

Polypropylene composition suitable for extrusion coating application**FIELD OF INVENTION**

The present invention relates to heat sealable films and articles. In particular, the invention relates to a blend of polymers comprising homopolypropylene (optional), polypropylene random copolymers or terpolymers, and a high pressure low density polyethylene. The blends of the invention exhibit excellent hot tack, heat sealing, processability and other physical properties. The blends may be used to make films, bags, pouches, tubs, trays, lids, packages, containers and other articles employing a heat seal.

BACKGROUND

The listing or discussion of a prior-published document in this specification should not necessarily be taken as an acknowledgement that the document is part of the state of the art or is common general knowledge.

In the commercial packaging industry, Form-Fill-Seal machines have been widely used in the food, pharmaceutical, cosmetics and other industries. In the filling production line, the machine constructs plastic bags from a flat roll of film, which bag is then filled with product almost immediately thereafter. The conventional method of filling in such lines is to drop the product into the package from a certain height which can cause a strong impact on the bottom of the newly-constructed plastic bag. If the bottom of the bag cannot withstand the impact, it will break and so contaminate the surrounding environment, as well as reducing the filling efficiency of the overall process. As the interval between the heat seal process to form the bag from the film and product filling is quite short, it is impossible for the sealing area to cool down completely before filling. Films that have a high hot tack strength can reduce the occurrence of package breakage in such operations. Thus, finding polymer films that have an increased hot tack strength compared to conventional films may increase the filling efficiency and reduce the package breakage rate of such processes.

In addition, in industries that use film packing the speed of packaging is an important factor. This is because assembly line speeds are very important to a manufacturer, as the faster the line speed, the higher production output can be, and thus the overall cost is lowered per unit. One property that affects these packaging speeds is the hot tack strength of the polymer, which can be described generically as the ability of a heat-sealed join to survive the application of a stress (e.g. drop-filling) to it while the seal is still hot from the sealing operation. However, the speed of packing can be affected by fluctuations in the temperature

of the heat sealing machine. For example, in cases where the polymer has a narrow sealing temperature window with sufficient hot tack strength for later operations, an unstable heat sealing temperature in a heat sealing machine (e.g. fluctuations outside the accepted heat seal window for the film in question) may require the operator to reduce the speed of the machine to achieve an acceptable breakage rate, as slowing the machine will allow the heat-sealed bags to cool sufficiently before filling. Unfortunately, this decrease in rate results in increased costs and potentially still includes significant wastage due to breakages of the bags.

In general, extrusion coating of substrates such as paper, paperboard, fabrics and metal foils with a thin layer of plastic is practiced on a large scale. The coating composition is extruded in a first step whereby the flux of molten polymeric material passes through a flat die to obtain a film having a thickness of a few microns. In the second step, i.e. the coating step, the film is laid on a support and passed on a cooling cylinder. Upon cooling, the polymer adheres to its support.

Biaxially oriented crystalline polypropylene film (abbreviated as BOPP) has been widely used as a packaging film because it has good stiffness, transparency and moisture impermeability. However, BOPP itself has unsatisfactory heat sealing properties. To overcome this deficiency, laminated BOPP films obtained by laminating a resin having good heat sealing properties (hereinafter heat sealing resin) on one or both surfaces of a BOPP film have been used in the packaging industry.

As noted above, both low-temperature heat sealability and a wider hot tack window are considered to be most important properties for a heat sealing resin for use in such laminates. This is because lowering the heat sealing temperature of the heat sealing permits the process of making bags from the laminated film to be sped up, and widening the hot tack window facilitates high speed filling of the resulting bags in the Form-Fill-Seal process, both of which improve the productivity of the process.

Various resins have been proposed for use as the heat sealing resin for BOPP. According to patent application WO1982US1106A, a thermally degraded polypropylene was used in an attempt to provide increased seal strength. However, the hot tack window of the resulting product was not also broadened by this approach. In patent application US4359553A, up to 30 weight percent of a degraded polypropylene was blended with LDPE for good coatability and a broad heat seal range. As the polymer matrix is made of LDPE, the hot tack strength

is inferior to those films made using polypropylene. In patent application KR375666B1, it is mentioned that propylene ionomer resin was blended with propylene-ethylene-butene-1 copolymer. The hot tack properties of the resulting film would not be better at high sealing temperatures because the expensive ionomer resin has a low melting temperature and would detrimentally affect the hot tack performance at high sealing temperatures. In another patent application KR2002040224, MDPE was added to the disclosed recipe in order to seek good film strength as well as good film formability at high speeds. However, according to an experiment by the present inventors, the MDPE-blend proved to have an unsatisfactory hot tack property.

Therefore, there remains a need to find new polypropylene materials with an enhanced hot tack property that can be used to form laminated films that are intended to be subjected to high speed packaging.

SUMMARY OF INVENTION

This invention provides polypropylene blend compositions that contain a random polypropylene terpolymer or copolymer and a low density polyethylene, and optionally a homopolypropylene, which blends show increased hot tack window and lowered heat sealing temperature with good processability compared to polypropylene compositions where the random terpolymer or, in some embodiments of the invention, where the homopolypropylene is absent. The blend may further comprise an organic peroxide that may enhance the properties of the blend yet further.

Thus, in a first aspect of the invention, there is provided an extrusion coating composition blend, comprising:

(a) from about 0 wt% to about 15 wt% of at least one homopolypropylene resin that has a melt flow rate of from 2 to 100 g/10min at 230°C;

(b) from about 70 wt% to about 95 wt% of a propylene random copolymer or terpolymer having a melt flow rate of from 2 to 30g/10min at 230° C; and

(c) from 5 wt% to about 15 wt% of a low density polyethylene having a density of 0.910 to 0.940 and a melt flow rate of from 4 to 70 g/10min at 190° C, wherein

the blend has a melt flow rate of from 7 to 50 g/10min at 230°C, and a T_m of from 120°C to 165°C.

In embodiments of the first aspect of the invention:

(a) the at least one homopolypropylene resin, when present, may have a melt index of from 3 to 50 g/10min at 230°C (e.g. from 4 to 20 g/10min at 230°C, such as from 5 to 10 g/10min at 230°C, such as 7 g/10min at 230°C);

(b) the propylene random copolymer or terpolymer may have a melt index of from 3 to 15g/10min at 230°C (e.g. from 4 to 10 g/10min at 230°C, such as from 5.5 to 7 g/10min at 230°C);

(c) the low density polyethylene may have a melt index of from 4 to 70 g/10min at 190°C (e.g. from 10 to 50 g/10min at 190°C, such as from 15 to 40 g/10min at 190°C, such as from 21 to 35 g/10min at 190°C);

(d) the at least one homopolypropylene, when present, may have a melting temperature (T_m) in the range of from 150°C to 170°C (e.g. from 160°C to 169°C, such as 167°C);

(e) the at least one homopolypropylene, when present, may further comprise ethylene and/or a C_4 - C_{10} α -olefin in a total amount of less than 1 wt% relative to the total weight of the homopolypropylene resin used;

(f) the propylene random copolymer or terpolymer may have a T_m of from 120°C to 135°C (e.g. from 125°C to 135°C, such as from 130°C to 135°C);

(g) in the propylene random copolymer or terpolymer the non-propylene monomers are selected from the group consisting of ethylene and a C_4 - C_{10} α -olephin (e.g. the propylene random copolymer or terpolymer may be a terpolymer, such as a propylene-ethylene-but-1-ene terpolymer (e.g. the propylene-ethylene-but-1-ene terpolymer may have an ethylene content of from about 1.0 wt% to about 5.0 wt% and a but-1-ene content of from about 3.0 wt% to about 15 wt% (e.g. the propylene-ethylene-but-1-ene terpolymer may have an ethylene content of about 2.6 wt% and a but-1-ene content of about 7.0 wt%)));

(h) the low density polyethylene may have a density of from 0.916 to 0.920 g/cm³ (e.g. a density of 0.917 g/cm³);

(i) the at least one homopolypropylene resin may be present in an amount of from about 3 wt% to about 10 wt% (e.g. from about 5 wt% to about 9 wt%);

(j) the propylene-ethylene-but-1-ene terpolymer may be present in an amount of from about 70 wt% to about 90 wt% (e.g. 80 wt% to about 84 wt%);

(k) the low density polyethylene may be present in an amount of from 10 wt% to about 12 wt%;

(l) when the blend may be laminated onto one side of a polymeric film substrate material at a thickness of 20 μ m, the laminated film has a hot tack temperature window having a minimal value and a maximal value, wherein the difference between the minimal and maximal value is from 20°C to 100°C, optionally wherein the polymeric film substrate

material may be a BOPP film (e.g. the polymeric film substrate material may be a BOPP film having a thickness of 20 μm), such as where the difference between the minimal and maximal value of the hot tack temperature window of the laminated film may be from 35°C to 70°C, optionally wherein the difference between the minimal and maximal value of the hot tack temperature window of the laminated film may be from 40°C to 50°C (e.g. a range of from 42°C to 46°C), for example the hot tack window of the laminated film may have a minimal value of from about 110°C to about 120°C and a maximal value of from about 145°C to about 170°C, optionally wherein the hot tack window may have a minimal value of the film of from about 113°C to about 115°C and a maximal temperature of from about 148°C to about 160°C (e.g. a minimal value of from about 113°C to about 114°C and a maximal value of from about 149°C to about 157°C);

(m) the at least one homopolypropylene resin, the propylene random copolymer or terpolymer and the low density polyethylene together form a polymeric component and the blend further comprises an organic peroxide may be present in an amount of from 0.010 to 0.50 parts by weight, per 100 parts by weight of the polymeric component (e.g. from 0.020 to 0.040 parts by weight per 100 parts by weight of the polymeric component), optionally where the organic peroxide may be selected from the group consisting of hydroperoxides, dialkyl peroxides, diacyl peroxides, peroxydicarbonates, peroxyesters, ketone peroxides, peroxyketals, and alkyl peroxy carbonates.

In a second aspect of the invention there is provided a film suitable for manufacturing a packaging article using a form-fill-seal machine comprising:

a substrate material having a first side and a second side; and
an extrusion coating composition blend according to the first aspect of the invention
and any technically sensible combination of its embodiments, wherein
the extrusion coating composition blend is coated on one or both of the first and second sides of the substrate material.

In embodiments of the second aspect of the invention:

- (a) the substrate material may be BOPP, OPET or paper;
- (b) the coating on each side of the substrate may be less than 60 μm (e.g. from 5 to 25 μm , such as 20 μm);
- (c) the substrate may have a thickness of from 10 to 60 μm , such as from 15 to 30 μm , such as 20 μm ;
- (d) the film has a hot tack temperature window may have a minimal value and a maximal value, wherein the difference between the minimal and maximal value may be from

20°C to 100°C, optionally from 35°C to 70°C, such as from 40°C to 50°C (e.g. a range of from 42°C to 46°C), optionally where the hot tack window of the film may have a minimal value of from about 110°C to about 120°C and a maximal value of from about 145°C to about 170°C, optionally wherein the hot tack window may have a minimal value of the film of
5 from about 113°C to about 115°C and a maximal temperature of from about 148°C to about 160°C (e.g. a minimal value of from about 113°C to about 114°C and a maximal value of from about 149°C to about 157°C).

In a third aspect of the invention, there is provided a process of manufacturing a packaging
10 article comprising the steps of:

(a) providing a film comprising:

a substrate material having a first side and a second side; and

an extrusion coating composition blend according to the first aspect of
the invention and any technically sensible combination of its embodiments,
15 where the extrusion coating composition blend is coated on one or both of the
first and second sides of the substrate material;

(b) subjecting the film to a form-fill-seal process to provide a packaging article.

DESCRIPTION

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When used herein, the terms “comprises” and “comprising” and equivalents thereof are intended to be non-limiting in nature. Said terms are intended to encompass the terms “consists essentially of” and “consists of” and equivalents thereof. It is intended that the terms “comprises” and “comprising” and equivalents thereof may be replaced by the terms
25 “consists essentially of” and “consists of” and equivalents thereof.

The applicants have surprisingly found that blending a random polypropylene terpolymer or copolymer with a low density polyethylene, and optionally a homopolypropylene, results in a blend with a surprisingly useful hot tack window and lowered heat sealing temperature
30 compared to polypropylene compositions where the random terpolymer or, in some embodiments of the invention, where the homopolypropylene is absent. The blend may further comprise an organic peroxide that may enhance the hot tack effect and improve processability.

35 Thus, in a first aspect of the invention, there is provided an extrusion coating composition blend, comprising:

(a) from about 0 wt% to about 15 wt% of at least one homopolypropylene resin that has a melt flow rate of from 2 to 100 g/10min at 230°C;

(b) from about 70 wt% to about 95 wt% of a propylene random copolymer or terpolymer having a melt flow rate of from 2 to 30g/10min at 230° C; and

5 (c) from 5 wt% to about 15 wt% of a low density polyethylene having a density of 0.910 to 0.940 and a melt flow rate of from 4 to 70 g/10min at 190° C.

When used herein the term "homopolypropylene resin" relates to any suitable homopolymer of propylene that provides the stated melt flow rate herein before. A method for measuring
10 the melt flow rate of all polymers and blends mentioned herein is provided in the examples section below. Alternatively, if there is not enough sample for experimental melt flow rate (i.e. melt index) determinations or if it is necessary to determine melt flow rate of fractions of a polymer blend composition (or individual polymers), an alternative molecular weight measurement, such as gel permeation chromatography can be used together with known
15 correlations between molecular weight and melt flow rate to determine the melt flow rate for the polymer blend composition. For an example, see A. Gijsels, Ind. Polym. Process, 9, 252 (1994).

In certain embodiments, then the homopolypropylene is present as part of the blend, the
20 homopolypropylene may contain, as impurities, ethylene and/or a C₄-C₁₀ α-olefin in minor amounts. For example, the homopolypropylene may contain up to 1 wt% of these impurities.

When used herein the term "a propylene random copolymer" refers to a polymeric material that is formed by the copolymerisation of propylene monomer with one other monomeric
25 material, which has the desired melt flow rate mentioned above. This may be as an entirely random polymerisation or as a random block copolymerisation. Suitable monomeric materials that may be reacted with monomeric propylene include, but are not limited to, ethylene and an olefin selected from one of a C₄-C₁₀ α-olefin. Correspondingly, "a propylene random terpolymer" refers to a polymeric material that is formed by the copolymerisation of
30 propylene monomer with two other monomeric materials that may be selected from the list provided for the copolymerisation and which retains the desired melt flow rate.

In embodiments of the invention that may be mentioned herein:

(a) the at least one homopolypropylene resin, when present, may have a melt
35 flow rate of from 3 to 50 g/10min at 230°C (e.g. from 4 to 20 g/10min at 230°C, such as from 5 to 10 g/10min at 230°C, such as 7 g/10min at 230°C); and/or

(b) the propylene random copolymer or terpolymer may have a melt flow rate of from 3 to 15g/10min at 230°C (e.g. from 4 to 10 g/10min at 230°C, such as from 5.5 to 7 g/10min at 230°C); and/or

(c) the low density polyethylene may have a melt flow rate of from 4 to 70 g/10min at 190°C (e.g. from 10 to 50 g/10min at 190°C, such as from 15 to 40 g/10min at 190°C, such as from 21 to 35 g/10min at 190°C).

It will be suited that the blends disclosed herein will have properties defined in part by the combined material used in the blends. As an example, the polymer blend composition may have a melt flow rate of from 7 to 50 g/10 minutes at 230°C, such as from 8 to 49 g/10 minutes at 230°C, more particularly of from 15 to 30 g/10 minutes at 230°C such as from 18 to 25 g/10 minutes at 230°C. As a further example, the T_m of the polymer blend composition may be from 123°C to 145°C (e.g. a T_m of from 125°C to 135°C, such as a T_m of from 128°C to 133°C). For completeness, it is noted that the T_m ranges and the Melt flow ranges listed here may be combined in any manner whatsoever.

In certain embodiments, the selection of a random polypropylene copolymer or terpolymer, or a homopolypropylene having a defined T_m (i.e. melting point or crystalline melting temperature) may be useful to control the overall properties of the blend. For example, when present, the T_m of the homopolypropylene may be from 150°C to 170°C (e.g. from 160°C to 169°C, such as 167°C) and/or the T_m of the copolymer or terpolymer may be from 120°C to 135°C (e.g. from 125°C to 135°C, such as from 130°C to 135°C).

In certain embodiments of the invention that may be mentioned herein, the random polypropylene copolymer or terpolymer may be a terpolymer. When it is a terpolymer, the terpolymer may comprise both ethylene and a C₄-C₁₀ α-Olefin as comonomers. For example, the random terpolymer may be propylene-ethylene-but-1-ene. It will be appreciated that any suitable propylene-ethylene-but-1-ene that matches the physical requirements set out above may be used within the invention. Suitable, but non-limiting propylene-ethylene-but-1-enes that may be mentioned herein are ones in which the propylene-ethylene-but-1-ene terpolymer has an ethylene content of from about 1.0 wt% to about 5.0 wt% and a but-1-ene content of from about 3.0 wt% to about 15 wt% (e.g. the propylene-ethylene-but-1-ene terpolymer has an ethylene content of about 2.6 wt% and a but-1-ene content of about 7.0 wt%).

In certain alternative embodiments of the invention, the random polypropylene copolymer or terpolymer that may be mentioned herein is a random polypropylene copolymer containing ethylene or a C₄-C₁₀ α -Olefin in an amount of from about 1.0 wt% to about 15 wt%. Suitable, but non-limiting, random polypropylenes that may be mentioned herein has ethylene as
5 comonomer, with an ethylene content of from about 4.0 wt% to about 5.5 wt%.

When used herein, the C₄-C₁₀ α -Olefin monomers may include, but are not limited to, any suitable C₄-C₁₀ α -Olefin, such as 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, and any suitable derivatives thereof.

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In certain embodiments of the invention, the homopolypropylene resin is present in an amount of from about 3 wt% to about 10 wt%. In such compositions, the propylene copolymer or terpolymer (e.g. propylene-ethylene-but-1-ene terpolymer) may be present in an amount of from about 70 wt% to about 90 wt% and the low density polyethylene may be
15 present in an amount of from 10 wt% to about 12 wt%. Alternatively, in such compositions, the propylene copolymer or terpolymer (e.g. propylene-ethylene-but-1-ene terpolymer) may be present in an amount of from about 80 wt% to about 84 wt% and the low density polyethylene may be present in an amount of from 10 wt% to about 12 wt%.

20 In other certain embodiments of the invention that may be mentioned herein, the homopolypropylene resin may be present in an amount of from about 5 wt% to about 9 wt%. In such compositions, the propylene copolymer or terpolymer (e.g. propylene-ethylene-but-1-ene terpolymer) may be present in an amount of from about 70 wt% to about 90 wt% and the low density polyethylene may be present in an amount of from 10 wt% to about 12 wt%.
25 Alternatively, in such compositions, the propylene copolymer or terpolymer (e.g. propylene-ethylene-but-1-ene terpolymer) may be present in an amount of from about 80 wt% to about 84 wt% and the low density polyethylene may be present in an amount of from 10 wt% to about 12 wt%.

30 In other embodiments of the invention, the propylene copolymer or terpolymer (e.g. propylene-ethylene-but-1-ene terpolymer) may be present in an amount of from about 70 wt% to about 95 wt%. In such compositions, the homopolypropylene resin may be present in an amount of from about 3 wt% to about 10 wt% (e.g. from 5 wt% to about 9 wt%) and the the low density polyethylene may be present in an amount of from 5 wt% to about 15 wt%
35 (e.g. from 10 wt% to about 12 wt%).

In certain embodiments, the low density polyethylene having a density of from 0.916 to 0.920 g/cm³, for example a density of from 0.917 to 0.920 g/cm³.

5 In certain embodiments of the invention, the blend described herein may further comprise an organic peroxide. The amount of organic peroxide in the blend may be calculated relative to the total weight of polymeric materials (e.g. the homopolypropylene, when present, the propylene copolymer or terpolymer and the low density polyethylene, which may be described herein collectively as the "polymeric component") and may be expressed as parts by weight relative to 100 parts by weight of the polymeric component. For example, the
10 organic peroxide may be present in an amount of from 0.010 to 0.50 parts by weight, per 100 parts by weight of the polymeric component (e.g. from 0.020 to 0.040 parts by weight per 100 parts by weight of the polymeric component).

The organic peroxide may be selected from one or more of the group consisting of
15 hydroperoxides, dialkyl peroxides, diacyl peroxides, peroxy monocarbonates, peroxydicarbonates, peroxyesters, ketone peroxides, peroxyketals, and alkyl peroxy carbonates.

Hydroperoxides that may be mentioned herein include, but are not limited to, p-menthane
20 hydroperoxide.

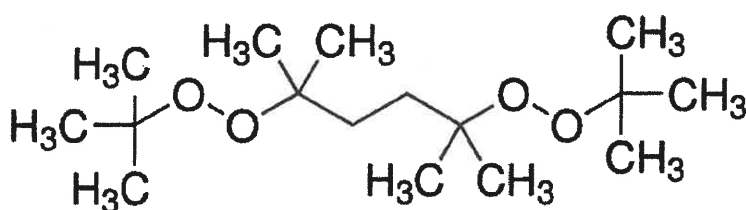
Peroxy monocarbonates that may be mentioned herein include, but are not limited to, tert-hexylperoxy isopropyl monocarbonate.

25 Peroxyesters that may be mentioned herein include, but are not limited to, tert-butylperoxy-3,5,5-trimethyl hexanoate, tert-butyl peroxy laurate, tert-butylperoxyacetate and tert-butylperoxybenzoate.

Peroxyketals that may be mentioned herein include, but are not limited to, n-butyl-4,4-
30 bis(tert-peroxy)valerate, 1,1-bis(tert-butylperoxy)cyclohexane, 2,2-bis(4,4-di-tert-butylperoxy)cyclohexyl)propane, 1,1-bis(tert-butylperoxy)cyclododecane and di-tert-butylperoxyisophthalate.

Diakyl peroxides that may be mentioned herein include, but are not limited to, 2,5-dimethyl-
35 2,5-di-(benzoylperoxy)hexane, 2,2-bis(tert-butylperoxy)butane, tert-butyl cumyl peroxide, di-tert-butyl peroxide, dicumyl peroxide, α-α'-bis(tert-butylperoxy-m-isopropyl)benzene, 1,3-

bis(*tert*-butylperoxydiisopropyl)benzene, 2,5-bis(*tert*-butylperoxy)-2,5-dimethylhex-3-yne, 2-methyl-2-[(2-methyl-2-propanyl)peroxy]propane, 2-methyl-2-[(2-methyl-2-butanyl)peroxy]butane, {2-[(2-methyl-2-propanyl)peroxy]-2-propanyl}benzene, 1,3-bis{1-[(2-methyl-2-propanyl)peroxy]-2-propanyl}benzene, 2,5-dimethyl-2,5-bis[(2-methyl-2-propanyl)peroxy]hexane, 1,1'-(dioxidi-2,2-propanediyl)dibenzene, and 2,5-bis(*tert*-butylperoxy)-2,5-dimethylhexane. A particular dialkyl peroxide that may be mentioned herein is 2,5-bis(*tert*-butylperoxy)-2,5-dimethylhexane, also represented by the chemical structure shown below.



In certain embodiments, the organic peroxide may include TrigonoxTM101-20PP and/or LuperoxTM 101 PP20.

While not wishing to be bound by theory, it is believed that the organic peroxide may act as chain transfer agent to influence the molecular viscosity and/or melt flow rate of the polymer blend composition. In addition, the molecular weight distribution of the polymer blend composition is narrowed when an organic peroxide is added to the composition, as compared to other conventional chain transfer agents such as hydrogen.

The polymer blend composition may also include additives such as, but not limited to, neutralising agents, anti-oxidants, slipping agent, or any combination thereof.

In certain embodiments, the neutralising agent may be any metal stearate such as zinc stearate, sodium stearate, calcium stearate, magnesium stearate or any combination thereof. For example, the neutralising agent may be calcium stearate. In other embodiments, the neutralising agent may include a carbonate mineral such as hydrotalcite (e.g. magnesium aluminium hydroxy carbonate). When present in the composition, the neutralising agent may be present in an amount of from 0.001 to 1 parts by weight per 100 parts by weight of the polymeric component (e.g. from 0.01 to 0.10 parts by weight, such as 0.05 parts by weight per 100 parts by weight of the polymeric component).

Anti-oxidants that may be mentioned herein include any suitable phenolic compound and phosphite and/or phosphate. For example, the anti-oxidant may include Pentaerythritol Tetrakis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate), even more particularly Irganox™ 1010, tris-(2,4-di-tert-butyl phenyl) phosphate, bis(2,4-di-t-butyl phenyl) pentaerythritol diphosphite, even more particularly Irgafos™ 168. When present in the composition, the anti-oxidant may be present in an amount of from 0.001 to 1 parts by weight per 100 parts by weight of the polymeric component (e.g. from 0.05 to 0.20, such as from 0.10 to 0.15 parts by weight per 100 parts by weight of the polymeric component).

Slipping agents that may be mentioned herein include, but are not limited. Examples of the slipping agent are higher fatty acids such as behenic acid (a melting peak temperature: 80° C.); metal salts such as aluminum, calcium, magnesium, etc. of fatty acids, for example, magnesium palmitate (a melting peak temperature: 129° C.), calcium stearate (a melting peak temperature: 145° C.), zinc stearate (a melting peak temperature: 140° C.); amides of fatty acids having 16 to 22 carbon atoms such as erucyl amide (a melting peak temperature: 84° C.), stearyl amide (a melting peak temperature: 103° C.), behenyl amide (a melting peak temperature: 110° C.); esters of stearic acid with an saturated alcohols, etc. When present in the composition, the slip agent may be present in an amount of from 0.001 to 1 parts by weight per 100 parts by weight of the polymeric component (e.g. from 0.05 to 0.20, such as from 0.10 to 0.15 parts by weight per 100 parts by weight of the polymeric component).

As noted hereinbefore, the blends of the currently claimed invention may provide a film that has a particularly good hot tack window. When used herein, the term "hot tack" is generically the capability of a heat-seal joint to hang together when it is stressed, while still hot from the sealing operation. A more technical definition that may be used herein states that hot tack is the sum of the cohesive strength of a sealant material as well as its adhesive strength to the remaining elements of the multilayer structure while in the heat-seal temperature range. When used herein "hot tack window" is defined with reference to the experimental section hereinbelow. In embodiments of the invention, when the blend is laminated onto one side of a polymeric film substrate material at a thickness of 20 µm, the laminated film has a hot tack temperature window having a minimal value and a maximal value, wherein the difference between the minimal and maximal value may be from 20°C to 100°C, optionally wherein the polymeric film substrate material is a BOPP film (e.g. the polymeric film substrate material is a BOPP film having a thickness of 20 µm). For example, in particular embodiments that may be mentioned herein, the difference between the minimal

and maximal value of the hot tack temperature window of the laminated film may be from 35°C to 70°C, such as from 40°C to 50°C (e.g. a range of from 42°C to 46°C).

In certain embodiments, the hot tack window may be defined by a minimal value of from about 110°C to about 120°C and a maximal value of from about 145°C to about 170°C. Suitable hot tack windows that may be mentioned herein include those with a minimal value of the film of from about 113°C to about 115°C and a maximal temperature of from about 148°C to about 160°C (e.g. a minimal value of from about 113°C to about 114°C and a maximal value of from about 149°C to about 157°C).

Without wishing to be bound by theory, it is believed that the blends of the currently claimed invention provide a widened hot tack window when laminated onto a substrate film material and thus enables the improved running of form-fill-seal machines. This may also result in the reduction of the unit price and reduce delays caused by the use of materials that have narrower hot tack windows, which may be less suitable for a form-fill-seal machine even in peak operating condition, but which may struggle even more significantly if the heating portion of the machine is unable to maintain a stable temperature. In addition, it is believed that the polymer blends disclosed herein have a higher unpeeling distance, meaning that it is able to contain more of a good within it without breakage (e.g. the polymer blends herein are able to hold more weight for an equivalent amount of material in comparison to conventional materials).

The random polypropylene copolymers, terpolymers and homopolypropylene that are present in the polymeric component (including those presented in Table 1 below) may be produced using a conventional polymerization technique and a conventional catalyst.

Examples of the conventional catalyst include:

(1) a catalyst comprising a solid catalyst component obtained by reacting a magnesium compound with a titanium compound, and an organoaluminium compound;

(2) a catalyst comprising a solid catalyst component obtained by reacting a magnesium compound with a titanium compound, an organoaluminium compound, and, optionally, a third component such as an electron donating compound; and

(3) a metallocene based catalyst.

In certain embodiments, catalysts of type (2) are used. Catalysts of type (2) may comprise a solid catalyst component comprising magnesium, titanium, and halogen (e.g. TiCl_4 , MgCl_2)

as essential components (i.e. a heterogeneous Ziegler–Natta catalyst suitable for use in the polymerisation of propylene), an organoaluminium compound (e.g. $\text{Al}(\text{C}_2\text{H}_5)_3$), and an electron donating compound may optionally be used. Examples of this type of catalyst include the catalysts disclosed in JP 61-218606 A, JP 61-287904 A, or JP 7-216017 A.

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Examples of conventional polymerization include:

(a) slurry polymerization and solvent polymerization, each using an inactive hydrocarbon solvent;

(b) liquid phase polymerization using a monomer as a solvent without using any
10 inactive hydrocarbon solvent,

(c) gas phase polymerization; and

(d) liquid phase-gas phase polymerization, in which liquid phase polymerization and gas phase polymerization are conducted continuously.

15 In the production of the random polypropylene copolymer or terpolymer and homopolypropylene, the random polypropylene copolymer or terpolymer or homopolypropylene formed as a result of polymerization may be heated under reduced pressure at a temperature lower than the temperature at which the polypropylene melts in order to remove the remaining solvent and oligomers generated as by-products of the
20 polymerisation process. Examples of the method of heating under reduced pressure include the methods of drying under reduced pressure disclosed in JP 55-75410 A and JP 2-80433 A.

Random polypropylenecopolymers or terpolymers may be combined with any suitable low
25 density polyethylene and, optionally, with any suitable homopolypropylene to form the polymeric component as described herein. In certain embodiments that presence of a suitable homopolypropylene may be required in order to provide the most desired properties. The polymeric component may then be used to produce the polymer blend compositions, as described herein. The polymer blend compositions may be provided as, but not limited to,
30 pellets, granules or sheets.

The formation of polymer blend compositions can be performed using any suitable technique including, but not limited to, blending the desired components (e.g. polymeric component, organic peroxide and/or additives) in the desired proportions using conventional blending
35 techniques and apparatus, including high speed mixers from Mitsui Mike Machinery Co, Banbury mixer (available from Farrel Corp., Ansonia, Conn.) or laboratory extruders. The

mixing apparatus used may include any suitable tank capacity and/or processing capacity, for example, the mixing apparatus may include a tank capacity of 75 litres and a process capacity of 50 litres.

- 5 The polymer blend compositions may be prepared using other types of mixing equipment capable of premixing and directly feeding materials into downstream processing apparatus. Such downstream processing apparatus may include, but is not limited to, an extruder or any suitable polymer manufacturing equipment to produce polymer blend compositions as pellet samples.

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When producing the polymer blend compositions, the desired components may be premixed using a high speed mixer to provide "premixed material". The premixing may be performed for from 10 seconds to 3600 seconds or more specifically, from 20 seconds 1800 seconds, such as 30 seconds.

15

The premixing of desired components may be performed at a speed of from 500 to 3000 rpm, such as from 750 to 2500 rpm or more particularly from 820 rpm to 1640 rpm.

20

The premixed material may be converted into polymer blend composition pellets using other kinds of equipment capable of melting, mixing and extruding the polymer blend compositions. Extruded polymer blend compositions may then be converted into polymer blend composition pellet and/or granule samples using any suitable equipment, for example an underwater pellet cutter or pellet maker. Commercial scale pelletizing extruders may also be used for preparing larger quantities of the blend.

25

The polymer blend compositions disclosed herein may be used to prepare various kinds of lamination film suitable for different packaging application. For example, the polymer blend compositions may be used to prepare lamination film packaging for consumer goods.

30

The lamination film may be prepared from the polymer blend compositions by any suitable extrusion processing. The lamination process may include, but is not limited to, a step of feeding the desired polymer blend composition into any suitable extrusion machine. The polymer blend composition may be in the form of a polymer blend composition pellet and/or granule samples.

35

The lamination process may also include a step of heating the polymer blend composition in a heating barrel/chamber to produce a polypropylene polymer melt. The step of heating the polymer blend composition to produce a polypropylene polymer melt may be performed at a temperature of from 200°C to 330°C, more particularly, from 250 to 300°C such as from 280 to 300°C.

The polypropylene laminated film of the present invention can be obtained by laminating the aforesaid molten polymer blend on one side or on the both sides (one side and the opposite side) of crystalline polypropylene base film by conventional methods. Thus, the laminated film of the present invention can be obtained, for example, by (i) adhering a crystalline propylene film and a previously formed sheet of the heat sealing resin with an adhesive by passing them between pressure rollers, (ii) coating the heat sealing resin in the form of solution or dispersion in a solvent, such as toluene, etc., on a crystalline propylene base film to effect lamination, (iii) melt-extrusion coating the heat sealing resin on a crystalline propylene base film to effect lamination, or (iv) extruding the heat sealing resin and the crystalline propylene base polymer through separate extruders and then bonding them in or at the outlet of a common die while the two are still in a molten state.

Based upon the above, there is provided a second aspect of the invention, which is a film suitable for manufacturing a packaging article using a form-fill-seal machine comprising:

a substrate material having a first side and a second side; and
an extrusion coating composition blend according to the first aspect of the invention and any technically sensible combination of its embodiments, wherein
the extrusion coating composition blend is coated on one or both of the first and second sides of the substrate material.

Suitable substrate materials that may be used, include, but are not limited to BOPP, OPET or paper. The coating on each side of the substrate may be less than 60 µm (e.g. from 5 to 25 µm, such as 20 µm) and/or the substrate has a thickness of from 10 to 60 µm, such as from 15 to 30 µm, such as 20 µm. The resulting films may benefit from the hot tack windows discussed in detail above. For example, the films may have a hot tack window that may be defined by a minimal value of from about 110°C to about 120°C and a maximal value of from about 145°C to about 170°C. Suitable hot tack windows that may be mentioned herein include those with a minimal value of the film of from about 113°C to about 115°C and a maximal temperature of from about 148°C to about 160°C (e.g. a minimal value of from about 113°C to about 114°C and a maximal value of from about 149°C to about 157°C). it

will be appreciated that this is merely an example and that the discussion of the hot tack window hereinbefore applies here too.

Finally in a third aspect of the invention, there is provided a process of manufacturing a packaging article comprising the steps of:

(a) providing a film comprising:

a substrate material having a first side and a second side; and

an extrusion coating composition blend as described hereinbefore,

where the extrusion coating composition blend is coated on one or both of the first and second sides of the substrate material;

(b) subjecting the film to a form-fill-seal process to provide a packaging article.

EXAMPLES

Materials used

Unless otherwise stated, materials were obtained from commercial sources and used without further purification.

Corona-treated biaxially-oriented polypropylene (BOPP) was obtained from Tobe Packaging Industries PTE. LTD., Singapore.

2,5-Bis(*tert*-butylperoxy)-2,5-dimethylhexane (an organic peroxide) was obtained as Luperox™ 101 PP20 from Arkema or as Trigonox 101-20PP from Akzo Nobel. Both materials listed provide the organic peroxide mixed with a carrier material (polypropylene) and in a concentration of from 10 wt% to 30 wt%. Unless otherwise stated herein, the peroxide is provided at a concentration of 20 wt%.

Calcium stearate, obtained from FACI, was used as a neutralising agent. Alternatively, DHT-4C (Hydrotalcite; Magnesium Aluminium Hydroxy Carbonate) from Kyowa Chemical Industry Co Ltd was used as the neutralising agent instead.

Pentaerythritol Tetrakis(3-(3,5-di-*tert*-butyl-4-hydroxyphenyl)propionate) and Tris-(2,4-di-*tert*-butyl phenyl) phosphate (an anti-oxidant) were obtained from BASF as Irganox™ 1010, and Irgafos™ 168, respectively.

Erucamide fatty acid derivatives Neutron – S from Nippon Seika Co. was used as slipping agent.

Preparation 1

5 Polypropylene homopolymer, Random polypropylene copolymer, terpolymers

The homopolymers and random terpolymers described herein are prepared using a Ziegler–Natta catalyst, using $\text{Al}(\text{C}_2\text{H}_5)_3$ as a co-catalyst using the liquid phase-gas phase polymerisation technique. Examples of suitable catalysts are disclosed in JP 61-218606 A,
10 JP 61-287904 A, or JP 7-216017 A.

The polypropylenes were formed as a result of polymerization are heated under reduced pressure at a temperature lower than the temperature at which the polypropylene melts in order to remove the remaining solvent and oligomers generated as by-products of the
15 polymerisation process. Examples of the method used to make the current polypropylenes are disclosed in JP 55-75410 A and JP 2-80433 A. The polypropylenes prepared are listed in Table 1.

Polypropylene (PP) No.	Polymer Type	Comonomer (content wt%)	Tm (°C)	Melt Flow Rate (MFR)	CXS (%wt)
PP1	Homopolymer	ethylene (0%)	167	7	0.8%
PP2	Random Terpolymer	ethylene (2.2%) 1-butene (9.2%)	128	7	7.0%
PP3	Random Terpolymer	ethylene (2.6%) 1-butene (7.0%)	131	5.5	5.5%
PP4	Random Copolymer	ethylene (4.0%)	136	7	5.5%

20

Table 1

Low Density Polyethylene

The low density polyethylene herein is prepared using a high pressure tubular process technique.

Polyethylene (PE) No.	Polymer Type	T _m (°C)	Melt Flow Rate (MFR)	Density (g/cm ³)
PE1	Homopolymer	106	21	0.917
PE2	Homopolymer	106	35	0.917
PE3	Homopolymer	106	3.5	0.917

Table 2

Preparation 2

- 5 The compositions were prepared using the amounts provided in Table 3.

Example	Composition
1	(PP1 (5 wt% of polymer component), and PP2 (85 wt% of polymer component), and low density polyethylene PE1 (10 wt% of polymer component) (100 parts by weight (pbw)) Trigonox 101-20PP (0.12 pbw per 100 pbw of polymer component; i.e. 0.024 pbw of peroxide per 100 pbw of polymer component) Calcium Stearate (0.025 pbw per 100 pbw of polymer component) Irganox 1010 (0.05 pbw per 100 pbw of polymer component) Irgafos 168 (0.10 pbw per 100 pbw of polymer component) Neutron – S (0.09 pbw per 100 pbw of polymer component)
2	(PP1 (10 wt% of polymer component), and PP2 (80 wt% of polymer component), and low density polyethylene PE1 (10 wt% of polymer component) (100 parts by weight (pbw)) Trigonox 101-20PP (0.12 pbw per 100 pbw of polymer component; i.e. 0.024 pbw of peroxide per 100 pbw of polymer component) Calcium Stearate (0.025 pbw per 100 pbw of polymer component) Irganox 1010 (0.05 pbw per 100 pbw of polymer component) Irgafos 168 (0.10 pbw per 100 pbw of polymer component) Neutron – S (0.09 pbw per 100 pbw of polymer component)

Example	Composition
3	(PP1 (7 wt% of polymer component), and PP3 (83 wt% of polymer component), and low density polyethylene PE1 (10 wt% of polymer component) (100 parts by weight (pbw)) Trigonox 101-20PP (0.15 pbw per 100 pbw of polymer component; i.e. 0.030 pbw of peroxide per 100 pbw of polymer component) Calcium Stearate (0.025 pbw per 100 pbw of polymer component) Irganox 1010 (0.05 pbw per 100 pbw of polymer component) Irgafos 168 (0.10 pbw per 100 pbw of polymer component) Neutron – S (0.09 pbw per 100 pbw of polymer component)
4	(PP1 (7 wt% of polymer component), and PP3 (83 wt% of polymer component), and low density polyethylene PE2 (10 wt% of polymer component) (100 parts by weight (pbw)) Trigonox 101-20PP (0.15 pbw per 100 pbw of polymer component; i.e. 0.030 pbw of peroxide per 100 pbw of polymer component) Calcium Stearate (0.025 pbw per 100 pbw of polymer component) Irganox 1010 (0.05 pbw per 100 pbw of polymer component) Irgafos 168 (0.10 pbw per 100 pbw of polymer component) Neutron – S (0.09 pbw per 100 pbw of polymer component)
5	(PP1 (6 wt% of polymer component), and PP3 (82 wt% of polymer component), and low density polyethylene PE2 (12 wt% of polymer component) (100 parts by weight (pbw)) Trigonox 101-20PP (0.15 pbw per 100 pbw of polymer component; i.e. 0.030 pbw of peroxide per 100 pbw of polymer component) Calcium Stearate (0.025 pbw per 100 pbw of polymer component) Irganox 1010 (0.05 pbw per 100 pbw of polymer component) Irgafos 168 (0.10 pbw per 100 pbw of polymer component) Neutron – S (0.09 pbw per 100 pbw of polymer component)

Example	Composition
6	(PP2 (90 wt% of polymer component), and PE1 (10 wt% of polymer component) (100 parts by weight (pbw)) Trigonox 101-20PP (0.12 pbw per 100 pbw of polymer component; i.e. 0.024 pbw of peroxide per 100 pbw of polymer component) Calcium Stearate (0.025 pbw per 100 pbw of polymer component) Irganox 1010 (0.05 pbw per 100 pbw of polymer component) Irgafos 168 (0.10 pbw per 100 pbw of polymer component) Neutron – S (0.09 pbw per 100 pbw of polymer component)
Comparative Example 1	(PP4 (90 wt% of polymer component), and low density polyethylene PE1(10 wt% of polymer component) (100 parts by weight (pbw)) Trigonox 101-20PP (0.12 pbw per 100 pbw of polymer component; i.e. 0.024 pbw of peroxide per 100 pbw of polymer component) Calcium Stearate (0.025 pbw per 100 pbw of polymer component) Irganox 1010 (0.05 pbw per 100 pbw of polymer component) Irgafos 168 (0.10 pbw per 100 pbw of polymer component) Neutron – S (0.09 pbw per 100 pbw of polymer component)
Comparative Example 2	(PP4 (90 wt% of polymer component), and PE3 (10 wt% of polymer component) (100 parts by weight (pbw)) Trigonox 101-20PP (0.13 pbw per 100 pbw of polymer component; i.e. 0.024 pbw of peroxide per 100 pbw of polymer component) Calcium Stearate (0.025 pbw per 100 pbw of polymer component) Irganox 1010 (0.05 pbw per 100 pbw of polymer component) Irgafos 168 (0.10 pbw per 100 pbw of polymer component) Neutron – S (0.09 pbw per 100 pbw of polymer component)

Table 3

a) Pellet manufacture

5

All of the ingredients listed in Table 2 were dry-premixed using a high speed mixer for about 30 seconds at a speed of from 820 to 1640 rpm. The high speed mixer is manufactured by Mitsui Mike Machinery Co., having a tank capacity of 75 L and a process capacity of 50 L.

The premixed material was then fed into an extruder to produce pellet samples. A single screw extruder was used (manufactured by Tanabe Plastic Machinery Co.), having the following parameters:

- (a) a screw diameter of 65mm;
- 5 (b) L/D of 32;
- (c) Die hole size of 4mm; and
- (d) extruder temperature of between 200 -240°C (inclusive).

Following extrusion the polymer blend were cut into pellets.

10

b) Lamination film processing

The pellets produced in step (a) were converted into a lamination film for property measurement by an extrusion coating process on one side of a 20 micrometer thick BOPP film substrate, wherein the pellets were provided to an co-extrusion lamination processing machine (Model V65 / V50 /V50-F850 TYPE Tanabe Plastics Machinery Co, Ltd., having a screw diameter of 65 mm, 50 mm, and 50 mm) and were formed into a laminated film having 20 micrometer coating thickness BY using a barrel temperature of between 200 to 300°C (inclusive). The resulting films were conditioned for at least 12 hours at 23°C and 50% RH before analysis.

20

Analysis

Melt Flow Rate

Determined according to ASTM D1238 – Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.

25

Machine: Toyoseiki Melt Indexer F-B01

Temperature: 230°C for polypropylene, or 190°C for low density polyethylene

Load: 2.16 kg

30 Conditioning Time: 6 minutes

Orifice Dimension: 2.095 mm inner diameter, 8.0 mm length

Density Testing for Low Density Polyethylene

Samples for density testing were prepared by compression moulding. Before subjecting the specimens to compression, the specimen was pre-heated to 150°C and was then subjected to bumping to remove any gas bubbles. Each specimen had the dimensions of 30 mm x 25

35

mm x 1mm and was subjected to a moulding temperature of 150°C at a moulding pressure of 50 kg/cm³ for 5 minutes using Tester Sangyo Co. Ltd, Model: SA-303. The specimen was then subjected to a cooling temperature of 23°C and a cooling pressure of 20 kg/cm³ for 3 minutes using Tester Sangyo Co. Ltd, Model: SA-302. Subsequently, the specimen was
5 annealed at 100°C for 1 hour in distilled water, after which the specimen was conditioned in a standard laboratory atmosphere (23°C, 50% relative humidity) for 16 hours.

The density of the specimens produced by the procedure above were then tested using ASTM D792 – standard test methods for density and specific gravity (relative density) of
10 plastics by displacement, using Test Method A – for testing solid plastics in water.

The tests were conducted using equipment from Ohaus Corporation, Model: DV215D (Balance) & 77402-00 (Density Kit).

15 Melting Temperature (T_m)

Polymer sample was first compressed into sheet of 0.3 mm or 0.5 mm thickness by using a compressing moulding machine.

Moulding temperature: 230°C

20 Preheating Period: 180 seconds

Pressure – kg/cm²/ Moulding time –minutes: I-50/60, II- 50/30, III-50/30

Cooling Temperature: 180 seconds

Cooling pressure: 20 kg/cm²

25 The moulded sheet or film sample was punched into small circular pieces and a sample of 10.000±0.1 mg was obtained on an accurate mass balance.

The melting temperature was measured using a Differential Scanning Calorimeter, where the weighed sample of circular pieces were cut into smaller pieces that better fit into the
30 aluminium sample pan of the equipment.

The sample was annealed by rapidly heating it up to 220°C, which temperature was then held for 5 minutes and then the sample was cooled down to 65°C. The sample was then heated from 65°C to 220°C at 5°C/min. The endothermic peak temperature recorded at this
35 step is the Melting Temperature, as reported herein.

Instrument: Perkin Elmer Diamond DSC

Ethylene content analysis

The polymer samples were compressed into sheet of 0.3 mm thickness using a compressing
5 moulding machine using the parameters below.

Moulding temperature: 230°C

Preheating Period: 180 seconds

Pressure – kg/cm²/ Moulding time –minutes: I-50/60, II- 50/30, III-50/30

10 Cooling Temperature: 180 seconds

Cooling pressure: 20 kg/cm²

Ethylene content (wt%) for the compressed sheet was measured using an IR spectrum
measurement method described in the Polymer Analysis Hand Book (issued by Asakura
15 Publishing Co. Ltd., 1985) on page 256.

1-Butene content analysis

The polymer samples were compressed into sheet of 0.3 mm thickness using a compressing
moulding machine using the parameters below.

20

Moulding temperature: 230°C

Preheating Period: 180 seconds

Pressure – kg/cm²/ Moulding time –minutes: I-50/60, II- 50/30, III-50/30

Cooling Temperature: 180 seconds

25 Cooling pressure: 20 kg/cm²

1-butene content was measured using the IR spectrum measurement method described in
Polymer Analysis Handbook (published by Kinokuniya Co., Ltd., 1995) on page 619.

30 The content of components soluble in 20°C xylene (CXS, unit: % by weight)

A sample of 1 g was dissolved completely in 100 mL of boiling xylene, and then cooled to
20°C and left at rest for 4 hours. Subsequently, the resultant mixture was separated into
precipitates and a solution by filtration, and the filtrate was dried at 70°C under reduced
pressure, affording a residue. The residue was weighed and the content of components
35 soluble in 20°C xylene (henceforth called CXS) was calculated.

Low temperature heat sealability (seal initiation temperature (SIT)) (° C)

Two sheets of film were placed one upon the other so that the random terpolymer-carrying surfaces face each other, and heat-sealed by pressing them with a heat sealer (Model SA 5 HS-1, mfd. by SAGA Instruments Pte Ltd) heated to a predetermined temperature under a load of 2 kg/cm² G for 2 seconds. After standing overnight, the sealed sheets were peeled at 23° C. at a peeling rate of 200 mm/min. and a peeling angle of 180°. The temperature of the sealer at which the peeling resistance force reached 300 g/25 mm was taken as the seal initiation temperature (SIT).

10 Hot tack property

The laminated films were cut into 250 x 15mm (L x W) film strips while length direction is along machine direction. The film strip was folded along transverse direction at the centre portion in a way that the random copolymer or terpolymer-carrying surfaces face each other while the end of the bottom layer was fixed to a 100g load and the other end of the film strip on top layer was hold by fingers. The thus overlapped films trips were heat sealed in a heat sealer (mfd. by RIKEN SEIKI SEISAKU - SHU, LTD.) and heated to a predetermined temperature under a pressure of 2 kg/cm² G for 2 seconds. Then, a peeling force was immediately applied to the heat sealed part by holding the end of the top layer of the folded film strip before raising a heat seal bar. A length of a peeled part was measured. Hot tack property was determined based on the unpeeled distance of the seam of the overlapped film strip. A plot regarding heat sealing temperature versus unpeeled distance was obtained for indicating hot tack property. The more the unpeeled distance, the better the hot tack property.

25 Bonding strength:

The laminated films were cut into 100 x 15mm (L x W) film strips while length direction is along machine direction. Then the coating layer will be peeled off from BOPP substrate by Instron (Model: 5567) at crosshead speed 200mm/min in a standard laboratory atmosphere (23°C, 50% relative humidity). The maximum force obtained is the bonding strength value.

30 Neck-in:

It is the difference between die width and coating width on BOPP substrate.

Results

Example 1: 85% by weight of PP2, together with 5% by weight of PP1, was melt blended with 10% by weight of PE1 in the presence of peroxide. The blend had a melt flow rate of 19g/10min at 230°C and a Tm of 130°C. The composition thus-obtained was extruded and coated onto a 20 micrometer BOPP film substrate. The laminated film showed a SIT of 108°C, and a hot tack window of from 113°C to 149°C, where the corresponding unpeeled distance is at least 3mm.

Example 2: 80% by weight of PP2, together with 10% by weight of PP1 was melt blended with 10% by weight of PE1 in the presence of peroxide. The blend had a melt flow rate of 19g/10min at 230°C and a Tm of 131°C. The composition thus-obtained was extruded and coated onto a 20 micrometer BOPP film substrate. The laminated film showed a SIT of 109°C, and a hot tack window of from 113°C to 157°C, where the corresponding unpeeled distance is at least 3mm.

Example 3: 83% by weight of PP3, together with 7% by weight of PP1, was melt blended with 10% by weight of PE1 in the presence of peroxide. The blend had a melt flow rate of 18g/10min at 230°C and a Tm of 133°C. The composition thus-obtained was extruded and coated onto a 20 micrometer BOPP film substrate. The laminated film showed a SIT of 111°C, and a hot tack window of from 114°C to 157°C, where the corresponding unpeeled distance is at least 3mm.

Examples 4: 83% by weight of PP3, together with 7% by weight of PP1, was used to melt blend with 10% by weight of PE2 in the presence of peroxide. The blend had a melt flow rate of 19g/10min at 230°C and a Tm of 133°C. The composition thus-obtained was used to extrude and coat on 20 micrometer BOPP film substrate. The laminated film showed a SIT of 110°C, and a hot tack window from 113°C to 156°C where the corresponding unpeeled distance is at least 3mm.

Example 5: 82% by weight of PP3, together with 6% by weight of PP1, was used to melt blend with 12% by weight of PE2 in the presence of peroxide. The blend had a melt flow rate of 19g/10min at 230°C and a Tm of 133°C. The composition thus-obtained was used to extrude and coat on 20 micrometer BOPP film substrate. The laminated film showed a SIT of 110°C, and a hot tack window from 113°C to 156°C where the corresponding unpeeled distance is at least 3mm.

Example 6: 90% by weight of PP2 was used to melt blend with 10% by weight of PE1 in the presence of peroxide. The blend had a melt flow rate of 19g/10min at 230°C and a T_m of 128°C. The composition thus-obtained was used to extrude and coat on 20 micrometer BOPP film substrate. The laminated film showed a SIT of 107°C, and a hot tack window from 113°C to 147°C where the corresponding unpeeled distance is at least 3mm.

Comparative example 1: 90% by PP4 was melt blended with 10% by weight of PE1 in the presence of peroxide. The blend had a melt flow rate of 19g/10min at 230°C and a T_m of 136°C. The composition thus-obtained was used to extrude and coat on 20 micrometer OPP film substrate. The laminated film showed a SIT of 122°C, and a hot tack window of from 134°C to 147°C where the corresponding unpeeled distance is at least 3mm.

Comparative example 2: 90% by PP4 was used to melt blend with 10% by weight of PE3 in the presence of peroxide. The blend had a melt flow rate of 19g/10min at 230°C and a T_m of 136°C. The composition thus-obtained was used to extrude and coat on 20 micrometer OPP film substrate. The laminated film showed a SIT of 122°C, and a hot tack window from 134°C to 147°C where the corresponding unpeeled distance is at least 3mm.

The results of SIT and bonding strength obtained from the laminated films above are provided in Table 4 while the hot tack property is plotted in Figure 1.

		Ex 1	Ex 2	Ex 3	Ex 4	Ex 5	Ex6	Comp. Ex 1	Comp. Ex 2
T _m	°C	130	131	133	133	133	128	136	136
Thickness	μm	40	40	40	40	40	40	40	40
HST	°C	108	109	111	110	110	107	122	122
Bonding strength	g/15mm	132	143	116	152	157	129	143	100
Neck-in	mm	166	155	166	135	130	157	152	170

Table 4

As shown in the table and figure, the properties of the prepared films of the current invention have superior hot tack windows with good balance of sealing property (lower SIT), physical property (higher bonding strength) and processibility (lower Neck-in) than those of the

comparative examples, making the resulting composite material easier to use in a form-fill-seal machine, while also increasing the efficiency and reducing the cost per unit.

CLAIMS

1. An extrusion coating composition blend, comprising:
 - (a) from 3 wt% to 15 wt% of at least one homopolypropylene resin that has a melt flow rate of from 2 to 100 g/10min at 230°C;
 - (b) from 70 wt% to 92 wt% of a propylene random copolymer or terpolymer having a melt flow rate of from 2 to 30g/10min at 230° C; and
 - (c) from 5 wt% to 15 wt% of a low density polyethylene having a density of 0.910 to 0.940 g/cm³ and a melt flow rate of from 4 to 70 g/10min at 190° C, wherein the blend has a melt flow rate of from 7 to 50 g/10min at 230°C, and a T_m of from 120°C to 165°C.
2. The blend of Claim 1, wherein:
 - (a) the at least one homopolypropylene resin has a melt flow rate of from 3 to 50 g/10min at 230°C; and/or
 - (b) the propylene random copolymer or terpolymer has a melt flow rate of from 3 to 15g/10min at 230°C.
3. The blend of Claim 1, wherein:
 - (a) the at least one homopolypropylene resin has a melt flow rate of from 4 to 20 g/10min at 230°C (e.g. from 5 to 10 g/10min at 230°C, such as 7 g/10min at 230°C); and/or
 - (b) the propylene random copolymer or terpolymer has a melt flow rate of from 4 to 10 g/10min at 230°C (e.g. from 5.5 to 7 g/10min at 230°C).
4. The blend of any one of the preceding claims, wherein the blend has a melt flow rate of from 8 to 49 g/10min at 230°C, and a T_m of from 123°C to 145°C.
5. The blend of Claim 4, wherein the blend has a melt flow rate of from 15 to 30 g/10min at 230°C, and a T_m of from 125°C to 135°C (e.g. the blend has a melt flow rate of from 18 to 25 g/10min at 230°C, and a T_m of from 128°C to 133°C).
6. The blend of any one of the preceding claims, wherein the low density polyethylene has a melt flow rate of from 10 to 50 g/10min at 190°C (e.g. from 15 to 40 g/10min at 190°C, such as from 21 to 35 g/10min at 190°C).

7. The blend of any one of the preceding claims, wherein the at least one homopolypropylene has a melting temperature (T_m) in the range of from 150°C to 170°C (e.g. from 160°C to 169°C, such as 167°C).
8. The blend of any one of the preceding claims, wherein the at least one homopolypropylene further comprises ethylene and/or a C_4 - C_{10} α -olefin in a total amount of less than 1 wt% relative to the total weight of the homopolypropylene resin used.
9. The blend of any one of the preceding claims, wherein the propylene random copolymer or terpolymer has a T_m of from 120°C to 135°C (e.g. from 125°C to 135°C, such as from 130°C to 135°C).
10. The blend of any one of the preceding claims, wherein in the propylene random copolymer or terpolymer the non-propylene monomers are selected from the group consisting of ethylene and a C_4 - C_{10} α -olefin.
11. The blend of Claim 10, wherein the propylene random copolymer or terpolymer is a terpolymer.
12. The blend of Claim 11, wherein the propylene random copolymer or terpolymer is a propylene-ethylene-but-1-ene terpolymer.
13. The blend of Claim 12, wherein the propylene-ethylene-but-1-ene terpolymer has an ethylene content of from 1.0 wt% to 5.0 wt% and a but-1-ene content of from 3.0 wt% to 15 wt%.
14. The blend of Claim 13, wherein the propylene-ethylene-but-1-ene terpolymer has an ethylene content of about 2.6 wt% and a but-1-ene content of about 7.0 wt%.
15. The blend of any one of the preceding claims, wherein the low density polyethylene has a density of from 0.916 to 0.920 g/cm³ (e.g. a density of 0.917 g/cm³).
16. The blend of any one of the preceding claims, wherein
 - (a) the at least one homopolypropylene resin is present in an amount of from 3 wt% to 10 wt% (e.g. from 5 wt% to 9 wt%); and/or

(b) the propylene copolymer or terpolymer is present in an amount of from 70 wt% to 90 wt% (e.g. 80 wt% to 84 wt%); and/or

(c) the low density polyethylene is present in an amount of from 10 wt% to 12 wt%.

17. The blend of any one of the preceding claims, wherein the at least one homopolypropylene resin, the propylene random copolymer or terpolymer and the low density polyethylene together form a polymeric component and the blend further comprises an organic peroxide is present in an amount of from 0.010 to 0.50 parts by weight, per 100 parts by weight of the polymeric component (e.g. from 0.020 to 0.040 parts by weight per 100 parts by weight of the polymeric component).

18. The blend of any one of the preceding claims, wherein the organic peroxide is selected from the group consisting of hydroperoxides, dialkyl peroxides, diacyl peroxides, peroxydicarbonates, peroxyesters, ketone peroxides, peroxyketals, and alkyl peroxy carbonates.

19. A film suitable for manufacturing a packaging article using a form-fill-seal machine comprising:

a substrate material having a first side and a second side; and

an extrusion coating composition blend according to any one of Claims 1 to 18,

wherein

the extrusion coating composition blend is coated on one or both of the first and second sides of the substrate material.

20. The film of Claim 19, wherein the substrate material is BOPP, OPET or paper.

21. The film of Claim 19 or Claim 20, wherein the coating on each side of the substrate is less than 60 μm (e.g. from 5 to 25 μm , such as 20 μm).

22. The film of any one of Claims 19 to 21, wherein the substrate has a thickness of from 10 to 60 μm , such as from 15 to 30 μm , such as 20 μm .

23. The film of any one of Claims 19 to 22, wherein the film has a hot tack temperature window having a minimal value and a maximal value, wherein the difference between the minimal and maximal value is from 20°C to 100°C, optionally from 35°C to 70°C, such as from 40°C to 50°C (e.g. a range of from 42°C to 46°C).

24. The film of Claim 23, wherein the hot tack window of the film has a minimal value of from 110°C to 120°C and a maximal value of from 145°C to 170°C, optionally wherein the hot tack window has a minimal value of the film of from 113°C to 115°C and a maximal temperature of from 148°C to 160°C (e.g. a minimal value of from 113°C to 114°C and a maximal value of from 149°C to 157°C).

25. A process of manufacturing a packaging article comprising the steps of:

(a) providing a film comprising:

a substrate material having a first side and a second side; and

an extrusion coating composition blend according to any one of Claims 1 to 18, where the extrusion coating composition blend is coated on one or both of the first and second sides of the substrate material;

(b) subjecting the film to a form-fill-seal process to provide a packaging article.