

ORIENTED OPAQUE MULTILAYER HEAT SEALABLE FILM

This invention relates to a multilayer film and, more particularly, to a flexible multilayer heat-sealable film especially suited for packaging; and to a method of forming the same.

5 In the packaging of certain types of foods; for example, snack foods like corn-based products, potato chips and cookies it is common practice to employ multilayer film having two or more polymeric layers wherein one of the layers is known to be an effective heat-seal layer. In the packaging process, a supply of such a multilayer film can be shaped into a tube in a vertical
10 form-and-fill machine. Marginal regions of the heat-seal layer are brought in face-to-face relationship and heat sealed together to form a tube. Next the packaging machine automatically forms both a horizontal heat-seal to define a bag and a horizontal severance to
15 detach the base of the bag from downstream. Product is dispensed into the open end of the bag; and, finally, a second horizontal heat-seal and severance is effected to provide a product packaged in a tube which is heat-sealed at both ends and along a seam joining the sealed ends. While the food or other product is being
20 dispensed into the package, air also is present in the package and this air assists in protecting and cushioning the product during subsequent shipment of the finished packages. During shipment of the product, particularly with the larger sized bags, e.g., those containing 0.5 kilogram (16 ounces) of product, the bags have a tendency to split or burst at the end seals.

25 U.S. Patent No. 4,565,739 describes an oriented heat sealable multi-layer structure including a polyolefin film substrate. A second layer, positioned on at least one surface of the film substrate, includes a member selected from the group consisting of a medium density polyethylene, a high density
30 polyethylene and mixtures thereof and polypropylene. A primer

coating is positioned on at least one surface of the second layer and, finally, a heat sealable layer is positioned on the primer coating. The heat sealable layer includes a member of the group consisting of an acrylic polymer layer and a vinylidene chloride polymer layer.

U.S. Patent No. 4,377,616 discloses an opaque, biaxially oriented polymeric film structure comprising a thermoplastic core matrix having a strata of voids; said voids being created by the inclusion within the matrix material of spherical void-initiating solid particles which are incompatible with the matrix material. The void space occupied by the particle is substantially less than the volume of the void. The polymer matrix material is extruded in the form of a film and positioned on opposite surfaces of the film are void free, transparent thermoplastic skin layers adhering to said surface. The voids present in this structure cause light diffraction resulting in an opalescent appearance.

The present invention seeks to provide heat-sealable film suited to packaging and having improved properties, especially: greater heat-seal capabilities and improved fluid transport properties.

In accordance with the present invention, there is provided a heat-sealable structure, preferably an oriented multi-layer heat-sealable structure, comprising:

- (a) a substrate comprising an opaque, preferably white, polyolefin film;
- (b) a second layer coextruded on at least one surface of the substrate (a), the second layer (b) comprising a heat-sealable homopolymer, copolymer or blend thereof;
- (c) a primer coating on at least one surface of the second layer (b), the surface having been previously treated to increase the energy of the surface; and
- (d) a heat-sealable layer on the primer coating (c), the heat-sealable layer (d) including a vinylidene chloride copolymer containing at least 50% by weight of vinylidene chloride.

Where layer (b) is coextruded on both surfaces of substrate (a), the layer (b¹) may either be identical to or different from layer (b).

This invention also provides a process for producing a heat-sealable structure of the present invention, which process comprises:

- (i) coextruding a substrate (a) including an opaque polyolefin film with at least one second layer (b) including a heat-sealable homopolymer, copolymer or blend thereof;
- (ii) biaxially orienting the coextruded product of step (i);
- (iii) treating the coextruded product of step (i) to increase the energy of the surface;
- (iv) applying a primer coating (c) to a surface of the second layer (b); and
- (v) applying a heat-sealable layer (d) on primer coating (c); the heat-sealable layer (d) including a vinylidene chloride copolymer containing at least 50% by weight of vinylidene chloride.

This invention further provides the use, in a multi-layer heat-sealable structure, of a substrate which has been opacified by cavitation.

The polyolefin contemplated for use in the substrate (or core) material (a) of the multi-layer, heat-sealable film structure of this invention includes polyethylene, polypropylene, polybutene, a copolymer or a blend thereof, preferably homopolymeric polypropylene. Particularly preferred is an isotactic polypropylene containing at least 80% by weight of isotactic polypropylene. It is also preferred that the polypropylene has a melt flow index from 4 to 8/g/10 minutes. The substrate or core layer (a) of the present invention is opaque. Opacity can be imparted to the substrate layer in any known manner; for example, the polyolefin substrate can become opacified in the manner described in U.S. Patent 4,377,616. In addition, the substrate or core layer (a) of

the present invention is preferably white. The whiteness can be imparted to the substrate layer in any known manner. For example, the white opaque substrate or core (a) can be made by mixing a major proportion of polyolefin with a second material of higher melting point and which is in the form of microspheres. The mixture is heated to melt the polyolefin and the microspheres are dispersed throughout the molten material. The mixture is then coextruded as a core layer and the layer is biaxially oriented to create cavitation in the layer. In addition, 1 to 3% TiO_2 can be added to impart a further degree of whiteness. In a most preferred embodiment, the white opaque polyolefin film substrate is opacified by cavitation.

The homopolymer, copolymer (including terpolymer) or blend thereof contemplated for use in the layer (b) functions, in some way not completely understood, to increase the overall bond strength formed in ESM seals or crimp seals when employing vinylidene chloride polymer heat seals. Desirably, it may comprise high density polyethylene, medium density polyethylene, or linear low density polyethylene.

The copolymer contemplated herein may comprise any copolymer (which may be a random or a block copolymer) typically employed in the manufacture of multi-layered films. For example, an ethylene propylene copolymer, preferably an ethylene-propylene random copolymer (which is formed by the simultaneous polymerization of the respective monomers in admixture) can be used to form layer (b). Effective formation of a random copolymer of ethylene and propylene is accomplished when the ethylene is present simultaneously with the propylene in the amount sufficient to result in from 0.5 to 10% by weight of ethylene in the resulting copolymer. Where the copolymer is a block copolymer it may include from 10 to 30 weight percent of ethylene.

The copolymer may comprise a terpolymer. The contemplated terpolymers are comparatively low stereoregular polymers. The terpolymers can have a melt flow rate at 446°F ranging from 2 to 10

grams per 10 minutes and preferably from 4 to 6 grams per 10 minutes. The crystalline melting point can range from less than 250°F to somewhat greater than 271°F. The terpolymers will predominate in propylene, and the ethylene and 1-butene monomers can be present in approximately from 0.3:1 to 1:1 mole percentage in relation to each other.

The preferred base substrate layer can be homopolypropylene having a melting point range from 321°F to 336°F. A commercially available material of this description is FINA W828. For the coextruded skinlayers, preferred terpolymers such as, ethylene-propylene-butene terpolymers, would have melting points of 266°F and 255°F, respectively. The materials are commercially available as Chisso XF7500 and Chisso XF 7700. These terpolymers contain from 1 to 7 wt. % ethylene and from 1 to 7 wt. % 1-butene.

In preparing the multi-layer structure of the present invention, the substrate layer (a) and layer (b) are coextruded so that layer (b) is from 2 to 25% of the total thickness of the two layers. For some purposes, layer (b) can be present on both surfaces of a core layer of polypropylene (a) in which case both layers (b) would amount to from 4 to 50% of the total thickness of the three layers. In preparing the coextruded film it has been found advantageous and convenient to recycle certain quantities of scrap extrudate back into the base homopolymer polypropylene or other polyolefin. Thus, the homopolymer polypropylene or other polyolefin can have from 0 to 30% of reclaimed material blended therein.

It has been found that heat seal layers, such as vinylidene chloride copolymer heat seal layers, do not adhere well to polyolefin film surfaces, especially polypropylene film surfaces, even when the latter have been subjected to well known pretreatment operations such as, for example, treatment by corona discharge, flame or oxidizing chemicals. The same has been found to be true in adhering the heat seal layers contemplated herein to the surface of layer (b). However, it has been found that the use of a primer coating (c)

intermediate layer (b) and the heat seal layer provides an unexpectedly high level of adherence.

5 The primer materials contemplated for enhancing the bond between layer (b) and the vinylidene chloride copolymer heat seal layer (d) include the reaction product of an epoxy resin and an acidified aminoethylated vinyl polymer. The contemplated epoxy resins are glycidyl ethers of polyhydroxy compounds. Typical polyhydroxy compounds which may be used include bisphenol A; a ring substituted bisphenol A; resorcinol; hydroquinone; 10 phenol-formaldehyde; a novolac resin; an aliphatic diol, such as ethylene glycol, propylene glycol, 1,4-butanediol, 1,6-hexanediol; glycerol; a lower alkyl hydantoin or a mixture thereof.

15 The preferred epoxy resins of the present invention are those made by the glycidation reaction between epichlorohydrin and bisphenol A. Epoxy resins of this type are commonly classified by their epoxy equivalent weight (EEW) which is defined as the weight of resin in grams which contains one gram equivalent of epoxy groups. Resins with an EEW ranging from 170 to 280 may be used in the present invention, but the preferred range is from 180 to 210.

20 A variation in the composition of the epoxy resin component is one in which a hydantoin compound is substituted for the bisphenol A. For example, 1,1-dimethyl hydantoin may be employed in a low molecular weight epoxy resin since resins based on this material are completely water soluble thereby eliminating the necessity for 25 emulsification.

30 Although the specific structure of the epoxy resin is not critical to the primer employed in the present invention, important considerations in the selection of the epoxy resin depend upon its physical state. For example, it must be liquid and capable of being readily dispersed or dissolved with the second component or curing agent as described hereinbelow. If the epoxy resin is of low viscosity, it may be stirred directly into the second component, i.e., curing agent. However, it is preferred to employ the epoxy resin in an aqueous emulsion.

The second component in the epoxy primer compositions of the present invention is an amino modified acrylic polymer which is water soluble. This polymer is a curing agent for the epoxy compound. The preferred material is described in the U.S. Patent
5 No. 3,719,629 and may be generically described as an acidified amino-ethylated interpolymer having pendant aminoalkylate groups. This material is produced by polymerizing acrylate, methacrylate, styrene or other suitable monomers with sufficient methacrylic or acrylic acid to give a -COOH content from 7.5 to 12.5%. Solvent
10 polymerization techniques are preferred. The polymer is then reacted with ethyleneimine monomer and acidified with hydrochloric acid to render the polymer water soluble.

The primer coating may be applied to the layer (b) as a dispersion or as a solution, from an organic vehicle, for example,
15 an alcohol or an aromatic hydrocarbon, such as xylene or a mixture thereof.

In one embodiment of the present invention, a liquid epoxy
resin is emulsified in a solution of the curing agent by rapid
stirring. Thereafter, the resultant dispersion is diluted with
20 water to the desired concentration for coating, which typically includes from 2 to 25% solids.

When mixing the epoxy resin with the curing agent, it is generally preferred to use a stoichiometric equivalent balance of epoxy and amine groups. However, it has been found that the
25 stoichiometric ratio may be varied over a wide range, for instance, from one epoxy group to three amine groups to three epoxy groups to one amine group and, preferably, from one epoxy group to two amine groups to two epoxy groups to one amine group, without seriously affecting the product's usefulness as a primer coating.

30 It is to be understood that the solution or dispersion of epoxy resin and curing agent can contain small amount of wetting agents in order to facilitate the application of the primer material to the surface of layer (b). Conventional non-ionic wetting agents which can be employed include the hexyl or benzyl ether of ethylene

glycol, the hexyl ether of diethylene glycol, butyl alcohol, hexyl alcohol, octyl alcohol and, diacetone alcohol.

Although mixtures of the epoxy resin and the curing agents will cross-link or cure without the necessary addition of a catalyst, it has been found advantageous in certain instances to use an amine catalyst. Such catalysts include propylene diamine and hexamethylene diamine.

It is to be understood that the present multi-layer structure is not limited to the specific class of primer compositions defined hereinabove. Other operable primer compositions include those defined in U.K. Patent No. 1,134,876 which discloses a primer produced by condensing a monoaldehyde with an interpolymmer of acrylamide or methacrylamide and at least one other unsaturated monomer. U.K. Patent No. 1,174,328 discloses a material which has utility as a primer in the present invention. The material described is the product resulting from condensing aminoaldehyde with acrylamide or methacrylamide and, subsequently, interpolymmerizing the condensation product with at least one other unsaturated monomer in the presence of a C_1-C_6 alkanol.

A preferred primer coating resin of this type comprises a copolymer containing up to 90% by weight of styrene, up to 80% by weight of an alkyl acrylate, up to 15% by weight of methacrylic acid and from 5% to 25% by weight of acrylamide, which has been condensed with a solution of formaldehyde in n-butanol containing from 0.2 to 3 equivalents of formaldehyde for each amide group in the copolymer. A particularly preferred primer resin is a 50% solids solution of a copolymer resins containing 38.5 parts of styrene, 44 parts of ethyl acrylate, 2.5 parts of methacrylic acid and 15 parts of acrylamide, which has been condensed with 5.2 parts of formaldehyde in n-butanol.

A composition of the vinylidene chloride polymer latex which is employed as the heat sealable top coating material layer (d) on the primer coating (c), is not critical to the practice of the invention. Commercially available vinylidene chloride latexes having a vinylidene chloride content of at least 50% and,

preferably, from 75% to 92% may be employed. The other ethylenically unsaturated comonomers may include alpha, beta ethylenically unsaturated acids, such as acrylic and methacrylic acids; alkyl esters containing 1 to 18 carbon atoms of said acids, such as methylmethacrylate, ethyl acrylate and butyl acrylate. In addition, alpha, beta ethylenically unsaturated nitriles, such as acrylonitrile and methacrylonitrile can be employed, as well as monovinyl aromatic compounds, such as styrene and vinyl chloride.

Specific vinylidene chloride polymer latexes contemplated include 82% by weight vinylidene chloride, 14% by weight ethyl acrylate and 4% by weight acrylic acid. Alternatively, a polymer latex comprising 80% by weight vinylidene chloride, 17% by weight methyl acrylate and 3% by weight methacrylic acid can likewise be employed. In addition, the heat seal composition described in the U.S. Patent No. 4,058,649 can be employed.

The multi-layer structure of the present invention can have an overall thickness within a wide range, but is preferably from 0.5 up to 3.0 mils in thickness.

Before applying the primer coating composition to the second layer, the exposed surface of layer (b) is treated to increase its surface energy and therefore ensure that the coating layer (c) will be strongly adherent thereto thereby eliminating the possibility of the coating peeling or being stripped from the film laminate. This treatment can be accomplished employing known techniques such as, for example, film chlorination, i.e., exposure of the film surface to gaseous chlorine, treatment with oxidizing agents such as chromic acid, hot air or steam treatment, or flame treatment. Although any one of these techniques is effectively employed to pretreat the film surface, a particularly desirable method of treatment is the so called electronic treatment method which comprises exposing the film surface to a high voltage corona discharge while passing the film between a pair of spaced electrodes. After electronic treatment of the film surface, the coating composition is then applied thereto.

The primer dispersion to be applied to the surface of layer (b) can have a solids concentration from 5% to 25%.

The primer dispersion can be applied to the surface of layer (b) utilizing standard coating techniques so that a dry coating weight from 0.05 to 0.25 gram/1,000 square inches of film is obtained. The thus coated film can be subsequently passed through a hot air oven to remove completely water and solvent. Thereafter, this primer coated film can be coated with the selected vinylidene chloride polymer latex also using standard coating techniques such as graveur and roll coating. The vinylidene chloride polymer coated system can then be dried by passing it through a conventional hot air oven.

The amount of vinylidene chloride polymer applied to the multi-layer film may be varied over a wide range depending upon the specific properties desired in the final film product. Coating weights from 1 to 6 grams per 1,000 square inches may be employed. If a two-sided coated film is desired, the beneficial corona treating of the substrate coating with layer (b) the priming and the vinylidene chloride polymer application can be repeated, either in line or out-of-line.

The following Example illustrates the invention.

EXAMPLE

Known conventional coextrusion and orientation techniques were employed in preparing a number of PVDC coated, oriented polymer films within the scope of this invention and, for comparison purposes, PVDC coated, oriented polymer films outside the scope of the invention.

The PVDC coated white opaque films were tested for crimp seal strength. The type of polymer used in the skin layer and the percent of the core layer that the polymer represented were varied. Crimp seals were tested skin to skin and the force needed to separate the seals was determined.

The results are shown in the table below. It is clear from the table that samples containing PVDC coated white opaque films with ethylene propylene random copolymer, ethylene-propylene block

5 copolymers and ethylene-propylene butene-1 terpolymer had heat seal strengths significantly greater than the control. In fact, the strength of the seal in the film with ethylene propylene random copolymer present at 15% of the core layer was outstanding. At the same time, the PVDC coated white opaque films presented unusually good appearance characteristics.

TABLE: FILM SEALABILITY

	<u>Skin Resin with PVDC Coating</u>	<u>Skin %</u>	<u>Crimp Seal @ 260°F(g/in)</u>
10	Ethylene propylene random copolymer	5	855
	Ethylene propylene random copolymer	15	1185
	Ethylene propylene block copolymer	5	548
15	Ethylene-propylene-butene-1 terpolymer	5	875
	Polypropylene homopolymer (control)	5	360
20	Polypropylene homopolymer (control)	15	380

25 The multi-layer, heat-sealable structure of this invention affords many highly desirable characteristics. The enhanced sealability is especially effective for the packaging of comparatively large quantities of product since there has been a tendency for such packages to split or burst at the end seams. At the same time, this packaging material is effective for the packaging of comparatively small quantities of product.

30 In addition, the second layer provides excellent wet-out to water based inks and coatings and higher bond strength between that layer and a substrate. Furthermore, the opaque film presents an attractive appearance while providing low light transmission, low

water vapor transmission rate and low oxygen transmission rate since the cavitation included therein provides no path through which light, liquid or oxygen can traverse.

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CLAIMS:

1. A heat-sealable structure comprising:
 - (a) a substrate comprising an opaque polyolefin film;
 - (b) a second layer coextruded on at least one surface of the substrate (a), the second layer (b) comprising a heat-sealable homopolymer, copolymer or blend thereof;
 - (c) a primer coating on at least one surface of the second layer (b), the surface having been previously treated to increase the energy of the surface; and
 - (d) a heat-sealable layer on the primer coating (c), the heat-sealable layer (d) including a vinylidene chloride copolymer containing at least 50% by weight of vinylidene chloride.
2. A heat-sealable structure according to claim 1 wherein the polyolefin film of substrate (a) comprises polyethylene, polypropylene, polybutene, a copolymer or a blend thereof.
3. A heat-sealable structure according to claim 1 or 2, wherein the polyolefin film comprises homopolymeric polypropylene.
4. A heat-sealable structure according to any preceding claim wherein the polyolefin film comprises an isotactic polypropylene containing at least 80% by weight of isotactic polypropylene.
5. A heat-sealable structure according to any preceding claim wherein the polyolefin film substrate is opacified by cavitation.
6. A heat-sealable structure according to any preceding claim wherein the homopolymer of second layer (b) comprises high density polyethylene, medium density polyethylene, or linear low density polyethylene.





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7. A heat-sealable structure according to any preceding claim wherein the copolymer of second layer (b) comprises an ethylene-propylene copolymer.

8. A heat-sealable structure according to any preceding claim wherein the copolymer comprises a random copolymer.

9. A heat-sealable structure according to claim 8 wherein the copolymer includes from 0.5 to 10% by weight of ethylene and from 90 to 99.5 by weight of propylene.

10. A heat-sealable structure according to any preceding claim wherein the copolymer comprises a block copolymer.

11. A heat-sealable structure according to claim 10 wherein the copolymer includes from 10 to 30 weight percent of ethylene.

12. A heat-sealable structure according to any preceding claim wherein the copolymer comprises a terpolymer.

13. A heat-sealable structure according to any preceding claim wherein the terpolymer is an ethylene-propylene-1-butene terpolymer which includes from 1 to 7 weight percent ethylene and from 1 to 7 weight percent of 1-butene.

14. A heat-sealable structure according to claim 12 or 13 wherein the terpolymer has a melt flow rate at 230°C (446°F) ranging from 2 to 10.

15. A heat-sealable structure according to claim 12 or 13 wherein the terpolymer has a melt flow rate at 230°C (446°F) ranging from 4 to 6.





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5 16. A heat-sealable structure according to any preceding claim wherein the primer coating (c) comprises the reaction product of an epoxy resin and an acidified aminoethylated vinyl polymer; the condensation product of a monoaldehyde with an interpolymer of acrylamide or methacrylamide and at least one other unsaturated monomer; or the condensation product of amino-aldehyde with acrylamide or methacrylamide interpolymerized with at least one other unsaturated monomer in the presence of a C_1 to C_6 alkanol.

17. A heat sealable structure according to claim 16 wherein the epoxy resin comprises a glycidyl ether of a polyhydroxy compound.

5 18. A heat-sealable structure according to claim 17 wherein the polyhydroxy compound comprises bisphenol A, a ring substituted bisphenol A, resorcinol, hydroquinone, phenol-formaldehyde, a novolac resin, an aliphatic diol, glycerol, a lower alkyl hydantoin or a mixture thereof.

19. A heat-sealable structure according to claims 16, 17 or 19 wherein the epoxy resin has an epoxy equivalent weight from 170 to 280.

20. A heat-sealable structure according to any of claims 16 to 19 wherein the acidified aminoethylated vinyl polymer includes pendant aminoalkylate groups.

21. A heat-sealable structure according to any preceding claim wherein the vinylidene chloride copolymer of heat sealable layer (d) contains from 75% to 92% by weight of vinylidene chloride.

22. A process for producing a heat-sealable structure, which process comprises:





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- (i) coextruding a substrate (a) including an opaque polyolefin film with at least one second layer (b) including a heat-sealable homopolymer, copolymer or blend thereof;
 - (ii) biaxially orienting the coextruded product of step (i);
 - (iii) treating the coextruded product of step (i) to increase the energy of the surface;
 - (iv) applying a primer coating (c) to a surface of the second layer (b); and
 - (v) applying a heat-sealable layer (d) on primer coating (e), the heat-sealable layer (d) including a vinylidene chloride copolymer containing at least 50% by weight of vinylidene chloride.

23. A process according to claim 22 wherein substrate (a) and second layer (b) are coextruded so that the second layer is from 2 to 25% of the total thickness of coextrudate.

24. A process according to claim 22 or 23 wherein second layer (b) is coextruded onto two surfaces of substrate (a) so that second layer (b) is from 4 to 50% of the total thickness of coextrudate.

25. A process according to claim 22, 23 or 24 wherein primer coating (c) is applied to second layer (b) as a dispersion.

26. A process according to any of claims 22 to 25 wherein primer coating (c) is applied to surface of second layer (b) as a solution.

27. The use, in a multi-layer heat-sealable structure, of a substrate which has been opacified by cavitation.

