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PREPARATION OF POLYETHYLENE ALUMINUM LAMINATES

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ABSTRACT OF THE DISCLOSURE

The adhesion of polyethylene to aluminum substrates is improved by first treating the aluminum substrates with hot formic acid followed by treatment with a fatty acid having 10 to 24 carbon atoms before application of the polyethylene layer.

BACKGROUND OF INVENTION

Field of invention

This invention relates to the preparation of laminates and more particularly to such laminates wherein a polyethylene layer is adhered to at least one layer of an aluminum substrate.

The prior art

Polymeric coatings in combination with thin layers of aluminum in the form of laminates have found widespread employment in containers such as for packaging food, beverages and the like. In such applications, the coating must possess excellent adhesion characteristics. It must withstand processing of the container contents at elevated temperatures, e.g., 1 to 2 hours at 120° to 125° C. in the presence of water and foodstuff. The coating must remain strongly adherent to the aluminum surface and impermeable during processing operations; otherwise, a satisfactory product cannot be obtained.

It is known that polyethylene is an excellent material for forming coatings for aluminum and other metallic surfaces because of its high resistance to attack by chemicals. Wider application of polyethylene as a protective coating for aluminum surfaces, however, has been inhibited by the fact that good adhesion to the aluminum surface is difficult to accomplish because of the inert nature of polyethylene.

SUMMARY OF THE INVENTION

In accordance with the present invention, the adhesion of polyethylene to aluminum substrates may be improved by the process wherein the aluminum substrate to be coated with polyethylene is subjected to a preparatory treatment comprising first contacting the aluminum substrate with a hot solution of concentrated formic acid and subsequently contacting the formic acid-treated surface with a fatty acid at an elevated temperature.

On the surface thus prepared, the polyethylene, in the form of film or powder, is then fused to the aluminum substrate by baking at elevated temperatures.

It is a critical and essential step of the present invention that the aluminum substrate be first treated with formic acid prior to the contact of the substrate with the fatty acid. While it is not intended to have the process of the present invention limited to any theory regarding the cause or the results obtained by the present process and the improved adhesion properties of the resultant laminated product, it is believed that the criticality in the pretreatment of the aluminum surface with formic acid is due to the fact that the untreated aluminum surface is originally covered with a hydrated aluminum

oxide film which interferes with the reaction of the aluminum surface with the fatty acid. Due to the presence of this oxide film, a non-uniform, discontinuous monomolecular layer of the fatty acid forms when the aluminum substrate is contacted with the fatty acid without pretreatment of the substrate with formic acid. The discontinuous layer of the fatty acid forms a poor bonding surface for the adhesion of the polyethylene. Formic acid, being much more highly reactive than the fatty acid, is believed to completely remove the hydrated aluminum oxide from the aluminum substrate and form an aluminum formate in place thereof which is readily displaced upon contact of the substrate with the fatty acid. The formic acid pretreatment is, therefore, believed to permit a more complete reaction on the aluminum surface with the fatty acid to form a more uniform, continuous monomolecular layer having a greater number of fatty acid molecules per unit area of aluminum surface, thereby improving the bonding surface of the aluminum to form stronger bonds with polyethylene.

PREFERRED EMBODIMENTS OF THE INVENTION

In the practice of the present invention, before the aluminum surface is contacted with the formic acid solution, it is desirable that the surface be celan and free from dirt, grease and other foreign substances. The cleaning and degreasing of the aluminum surface may be accomplished by any suitable means known to the art, such as exposure of the aluminum surface to the hot vapors of a high-boiling, organic solvent. After cleaning and degreasing of the aluminum surface, the surface is exposed to a solution of formic acid containing about 77 to about 85 percent by weight formic acid heated to about 150° to about 212° F. Preferably, the formic acid is dissolved in an aqueous solution, although mixtures of water with other suitable solvents such as aliphatic alcohols, such as methanol and propanol, may also be employed.

The required time of exposure of the aluminum to the formic acid solution should be sufficient to allow the formic acid to react with and replace the aluminum oxide film on the surface of the aluminum substrate to form a continuous film of aluminum formate thereon. Ordinarily, a time of about 2 seconds will suffice, although longer immersion periods may be employed if so desired.

Following the formic acid treatment, the formic acid-treated aluminum substrate is treated with a fatty acid. Fatty acids preferred in the practice of the present invention are saturated fatty acids having a carbon content of from 10 to 24 carbon atoms. The fatty acid may be used alone or dissolved in a suitable solvent. Preferably, when used in the practice of the present invention, the fatty acid is heated to a temperature of at least 224° F. (the boiling point of formic acid).

Saturated fatty acids containing from 10 to 24 carbon atoms useful in the practice of the present invention include capric, undecylic, lauric, tridecylic, myristic, pentadecylic, palmitic, margaric, stearic, nondecylic, arachidic, n-heneicosic, behenic, n-tricosic, lignoceric acids and mixtures thereof.

The product obtained in accordance with the process of this invention exhibits a good adhesion between the polyethylene coating and the aluminum surface.

Depending upon the thickness of the aluminum material and the applied polyethylene coating, the coated aluminum article may be flexible or rigid.

After contacting the aluminum substrate with the fatty acid, the laminating stratum of a polyethylene can be adhesively attached to the fatty acid-treated aluminum surface by contacting the two materials at a sufficiently elevated temperature under pressure in a manner well known to those in the art to fuse the polyethylene film

to the aluminum substrate. The temperature and time required for fusion will, of course, vary depending on the polyethylene used. The film thickness of the polyethylene is also a factor in determining the time and temperature required for fusing the polyethylene to the aluminum surface. Thus, the temperature and time required for preparing the polyethylene/aluminum laminate may vary from about 390° to about 450° F. for periods ranging from about 4 to about 6 minutes for polyethylene films ranging in thickness from about 1 to about 5 mils.

The invention will be more clearly understood by referring to the example which follows. It shoud be understood that this example is merely illustrative and should not be considered limitative of the present invention.

EXAMPLE

An aluminum panel was cleaned by exposing the panel to the vapor of boiling toluene and then dipped into an aqueous solution of 77 percent formic acid containing 0.01 percent of an ammonium salt of pentadecafluoroctanoic acid as a wetting agent, the solution being maintained at 200° F. The aluminum panel was allowed to remain in the formic acid solution for about 2 seconds. The formic acid-treated panel was then dipped into a container of molten palmitic acid maintained at 400° F. for 2 seconds.

The visible excess of palmitic acid on the aluminum panel was removed by exposing the panel to the vapor of boiling toluene followed by further degreasing in the vapor of an aliphatic solvent boiling between 242° and 292° F.

A strip of a 5 mil polyethylene film having a density of about 0.95 was pressed onto the surface of the fatty acid-treated aluminum panel in a hydraulic press having heatable platens heated to 300° F. A pressure of 1000 p.s.i. was exerted upon the assembly for 2 seconds, after which time the loosely coated panel was placed in an oven and baked at 400° F. for 6 minutes to provide an adherent coating thereon.

The resulting laminate was tested for adhesion and the force required to peel the laminate apart was qualitatively judged by hand tests. The strength of adherence of the polyethylene film was found to be stronger than the strength of the polyethylene itself so that when it was attempted to remove the film from the aluminum surface, the film tore before separation from the aluminum surface.

By way of contrast, when aluminum panels, coated with polyethylene in the manner described with the exception that the aluminum panels were not pretreated with formic acid prior to treatment with the fatty acid, were tested for adhesion, the bonds between the polyethylene film and the aluminum panel were found to have very little strength and the film could be stripped away cleanly from the aluminum panel when the laminate was pulled apart.

What is claimed is:

1. A method of coating aluminum surfaces with polyethylene to provide an adherent coating thereon which comprises first contacting the aluminum surface to be coated with a heated solution of concentrated formic acid, contacting the formic acid-treated aluminum surface with a fatty acid heated to an elevated temperature, applying a laminating stratum of polyethylene to the thus modified surface of the aluminum substrate, and heating the same to produce an adherent coating of polyethylene on the aluminum substrate.

2. The method of claim 1 wherein the fatty acid is a saturate fatty acid having a carbon chain of 10 to 24 carbon atoms.

3. The method of claim 1 wherein the fatty acid is palmitic.

4. The method of claim 1 wherein the formic acid solution is an aqueous solution of formic acid heated to a temperature ranging from about 150° F. to about 212° F.

5. The method of claim 1 wherein the fatty acid is heated to a temperature of at least 224° F.

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