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# METAL-SIMULATING FILM PRODUCT

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## ABSTRACT OF THE DISCLOSURE

A film product that simulates the appearance of satin-finish metal comprising a grainy-surfaced light-transmissive film and an opaque metallic layer adhered to a surface of the film opposite the grainy surface.

These novel film products realistically simulate delustered, or machined, metal surfaces when adhered over a substitute substrate. While presenting the appearance of delustered metal, the products permit economies or permit possibly undesirable properties of metal, such as weight and electrical or heat conductivity, etc., to be avoided. The new surface-covering film products are advantageously employed in various construction uses in which nonmetallic materials offer satisfactory structural properties, but the traditional use of metal makes its apparent presence desirable. In other instances, nonfunctional metal-appearing surfaces or panels, as on a building wall, may offer contrast or variation, or in other ways be esthetically pleasing. Signs, labels and the like often incorporate a metal surface in their design though the actual use of metal is in some cases desirably avoided. Another example, showing a more functional use, is the application of the film products of the invention to a substrate to provide diffuse reflectors for electric lights.

Prior attempts at simulating satin-finish metal surfaces have principally depended on paints, pastes, rubbing powders, or the like. These latter materials have not been fully satisfactory since surfaces treated with them as a rule lack authenticity and tend to be easily marred. Accordingly, the opportunities for using a satin-finish, metal-simulating surfacing material have not been widely exploited.

The product of the present invention is the first tough, durable, and conveniently handled and applied surface-covering film product, to the inventors' knowledge, that authentically and inexpensively simulates a delustered metal surface. A variety of metals and finishes may be duplicated. Application of the simulated delustered metal surface is quickly accomplished. Further, the novel film product provides a surface highly resistant to scratching, scuffing, and tearing.

The film product of the invention includes, in general, a film of light-transmissive, high molecular weight, thermoplastic, biaxially oriented, linear polymer having at least one uniform fine grainy surface as judged by optical standards, and a thin substantially opaque metallic layer firmly adhered over the film surface opposite said grainy surface. It has been found that metal-covered film having such a fine grainy, or matte-finish, surface has a redistribution of light off its grainy surface similar to the characteristic redistribution of light off a satin-finish metal surface. In addition, the film with its grainy surface modifies the color of the metallic layer, making, for example, the silver of shiny aluminum the gray of machined aluminum. By controlling the coarseness of the surface and the light transmissivity of the film, the effect may be varied.

Articles of the invention are typically manufactured by covering one surface of a previously prepared film with metal, preferably by vapor deposition. Conventional vacuum chamber procedures for vapor depositing metal may be used. It is desirable that the metal layer be thick enough so as to transmit no more than about 10% of the light striking it. Alternatives to vapor deposition include the adhesion of metal foil to the film, or the coating of a solution or suspension that dries as a metallic layer. A variety of metals—including aluminum, copper and gold—may be applied to duplicate a wide variety of metal surfaces.



Besides being light-transmissive, the film should have good tensile strength, and be tough enough to resist scratching, scuffing, etc. In addition, the film should not incorporate substances that might have a deleterious effect on the final product, such as any plasticizer that might oxidize the metal or cause loss of adhesion of the metal layer. Useful products of this invention are obtained with oriented films of organic polymers which, when cold drawn, show characteristic linear orientation in X-ray analysis, such as the so-called "superpolymers" obtained from bifunctional condensations such as esterification, ester interchange, amide formation, etherification, etc. More specifically, polymeric linear terephthalate ester film such as polyethylene terephthalate which has been biaxially oriented by stretching to about 2.5 to 3.5 times its original dimensions is especially useful and provides a strong, tough, dimensionally stable, long-lasting film that retains its clarity indefinitely.

One aspect of the utility of particular grainy-surfaced films in metal-simulating products of the invention is determined by the light-redistribution characteristics of the film. These characteristics can be measured with the procedures of goniophotometry discussed in a report of the American Society for Testing Materials, ASTM designation: E 167–60T. Diffusion characteristics, measured as the light reflected at an arbitrary angle different from the angle of incidence, and specular reflectance characteristics, measured as the light reflected at the angle of incidence, have been used as tests of suitability. In one test procedure (hereinafter the procedure meant when referring to goniophotometry measurements) performed in accordance with the ASTM standards cited above, the film to be tested is placed on a black surface having a very low reflectivity and the sample mounted in a goniophotometer, specifically a model AUX–9 Gardner Goniophotometer to which is attached a Gardner Automatic Photometric Unit, both being manufactured by the H. A. Gardner Laboratory, Inc., Bethesda, Maryland. The goniophotometer is set to source stop #2 and to the B cell filter, and the machine is standardized against a Gardner standard white tile, #UX–9–33. The diffusion characteristic is determined by beaming the light source vertically on the sample and measuring the light reflected at a 45° angle. The spectral reflectance characteristic is determined by beaming the light source on the sample at an angle of 60° from the vertical and measuring the light reflected, also at a 60° angle.

Applicant has found that realistic simulation of metal surfaces is accomplished with films, that, when tested as above, measure not greater than about 6 in the diffusion test and not greater than about 2500 in the spectral reflectance test. Films with a diffusion reading greater than about 6 scatter the light rays to such an extent that the coated metal is not sufficiently visible and the metal coated product is whiter than a delustered metal surface. On the other hand, films with a spectral reflectance reading greater than about 2500 produce a metal coated product that is too glossy to satisfactorily simulate a delustered metal surface. Even more realistic effects can be produced with films in which the diffusion reading is not greater than about 2.

A convenient and inexpensive procedure for preparing

a grainy-surfaced film and one that provides a superior product is the incorporation of minute, substantially incompressible inert particles within the film, especially in polyethylene terephthalate, as described in the U.S. patent to Johnson 3,154,461, issued October 27, 1964. Upon stretching of such a modified film after its original formation, the polymeric matrix recedes inwardly between particles adjacent the film surfaces. The protrusion of the particles leaves both surfaces grainy, normally without surface rupture by the particles.

Depending on the color effect desired, the particles may be colored or not. Typically they will be light-transmissive and uncolored. Typically also, their index of refraction will be simular to that of the polymeric matrix, thus maintaining transparency, though additional internal refraction may be desirable in achieving a particular effect.

Particles in a range of sizes—from about 0.1 micron to about 20 microns—are useful in providing satisfactory diffusion. A very small amount of particles significantly alters the diffusion and specular reflectance characteristics of the film and gives a useful product. The lowest useful percentage of particles for the light distributing purposes of this invention is lower than that desired for the surface roughening purposes of the invention in the above-mentioned Johnson patent. For example, 0.25 micron particles of titanium dioxide added in the amount of only one-fourth percent of the weight of the polymer provide a diffusion useful in giving a realistic metal coated product. Films including particles in amounts much more than about 4 percent by weight of the resin are found to ordinarily have an excessive opacity and produce a product with a color not representative of most metals. A preferred film product is obtained with oriented films containing particles in an amount less than about one weight percent of the resin.

Illustrative kinds of particles are titanium dioxide, calcium carbonate, mica, silica, calcium silicate, glass, and clay. Typically, for polyethylene terephthalate, these particles are added prior to polymerization so that they are thoroughly admixed during polymerization.

Conventional film tensilizing equipment and procedures are used in stretching the film, and the operation is facilitated at temperatures above the second order transition temperature and below the softening and melting temperature range of the matrix polymer. The amount by which the film is stretched varies with the polymer, the original thickness of the web, the size of the particles, etc. For polyethylene terephthalate the film should be stretched at least 1.3× (times) its initial longitudinal and transverse dimensions and preferably about 2.5× or more to give good strength and toughness in both directions. It is often desirable to stretch the film about 3.5× in one or both directions to give increased coarseness in addition to increased strength. Polyethylene terephthalate film at this latter degree of stretching is somewhat opacified as a result of separation of the matrix polymer from the particles to leave small voids, and in this way the appearance of the ultimate product is further controlled.

Beside films modified by the incorporation of particles, the product of the invention may include films given a grainy surface by abrasion, as with friction wheels or blocks, implements providing a pressurized fluid stream of abrasive particles, or the like. Using this procedure, the directional grain of a machined surface may be put on the film. For such a surface, reflectance and diffusion characteristics vary depending on whether impinging light rays are perpendicular or parallel to the grain of the machining marks. It has been found that film incorporating particles can also be abraded for the purpose of altering light redistribution characteristics and for simulating a machining pattern.

Another useful but less preferred approach is to use unmodified film having a thin top coat of a particle-carrying, flexible, light-transmissive polymeric material. This coating produces a grainy, diffusely light-redistributing surface on the final metal-covered product that simulates the characteristics of satin-finish metal.

In the following examples further describing the invention, the light redistributing characteristics of the films of the various samples were measured on a goniophotometer using the procedure described above. In all of the film products of these examples a satisfactory simulation of delustered, or machined, aluminum surfaces was achieved, the products of the samples varying in color and in the degree of their delustered appearance.

Example 1

Polyethylene terephthalate was prepared from dimethyl terephthalate and ethylene glycol with calcium carbonate particles 5–10 microns in size added before polymerization in an amount one percent by weight of the generated polyethylene terephthalate resin. The mixture was extruded into film and then stretched 3× in both the longitudinal and transverse directions to a final thickness of about one mil and heat set. Goniophotometer readings were 0.32 for diffusion and 660 for specular reflectance. When this film was vapor coated on one side with aluminum in a vapor chamber, a product resulted that was low in gloss and very similar in appearance to typical uniformly brushed aluminum.

Example 2

A product the same as that of Example 1 was prepared except that 0.25 micron particles of titanium dioxide were added in an amount 0.25 weight percent of the resin. Goniophotometer readings were 0.82 for diffusion and 1490 for specular reflectance. The product produced by coating this film with aluminum was more glossy and less silvery than that of Example 1.

Example 3

Unmodified polyethylene terephthalate film which had been biaxially oriented about 3× in each direction and heat set, and had a thickness of about one mil, was abraded on one side by a stream of dry sand particles in air at 15 p.s.i. for 30 seconds using Argillite rock measured at 80–150 mesh through a Tyler screen. Diffusion was measured at 1.91 and specular reflectance at 15.1 on the goniophotometer. The film was vapor-coated on the smooth side with aluminum to give a film product having a dull, machined-aluminum appearance.

Example 4

Unmodified biaxially-oriented polyethylene terephthalate film (similar to the starting film of Example 3) was coated on one surface with a polyester-polyol copolymer in which were dispersed alpha quartz particles in an amount comprising about half the weight of the coating. When dry, the coating had a thickness of about one-half mil. The goniophotometer measured 2.20 for diffusion and 19.1 for specular reflectance. The reverse side of the film was vapor coated with aluminum to give a film product having a dull, machined-aluminum appearance.

We claim:

1. A surface-covering film product for simulating satin-finish metal comprising (*a*) a film that (*i*) includes light-transmissive high molecular weight thermoplastic biaxially oriented linear polymer and (*ii*) has at least one uniform fine grainy surface exhibiting light redistribution characteristics such that the film is light-diffusing and has goniophotometer readings as herein defined of not greater than about 6 for diffusion and 2500 for specular reflectance, and (*b*) a thin substantially opaque metallic layer firmly adhered to the film surface opposite said grainy surface.

2. A surface-covering film product for simulating satin-finish metal comprising (*a*) a film that (*i*) includes light-transmissive high molecular weight thermoplastic biax-

ially oriented linear polymer and (*ii*) has at least one uniform fine grainy surface exhibiting light redistribution characteristics such that the film is light-diffusing and has goniophotometer readings as herein defined of not greater than about 2 for diffusion and 2500 for specular reflectance, and (*b*) a thin substantially opaque metallic layer firmly adhered to the film surface opposite said grainy surface.

3. A surface-covering film product for simulating satin-finish metal comprising (*a*) a film including light-transmissive high molecular weight thermoplastic biaxially oriented linear polymer, (*b*) substantially incompressible inert particles about 0.1 to 20 microns in diameter dispersed in the film in an amount up to about 4 percent of the weight of the polymer, said polymer receding inwardly between particles adjacent to the surfaces of the film to give uniform fine grainy film surfaces such that the film is light-diffusing and has goniophotometer readings as herein defined of not greater than about 6 for diffusion and about 2500 for specular reflectance, and (*c*) a thin substantially opaque metallic layer firmly adhered to one film surface.

4. A surface-covering film product for simulating satin-finish metal comprising (*a*) a film including light-transmissive high molecular weight thermoplastic biaxially-oriented linear polymer, (*b*) substantially incompressible inert particles about 0.1 to 20 microns in diameter dispersed in the film in an amount up to about one percent of the weight of the polymer, said polymer receding inwardly between particles adjacent to the surfaces of the film to give uniform fine grainy film surfaces such that



the film is light-diffusing and has goniophotometer readings as herein defined of not greater than about 2 for diffusion and about 2500 for specular reflectance, and (*c*) a thin substantially opaque metallic layer firmly adhered to one film surface.

5. A surface-covering film product for simulating satin-finish metal comprising (*a*) a film including biaxially-oriented polyethylene terephthalate, (*b*) substantially incompressible inert particles about 0.1 to 20 microns in diameter dispersed in the film in an amount up to about 4 percent of the weight of the polymer, said polymer receding inwardly between particles adjacent to the surfaces of the film to give uniform fine grainy film surfaces such that the film is light-diffusing and has goniophotometer readings as herein defined of not greater than about 6 for diffusion and about 2500 for specular reflectance, and (*c*) a thin substantially opaque metallic layer firmly adhered to one film surface.

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