

HIGH MOISTURE BARRIER ORIENTED POLYPROPYLENE FILM

The present invention relates to a polypropylene-based multilayer film exhibiting improved moisture barrier and enhanced mechanical properties.

Polymeric films are used in many industrial applications. One particularly important application is the food packaging industry. Films employed in the food packaging industry are chosen and/or designed to provide characteristics necessary for proper food containment. Such characteristics include water vapor barrier properties, oxygen and gas barrier properties and flavor and aroma barrier properties.

Polypropylene is a polymer commonly employed in the manufacture of films used in the food packaging industry. In the case of multilayer films, polypropylene is the polymer used in the base or core layer. Often the polypropylene layer is modified to obtain desired characteristics which are not inherent in unmodified polypropylene. For example, a resin modifier, additive and/or second polymer, may be blended with the polypropylene.

Attempts to vary the characteristics of polypropylene are often directed towards the improvement of the moisture barrier provided by films formed of such polymer. To this end, it is known that blending the polypropylene with a resin modifier will improve the moisture barrier properties of the resultant film. Typically, from about 10% to about 20% resin modifier must be added to the film to achieve the desired reduction in water vapor transmission.

However, the addition of the resin modifier, within the aforementioned ranges, is not without its disadvantage. Particularly, at the loading ranges typically employed in the art, the polypropylene suffers a significant decrease in dimensional stability. This in turn hinders the machinability and processability of the resultant films, resulting in increased manufacturing costs and/or films of inferior quality.

The mechanical properties of a polymeric film are another important characteristic of such a film, particularly with respect to such applications as wrappings for tobacco products. Films having enhanced mechanical properties facilitate handling and packaging because such films are more readily accommodated by typical industrial machinery. Attempts have been made to improve the mechanical properties of a polymeric film, e.g., machine direction (MD) modulus and transverse direction (TD) modulus, by increasing the orientation of the film and/or by the addition of additives. However, increased orientation often increases the likelihood of film splitting during manufacturing, while the addition of additives typically provides limited enhancement of mechanical properties but can negatively impact other film characteristics such as clarity.

There is therefore a need in the art for a resin modified polypropylene-based film which exhibits improved moisture barrier properties and enhanced mechanical properties, while maintaining dimensional stability, machinability, processability and clarity.

The present invention, which addresses the needs of the prior art, relates to a polymeric film having improved moisture barrier characteristics. The film includes a base layer of a high crystallinity polypropylene having an isotactic stereoregularity greater than 93% and a resin modifier in an amount up to 8% by weight of the base layer.

In one preferred embodiment, the high crystallinity polypropylene has isotactic stereoregularity of from 94% to 98%. The base layer preferably includes from 3% to 6% by weight of resin modifier. Preferably, the resin modifier is a hydrogenated hydrocarbon resin or a saturated alicyclic hydrocarbon resin.

In another preferred embodiment, the film includes at least one skin layer adhered to the base layer, preferably

with a coating layer thereon. The skin layer is preferably formed from ethylene-propylene random copolymers or
5 ethylene-propylene-butene-1 terpolymers.

The present invention also relates to a method for preparing a high moisture barrier oriented polypropylene film which includes the steps of (a) blending (1) a high crystallinity polypropylene having isotactic
10 stereoregularity greater than 93% and (2) a resin modifier in an amount up to 8% by weight to form a base layer precursor; (b) forming said base layer precursor into a film, preferably extruding the base layer precursor to form a base layer and orienting the sheet in a longitudinal and
15 transverse direction to obtain biaxially oriented film.

In one preferred embodiment, the high crystallinity polypropylene has an isotactic stereoregularity of from 94% to 98%. The base layer preferably includes from 3% to 6% by weight of resin modifier. Preferably, the resin
20 modifier is a hydrogenated hydrocarbon resin or a saturated alicyclic hydrocarbon resin.

In another preferred embodiment, the base layer precursor is coextruded with at least one skin layer. The skin layer may be formed of ethylene-propylene random
25 copolymers or ethylene-propylene-butene-1 terpolymers. Preferably, the base layer is coextruded with skin layers on both sides.

The present invention further relates to a polymeric film structure having improved moisture barrier
30 characteristics and enhanced mechanical properties. The film structure includes a base layer of a high crystallinity polypropylene having isotactic stereoregularity greater than 93% and a resin modifier in an amount up to 8% by weight of said base layer. The film
35 structure further includes at least one skin layer adhered to the base layer. The skin layer includes an amount of an antiblocking agent effective to reduce blocking of the film

when wound and an amount of a silicone oil affective to maintain a low coefficient of friction on the exposed surface thereof. The film structure preferably includes opposing skin layers adhered to each side of the base layer, the skin layers being formed of a ethylene-propylene-butene-1 terpolymer.

As a result, the present invention provides a polypropylene-based film exhibiting improved moisture barrier properties and enhanced mechanical properties. These improved properties are obtained without a loss of dimensional stability in the resultant film and without a negative impact on other film characteristics such as clarity. Moreover, the resultant film maintains a high degree of machinability and processability, resulting in better quality film and/or reduced manufacturing costs.

Figure 1 is a graph which demonstrates change in Water Vapor Transmission Rate (WVTR) of a polypropylene film which has been modified by various percentages of a resin modifier.

The present invention is prepared by blending high crystallinity polypropylene (HCPP) with a resin modifier to form a base layer precursor. The HCPP has an isotactic stereoregularity of greater than 93%, preferably from 94% to 98%. The base layer includes up to 8% by weight of the resin modifier, preferably from 3% to 6% by weight of the resin modifier.

Suitable HCPPs (film grade) include Amoco 9117 and Amoco 9119, available from Amoco Chemical Co. of Chicago, IL; Chisso HF5010 and Chisso XF2805, available from Chisso Chemical Co., Ltd. of Tokyo, Japan. Suitable HCPPs are also available from Solvay in Europe. The HCPP has a high isotactic stereoregularity, which results in higher crystallinity than conventional polypropylene polymers, exhibits higher stiffness, surface hardness, lower deflection at higher temperatures and better creep

properties. Further information relating to HCPP, including methods for preparation thereof, is disclosed in
5 U.S. Patent No. 5,063,264.

For purposes of the present invention, stereoregularity can be determined by IR spectroscopy according to the procedure set out in "Integrated Infrared Band Intensity Measurement of Stereoregularity in
10 Polypropylene," J.L. Koenig and A. Van Roggen, Journal of Applied Polymer Science, Vol. 9, pp. 359-367 (1965) and in Chemical Microstructure of Polymer Chains, Jack L. Koenig, Wiley-Interscience Publication, John Wiley and Sons, New York, Chichester, Brisbane, Toronto. Tacticity can also be
15 determined by decahydronaphthalene (decalin) solubility and nuclear magnetic resonance spectroscopy (NMR).

The HCPP component is blended with a resin modifier in an amount of up to 8% by weight, preferably from 3% to 6% by weight. Preferred resin modifiers include hydrogenated
20 hydrocarbon resins and saturated alicyclic resins. Examples of other suitable resin modifiers are the petroleum hydrocarbons, asphalt, hydrocarbon resins such as petroleum and coal resins, rosins, rosin derivatives, and styrene resins.

25 The resin modifier, which is preferably of a low molecular weight, has a number average molecular weight as measured by vapor phase osmometry and is usually less than 5000, preferably less than 2000, for example, 500 to 1000. The resin modifier can be natural or synthetic.

30 The petroleum resins may be obtained by the catalytic or thermal polymerization of a mixture of monomers derived from deep cracking petroleum which monomers are chiefly mono- and di-olefins. The catalytic polymerization of such mixtures is generally carried out at low temperatures using
35 Friedel-Crafts catalysts. The petroleum resins can be hydrogenated to reduce their unsaturation, lighten their color and otherwise improve their properties.

One type of hydrocarbon resin useful in the present invention is the polymer of unsaturated coal tar by-products, such as the polyindene and coumaroneidene resins. Also useful are the hydrocarbon resins known as styrene-diolefin copolymers.

Any of the usual types of rosins can be used in accordance with this invention, such as wood rosin, gum rosin, tar oil rosin, and the modified rosins, such as partially or substantially hydrogenated rosins, dehydrogenated rosins, disproportioned rosins, polymerized rosins, as well as rosin alcohols and heat-treated rosins.

Suitable rosins can also include polyhydric alcohol esters of rosins, hydrogenated rosins, polymerized rosins, such as the glycerol and pentaerythritol esters of wood rosin, ethylene glycol, glycerol and pentaerythritol esters of hydrogenated rosins.

Particularly suitable resins which can subsequently be hydrogenated are hydrocarbon resins, ketone resins, polyamide resins, colophonium, coumarone resins, terpene resins, chlorinated aliphatic or aromatic hydrocarbon resins. Examples of hydrocarbon resins are polymers of coke oven gas, cracked naphtha, gas oil and terpene oil.

Preferred hydrogenated resins are hydrogenated petroleum resins. These are usually prepared by catalytically hydrogenating a thermally polymerized steam cracked petroleum distillate fraction. It is also possible to hydrogenate resins produced by the catalytic polymerization of unsaturated hydrocarbons.

Examples of commercially available hydrogenated hydrocarbon resins suitable for use in the present invention are those sold under the trademarks REGALREZ and REGALITE by Hercules Corporation.

Preferred saturated alicyclic resins used in the invention are obtained by the hydrogenation of aromatic hydrocarbon resins. The aromatic resins are themselves obtained by polymerizing reactive unsaturated hydrocarbons

containing, as the principal component, aromatic hydrocarbons in which the reactive double bonds are generally in side-chains. The alicyclic resins are obtained from the aromatic resins by hydrogenating the latter until all, or almost all, of the unsaturation has disappeared, including the double bonds in the aromatic rings.

Although the aromatic hydrocarbons useful in the preparation of the alicyclic resins are mainly compounds containing reactive double bonds in side-chains, they may also comprise aromatic hydrocarbons having reactive double bonds in condensed ring systems. Examples of such useful aromatic hydrocarbons include vinyltoluene, vinylxylene, propenylbenzene, styrene, p methylstyrene, indene, methylindene and ethylindene. Mixtures of several of these hydrocarbons may be used. A very convenient industrial source of such aromatic hydrocarbons is a fraction having a boiling point range of 20° to 300°C, preferably 140° to 300°C, of the residue obtained by distilling off useful olefins such as ethylene and propylene from the thermal cracking products of heavy petroleum fractions. The polymerization of the reactive hydrocarbons can be effected in the presence of polymerization catalysts such as sulphuric acid, phosphoric acid, or amphoteric metal chlorides.

The obtained aromatic hydrocarbon resin are hydrogenated until the unsaturated bonds, including the double bonds in the aromatic rings, are substantially completely saturated. The hydrogenation will generally be carried out at a high temperature under a hydrogen pressure of at least 150 kg/cm², in the presence of a large amount of a highly active catalyst such as Raney nickel or palladium. The hydrogenation of the aromatic double bonds can be confirmed by comparing the infra-red or ultraviolet absorption spectra of the resin before and after hydrogenation. The aromatic rings give rise to characteristic absorptions at

700 cm^{-1} and 750 cm^{-1} in the infra-red spectrum, and at 261.5 $\text{m}\mu$ and 274.5 $\text{m}\mu$ in the ultraviolet spectrum, which are
5 reduced as the aromatic rings are hydrogenated to alicyclic rings, and disappear when all the rings have been saturated. It is desirable to achieve at least 80%, and preferably at least 90%, hydrogenation as measured by the disappearance of the characteristic absorptions.

10 The alicyclic resins used in the invention have a softening point from 85° to 140°C, preferably 100° to 140°C, as measured by the ball and ring method. Examples of commercially available alicyclic resins suitable for use in the present invention are those sold under the trademark
15 ARKON-P by Arakawa Forest Chemical Industries, Ltd. of Japan.

The film of the present invention preferably includes at least one skin layer of an olefinic polymer adhered to at least one side of the base layer. The skin layer is
20 preferably coextruded with the base layer. In one preferred embodiment, skin layers are simultaneously co-extruded on both sides of the base layer.

In one preferred embodiment, a coating is applied to the outer surface of the skin layer(s). An acrylic
25 coating, which provides improved printability, machinability and aroma barrier characteristics, may be applied to one of the skin layers. A heat seal coating such as ethylene methyl acrylate (EMA) or ethylene acrylic acid (EAA) may be applied to the other skin layer. Other
30 suitable coatings include polyvinylidene chloride (PVDC), polyvinyl alcohol (PVOH) and low temperature heat seal coatings, such as disclosed in commonly-owned U.S. Patent No. 5,419,960.

Suitable olefinic polymers utilized for the skin
35 layer(s) include i) ethylene homopolymers, ii) copolymers of ethylene and propylene, iii) copolymers of ethylene or propylene and butylene or another alphaolefin having 5 to 10 carbon atoms, iv) terpolymers of ethylene, propylene and

butylene or another alpha-olefin having 5 to 10 carbon atoms, and v) mixtures thereof.

5 Olefinic polymers which are particularly preferred for the skin layer(s) include ethylene-propylene copolymers with propylene as the main constituent and an ethylene content of 2 to 10% by weight (relative to the weight of the copolymer), propylene-butylene copolymers with
10 propylene as the main constituent and a butylene content of 0.5 to 25% by weight (relative to the weight of the copolymer), and ethylene-propylene-butylene terpolymers with propylene as the main constituent, 0.5 to 7% by weight of ethylene and 5 to 30% by weight of butylene (each time
15 relative to the weight of the terpolymer), and mixtures of these polymers. The co- and terpolymers are preferably random polymers.

 In order to further improve certain properties of the resultant film, effective amounts of additives such as
20 antiblocking agents, antistatic agents and/or slip agents may be contained in the base layer and/or in the skin layer(s).

 Preferred antiblocking agents include silica, talc, clay, sodium aluminum silicate, and conventional inorganic
25 anti-blocks. Other suitable antiblocking agents include inorganic additives, such as silicon dioxide, calcium carbonate, magnesium silicate, aluminum silicate, calcium phosphate, and the like, and/or incompatible organic polymers, such as polyamides, polyesters, polycarbonates
30 and the like.

 Preferred antistatic agents include alkali alkane sulfonates and essentially straight-chain, saturated aliphatic tertiary amines possessing aliphatic radicals with 10 to 20 carbon atoms and being substituted by 2-
35 hydroxyalkyl-(C₁ to C₄) groups. Preferred amines are N,N-bis-(2-hydroxyethyl)-alkylamines having 10 to 20, preferably 12 to 18, carbon atoms in their alkyl groups. The effective amount of antistatic agent varies in the

range from 0.05 to 3% by weight, relative to the weight of the layer.

5 Preferred slip agents include higher aliphatic acid amides, higher aliphatic acid esters, waxes, metallic soaps and silicone oils such as polydimethylsiloxane. The effective added amount of lubricant varies from 0.1% to 2% by weight.

10 In one embodiment of the present invention, the film includes skin layers adhered to opposing sides of the core layer. Each of the skin layers includes an antiblocking agent (e.g., silica) in an amount effective to reduce blocking of the wound film and at least one of the skin
15 layers includes a silicone oil (e.g., a polydimethylsiloxane) in an amount effective to maintain a low coefficient of friction on the exposed surface(s) of the skin layer(s). The antiblocking agent is preferably present in an amount of from 0.1% to 0.3% by weight. The
20 silicone oil is present in an amount of from 0.5% to 2.0% by weight, and preferably from 0.8% to 1.2% by weight, and has a viscosity of from 350 to 600,000 centistokes, and preferably from 10,000 to 30,000 centistokes. If the
25 silicone oil is added to both skin layers, an ABA structure is produced. In those embodiments in which silicone oil is added to only one of the skin layers (resulting in an ABC structure), an amount of oil may still be transferred to the opposing skin layer upon winding of the film. In this
30 particular ABC structure, the non-oil containing side may be flame or corona treated prior to winding.

The multilayer films of the present invention may be prepared employing commercially available systems for coextruding resins. As mentioned, the blended HCPP and resin modifier are preferably coextruded with at least one
35 second polymer which forms the skin layer. The polymers can be brought to the molten state and coextruded from a conventional extruder through a flat sheet die, the melt streams being combined in an adapter prior to being

extruded from the die. After leaving the die orifice, the multilayer film structure is quenched.

5 The film of the present invention is preferably biaxially oriented. In one preferred embodiment, the film is stretched from 4.5 to 6 times in the machine direction (MD), and from 6 to 13 times in the transverse direction (TD). The overall orientation (MD X TD) preferably ranges
10 from 25 to 80. After orientation, the edges of the film can be trimmed and the film wound onto a core.

 The film structures of the present invention are formed having a thickness ranging from 10μ to 60μ , preferably from 15μ to 50μ .

15

EXAMPLES

 The following examples illustrate the present invention. Examples 1-4 below are comparative examples illustrating the moisture properties of prior art films.
20 Examples 5-13 illustrate the improved and unexpected properties exhibited by the films of the present invention. Moisture barrier in each of the following examples was measured at 37.8°C (100°F) and 90% Relative Humidity (ASTM F 372) and is expressed in $\text{g}/100 \text{ cm}^2/\text{day}/\text{mil}$ ($\text{g}/100$
25 $\text{in}^2/\text{day}/\text{mil}$) using a conversion factor of $6.4516 \text{ cm}^2/\text{in}^2$ and rounding off to thousandths. Example 14 illustrates the enhanced mechanical properties exhibited by the films of the present invention.

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EXAMPLE 1

 Sample 1 was produced to demonstrate the moisture barrier of a conventional polypropylene-based film. A core layer of an isotactic polypropylene homopolymer (Fina 3371) having a thickness of 23.75 microns was melted and
35 thereafter coextruded with skin layers of an ethylene-propylene copolymer (Fina 8573HB) each having a thickness of 0.6 microns. The skin layers contained 1,000 ppm of

Sylobloc 48 antiblock agent comprising silica, a product of Grace Divison Co.

The ABA extrudate was quenched, reheated, and stretched 4-6 times in the machine direction at 104°C (220°F) to 143°C (290°F). Subsequently, the MD oriented base sheet was stretched 8-12 times in the transverse direction at approximately 157°C (315°F) to 193°C (380°F).

Sample	Core Layer	% Resin Modifier	WVTR Ambient	WVTR Aged
1	Fina 3371	0	0.048 (.311)	0.048 (.311)

EXAMPLE 2

Samples 2a, 2b and 2c were produced to demonstrate the moisture barrier of conventional polypropylene based films containing varying levels of resin modifier. A conventional polypropylene, Exxon 4612, available from Exxon Chemical Co. of Houston, TX and blends thereof containing 10 wt.% and 20 wt.% terpene polymer were made. The terpene polymer contained d-limonene and is available as Piccolyte C-115 obtainable from Hercules Corporation. The resin was added by melt blending.

Sample	Core Layer	% Resin Modifier	WVTR Ambient	WVTR Aged
2a	Exxon 4612	0	---	0.045(0.29)
2b	Exxon 4612	10	---	0.039(0.25)
2c	Exxon 4612	20	---	0.037(0.24)

EXAMPLE 3

Samples 3a, 3b and 3c were produced to demonstrate the moisture barrier of conventional polypropylene based films containing varying levels of modifier. A conventional polypropylene, Fina 3371, available from Fina Oil and Chemical Co. of Dallas, TX and blends thereof containing 10

wt.% and 20 wt.% terpene polymer comprising d-limonene (Piccolyte C-115 obtainable from Hercules Corporation) added by melt blending were coextruded with Fina 8573 which is an ethylene-propylene random polymer containing 3.5 wt.% ethylene. This combination was coextruded and oriented so as to have outer skin layer dimensions of 0.6 micron and a core layer dimension of 20 microns.

Sample	Core Layer	% Resin Modifier	WVTR Ambient	WVTR Aged
3a	Fina 3371	0	---	0.050(0.325)
3b	Fina 3371	10	---	0.042(0.27)
3c	Fina 3371	20	---	0.039(0.25)

EXAMPLE 4

Sample 4 was produced to demonstrate the moisture barrier of a HCPP film. Example 1 was repeated with a core layer of a high crystallinity homopolymer polypropylene (Amoco 9117).

Sample	Core Layer	% Resin Modifier	WVTR Ambient	WVTR Aged
4	Amoco 9117	0	0.038 (.246)	0.034 (.218)

EXAMPLE 5

Samples 5a, 5b and 5c were produced. An alicyclic resin having a softening point at 115°C, ARKON P-115, was added through a masterbatching process. The final concentration of the core layer was 3%, 6% and 10% ARKON P-115 in Samples 5a, 5b and 5c, respectively. The film was oriented as follows: MDX = 5.0, TDX = 9.0.

Sample	Core Layer	% Resin Modifier	WVTR Ambient	WVTR Aged
5a	Amoco 9117	3	0.035 (.227)	0.030 (.194)
5b	Amoco 9117	6	0.032 (.206)	0.027 (.176)
5c	Amoco 9117	10	0.032 (.205)	0.027 (.173)

EXAMPLE 6

Samples 6a and 6b were produced. An alicyclic resin having a softening point of 125°C, ARKON P-125, was added to the film of Example 4 through a masterbatching process. The final concentration of the core layer was 3% and 6% ARKON P-125 in Samples 6a and 6b, respectively. The film was oriented as follows: MDX = 5.0, TDX = 9.0.

Sample	Core Layer	% Resin Modifier	WVTR Ambient	WVTR Aged
6a	Amoco 9117	3	0.036 (.230)	0.032 (.207)
6b	Amoco 9117	6	0.033 (.214)	0.033 (.210)

EXAMPLE 7

Samples 7a and 7b were produced. An Alicyclic resin having a softening point of 140°C, ARKON P-140, was added to the film of Example 4 through a masterbatching process. The final concentration of the core layer was 3% and 6% ARKON P-140 in Samples 7a and 7b, respectively. The film was oriented as follows: MDX = 5.0, TDX = 9.0.

5	Sample	Layer (B)	Resin Modifier	WVTR Ambient	WVTR Aged
10	7a	Amoco 9117	3%	0.035 (.223)	0.033 (.210)
	7b	Amoco 9117	6%	0.033 (.214)	0.030 (.196)

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EXAMPLE 8

Samples 8a, 8b and 8c were produced. A hydrogenated hydrocarbon resin, REGALITE 101, was added to the film of Example 4 through a masterbatching process. The final concentration of the core layer was 1.5%, 3% and 6% Regalite 101 in Samples 8a, 8b and 8c, respectively. The film was oriented as follows: MDX = 5.0, TDX = 9.0.

25	Sample	Core Layer	% Resin Modifier	WVTR Ambient	WVTR Aged
30	8a	Amoco 9117	1.5	0.036 (.232)	0.034 (.217)
	8b	Amoco 9117	3	0.034 (.219)	0.031 (.200)
35	8c	Amoco 9117	6	0.032 (.208)	0.030 (.193)

EXAMPLE 9

Samples 9a and 9b were produced. A hydrogenated hydrocarbon resin, REGALITE 1094, was added to the film of Example 4 through a masterbatching process. The final concentration of the core layer was 3% and 6% Regalite 1094 in Samples 9a and 9b, respectively. The film was oriented as follows: MDX = 5.0, TDX = 9.0.

5	Sample	Core Layer	% Resin Modifier	WVTR Ambient	WVTR Aged
	9a	Amoco 9117	3%	0.036 (.234)	0.032 (.209)
10	9b	Amoco 9117	6%	0.034 (.218)	0.030 (.193)

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EXAMPLE 10

Samples 10a and 10b were produced. Another hydrogenated hydrocarbon resin, REGALITE 1128, was added to the film of Example 4 through a masterbatching process. The final concentration of the core layer in 10a was 3% and 6% Regalite 1128 in Samples 10a and 10b, respectively. The film was oriented as follows: MDX = 5.0, TDX = 9.0.

25	Sample	Core Layer	% Resin Modifier	WVTR Ambient	WVTR Aged
	10a	Amoco 9117	3%	0.035 (.227)	0.034 (.217)
30	10b	Amoco 9117	6%	0.035 (.228)	0.031 (.202)

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EXAMPLE 11

Samples 11a and 11b were produced. Another hydrogenated hydrocarbon resin, REGALITE 1139, was added to the film of Example 4 through a masterbatching process. The final concentration of the core layer was 3% and 6% Regalite 1139 in Samples 11a and 11b, respectively. The film was oriented as follows: MDX = 5.0, TDX = 9.0.

Sample	Core Layer	% Resin Modifier	WVTR Ambient	WVTR Aged
11a	Amoco 9117	3%	0.037 (.240)	0.034 (.217)
11b	Amoco 9117	6%	0.037 (.237)	0.033 (.210)

EXAMPLE 12

Samples 12a, 12b, 12c and 12d were produced. High crystallinity polypropylene, Amoco 9117, available from Amoco Chemical Co. of Chicago, IL and blends thereof containing 5 wt.%, 10 wt.% and 20 wt.% terpene polymer comprising d-limonene (Piccolyte C-115 obtainable from Hercules Corporation) added by melt blending were coextruded with Fina 8573. This combination was coextruded and oriented so as to have outer skin layer dimensions of 0.6 micron and a core layer dimension of 20 microns.

Sample	Core Layer	% Resin Modifier	WVTR Ambient	WVTR Aged
12a	Amoco 9117	0	---	0.039(0.25)
12b	Amoco 9117	5	---	0.031(0.20)
12c	Amoco 9117	10	---	0.031(0.20)
12d	Amoco 9117	20	---	0.031(0.20)

EXAMPLE 13

Samples 13a, 13b and 13c were produced. High crystallinity polypropylene, Amoco 9117, available from Amoco Chemical Co. of Chicago, IL and blends thereof containing 3 wt.%, and 6 wt.% terpene polymer comprising d-limonene (Piccolyte C-115 obtainable from Hercules Corporation) added by melt blending were extruded and

oriented so as to have a core layer dimension of 20 microns.

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Sample	Core Layer	% Resin Modifier	WVTR Ambient	WVTR Aged
13a	Amoco 9117	0	---	0.034(0.22)
13b	Amoco 9117	3	---	0.026(0.17)
13c	Amoco 9117	6	---	0.026(0.17)

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EXAMPLE 14

Samples 14a, 14b, 14c and 14d were produced and the machine direction (MD) modulus of such films was measured. Each of the films comprised a coextruded ABA structure 21 microns thick, the core layer being 19.5 microns thick and formed of HCPP (Amoco 9218) and containing an Arkon P-115 resin modifier. The structure further included a pair of opposing heat sealable skin layers (Chisso 7504) formed of an ethylene-propylene-butene-1 terpolymer. The skin layers included 2300 ppm of Sylobloc 44, an antiblocking agent comprising silica and 8000 ppm of Dow Corning 200, a polydimethylsiloxane. Each of the film structures was oriented as follows: MDX = see table below, TDX = 9.0. The MD and TD moduli of Samples 14a to 14d were compared to the MD and TD moduli of a comparable ABA film structure (i.e., Sample 14e having a core layer of oriented conventional polypropylene without resin modifier).

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Sample	Core Layer	% Resin Modifier	MDX	MD Mod. 1000 kPa	TD Mod. (1000 psi)
14a	Amoco 9218	6	4.3	2999(435)	5792(840)
14b	Amoco 9218	6	5	3089(448)	5599(812)
14c	Amoco 9218	3	5	2937(426)	5419(786)
14d	Amoco 9218	3	4.3	2779(403)	5550(805)
14e	Fina 3371	0	4.3	2544(369)	4847(703)

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The results from Examples 1-13 are summarized below:

Sample	Core → Layer	Resin Modifier	WVTR Ambient	WVTR Aged
1	Fina 3371	0%	.048	.048
10 2a	Exxon 4612	0%	----	.045
2b	Exxon 4612	10 C-115	----	.039
2c	Exxon 4612	20 C-115	----	.037
3a	Fina 3371	0	----	.050
3b	Fina 3371	10 C-115	----	.042
15 3c	Fina 3371	20 C-115	----	.039
4	Amoco 9117	0%	.038	.034
5a	Amoco 9117	3% P-115	.035	.030
5b	Amoco 9117	6% P-115	.032	.027
5c	Amoco 9117	10% P-115	.032	.027
20 6a	Amoco 9117	3% P-125	.036	.032
6b	Amoco 9117	6% P-125	.033	.033
7a	Amoco 9117	3% P-140	.035	.033
7b	Amoco 9117	6% P-140	.033	.030
8a	Amoco 9117	1.5% R-101	.036	.034
25 8b	Amoco 9117	3% R-101	.034	.031
8c	Amoco 9117	6% R-101	.032	.030
9a	Amoco 9117	3% R-1094	.036	.032
9b	Amoco 9117	6% R-1094	.034	.030
10a	Amoco 9117	3% R-1128	.035	.034
30 10b	Amoco 9117	6% R-1128	.035	.031
11a	Amoco 9117	3% R-1139	.037	.034
11b	Amoco 9117	6% R-1139	.037	.033
12a	Amoco 9117	0%	----	.039
12b	Amoco 9117	5% C-115	----	.031
35 12c	Amoco 9117	10% C-115	----	.031
12d	Amoco 9117	20% C-115	----	.031
13a	Amoco 9117	0%	----	.034
13b	Amoco 9117	3% C-115	----	.026
40 13c	Amoco 9117	6% C-115	----	.026

For purposes of illustration, the WVTR vs. % Resin Modifier plot for Examples 2, 3, 5, 8 and 12 are graphically depicted in Figure 1.

As shown, the plots for Examples 2 and 3 (both of which represent prior art) remain substantially linear as the percentage of modifier is increased from 0% to 20%. The plots exhibit a generally negative slope, which graphically depicts the reduction in water vapor transmission that occurs as the modifier is added to the

resin. To achieve maximum WVTR, upwards of 20% modifier must be added to the resin. However, as mentioned above, resins containing large amount of modifier often suffer from a decrease in dimensional stability, machinability and processability.

The plots for Examples 5, 8 and 12 graphically depict the unexpected characteristics exhibited by the HCPP resin/modifier blends of the present invention. Specifically, the plots depict that an unexpectedly large decrease in water vapor transmission occurs with small additions of modifier to the HCPP resin. This is shown by the initial steepness in the slope of the plots. As more modifier is added to the HCPP resin, e.g. approaching 8%, the slope of the plots levels off to substantially zero, showing that no further decrease in WVTR is occurring.

Stated differently, the blends of the present invention reach minimum WVTR with relatively low levels of modifier, i.e., up to 8% by weight and, preferably, from 3% to 6% by weight of modifier. As a result, a polypropylene-based film exhibiting substantially maximum WVTR may be formed without suffering from a loss of dimensional stability, machinability and processability.

As demonstrated in Example 14, the film structures of the present invention also exhibit unexpectedly increased MD and TD moduli over film structures having conventional OPP-based core layers. It is significant that these increases in MD and TD moduli have been accomplished at relatively low orientation, while maintaining the improved moisture barrier properties demonstrated in Example 5 and without negatively impacting other film characteristics such as clarity. As a result, manufacturing efficiency is increased through increased production time (enhanced mechanical properties can be produced at relatively low MD), reduced cost and reduced likelihood of splitting.

CLAIMED:

- 5 1. A polymeric film having improved moisture barrier characteristics and enhanced mechanical properties, comprising:
- a base layer of (1) a high crystallinity polypropylene having isotactic stereoregularity greater than 93% and (2) a resin modifier in an amount up to 8% by weight of said base layer.
2. The film of claim 1, further comprising at least one skin layer adhered to at least one side of said base layer.
3. The film of claim 2, further comprising a coating layer on the outer surface of said skin layer.
4. The film of claim 1 made by
- a) blending (1) a high crystallinity polypropylene having an isotactic stereoregularity of greater than 93%, and (2) a resin modifier in an amount up to 8% by weight to form a base layer precursor; and
- b) forming said base layer precursor into a film.
5. The film of claim 4, wherein said forming step comprises the further steps of:
- a) extruding said base layer precursor to form a base layer; and
- b) orienting said base layer in a longitudinal and transverse direction to obtain a biaxially oriented film.
6. The film of claims 1 or 4, wherein said high crystallinity polypropylene has an isotactic stereoregularity of from 94% to 98%.
7. The film of claims 1 or 4, wherein said base layer includes 3% to 6% by weight of said resin modifier.



8. The film of claims 1 or 4, wherein said base layer further comprises an additive selected from the group consisting of antiblocking agents, antistatic agents and slip agents.

9. The film of claim 4, wherein said base layer precursor is coextruded with at least one skin layer adhered thereto.

10. The film of claims 2 or 9, wherein said skin layer further comprises an additive selected from the group consisting of antiblocking agents, antistatic agents, slip agents and silicone oil.

11. The film of claim 9, further comprising the step of applying a coating to the outer surface of said skin layer.

12. The film of claims 3 or 11, wherein said coating is selected from the group consisting of acrylic, ethylene methyl acrylate, ethylene acrylic acid, polyvinylidene chloride and polyvinyl alcohol.

13. A polymeric film having improved moisture barrier characteristics and enhanced mechanical properties, comprising:

a base layer of (1) a high crystallinity polypropylene having isotactic stereoregularity greater than 93% and (2) a resin modifier in an amount up to 8% by weight of said base layer; and

at least one skin layer adhered to said base layer, said skin layer including an amount of an antiblocking agent effective to reduce blocking of said film during winding thereof and an amount of a silicone oil effective to maintain a low coefficient of friction on the exposed surface thereof.



14. The film of claim 13, wherein said high crystallinity polypropylene has an isotactic stereoregularity of from 94% to 98% and wherein said base layer includes from 3% to 6% by weight of said resin modifier.

15. The film of claims 1, 4 or 13 wherein said resin modifier is a hydrogenated hydrocarbon resin or a saturated alicyclic hydrocarbon resin.

16. The film of claim 2, wherein said skin layer is selected from the group consisting of (i) ethylene-propylene-butene-1 terpolymer and (ii) ethylene-propylene random copolymers.

17. The film of claim 13, wherein said silicone oil comprises a polydimethylsiloxane and is present in said skin layer in an amount from 0.5% to 2.0% by weight, said silicone oil exhibiting a viscosity of from 10,000 to 30,000 centistokes.

18. The film of claim 13, further comprising a second skin layer adhered to the opposing side of said base layer.

19. The film of claim 16, wherein said skin layer includes an amount of an antiblocking agent effective to reduce blocking of such film during winding thereof and an amount of a silicone oil effective to maintain a low coefficient of friction on the exposed surface thereof.

20. The film of claims 18 or 19, wherein said skin layer includes from 1000 ppm to 3000 ppm by weight of said antiblocking agent and from 0.5% to 2.0% by weight of said silicone oil.

21. The film of claim 15, wherein said resin modifier is selected from the group consisting of polyterpene resins, styrenic-based resins, rosin derivatives, petroleum-derived resins and mixtures thereof.



22. The film of claim 9, wherein said skin layer is selected from the group consisting of (i) ethylene-propylene-butene-1 terpolymer, (ii) ethylene propylene random copolymers, (iii) propylene homopolymers, and (iv) high crystallinity polypropylene homopolymers.

23. The film of claim 13, wherein said skin layer comprises an ethylene-propylene-butene-1 terpolymer.