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(71) Applicant: NOVA CHEMICALS (INTERNATIONAL)
S.A. [CH/CH]; Avenue de la Gare 14, CH-1700 Fribourg
(CH).

(72) Inventors: VIGNOLA, Eric; 189 Coopers Close SW, Air-
drie, Alberta T4B 2X1 (CA). KLECZEK, Monika; Unit
506, 235 - 9A Street NW, Calgary, Alberta T2N 4H7 (CA).

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(54) Title: MULTILAYER POLYETHYLENE FILMS

(57) Abstract: Polyethylene film is often quite splitty – i.e. a tear will quickly propagate in the direction of poor tear strength – especially when the film is made from high density polyethylene. This problem may be further compounded when the polyethylene is made from a single site catalyst or when the polyethylene contains 5 a filler or nucleating agent. The present invention provided multilayer films having an improved balance of tear properties.



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MULTILAYER POLYETHYLENE FILMS

TECHNICAL FIELD

5 This invention relates to multilayer polyethylene film having an improved balance of tear properties.

BACKGROUND ART

Plastic film is in wide use for the preparation of bags, wraps and liners. The most common type of plastic for the preparation of film is polyethylene. There are
10 two general types of polyethylene, namely low density polyethylene that is prepared in a high pressure process using a free radical initiator (commonly referred to as “LD” polyethylene) and linear polyethylene that is prepared with a transition metal catalyst (commonly referred to as “linear” polyethylene).

Linear polyethylene generally has superior physical properties in comparison
15 to LD polyethylene.

Conventional linear polyethylene is typically prepared with a Zeigler-Natta (Z/N) catalyst or a chromium (Cr) catalyst. Such catalysts produce polymers having comparatively broad molecular weight distributions (MWD) and (in the case of copolymers) comparatively broad comonomer distributions.

20 More recently, so-called “single site” catalysts (such as metallocene catalysts) have been put into commercial use for the production of linear polyethylene. These catalysts enable the production of polyethylene having a uniform polymer structure – especially a narrow molecular weight distribution (MWD) and a narrow composition distribution. In general, these polymers have
25 exceptional puncture resistance. However, these polymers generally produce films having highly unbalanced tear strength properties – in the sense that the machine direction (MD) tear strength of the film is low (in comparison to the MD tear strength of a film having the same molecular weight and density, but prepared from a (“Z/N”) catalyst) and in the sense that the MD tear strength is lower than the transverse
30 direction (TD) tear strength.

The problem with unbalanced tear strengths generally becomes more pronounced with high density polyethylene (in comparison to lower density polyethylene).

The problem is especially pronounced in thin films.

The resulting films are “splitty” – i.e. once a tear has been initiated, the tear will generally propagate and split the film (or a garbage bag, heavy duty sack or a food package that is made from the film).

The present invention mitigates this problem and provides multilayer film
5 having an improved balance of tear properties.

DISCLOSURE OF INVENTION

In one embodiment, the present invention provides a multilayer film comprising:

- a) a first layer having unbalanced tear properties and comprising a
10 polyethylene having
 - i) a density of from 0.91 to 0.97 g/cc;
 - ii) a CDBI of greater than about 60%;
 - iii) a melt index, I_2 , of from 0.2 to 10 g/10 minutes, wherein said
first layer has unbalanced tear strengths such that the difference between
15 transverse direction tear strength and machine direction tear strength is at least 80
grams/mil; and
- b) a second layer comprising polyethylene having:
 - i) density of from 0.91 to 0.97 g/cc;
 - ii) a CDBI of greater than about 60%;
 - 20 iii) a melt index, I_2 , of from 0.2 to 10 g/10 minutes,
 wherein said second layer has tear properties that are oriented differently from the
tear properties of said first film, with the proviso that the difference in orientation in
said tear properties is affected by
 - i) at least one nucleating agent;
 - 25 ii) at least one filler; or
 - iii) cross orientation of said first layer and said second layer.

In another embodiment, the present invention provides:
a multilayer film comprising

- 1) at least one layer of a first polyethylene composition, said first
30 polyethylene composition comprising
 - 1a) a first polyethylene having a melt index, I_2 , of from 0.2 to 2 g/10
minutes, a CDBI of greater than 60%, a density of from 0.91 to 0.93 g/cc;
and

1b) from 300 to 3000 parts per million of an MD nucleating agent;
and

2) at least one layer of a second polyethylene composition comprising

2a) a second polyethylene having a melt index, I_2 , of from 0.2 to 2
g/10 minutes, a CDBI of greater than 60%, a density of from 0.91 to 0.93
g/cc;

wherein said multilayer film has an improvement in MD tear of at least 20 g/mil in comparison to a multilayer film made in the absence of said MD nucleating agent.

BEST MODE FOR CARRYING OUT THE INVENTION

The polyethylene used in this invention may be prepared with a single site catalyst (such as a metallocene catalyst) and is characterized by having a uniform composition distribution of molecular weights and/or comonomer. Such polyethylenes are well known and are in wide commercial use.

Two types of "conversion" processes are widely used to prepare film from these polyethylenes, namely the blown film process and the cast film process. It is well known that films made from single site catalyzed polyethylene, especially when made in a blown film process, have "unbalanced" tear properties – i.e. the transverse direction (TD) tear is higher than the machine direction (MD) tear. This imbalance has the effect of causing the film to be "splitty" – i.e. once a tear has been initiated, the tear will quickly propagate in the direction of the lowest tear strength. While not wishing to be bound by theory, it is believed that the above described imbalance in tear properties is caused by the manner in which the polyethylene freezes and crystallizes during the film extrusion process. More particularly, it is generally believed that single site catalyzed polyethylene becomes more aligned with the machine direction flow during the film extrusion process (in comparison to conventional, heterogeneously branched polyethylene that is extruded under similar conditions).

The present invention provided multilayer film that is prepared with single site catalyzed polyethylene and has an improved balance of tear properties. More generally, the present invention may also be useful in multilayer structures prepared by other molding processes such as injection molding or rotomolding.

PART A

Film Preparation Process

Polyethylene film is produced commercially most commonly in two types of processes, namely the cast film process and the blown film process.

5 **Cast Film Process**

A typical cast film process starts with an extruder which melts the polyethylene and forces it through a flat slit die. A properly designed die is required to ensure that the molten polyethylene is evenly distributed across the full width of the die. The die is generally made from metal (especially steel) and is of sufficient
10 mass to provide a thermal sink (to reduce the effect of temperature fluctuations) and sufficient strength to reduce the probability of twisting/defecting from the forces that are applied during extrusion.

The cast film is typically cooled/quenched on a series of highly polished (and often chrome plated) cooling rolls. A well designed quench system allows the
15 molten polyethylene to be frozen very quickly and thereby reduces the formation of large polyethylene crystals in the solid film.

Blown Film Process

The extrusion-blown film process is a well-known process for the preparation of plastic film. The process employs an extruder which heats, melts and conveys
20 the molten plastic and forces it through an annular die.

The polyethylene film is drawn from the die and formed into a tube shape and eventually passed through a pair of draw or nip rollers. Internal compressed air is then introduced from the mandrel causing the tube to increase in diameter forming a "bubble" of the desired size. Thus, the blown film is stretched in two
25 directions, namely in the axial direction also known as the transverse direction (by the use of forced air which "blows out" the diameter of the bubble) and in the lengthwise direction (also known as the machine direction) of the bubble (by the action of a winding element which pulls the bubble through the machinery). External air is also introduced around the bubble circumference to cool the melt as
30 it exits the die. Film width is varied by introducing more or less internal air into the bubble thus increasing or decreasing the bubble size. Film thickness is controlled primarily by increasing or decreasing the speed of the draw roll or nip roll to control the draw-down rate.

The bubble is then collapsed into two layers of film immediately after passing through the draw or nip rolls. The cooled film can then be processed further by cutting or sealing to produce a variety of consumer products. While not wishing to be bound by theory, it is generally believed by those skilled in the art of

5 manufacturing blown films that the physical properties of the finished films are influenced by both the molecular structure of the polyethylene and by the processing conditions. For example, the processing conditions are thought to influence the degree of molecular orientation (in both the machine direction and the axial or transverse direction).

10 A balance of "machine direction" ("MD") and "transverse direction" ("TD" - which is perpendicular to MD) molecular orientation is generally considered most desirable for polyethylene film that is used to manufacture trash bags, heavy duty sacks and food packages. However, the use of a homogeneously branched polyethylene in a blown film process generally produces a polyethylene having poor
15 tear strength in the machine direction and unbalanced tear properties (as used herein; the term unbalanced tear properties means that the MD tear strength is less than the TD tear strength). This effect is especially pronounced in films prepared from high density polyethylene.

The above description relates to the preparation of monolayer films.

20 Multilayer films may be prepared by 1) a "co-extrusion" process that allows more than one stream of molten polymer to be introduced to an annular die resulting in a multi-layered film membrane or 2) a lamination process in which film layers are laminated together.

Linear Polyethylene

25 Linear polyethylene is used in this invention. More particularly, the linear polyethylene has a narrow composition (as defined by having a Composition Distribution Branch Index, CDBI, of at greater than about 60%, as described below). The melt index (I₂, as determined by ASTM D 1238 is in the range of from 0.2 to 10 grams/10 minutes, especially from 0.5 to 5 grams/10 minutes. Such
30 polyethylenes are known items of commerce and may be prepared with a so-called single site catalyst (such as a metallocene catalyst). Suitable single site catalysts are well known in the art and are widely described in the open and patent literature (see, for example, U.S. Patent 8,431,657 (Wang et al.); and U.S. Patent 6,277,931

(Jaber et al.) which teaches a catalyst system containing a single site catalyst and a Ziegler Natta catalyst, which is also suitable for the present invention).

Monolayer polyethylene film prepared from linear polyethylene having a high CDBI generally has unbalanced tear strength properties, as described above.

5 The composition distribution of the polyethylene can be characterized by the SCBDI (Short Chain Branch Distribution Index) or CDBI (Composition Distribution Branch Index). The CDBI is defined as the weight percent of the polymer molecules having a comonomer content within 50 percent of the median total molar comonomer content (See U.S. Patent 5,206,075; Hodgson Jr.). The CDBI of a
10 polymer is readily calculated from data obtained from techniques known in the art, such as, for example, temperature rising elution fractionation (abbreviated herein as "TREF") as described, for example, in Wild et al, Journal of Polymer Science, Poly. Phys. Ed. Vol. 20, p. 441 (1982), or in U.S. Patent 4,798,081. The CDBI for the narrow composition distribution homogeneous polymers of the present invention is
15 preferably greater than about 60%, especially greater than about 70%. By convention, the CDBI of a homopolymer is defined as 100%.

In an embodiment, the CDBI is from 70 to 95%.

It is well known to those skilled in the art that linear ethylene homopolymers have poor tear properties. In contrast, linear ethylene copolymers have better tear
20 properties, and, in general, these tear properties improve as the amount of comonomer increases (and the density becomes lower). Many linear ethylene copolymers having a density of lower than about 0.925 g/cc (especially from about 0.910 g/cc to about 0.925 g/cc) have good tear properties. However, a sub-set of these polymers which is characterized by having a CDBI of greater than 70 and a
25 narrow molecular weight distribution (M_w/M_n) of from about 1.8 to about 3.9 (especially 1.8 to 3.3) typically has poor tear properties (as shown in the examples). The present invention offers especially good results when using such copolymers.

The homogeneous polymers used to make the novel polymer compositions of the present invention may be homopolymers or may be copolymers of ethylene
30 with at least one $C_3 - C_{20}$ alpha-olefin and/or $C_4 - C_{18}$ diolefins. Homogeneous copolymers of ethylene and propylene, butene-1, hexene-1, 4-methyl-1-pentene and octene-1 are preferred (and copolymers of ethylene and 1-octene are especially preferred).

It is within the scope of this invention to use a blend of more than one single site catalyzed polyethylene and/or a blend of a single site catalyzed polyethylene and a Z/N catalyzed polyethylene.

MD Nucleating Agent

5 The term MD nucleating agent as used herein refers to a nucleating agent which improves the MD tear property in a film made with the nucleating agent in comparison to a film having the same structure, made with the same polyethylene but made in the absence of the nucleating agent.

10 In one embodiment, the MD tear is improved by at least 20 grams per mil. In an embodiment, the MD tear is improved by 25 to 50 grams per mil (in comparison to a film having the same structure and being made with the same polyethylene composition, but in the absence of the nucleating agent).

15 Potentially suitable MD nucleating agents include those disclosed as formula (I) in US 2015/0054406 (Miley et al.); as formula CXX in US 2015/0087759 (Dotsan et al.); as formula CX in US 2015/0087758 (Qin et al.) and as formula C in US 2015/0087757 (Miley et al.).

20 In one embodiment, the MD nucleating agent is a metal salt of a haloamido benzoic acid where the metal is selected from potassium, sodium, calcium, magnesium and zinc (such as the sodium salt of a 4-chlorophenylamido-benzoic acid).

25 For clarity, the suitability of a potential MD nucleating agent may be quickly and easily determined by adding about 2500 parts per million by weight (ppm) of the nucleating agent to the linear polyethylene film being studied. Blown films are then prepared from 1) the nucleated polyethylene; and 2) the non-nucleated polyethylene. A nucleating agent is an MD nucleating agent (for use in this invention) if the MD tear strength of the nucleated film is at least 10 grams per mil higher than that of the non-nucleated film.

30 In commercial practice, it is desirable to minimize the use of the nucleating agent. Optimization experiments may be easily completed by those skilled in the art. Suitable concentrations of MD nucleating agent are from 300 to 3000 ppm in one embodiment.

End Uses

 In one embodiment, the films of this invention are suitable for the preparation of plastic bags/plastic sacks such as garbage bags, heavy duty sacks and food

packages used to package materials such as landscaping goods (peat moss; mulch, stones and the like) and food products (chicken, fresh produce, cereal, liquids and the like). Such films are preferably prepared from a linear polyethylene that is prepared with a single site catalyst and having a density of from about 0.91 to 0.93 g/cc; a melt index (I_2) of from about 0.2 to 2 g/10 minutes; a CDBI of from about 60% to about 95% and a molecular weight distribution (M_w/M_n) of from about 1.8 to 3.3.

The inventive films must contain at least two layers of which at least one layer contains an MD nucleating agent and at least one other layer does not contain an MD nucleating agent.

In an embodiment, at least one layer that contains the MD nucleating agent is a “core” layer (i.e. an interior layer of the multilayer films).

In another embodiment, at least one layer that contains the MD nucleating agent is a “skin” layer (i.e. an exterior layer of the multilayer films).

Tear Properties

As noted above, film that is prepared from linear polyethylene having a high CDBI generally exhibits poor machine direction (MD) tear strength and unbalanced tear properties in the sense that the TD tear strength is much higher than the MD tear strength.

While not wishing to be bound by theory, it is believed that molten linear polyethylenes having a high CDBI become highly aligned with the machine direction flow during the extrusion process and that this orientation is frozen into the film morphology, resulting in the unbalanced tear strengths.

As shown in the examples, this problem may be further compounded when the polyethylene contains a filler or nucleating agent. While not wishing to be bound by theory, it is believed that the fillers become aligned with flow and that nucleating agents align polyethylene crystals.

Film prepared from a single site catalyzed high density polyethylene that contains a nucleating agent can have a TD/MD tear strength ratio of greater than 10/1 (as shown in the examples) and the use of a filler such as talc can cause the imbalance to become even worse.

The examples also illustrate that this problem is mitigated by preparing multilayer “cross ply” films – e.g. films in which a first layer having highly unbalanced tear properties is laminated to a second layer that also has highly

unbalanced tear properties, such that the first layer and second layer are aligned with the MD of the first layer being normal (i.e. 90°) to the MD of the second layer. More generally, the balance of tear properties in such a multilayer film may be

5 improved by ensuring that the MD of the first layer is not aligned in the same direction as the MD of the second layer. It will be appreciated that such films are not prepared by co-extrusion (because the MD of all layers of a co-extruded film will be aligned in the same direction). However, as noted above, the use of a filler or nucleating agent may also affect the MD/TD tear balance of polyethylene film.

Thus, it is also within the scope of this invention to prepare a multilayer film in which
10 one or more layer contains a filler and/or nucleating agent in an amount that alters the MD/TD tear strength relative to another layer of the film. Further details of the present invention are provided in the following non limiting examples.

EXAMPLES

Test methods are described below:

- 15 1. Melt Index, "I₂", was determined substantially in accordance with ASTM D1238 (at 190°C, using a 2.16 kg weight). Test results are reported in decigrams per minute (grams/10 minutes).
2. Tear Strength measurements (Machine Direction or "MD", and Transverse Direction or "TD") were determined substantially in accordance with ASTM D9922
20 and are reported in grams/mil (g/mil).
3. Densities were determined substantially in accordance with ASTM D792 and are reported in grams/cc.
4. Weight average molecular weight (M_w) and number average molecular weight (M_n) were determined by gel permeation chromatography ("GPC") in
25 accordance with ASTM D6474-99.
5. Gloss was measured according to ASTM D2457.
6. Haze was measured according to ASTM D1003.
7. Puncture was measured according to ASTM D5748.

Example 1

30 The polyethylene used in this example was a single site catalyzed, ethylene-hexene copolymer having a melt index (I₂) of almost 1 gram per 10 minutes and a density of 0.918 g/cc. The polyethylene was produced in a gas phase polymerization process and had a CDBI of greater than 70%.

Step A: Preparation of Monolayer Blown Film

A monolayer film was prepared from the above described polyethylene on a conventional blown film line manufactured by Brampton Engineering of Brampton, Ontario, Canada.

5 The aiming point for the film thickness was 1.0 mil.

 The film showed the unbalanced tear strength properties that are typical for blown film that is prepared from a single site catalyzed polyethylene resin with the MD value being 205 grams per mil and the TD value being 327 grams per mil. For clarity, the difference between transverse tear (TD) strength and machine direction
10 (MD) tear strength is obtained by simply subtracting the MD value from the TD value – i.e.: $327 - 205 = 122$ g/mil).

Step 2: Inventive Cross laminated Films

 Square pieces having dimensions of 30 centimeters (cm) x 30 cm were cut from the film produced in Part A above. Two layer films were then prepared as
15 follows:

- a) comparative films were prepared by stacking two layers of film in the same alignment (i.e. the MD of both layers were aligned in the same direction); and
- b) inventive films were prepared by stacking the two layers such that the MD of the layers were offset by 90°.

20 The stacked layers were then laminated together in a laminator. The stacked layers were placed between layers of cardboard so that the films were not in direct contact with the heated surfaces of the laminating machine. The temperature of the laminating machine and dwell time of the laminating process were minimized so as to allow the two films to stick together without completely
25 melting the films.

 The tear strength properties of the laminated films were then tested and the tear strength properties of the comparative laminated films were found to be unbalanced, with the MD tear value being 296 g/mil and the TD tear value being 403 g/mil. The imbalance in tear strengths is $403 - 296$ or 107 grams per mil.

30 In contrast, the tear strength properties of the inventive, cross-laminated films are more evenly balanced, with the average of two tear strengths being 352 g/mil (note that there is not a true MD or TD in the cross laminated film).

Example 2

HDPE Films

The high density polyethylene (HDPE) used in this example is an ethylene homopolymer that was prepared with a single site polymerization catalyst in a dual reactor solution polymerization process. The polyethylene prepared in each reactor has a narrow molecular weight distribution (Mw/Mn of about 2). However, the molecular weight of the polyethylene produced in the first reactor is much higher than the molecular weight of the polyethylene produced in the second reactor, with the overall composition having a broad molecular weight distribution (Mw/Mn of about 8). The melt index, I₂, of the overall HDPE is about 1.2 and the density is 0.967 g/cc.

A first composition was prepared from the above described HDPE base resin and about 1200 parts per million by weight (1200ppm) of a nucleating agent sold under the trade name HPN 20E by Milliken Company. This nucleating agent is reported to a combination of the calcium salt of hexahydrophthalic acid, together with some zinc stearate (as dispersion aid). For convenience, this composition is referred to herein as "nucleated HDPE."

A second HDPE composition was prepared by adding 30 weight% of talc (as a filler) to the base HDPE described above. For convenience, this composition is referred to herein as "talc filled HDPE".

It will be recognized by those skilled in the art that this nucleating agent often causes the tear properties of polyethylene films to become unbalanced (even when the nucleating agent is used in small amounts of from 300 to 2000 ppm). It will be recognized by those skilled in the art that the addition of talc as a filler in polyethylene (in amounts up to 30%) can produce films having unbalanced tear properties.

Part A: Monolayer Films

Monolayer films were prepared from the nucleated HDPE and the talc filled HDPE compositions on a blown film line manufactured by Macro Engineering. The aiming point thickness of each film was 1 mil.

The film prepared from the nucleated HDPE composition has highly unbalanced tear properties, with a typical TD tear strength of about 225 grams per mil and an MD tear strength of about 22 grams per mil. The imbalance in tear

strength (TD-MD) is 203 grams per mil. The film prepared from the talc filled HDPE composition had an even lower MD tear strength.

Part B: Multi Layer Films

Two layer films were prepared as follows:

- 5 a) comparative films, in which both layers were aligned in the machine direction, and
- b) inventive films, in which the layers were aligned such that the machine directions were at 90° to each other.

10 The films were then subjected to a tear propagation test that was designed to simulate the performance of a trash bag or a heavy duty sack, or a bone puncturing a film for packaging meat.

A wooden pencil (having a circular cross section, with a diameter of about 5 millimeters, mm, sharpened to a point) was used to simulate the effect of a stick that penetrates a trash bag.

15 The sharpened end of the pencil easily punctured all four films.

 The films prepared from the talc filled HDPE compositions were most easily punctured. The comparative talc filled HDPE film was extremely splitty – with the tear being easily propagated in the machine direction along the full length of the film. In contrast, the inventive talc filled HDPE film was able to resist crack
20 propagation, with the pencil leaving a clean circular hole through the two layers of film. Both of the films prepared from the nucleated HDPE composition were resistant to tear propagation when the initial puncture was caused by the pencil.

 The films prepared from the nucleated HDPE composition were then subjected to a second tear propagation test using a metal probe to cause the initial
25 puncture point. The metal probe was roughly the shape of a flat triangle, with a thickness of about 3 mm. The point of the triangle was flattened so that the leading edge of the probe had a width of approximately the same dimension as the thickness of the probe (about 3 mm). The width of the probe increased to a total width of about 8 mm at a distance of about 2 cm from the (flattened) point of the
30 triangular probe. The metal probe was used to puncture the films prepared from the nucleated HDPE resins. The metal probe caused the tear to propagate in the machine direction of the comparative film, with the tear easily being propagated in the machine direction along the whole length of the film.

In contrast, the inventive film prepared from the talc filled HDPE composition was able to resist crack propagation.

Example 3

The polyethylene resin used in all experiments of this example was a single
5 site catalyzed, ethylene-octene copolymer having a density of 0.917 g/cc, a melt index of 1 and a CDBI of 76. The resin was made in a dual reactor, solution polymerization process as described in United States Patent 6,984,695 (Brown et al., to NOVA Chemicals). For convenience, this resin is referred to as R1 in Table 1.

10 The films of this example were prepared on a three layer blown film line – i.e. a blown film line having three extruders and three annular dies which enables the production of three layer films. The comparative film of experiment 1-c was prepared using R1 in all three layers – in essence, this is equivalent to a monolayer film of R1. The film of experiment 1 has poor machine direction (MD) tear.

15 The comparative film of experiment 2-c was prepared using “nucleated R1” for all three layers. The “nucleated R1” composition (shown in Table 1 as “n.R1”) was prepared by compounding 2000 parts per million by weight of a nucleating agent sold under the trade name HPN 210M by Milliken. As shown in Table 1, this film has improved MD tears in an amount of more than 20 g/mil (which confirms the
20 HPN 210M is an MD nucleating agent).

The inventive films of experiments 3, 4 and 5 were prepared using both of n.R1 and R1 in different layers (according to the structures shown in Table 1).

The total thickness of all films was 1.5 mils (3.8×10^{-3} cm). The “aiming point” for the thickness of each layer for experiments 4 and 5 was the same (i.e. 0.5
25 mils). Inventive film 3 was prepared so that the first layer contained 50% of the total resin (50% n.R1) and the second two layers contained a total of 50% of the total resin (25% R1 + 25% R1 = 50% R1). Inventive experiments 3, 4 and 5 show that it is possible to obtain improved MD tear properties in a multilayer structure in which only 1/3 of the total layer thickness contains the MD nucleating agent (see
30 experiment 4). This is a surprising result and it is commercially important because the nucleating agent is expensive and can be difficult to compound into the polyethylene.

It will be readily appreciated that preferred films for the preparation of garbage bags, heavy duty sacks and food packages should have a good balance of

puncture resistance and tear resistance, especially those made from all polyethylene for recyclability. The films of this invention demonstrate this desired balance – see experiments 3, 4 and 5 where all of the inventive films have a puncture of greater than 26N (as measured by ASTM D5748 in the TD) and an MD tear of more than 400 grams/mil (as measured by ASTM D9922).

TABLE 1

Experiment	Film Structure	Film Tear MD	Film Tear TD	Gloss	Haze	Puncture TD
		g/mil	g/mil	-	%	N
1-C	R1	383	480	40	17	26.8
2-C	n.R1	410	512	46	14.7	26.3
3	n.R1/R1	406	477	49	13.9	26.7
4	R1/n.R1/R1	419	471	43	15.9	26.4
5	n.R1/R1/n.R1	425	504	48	14.7	26.1

INDUSTRIAL APPLICABILITY

The films of this invention have an improved balance of tear properties between the machine direction (MD) and the transverse direction (TD). This makes the films especially suitable for the manufacture bags having reduced tear propagation. Examples of such bags include consumer trash bags and bags for packaging landscape materials such as mulch and stones.

CLAIMS

1. A multilayer polyethylene film comprising:

a) a first layer having unbalanced tear properties and comprising a first polyethylene having

- 5 i) a density of from 0.91 to 0.97 g/cc;
- ii) a CDBI of greater than about 60%;
- iii) a melt index, I_2 , of from 0.2 to 10 g/10 minutes, wherein said first layer has unbalanced tear strengths such that the difference between transverse tear strength and machine direction tear strength is at least 80

10 grams per mil; and

b) a second layer comprising a second polyethylene having:

- i) density of from 0.91 to 0.97 g/cc;
- ii) a CDBI of greater than about 60%;
- iii) a melt index, I_2 , of from 0.2 to 10 g/10 minutes,

15 wherein said second layer has tear properties that are oriented differently from the tear properties of said first film, with the proviso that the difference in orientation in said tear properties is affected by

- i) at least one nucleating agent;
- ii) at least one filler; or

20 iii) cross orientation of said first layer and said second layer.

2. The multilayer polyethylene film according to claim 1 wherein said first polyethylene and said second polyethylene are the same.

3. The multilayer polyethylene film according to claim 1 wherein said first layer and said second layer are cross laminated.

25 4. The multilayer polyethylene film according to claim 1 wherein at least one of said first layer and said second layer contain a nucleating agent.

5. The multilayer polyethylene film according to claim 1 wherein each of said first layer and said second layer contains a nucleating agent.

6. The multilayer polyethylene film according to claim 5 wherein the nucleating agent that is contained in said first layer is different from the nucleating agent that is

30 contained in said second layer.

7. A multilayer film comprising

1) at least one layer of a first polyethylene composition, said first polyethylene composition comprising

1a) a first polyethylene having a melt index, I_2 , of from 0.2 to 2 g/10 minutes, a CDBI of greater than 60%, a density of from 0.91 to 0.93 g/cc; and

1b) from 300 to 3000 parts per million of an MD nucleating agent;

and

2) a least one layer of a second polyethylene composition comprising

2a) a second polyethylene having a melt index, I_2 , of from 0.2 to 2 g/10 minutes, a CDBI of greater than 60%, a density of from 0.91 to 0.93 g/cc;

wherein said multilayer film has an improvement in MD tear of at least 20 g/mil in comparison to a multilayer film made in the absence of said MD nucleating agent.

8. The multilayer film of claim 7 wherein each of said first polyethylene and said second polyethylene are further characterized by having a CDBI of from 70% to 95% and a molecular weight distribution, M_w/M_n , of from 1.8 to 3.3.

9. The multilayer film of claim 8 where each of said first polyethylene and said second polyethylene are prepared with a single site catalyst.

10. The multilayer film of claim 9 where in each of said first polyethylene and said second polyethylene are the same polyethylene.

11. A garbage bag prepared from the multilayer film of claim 7.

12. A garbage bag prepared from the multilayer film of claim 10.

13. A heavy duty sack prepared from the multilayer film of claim 7.

14. A heavy duty sack prepared from the multilayer film of claim 10.

15. A food package prepared from the multilayer film of claim 7.

16. A food package prepared from the multilayer film of claim 10.

17. The multilayer film of claim 8 wherein said MD nucleating agent is a metal salt of a halo amido benzoic acid and wherein said metal is selected from the group consisting of potassium, sodium, calcium, magnesium and zinc.

18. The multilayer film of claim 13 wherein said MD nucleating agent is the sodium salt of 4-chlorophenyl benzoic acid.

19. The multilayer film of claim 8, further characterized by having an MD tear of more than 400 g/mil and a TD puncture of more than 26 N.

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER

INV. B32B7/00 B32B27/08 B32B27/20 B32B27/32
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B32B C08L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	paragraphs [0014], [0015], [0019] - [0021]	4-19
Y	----- US 6 503 637 B1 (VAN LOON ACHIEL JOS [BE]) 7 January 2003 (2003-01-07) column 6, line 65 - column 7, line 5	4-19
Y	----- US 2008/139718 A1 (REYNTJENS WOUTER [BE] ET AL) 12 June 2008 (2008-06-12) paragraph [0008]	4-19



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

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Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Aspeby, Erika

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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