

SEALS OF POLYETHYLENE TO A SUBSTRATE

Field of the Invention

This invention relates to heat sealable films comprising at least a layer of polyethylene, preferably metallocene polyethylene (mPE) sealed to a substrate, preferably polypropylene.

Background of the Invention

Polyethylene (PE) has traditionally been used as a sealing layer in polyolefin films and packaging because of its ability to seal quickly and maintain a strong seal strength. Typically polyethylene has been coextruded, laminated or otherwise bonded to other polyolefins. However polyethylene does not seal well to polypropylene (PP) and other non polar substrates. In general, special glues or tie layers must be used to seal the PE to the PP or other substrates. This causes difficulties in construction and packaging particularly with packages involving food.

Therefore there is a need in the art to provide a means to effectively seal polyethylene directly to polypropylene and other substrates.

US 806 182 addresses films comprising: (i) a first surface layer comprising a homopolymer of ethylene having an Mw/Mn of 3 or less or a copolymer of ethylene and up to 50 weight% of a C₃ to C₂₀ olefin having a CDBI of 50 % or more, and (ii) a second surface layer comprising a homopolymer of propylene or copolymer of propylene and up to 50 weight % of a comonomer where the ethylene layer is sealed directly to the propylene layer.

WO 95/00333 discloses heat shrinkable films where an outer layer of a multilayer heat shrinkable film is an ethylene or propylene polymer formed by polymerization in the presence of a single site catalyst. EXACTTM resins

are disclosed as suitable as the outer layer, but the films are not disclosed as being bonded to polypropylene.

EP Patent Application 0 597 502 discloses oriented single and multilayer films of metallocene polyethylenes, however polypropylene is not disclosed as suitable substrate to bond the film to.

US patent 5,482,770 discloses irradiated oriented multilayer films having a barrier layer of EVOH and other core or sealayers of metallocene polyethylenes.

Summary of the Invention

This invention relates to a film comprising a first surface layer comprising a homopolymer of ethylene having an Mw/Mn of 3 or less or a copolymer of ethylene and up to 50 weight % of a C₃ to C₂₀ olefin having an Mw/Mn of 6 or less, wherein the copolymer has a CDBI of 50 % or more, preferably 60% or more wherein the first surface layer is sealed to a polypropylene substrate. This invention has the benefit of producing seals with a good peel character, particularly when the polyethylene homopolymer or copolymer is blended with 50 % or less of a second polymer that has low or no seal strength to polypropylene.

Brief Description of the Drawing

Figure 1 is a graph of the heat seal strength of films 2, 3 and 4. Film 4 is the diamond shape (-◆-). Film 2 is the square shape (-■-). Film 3 is the triangle shape (-▲-).

Detailed Description of the Invention.

In a preferred embodiment, this invention relates to a film comprising a first surface layer comprising a homopolymer of ethylene having a Mw/Mn of 3 or less, or a copolymer of ethylene and up to 50 weight %, preferably 1 to 35 weight %, preferably 1-20 weight % of one or more C₃ to C₂₀ olefins, (based upon the weight of the copolymer) having an Mw/Mn of 6 or less, preferably 3 or less, even more preferably between 1 and 2.5, wherein the polymer or copolymer preferably has:

- a) a density of 0.86 g/cm³ to 0.96 g/cm³, preferably 0.88 to 0.94 g/cm³, more preferably between 0.88 g/cm³ and 0.935 g/cm³, more preferably between 0.88 g/cm³ and 0.93 g/cm³, more preferably between 0.910 g/cm³ and 0.925 g/cm³; and
- b) a CDBI of 50 % or more, preferably above 60%,

wherein the first surface layer is sealed to a substrate comprising a homopolymer of propylene or a copolymer of propylene and up to 50 weight %, preferably 1 to 35 weight %, even more preferably 1 to 6 weight % of ethylene and/or a C₄ to C₂₀ olefin. For purposes of this invention the term substrate means the sealing surface of the article the polyethylene homopolymer or copolymer is being sealed.

Composition Distribution Breadth Index (CDBI) is a measure of the composition distribution of monomer within the polymer chains and is measured by the procedure described in PCT publication WO 93/03093, published February 18, 1993 including that fractions having a weight average molecular weight (Mw) below 15,000 are ignored when determining CDBI. A homopolymer is defined to have a CDBI of 100%.

The C₃ to C₂₀ and C₄ to C₂₀ olefin comonomers for the polyethylene or polypropylene copolymers described above may be any polymerizable olefin monomer and are preferably a linear, branched or cyclic olefin, even more preferably an α -olefin. Examples of suitable olefins include propylene, butene,

isobutylene, pentene, isopentene, cyclopentene, hexene, isohexene, cyclohexene, heptene, isoheptene, cycloheptene, octene, isooctene, cyclooctene, nonene, cyclononene, decene, isodecene, dodecene, isodecene, 4-methyl-pentene-1, 3-methyl-pentene-1, 3,5,5-trimethyl hexene-1. Suitable comonomers also include dienes, trienes, and styrenic monomers. Preferred examples include styrene, α -methyl styrene, para-alkyl styrene (such as para-methyl styrene), hexadiene, norbornene, vinyl norbornene, ethylidene norbornene, butadiene, isoprene, heptadiene, octadiene, dicyclopentadiene, and cyclopentadiene.

Preferred comonomers for the copolymer of ethylene are propylene, butene, hexene and/or octene. Preferred comonomers for the copolymer of propylene are ethylene, butene and /or hexene.

The polyethylene or polypropylene copolymers described above may also contain termonomers and tetramonomers which may be one or more of: ethylene, any of the C₃ to C₂₀ olefins described above, any C₄ to C₃₀ linear, cyclic or branched dienes or trienes and any styreneic monomers such as styrene, α -methyl styrene, or para-methyl styrene. Preferred examples include butene, butadiene, pentadiene, cyclopentadiene, hexadiene, cyclohexadiene, heptadiene, octadiene, nonadiene, norbornene, vinyl norbornene, ethylidene norbornene, isoprene and heptadiene.

The polyethylene copolymers described above preferably have a composition distribution breadth index (CDBI) of 50 % or more, preferably above 60%, even more preferably above 70%. In one embodiment the CDBI is above 80%, even more preferably above 90%, even more preferably above 95%. In another particularly preferred embodiment, the polyethylene copolymer has a CDBI between 60 and 85 %, even more preferably between 65 and 85 %.

In a particularly preferred embodiment the ethylene homopolymer or copolymer has a CDBI of 65 to 85 %, a density of 0.89 to 0.96 g/cm³, preferably 0.915 to 0.96 g/cm³ and a Mw/Mn between 1 and 2.5.

In another preferred embodiment the ethylene homopolymer or copolymer has a density of 0.86 to 0.925 g/cm³ and a CDBI of over 80%, preferably between 80 and 99%.

In a preferred embodiment the polyethylene homopolymers and copolymers described above are metallocene polyethylenes (mPE's). The usage of the term polyethylene herein is defined to include metallocene polyethylenes. The mPE homopolymers or copolymers are typically produced using mono- or bis-cyclopentadienyl transition metal catalysts in combination with an activator of alumoxane and/or a non-coordinating anion in solution, slurry, high pressure or gas phase. The catalyst and activator may be supported or unsupported and the cyclopentadienyl rings by may substituted or unsubstituted. Several commercial products produced with such catalyst/activator combinations are commercially available from Exxon Chemical Company in Baytown Texas under the tradenames EXCEED™ and EXACT™. For more information on the methods and catalysts/activators to produce such mPE homopolymers and copolymers see WO 94/26816; WO 94/03506; EPA 277,003; EPA 277,004; US 5,153,157; US 5,198,401; US 5,240,894; US 5,017,714; CA 1,268,753; US 5,324,800; EPA 129,368; US 5,264,405; EPA 520,732; WO 92 00333; US 5,096,867; US 5,507,475; EPA 426 637; EPA 573 403; EPA 520 732; EPA 495 375; EPA 500 944; EPA 570 982; WO91/09882; WO94/03506 and US 5,055,438.

The polypropylene homopolymer or copolymer preferably has an MFR (melt flow rate) of 1 to 20 as measured according to ASTM D 1238 (230 °C, 2.16 kg). In another embodiment the polypropylene homopolymer or copolymer

preferably has a CDBI of 50 % or more, preferably above 60%, even more preferably above 70 %. Polypropylenes having a CDBI above 60% are available from Exxon Chemical Company in Baytown, Texas under the tradename ACHIEVE™.

In alternate embodiments, other polymers can be substituted for the polypropylene substrate. Such polymers include styrenic block copolymers (such as SBS or SIS block copolymers), polycarbonate, PMP Poly-4-methylpentene-1, PVC polyvinylchloride, Polyester, PET polyester, oriented polyester (either mono or biaxially oriented to the same or different extents), PBT Polybutylenetetracarboxylate, PS polystyrene, HIPS high impact polystyrene, EPS Expanded polystyrene, ABS Acrylonitrile butadiene styrene copolymers, and PA polyamides. PVDC and/or acrylate coatings can also be applied to these polymers or the polypropylene substrate and then bonded to the mPE.

In another embodiment the polypropylene homopolymer or copolymer can be blended with another propylene homopolymer or copolymer as described above or may be blended with another homopolymer and/or copolymer, including but not limited to, homopolypropylene, propylene copolymerized with up to 50 weight % of ethylene or a C₄ to C₂₀ α -olefin, polybutene, ethylene vinyl acetate, low density polyethylene (density 0.915 to less than 0.935 g/cm³) linear low density polyethylene, ultra low density polyethylene (density 0.86 to less than 0.90 g/cm³), very low density polyethylene (density 0.90 to less than 0.915 g/cm³), medium density polyethylene (density 0.935 to less than 0.945 g/cm³), high density polyethylene (density 0.945 to 0.98 g/cm³), ethylene vinyl acetate, EMA, copolymers of acrylic acid, polymethylmethacrylate or any other polymers polymerizable by a high-pressure free radical process, polyvinylchloride, polybutene-1, isotactic polybutene, ABS resins, elastomers such as ethylene-propylene rubber (EPR), vulcanized EPR, EPDM, block copolymer elastomers such as SBS,

nylons, polycarbonates, PET resins, crosslinked polyethylene, copolymers of ethylene and vinyl alcohol (EVOH), polymers of aromatic monomers such as polystyrene, poly-1 esters, high molecular weight polyethylene having a density of 0.94 to 0.98 g/cm³, low molecular weight polyethylene having a density of 0.94 to 0.98 g/cm³, graft copolymers generally, polyacrylonitrile homopolymer or copolymers, thermoplastic polyamides, polyacetal, polyvinylidene fluoride and other fluorinated elastomers, polyethylene glycols, polyisobutylene, ethylene homopolymers and copolymers (mPE) as described above, and propylene homopolymers and copolymers produced using catalysts comprising a mono- or bis-cyclopentadienyl transition metal catalysts in combination with an activator of alumoxane and/or a non-coordinating anion in solution, slurry, high pressure or gas phase. The catalyst and activator may be supported or unsupported and the cyclopentadienyl rings by may substituted or unsubstituted.

In a preferred embodiment the polypropylene is present in the blend at from 10 to 99 weight %, based upon the weight of the polymers in the blend, preferably 20 to 95 weight %.

In a preferred embodiment the substrate comprises a random copolymer of propylene and up to 6 weight % ethylene.

In another preferred embodiment the substrate comprises tactic polypropylene, preferably isotactic polypropylene, even more preferably polypropylene having a 90 % or more isotactic pentads as measured by ¹³C NMR. By tactic is meant having tacticity.

In another preferred embodiment the substrate is syndiotactic polypropylene, preferably syndiotactic polypropylene produced using mono- or bis-cyclopentadienyl transition metal catalysts in combination with an activator of

alumoxane and/or a non-coordinating anion in solution, slurry, high pressure or gas phase. The catalyst and activator may be supported or unsupported and the cyclopentadienyl rings may be substituted or unsubstituted. Such syndiotactic polypropylene produced with such catalyst/activator combinations is commercially available from Fina Oil and Chemicals in Belgium under the tradename FinaproTM.

The mPE homopolymers or copolymers described above for use as a surface layer may be used alone, may be blended with other mPE homopolymers or copolymers, or they may be blended with other polyolefin homopolymers and copolymers, including but not limited to, homopolypropylene, propylene copolymerized with up to 50 weight % of ethylene or a C₄ to C₂₀ α -olefin, polybutene, ethylene vinyl acetate, low density polyethylene (density 0.915 to less than 0.935 g/cm³) linear low density polyethylene, ultra low density polyethylene (density 0.86 to less than 0.90 g/cm³), very low density polyethylene (density 0.90 to less than 0.915 g/cm³), medium density polyethylene (density 0.935 to less than 0.945 g/cm³), high density polyethylene (density 0.945 to 0.98 g/cm³), ethylene vinyl acetate, EMA, copolymers of acrylic acid, polymethylmethacrylate or any other polymers polymerizable by a high-pressure free radical process, polyvinylchloride, polybutene-1, isotactic polybutene, ABS resins, elastomers such as ethylene-propylene rubber (EPR), vulcanized EPR, EPDM, block copolymer elastomers such as SBS, nylons, polycarbonates, PET resins, crosslinked polyethylene, copolymers of ethylene and vinyl alcohol (EVOH), polymers of aromatic monomers such as polystyrene, poly-1 esters, high molecular weight polyethylene having a density of 0.94 to 0.98 g/cm³, low molecular weight polyethylene having a density of 0.94 to 0.98 g/cm³, graft copolymers generally, polyacrylonitrile homopolymer or copolymers, thermoplastic polyamides, polyacetal, polyvinylidene fluoride and other fluorinated elastomers, polyethylene glycols and polyisobutylene. In a preferred

embodiment, selected polymers named above can be used to alter the peelability of the seal. For example if LDPE (not produced by metallocenes) is blended with the mPE a lower seal strength is obtained, hence a lower peel strength. Other polymers that can be used include HDPE, EVA's having less than 10 weight % VA, polybutene, elastomers, and the like.

In a preferred embodiment the mPE, is present in the blend at from 10 to 99 weight %, based upon the weight of the polymers in the blend, preferably the mPE is present at 20 to 95 weight %, even more preferably at least 30 to 90 weight %, even more preferably at least 40 to 90 weight %, even more preferably at least 50 to 90 weight %, even more preferably at least 60 to 90 weight %, even more preferably at least 70 to 90 weight %.

The blends described above may be produced by mixing the two or more polymers together, by connecting reactors together in series to make reactor blends or by using more than one catalyst in the same reactor to produce multiple species of polymer. The polymers can be mixed together prior to being put into the extruder or may be mixed in the extruder.

The polyethylene homopolymers or copolymers described above and the blends thereof are typically formed into bilayer or multilayer films. These films may be formed by any of the conventional techniques known in the art including extrusion, co-extrusion, extrusion coating, lamination, blowing and casting. The film may be obtained by the flat film or tubular process which may be followed by orientation in an uniaxial direction or in two mutually perpendicular directions in the plane of the film. For US purposes a copending application to biaxially oriented mPE films in shrink wrap was filed on November 22, 1996 under serial number 08/755,105.

In a preferred embodiment mPE is used as the sealing layer.

This invention also relates to films as described above where one or more of the layers are oriented in the transverse and/or longitudinal directions to the same or different extents. This orientation may occur before or after the individual layers are brought together. For example the polyethylene layer can be extrusion coated or laminated onto an oriented polypropylene layer or the polyethylene and polypropylene can be coextruded together into a film then oriented. Likewise, oriented polypropylene could be laminated to oriented polyethylene or oriented polyethylene could be coated onto polypropylene then optionally the combination could be oriented even further.

A preferred embodiment includes a structure where the ethylene homopolymer or copolymer, preferably mPE, described above is coated, preferably extrusion coated or laminated, onto a film of polypropylene, preferably oriented polypropylene then the mPE side is bonded to a substrate. The oriented polypropylene can be oriented in one direction or in both the longitudinal and transverse directions to the same or different degrees. Typically the films are oriented in the Machine Direction (MD) at a ratio of up to 15, preferably between 5 and 7, and in the Transverse Direction (TD) at a ratio of up to 15 preferably 7 to 9. However in another embodiment the film is oriented to the same extent in both the MD and TD directions.

In another embodiment the polyethylene surface layer is combined with one or more other layers. The other layer(s) may be any layer typically included in multilayer film structures. For example the other layer or layers may be:

1. Polyolefins

Preferred polyolefins include homopolymers or copolymers of C₂ to C₄₀ olefins, preferably C₂ to C₂₀ olefins, preferably a copolymer of an α -olefin and another olefin or α -olefin (ethylene is defined to be an α -olefin for purposes of this

invention). Preferably homopolyethylene, homopolypropylene, propylene copolymerized with ethylene and or butene, ethylene copolymerized with one or more of propylene, butene or hexene, and optional dienes. Preferred examples include thermoplastic polymers such as ultra low density polyethylene, very low density polyethylene, linear low density polyethylene, low density polyethylene, medium density polyethylene, high density polyethylene, polypropylene, isotactic polypropylene, highly isotactic polypropylene, syndiotactic polypropylene, random copolymer of propylene and ethylene and/or butene and/or hexene, elastomers such as ethylene propylene rubber, ethylene propylene diene monomer rubber, neoprene, and blends of thermoplastic polymers and elastomers, such as for example, thermoplastic elastomers and rubber toughened plastics.

2. Polar polymers

Preferred polar polymers include homopolymers and copolymers of esters, amides, acetates, anhydrides, copolymers of a C₂ to C₂₀ olefin, such as ethylene and/or propylene and/or butene with one or more polar monomers such as acetates, anhydrides, esters, alcohol, and or acrylics. Preferred examples include polyesters, polyamides, ethylene vinyl acetate copolymers, and polyvinyl chloride.

3. Cationic polymers

Preferred cationic polymers include polymers or copolymers of geminally disubstituted olefins, alpha-heteroatom olefins and/or styrenic monomers. Preferred geminally disubstituted olefins include isobutylene, isopentene, isoheptene, isohexane, isooctene, isodecene, and isododecene. Preferred alpha-heteroatom olefins include vinyl ether and vinyl carbazole, preferred styrenic monomers include styrene, alkyl styrene, para-alkyl styrene, alpha-methyl styrene, chloro-styrene, and bromo-para-methyl styrene. Preferred examples of cationic polymers include butyl rubber, isobutylene copolymerized with para methyl styrene, polystyrene, and poly- α -methyl styrene.

4. Miscellaneous

Other preferred layers can be paper, wood, cardboard, metal, metal foils (such as aluminum foil and tin foil), metallized surfaces, glass (including silicon oxide (SiO_2) coatings applied by evaporating silicon oxide onto a film surface), fabric, spunbonded fibers, and non-wovens (particularly polypropylene spun bonded fibers or non-wovens), and substrates coated with inks, dyes, pigments, PVDC and the like.

In addition, the multilayer structures can have more than one layer of the polyethylene homopolymer or copolymers, particularly the mPE homopolymers or copolymers. Further any of the above layers may be oriented before or after being combined with the other layers.

A particularly preferred embodiment includes an ABC structure film where the A layer comprises mPE or a blend comprising mPE and the B layer is isotactic polypropylene, highly isotactic polypropylene, one or more barrier layers, EVA, an adhesive layer/glue, or a metal foil, and the C layer is a random copolymer of propylene and up to 20 weight % of ethylene, preferably 3 to 6 weight % ethylene, even more preferably 3.5 to 5.5 weight % ethylene, or a terpolymer of propylene, ethylene and butene wherein the mPE layer is sealed to a polypropylene substrate.

In a preferred embodiment structures described herein are characterized by a heat seal strength of 8 N/15mm or more at a seal bar temperature of 90 to 150 °C. 8N/15mm is the minimum typically required for packaging integrity. In another preferred embodiment, peel strength can be adjusted by either treating the mPE surface, for example with corona treatment, (and the like) or by blending in additional polymers.

The films to be sealed to the substrate may vary in total thickness depending on the intended application, however films of a thickness from 5 to 250 μm are usually suitable. Films intended for packaging are usually from 10 to 150 μm thick. The thickness of the sealing layer is typically 2 to 50 μm . There may be a sealing layer on both the inner and outer surfaces of the film or the sealing layer may be present on only the inner or the outer surface.

In a preferred embodiment the first surface layer is heat sealed to a polypropylene substrate, particularly a substrate of a thick film (whether mono or coextruded), a blow molded article (whether mono or coextruded), an injection molded article (whether mono or coextruded), and thermoformed article (whether mono or coextruded), a sheet (whether mono or coextruded), a rotational molded article (whether mono or coextruded). In a particularly preferred embodiment the mPE layer is sealed to a formed article such as a packaging container (for example a microwave dinner dish, snack containers or a dairy cup). In another preferred embodiment, the mPE is sealed to a formed article for fresh produce packaging. The mPE layer has the benefit of producing breathable lid stock.

Additives such one or more of as tackifiers, antistats, antiblock, antioxidants, pigments, fillers, antifog, processing aids, UV stabilizers, neutralizers, lubricants, surfactants and/or nucleating agents may also be present in one or more than one layer in the films or the substrates. Preferred additives include polybutene, antifog, silicon dioxide, titanium dioxide, calcium carbonate, barium sulfate, polydimethylsiloxane, talc, dyes, wax, metal stearate, calcium stearate, carbon black, lactate, low molecular weight resins and glass beads.

In another embodiment one or both of surface layers may be modified by corona treatment, electron beam irradiation, gamma irradiation, or microwave. In a preferred embodiment one or both of the surface layers is modified by corona treatment.

The films described herein may also comprise from 5 to 60 weight %, based upon the weight of the polymer and the resin, of a hydrocarbon resin. The resin may be combined with the polymer of the seal layer(s) or may be combined with the polymer in the core layer(s). The resin preferably has a softening point above 100 °C, even more preferably from 130 to 180 °C. Preferred hydrocarbon resins include those described in EPA 288 227 and EPA 247 898. These films comprising a hydrocarbon resin may be oriented in uniaxial or biaxial directions to the same or different degrees. A preferred combination includes one surface layer of mPE and one surface or core layer of an isotactic polypropylene blended with hydrocarbon resin having a softening point between 130 and 180 °C, preferably between 140 and 180 °C wherein the mPE layer is sealed to a substrate, preferably polypropylene.

In a preferred embodiment this invention also relates to a method to produce a packaged article comprising:

- 1) selecting a first polymer having a CDBI of 50 % or more comprising homopolyethylene or a copolymer of ethylene and up to 50 weight % of a C₃ to C₂₀ olefin,
- 2) selecting a substrate, preferably a polymer comprising homopolypropylene or a copolymer of propylene and up to 50 weight % of ethylene or a C₄ to C₂₀ olefin,
- 3) sealing the first polymer and the substrate so that the first polymer and the substrate form a package around an article.

Examples**MATERIALS:**

PP4342C2 is a polypropylene homopolymer having an MFR of 2.4 and an isotactic index of 95 as measured by heptane insolubles.

ECD 103 is an ethylene hexene copolymer produced in the gas phase having approximately 7.6 weight % hexene, a melt index of about 1 g/10min, a Mw/Mn of about 2.3, a CDBI of about 67% and a density of about 0.917 g/cm³, sold under the tradename EXCEED™ by Exxon Chemical Company in Baytown, Texas.

EXACT 3132 is an ethylene hexene copolymer produced in a high pressure process having about 15.4 weight % hexene, a melt index of about 1.2 g/ 10 min, a density of about 0.900 g/cm³, a CDBI of about 91%, and an Mw/Mn of about 1.9 produced by and available from Exxon Chemical Company in Baton Rouge, Texas.

DOW NG 5056 E01 and Dow 5056 E are ethylene octene copolymers having about 11.6 weight % octene, an Mw/Mn of about 3.1, a melt index of about 1g/10min, a density of about 0.919 g/cm³, and a CDBI of about 45% produced by and available from Dow Chemical Company in Zurich, Switzerland. E differs from E01 in that slip and antiblock additives are included in E01.

VITRA BOPP is a 25 µm thick trilayer film of an ABA structure where the A layer is a random copolymer of propylene with about 4.5 weight % ethylene (RCP), and the B layer is a homopolymer of isotactic polypropylene, available from VITRA located in Wommelgem, Belgium. One of the A layers was corona treated for a final surface tension of about 38 dynes/cm (38 mN/m).

TESTING METHODS:

Composition Distribution Breadth Index (CDBI) is measured by the procedure described in PCT publication WO 93/03093, published February 18, 1993. Fractions having a molecular weight (Mw) less than 15,000 were ignored.

Melt Index (MI) was measured according to ASTM D 1238. (190 °C, 2.16 kg)

Melt Flow Rate (MFR) was measured according ASTM D 1238 (at 230 °C and 2.16 kg)

Density was measured to three significant figures according to ASTM D 1505.

Mw and Mn were measured by GPC (Gel Permeation Chromatography) on a Waters 150 gel permeation chromatograph equipped with a differential refractive index (DRI) detector and a Chromatix KMX-6 on line light scattering photometer. The system was used at 135 °C with 1,2,4-trichlorobenzene as the mobile phase. Shodex (Showa Denko America, Inc) polystyrene gel columns 802, 803, 804 and 805 were used. This technique is discussed in "Liquid Chromatography of Polymers and Related Materials III", J. Cazes editor, Marcel Dekker. 1981, p. 207, which is incorporated herein by reference. No corrections for column spreading were employed; however, data on generally accepted standards, e.g. National Bureau of Standards Polyethylene 1484 and anionically produced hydrogenated polyisoprenes (an alternating ethylene-propylene copolymer) demonstrated that such corrections on Mw/Mn (= MWD) were less than 0.05 units. Mw/Mn was calculated from elution times. The numerical analyses were performed using the commercially available Beckman/CIS customized LALLS software in conjunction with the standard Gel Permeation package. Calculations involved in the characterization of polymers by ¹³CNMR follow the work of F. A. Bovey in "Polymer Conformation and Configuration" Academic Press, New York, 1969.

Heat seal testing procedure: Seal were made on a Topwave sealing machine. The structure was folded between TEFLON™ film and inserted between the sealing bars. At various the sealing bars were closed with a pressure of 0.5 MPa for 0.5 seconds. The structure was removed from the Top wave machine and conditioned for a minimum of 12 hours at $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ and $50\%\text{ humidity} \pm 5\%\text{ humidity}$.

Seal Strength was tested according to the following procedure. After conditioning for a minimum of 12 hours at $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ and $50\%\text{ humidity} \pm 5\%\text{ humidity}$, the seal strength of 15mm wide sample was measured in a Zwick tensile instrument under the following conditions: speed-100 mm/min, load cell-200N, and clamp distance-50 mm. The structure was placed between the clamps and the clamps were moved apart at a speed of 100mm/min. During the rest the force (N) was recorded as a function of elongation (%). Four test specimens were measured and the average seal strength curve was recorded. The seal strength was the force at which the test specimen failed.

Example 1

Three trilayer polyethylene films (50 μm thick, approximately 17 μm per layer) were produced on a three layer Barmag blown film line with a die of 250 mm and a gap of 1.6 mm under the conditions listed in Tables 2-4. Table 1 shows the composition of the films labelled films 2-4). Thereafter the films were laminated to the 25 μm thick VITRA BOPP film which had been corona treated and had a measured surface tension of 38 dynes/cm(38 mN/m). Prior to adhesive lamination the polyethylene films had also been corona treated. The outside layer of the polyethylene film was laminated to the treated side of the VITRA BOPP film. The films were laminated on an RK Print Coat Rotary Koater laminator to the VITRA BOPP using an adhesive comprising ADCOTE™ 301A, ADCOTE™ 350A (6:4 ratio by weight) and ethyl acetate as solvent mixed at a 30% solids level. ADCOTE chemicals are available from Morton International in Germany. Table 5 contains lamination details.

Table 1

Film	Seal layer		Core layer		Outside layer	
	polymer	additives (ppm)	polymer	additives (ppm)	polymer	additives (ppm)
Film 2	Dow 5056 E 01 Dow 5056 E 70/30 blend	400 PPA	Dow 5056 E 01 Dow 5056 E 70/30 blend		Dow 5056 E 01 Dow 5056 E / 30%	400 PPA
Film 3	ECD 103	2500 AB 200 PPA	ECD 103	1500 S	ECD 103	2500 AB 200 PPA
Film 4	EXACT 3132	1250 S 3500 AB 1000 PPA	ECD 103		ECD 103	350 S 2500 AB 200 PPA

S= slip, Schulman's Polybatch CE 505E, AB = antiblock, Schulman's Polybatch

F15,

PPA = polymer processing aid, Schulman's Polybatch AMF 702.

Table 2 (Film 2)

Extruder temperature (°C) [zone 1/zone 2/zone 3/zone 4]	170/190/210/210
Melt temperature (°C) [layer 1/layer 2/ layer 3]	226/230/241
Melt pressure (kPa) [layer 1/layer 2/ layer 3]	2890/2940/2640-2680
Extruder speed (rpm) [layer 1/layer 2/ layer 3]	27/28/30-31
Extruder output (kg/hr) [layer 1/layer 2/ layer 3]	32.9/33.6/32.5
Head temperature (°C)	210
Blow up ratio//lay flat width (mm)	2.20//865
Frost line height (mm)//haul off speed (m/min)	625//20.8-21.1
Corona treatment level (mN/m)	50

Table 3 (Film 3)

Extruder temperature (°C) [zone 1/zone 2/zone 3/zone 4]	170/190/210/210
Melt temperature (°C) [layer 1/layer 2/ layer 3]	234/235/245
Melt pressure (kPa) [layer 1/layer 2/ layer 3]	3150/3360/2910
Extruder speed (rpm) [layer 1/layer 2/ layer 3]	33/30/32
Extruder output (kg/hr) [layer 1/layer 2/ layer 3]	32.0/32.0/32.0
Head temperature (°C)	210
Blow up ratio//lay flat width (mm)	2.20//865
Frost line height (mm)//haul off speed (m/min)	600//20.4
Corona treatment level (mN/m)	50

Table 4 (Film 4)

Extruder temperature (°C) [zone 1/zone 2/zone 3/zone 4]	170/190/210/210
Melt temperature (°C) [layer 1/layer 2/ layer 3]	228/236/245
Melt pressure (kPa) [layer 1/layer 2/ layer 3]	3110/3660/3120
Extruder speed (rpm) [layer 1/layer 2/ layer 3]	27/32/34
Extruder output (kg/hr) [layer 1/layer 2/ layer 3]	34.3/34.1/33.8
Head temperature (°C)	210
Blow up ratio//lay flat width (mm)	2.20//865
Frost line height (mm)//haul off speed (m/min)	550//21.1
Corona treatment level (mN/m)	50

Table 5 (temperature 20°C)

	Film 2/VITRA BOPP	Film 3/VITRA BOPP	Film 4/VITRA BOPP
Corona Treatment level (dyne/cm (mN/m))	38 on film 2	48 on film 3	48 on film 4
Adhesive coating weight (g/m ²)	1.72 - 1.88	1.95 - 2.02	1.83 - 2.17
Laminator			
Gravure roll	TR 26	TR 26	TR 26
Pressure head (kPa)	300	300	300
Temp. drying oven (°C)	75	75	75
Pressure nip roll (kPa)	450	450	450
Temp. nip roll (°C)	60	60	50
Pressure winding (kPa)	250	250	250
Line speed (m/min)	8	8	8

TR-26 is a gravure roll supplied by RK Print Coat.

These laminated films were then heat sealed to a 400 micron thick sheet of PP4342C2 at various temperatures from 120 °C to 200 °C at a speed of 100 mm/min. The data are reported in Tables 7, 8 and 9. The gloss side of the PP4342C2 was the side touching the glossy chill roll. The matt surface was the surface that did not touch the chill roll and was air cooled. All seals were between the surface layer of mPE and the PP4342C2.

Table 6 (Film 4)

Seal Bar Temperature (°C)	120	140	160	180	200
Seal Str (N/15mm) Matt side	7.1	16.6	23.7	28.1	22.4
Sealing mode	Peeling	Peeling	Peeling	Peeling	Peeling
Elongation (%)	19	24	32	31	15
Energy J/15mm	0.024	0.110	0.0240	0.252	0.084
Seal Str (N/15mm) Glossy side	3.0	8.5	13.4	24.2	20.0
Sealing mode	Peeling	Peeling	Peeling	Peeling	Peeling
Elongation (%)	18	20	22	21	43
Energy J/15mm	0.010	0.040	0.068	0.152	0.345

Table 7 (Film 3)

Seal Bar Temperature (°C)	120	140	160	180	200
Seal Str (N/15mm) Matt side	0.9	12.8	21.5	36.6	22.6
Sealing mode	Peeling	Peeling	Peeling	Peeling	Peeling
Elongation (%)	5	20	21	39	48
Energy J/15mm	0.001	0.053	0.126	0.524	0.428
Seal Str (N/15mm) Glossy side	0.4	6.3	9.0	27.2	21.4
Sealing mode	Peeling	Peeling	Peeling	Peeling	Peeling
Elongation (%)	9	18	21	32	34
Energy J/15mm	0.001	0.025	0.043	0.269	0.262

Table 8 (Film 2)

Seal Bar Temperature (°C)	120	140	160	180	200
Seal Str (N/15mm) Matt side	0.2	4.9	9.4	21.0	12.8
Sealing mode	Peeling	Peeling	Peeling	Peeling	Peeling
Elongation (%)	3	18	21	21	25
Energy J/15mm	0	0.019	0.050	0.102	0.100
Seal Str (N/15mm) Glossy side	0	3.7	5.7	11.8	10.7
Sealing mode	Peeling	Peeling	Peeling	Peeling	Peeling
Elongation (%)	0	17	19	21	21
Energy J/15mm	0	0.011	0.026	0.073	0.067

All documents described herein are incorporated by reference herein, including any priority documents and/or testing procedures. As is apparent from the foregoing general description and the specific embodiments, while forms of the invention have been illustrated and described, various modifications can be made without departing from the spirit and scope of the invention. Accordingly, it is not intended that the invention be limited thereby.



What is claimed is:

1. A film comprising a first surface layer comprising a homopolymer of ethylene having an Mw/Mn of 3 or less or a copolymer of ethylene and up to 50 weight% of a C₃ to C₂₀ olefin having a CDBI of 50 % or more, wherein the first surface layer is sealed to a substrate comprising a homopolymer of propylene or copolymer of propylene and up to 50 weight % of a comonomer.
2. The film of claim 1 wherein the first surface layer is a copolymer of ethylene and propylene, butene, hexene and/or octene.
3. The film of claim 2 wherein the copolymer of ethylene has a CDBI of 65 to 85 %, a density of 0.89 g/cm³ to 0.96 g/cm³ and an Mw/Mn of between 1 and 2.5.
4. The film of claim 2 wherein the copolymer of ethylene has a CDBI between 80 and 99 % and a density of 0.88 g/cm³ to 0.925 g/cm³.
5. The film of claim 1 wherein the first surface layer has been corona treated.
6. The film of claim 1 wherein the substrate is a formed article.
7. The film of claim 1 wherein the first surface layer comprises a blend of the homopolymer of ethylene or the copolymer of ethylene and another polyolefin, and/or the substrate comprises a blend of the homopolymer or copolymer of propylene and another polyolefin.



8. The film of claim 7 wherein the other polyolefin is homopolypropylene, propylene copolymerized with up to 50 weight % of ethylene or a C₄ to C₂₀ α -olefin, polybutene, ethylene vinyl acetate, low density polyethylene, linear low density polyethylene, ultra low density polyethylene, very low density polyethylene, medium density polyethylene, high density polyethylene, ethylene vinyl acetate, ethylene methyl acrylate, copolymers of acrylic acid, polymethylmethacrylate or polymers polymerizable by a high-pressure free radical process, polyvinylchloride, polybutene-1, isotactic polybutene, ABS resins, elastomers, ethylene-propylene rubber, vulcanized ethylene-propylene rubber, ethylene propylene diene monomer rubber, block copolymer elastomers, styrene butadiene styrene elastomer, nylons, polycarbonates, PET resins, crosslinked polyethylene, copolymers of ethylene and vinyl alcohol, polymers of aromatic monomers, polystyrene, poly-1 esters, high molecular weight polyethylene having a density of 0.94 to 0.98 g/cm³, low molecular weight polyethylene having a density of 0.94 to 0.98 g/cm³, graft copolymers, polyacrylonitrile homopolymer or copolymers, thermoplastic polyamides, polyacetal, polyvinylidene fluoride, fluorinated elastomers, polyethylene glycols, polyisobutylene, or a mixture thereof.
9. The film of claim 1 wherein the C₃ to C₂₀ olefin is a C₃ to C₂₀ alpha-olefin present at 1 to 35 weight % and the comonomer present in the copolymer of propylene is ethylene or a C₄ to C₂₀ alpha-olefin present at 1-35 weight %.
10. The film of claim 1 wherein the copolymer of ethylene comprises 1 to 20 weight % of propylene, butene, hexene and/or octene and the copolymer of propylene comprises 1 to 6 weight % of ethylene.
11. The film of claim 1 wherein the comonomer of the propylene copolymer comprises ethylene or a C₄ to C₂₀ α -olefin.



12. The film of claim 1 wherein the comonomer of the propylene copolymer comprises one or more of ethylene, butene, isobutylene, pentene, isopentene, cyclopentene, hexene, isohexene, cyclohexene, heptene, isoheptene, cycloheptene, octene, isooctene, cyclooctene, nonene, cyclononene, decene, isodecene, dodecene, isodecene, 4-methyl-pentene-1, 3-methyl-pentene-1, 3,5,5-trimethyl hexene-1, styrene, α -methyl styrene, para-methyl styrene, hexadiene, norbornene, vinyl norbornene, ethylidene norbornene, butadiene, isoprene, heptadiene, octadiene, and cyclopentadiene.
13. A method to produce a heat sealed package comprising:
 - 1) selecting a first polymer having a CDBI of 50 % or more comprising homopolyethylene having an Mw/Mn of 3 or less or a copolymer of ethylene and up to 50 weight % of a C₃ to C₂₀ olefin,
 - 2) selecting a substrate comprising homopolypropylene or a copolymer of propylene and up to 50 weight % of ethylene or a C₄ to C₂₀ olefin, and
 - 3) heat sealing a film of the first polymer to the substrate.
14. A method of packaging an article comprising:
 - 1) selecting a first polymer having a CDBI of 50 % or more comprising homopolyethylene having an Mw/Mn of 3 or less or a copolymer of ethylene and up to 50 weight % of a C₃ to C₂₀ olefin,
 - 2) selecting a substrate comprising homopolypropylene or a copolymer of propylene and up to 50 weight % of ethylene or a C₄ to C₂₀ olefin,
 - 3) forming the first polymer into a film,
 - 5) placing an article between the film and the substrate, and
 - 6) heat sealing the enclosed article such that at least one seal is formed by heat sealing the first polymer film to the substrate.