdot \text{cm}$. It is possible to reduce the volume specific resistivity of the undercoating film to not more than $10^{13} \Omega \cdot \text{cm}$ by a method of introducing conductive particles into the undercoating film. The conductive particles may be prepared from carbon black or a conductive metal oxide such as zinc oxide or tin oxide.

The undercoating film may alternatively contain an organic conductive material such as a cationic, anionic or nonionic surface active agent which is known as an antistatic agent, for example.

40 When the undercoating film is formed by a water-borne coating, the coating may be dried to leave moisture in the undercoating film, thereby providing the film with conductivity.

If the thickness of the undercoating film exceeds $200 \mu\text{m}$, improvement of the transfer efficiency is insufficient due to insufficient conductivity. The undercoating film may be formed by a single or a plurality of layers, so far as at least one of the layers is provided with conductivity.

45 According to the present invention, the undercoating film has a volume specific resistivity of not more than $10^{13} \Omega \cdot \text{cm}$ and a thickness of not more than $200 \mu\text{m}$. Therefore, charges of the powder coating adhering onto the undercoating film are not stored in but discharged through this film. Thus, no back ionization is caused by charges of the same polarity which are stored in the undercoating film, and it is possible to stick a charged powder coating onto the undercoating film in an excellent state, thereby improving the transfer efficiency.

50 Japanese Patent Laying-Open Nos. 58-64164 (1983), 61-74682 (1986) and 3-80966 (1991) disclose methods of forming conductive coating films on nonconductive materials such as plastic through conductive primers or the like and electrostatically coating the films. However, every one of these conductive coating films is formed as an earth electrode which is employed for electrostatically coating the nonconductive material such as plastic, and must have a considerably low volume specific resistivity.

On the other hand, it is not necessary to extremely reduce the volume specific resistivity of the undercoating film which is employed in the present invention, since its surface potential is only slightly increased due to presence of the metal surface provided under the same.

It is possible to remarkably improve the transfer efficiency in electrostatic powder coating by reducing the volume specific resistivity of the undercoating film to not more than $10^{13} \Omega \cdot \text{cm}$ according to the present invention.

The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view showing an undercoating film and an overcoating layer in Example of the present invention; and
Fig. 2 is a block diagram for illustrating a method of measuring a volume specific resistivity in Example of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is now described with reference to Examples.

Example 1 and Comparative Example 1

Steel plates were coated with undercoats A and B according to Example 1 and comparative example 1 respectively, and the undercoating films as formed were coated with a polyester-based powder coating (by Nippon Paint Co., Ltd.) respectively, to be subjected to comparison of transfer efficiencies.

Solid contents in the undercoats A and B were adjusted as shown in Table 1.

Table 1

	Undercoat A	Undercoat B
Polyester Resin	41.0	41.0
Melamine Resin	24.1	24.1
Titanium Oxide	9.2	24.1
Carbon Black	12.0	0.1
Barium Sulfate	13.7	13.7
Total	100.0	100.0

The undercoats A and B contained polyester resin (by Nippon Paint Co., Ltd.) and curing agents of melamine resin (by Nippon Paint Co., Ltd.).

Table 1 shows the results of the transfer efficiencies as measured as to Example 1 and comparative example 1 employing the undercoats A and B respectively.

Table 2

		Baking Temperature (°C)	Baking Time (min.)	Film thickness (μm)	Volume Specific Resistivity in Powder Coating ($\Omega \cdot \text{cm}$)	Relative Transfer Efficiency (%)
Example 1	Under Coat A	140	20	50	2.3×10^9	100
Comparative Example 1	Under Coat B	140	20	50	3.2×10^{15}	78

As understood from Table 2, the undercoating film according to Example 1, having a volume specific resistivity of not more than $10^{13} \Omega \cdot \text{cm}$, exhibited an excellent transfer efficiency which was similar to that in a case of directly powder-coating a steel plate.

Examples 2 to 4 and Comparative Examples 2 and 3

As shown in Fig. 1, a steel plate 1 was coated with an undercoating film 5 consisting of an electrodeposition layer 2, an intermediate layer 3 and a base coating layer 4, and this undercoating film 5 was powder-coated with an overcoating layer 6, for evaluation of the transfer efficiency of the undercoating film 5.

The electrodeposition layer 2 was prepared from a cationic electrodeposition coating (Powertop U-80 (trade name) by Nippon Paint Co., Ltd.) and the intermediate layer 3 was prepared from a polyester intermediate coating (Orga P-2 Gray (trade name) by Nippon Paint Co., Ltd.), and these layers 2 and 3 were coated on the steel plate 1 under baking conditions shown in Table 3, to have thicknesses shown therein.

Table 3

Electrodeposition/Intermediate Coating Conditions for Examples 2 to 4 and Comparative Example 2			
	Baking Temperature (°C)	Baking Time (min.)	Film Thickness (μm)
Electrodeposition Layer	170	20	30
Intermediate Layer	140	20	40
Electrodeposition/Intermediate Coating Conditions for Comparative Example 3			
	Baking Temperature (°C)	Baking Time (min.)	Film Thickness (μm)
Electrodeposition Layer	170	20	30
Intermediate Layer	140	40	180

Base coats A (Example) and B (Comparative example) were prepared as shown in Table 4, and coated on intermediate layers which were prepared in the aforementioned manner. The base coats A and B contained resin Nos. 1 and 2 which were prepared from acrylic resin (by Nippon Paint Co., Ltd.), curing agents (Cymel 303 (trade name) by Mitsui Toatsu Chemicals, Ltd.), and aluminum powder (Alupaste 7160N (trade name) by Toyo Aluminum K.K.) respectively. The amounts of the resin Nos. 1 and 2 shown in Table 4 are those of solids.

Table 4

(parts by weight)

	Base Coat A	Base Coat B
Resin No. 1	38	60
Resin No. 2	29	40
Curing Agent	16	40
Carbon Black	12	----
Aluminum Powder	0.1	16.1
Barium Sulfate	6	----
Total	101.1	156.1

Base coating layers were formed under the baking conditions and in the thicknesses shown in Table 3, to prepare undercoating films according to Examples 2 to 4 and comparative examples 2 and 3.

The thickness of each undercoating film was measured with a thickness meter, to obtain the volume specific resistivity R_v by the following equation:

$$R_v = E \cdot S / i \cdot t$$

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where E represents 100 V, S represents the area of an electrode 10, i represents the current quantity, and t represents the thickness of the undercoating film.

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The undercoating films of Examples 2 to 4 and comparative examples 2 and 3 were powder-coated with an acrylic powder coating (by Nippon Paint Co., Ltd.) respectively, for evaluation of transfer efficiencies. Each of the transfer efficiencies was relatively evaluated with reference to a transfer quantity (100 %) in a case of directly powder-coating the steel plate (substrate). Table 5 shows the volume specific resistivities and the transfer efficiencies of the undercoating films according to Examples 2 to 4 and comparative examples 2 and 3.

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Table 5

	Base Coating Layer					Electrodeposition /Intermediate/ Base Coating	Test Result	
	Type	Baking Tempera- ture (°C)	Baking Time (min.)	Film Thick- ness (μm)	Film Thickness (μm)		Volume Specific Resistivity ($\Omega \cdot \text{cm}$)	Relative Transfer Efficiency (%)
Example 2	A	140	20	15	85		1.9×10^{10}	100
Example 3	A	80	3	15	85		8.3×10^{12}	99
Example 4	A	80	3	20	90		5.0×10^{12}	100
Comparative Example 2	B	140	20	15	85		8.7×10^{15}	70
Comparative Example 3	A	140	20	15	225		7.5×10^{14}	78

As clearly understood from Table 5, the undercoating films according to Examples 2 to 4, having volume specific resistivities of not more than $10^{13} \Omega \cdot \text{cm}$, exhibited excellent transfer efficiencies, similarly to the case of directly powder-coating the steel plates.

Thus, it is understood possible to extremely improve the transfer efficiency in electrostatic powder coating by reducing the volume specific resistivity of the undercoating film to not more than $10^{13} \Omega \cdot \text{cm}$.

While the above Examples have been described with reference to a single-layer undercoating film and three-layer films consisting of electrodeposition, intermediate and base coating layers, the undercoating film according to the present invention is not restricted to such structures, but may have any structure so far as the same can serve as a substrate for electrostatic powder coating.

5 The volume specific resistivity of each undercoating film obtained in the aforementioned Examples and comparative example was measured by an ordinary method. As shown in Fig. 2, an electrode 10 of conductive rubber having a diameter of 50 mm was placed on an undercoating film 5 as shown in Fig. 2 and a ring-shaped guard electrode 11 was placed around the electrode 10 while another electrode 12 was provided under the undercoating film 5, and the volume specific resistivity was measured with application of
10 a voltage of 100 V.

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

15 Claims

1. An electrostatic powder coating method comprising the steps of:
forming an undercoating film having a volume specific resistivity of not more than $10^{13} \Omega \cdot \text{cm}$ and a thickness of not more than $200 \mu\text{m}$ on a metal surface; and
20 forming an overcoating layer on said undercoating film by electrostatic powder coating.
2. The electrostatic powder coating method in accordance with claim 1, wherein said volume specific resistivity of said undercoating film is 10^8 to $10^{13} \Omega \cdot \text{cm}$.
- 25 3. The electrostatic powder coating method in accordance with claim 1, wherein said undercoating film is formed by a single or a plurality of layers, at least one of said layers being provided with conductivity.
4. The electrostatic powder coating method in accordance with claim 3, wherein a coating containing a conductive material is employed in a method of providing said conductivity.
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5. The electrostatic powder coating method in accordance with claim 4, wherein said conductive material is carbon black.
6. The electrostatic powder coating method in accordance with claim 4, wherein said conductive material
35 is zinc oxide or tin oxide.
7. The electrostatic powder coating method in accordance with claim 1, wherein said undercoating film is a multilayer coating film consisting of an electrodeposition layer, an intermediate layer and a base coating layer, said base coating layer containing a conductive material.
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Fig. 1

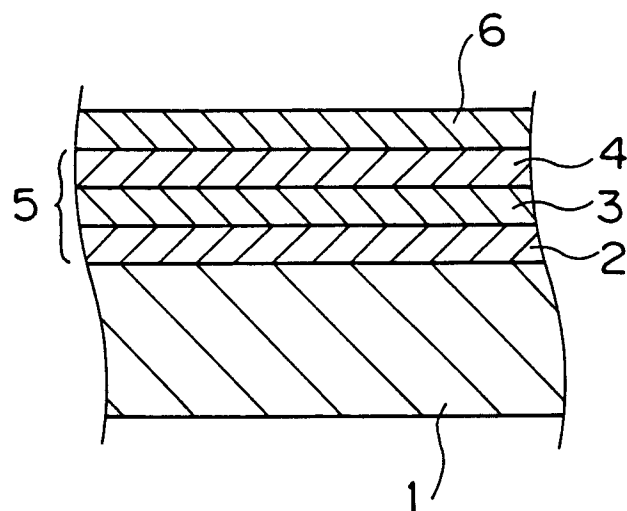


Fig. 2

