(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 August 2008 (21.08.2008)

PCT

(10) International Publication Number
WO 2008/100612 A1

(51) International Patent Classification:
C08J 5/18 (2006.01)

(21) International Application Number:
PCT/US2008/002094

(22) International Filing Date:
15 February 2008 (15.02.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/901,387 15 February 2007 (15.02.2007) US

(71) Applicant *(for all designated States except US)*: **E. I. DU PONT DE NEMOURS AND COMPANY** [US/US]; 1007 Market Street, Wilmington, DE 19898 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **HAYES, Richard, Allen** [US/US]; 630 Belvedere Drive, Beaumont, TX 77706 (US). **SAMUELS, Sam, Louis** [US/US]; 34 Pelham Drive, Landenberg, PA 19350 (US). **HALL, Matthew, Scott** [US/US]; 115 Cambridge Road, Landenberg, PA 19350 (US).

(74) Agent: **KULLER, Mark, D.**; E. I. du Pont de Nemours and Company, Legal Patent Records Center, 4417 Lancaster Pike, Wilmington, DE 19805 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

WO 2008/100612 A1

(54) Title: HIGH MELT FLOW IONOMERIC COMPOSITIONS

(57) Abstract: A polymeric film or sheet comprising an ionomeric composition comprising ionomeric copolymer of an alpha olefin and about 1 to about 30 wt% of alpha,beta-ethylenically unsaturated carboxylic acid having 3 to 8 carbons, based on the total weight of the ionomeric copolymer, wherein the carboxylic acid is neutralized to a level of 1 to 100 mol%, with one or more metal ions, based on the total number of moles of carboxylate groups in the ionomeric copolymer, and wherein the ionomeric copolymer has a Melt Index of about 20 to about 300 g/10 min. The ionomeric composition preferably comprises an additive selected from the group consisting of silane coupling agent, organic peroxide, and combinations thereof. In addition, an article comprising an interlayer formed of the polymeric film or sheet and an additional layer selected from the group consisting of glass, other polymeric interlayer sheets, polymeric film layers, and metal films or sheets. Examples of articles include safety windows and solar cells.

TITLE

ARTICLES COMPRISING HIGH MELT FLOW IONOMERIC COMPOSITIONS

FIELD OF THE INVENTION

The invention relates to ionomeric compositions, polymeric films or sheets derived therefrom, and their utility in safety laminates and solar cell modules.

BACKGROUND OF THE INVENTION

Glass laminated products have contributed to society for almost a century. Beyond the well known, every day automotive safety glass used in windshields, laminated glass is used in all forms of the transportation industry. Safety glass is characterized by high impact and penetration resistance and does not scatter glass shards and debris when shattered.

Safety glass typically consists of a sandwich of two glass sheets or panels bonded together with an interlayer of a polymeric sheet. One or both of the glass sheets may be replaced with optically clear rigid polymeric sheets, such as sheets made of polycarbonates. Safety glass has further evolved to include multiple layers of glass and polymeric sheets bonded together with interlayers of polymeric sheets.

The interlayers used in safety glass are typically made from relatively thick polymer sheets, which exhibit toughness and bondability to the glass in the event of a crack or crash. Widely used interlayer materials include complex, multicomponent compositions based on poly(vinyl butyral) (PVB), poly(urethane) (PU), poly(ethylene vinyl acetate) (EVA), ionomers, and the like.

As a renewable energy resource, the use of solar cell modules is rapidly expanding. One preferred way of manufacturing a solar cell module involves forming a pre-laminate assembly comprising at least 5 structural layers. The solar cell pre-laminates are constructed in the following order starting from the top, or incident layer (that is, the layer first contacted by light) and continuing to the backing (the layer furthest removed from the incident layer): (1) incident layer (typically a glass plate

or a thin polymeric film (such as a fluoropolymer or polyester film), but could conceivably be any material that is transparent to sunlight), (2) front encapsulant layer, (3) voltage-generating component (or solar cell component), (4) back encapsulant layer, and (5) backing layer.

The encapsulant layers are designed to encapsulate and protect the fragile voltage-generating component. Generally, a solar cell pre-laminate will incorporate at least two encapsulant layers sandwiched around the solar cell component. The optical properties of the front encapsulant layer must be such that light can be effectively transmitted to the solar cell component. Additionally, encapsulant layers generally have similar requirements and compositions to that described above for glazing interlayers.

The use of ionomeric compositions as threat resistant safety laminate interlayer sheets has been known within the art (see, e.g. US 3,344,014; US 3,762,988; US 4,663,228; US 4,668,574; US 4,799,346; US 5,759,698; US 5,763,062; US 5,895,721; US 6,150,028; US 6,432,522; US 2002/0155302; US 2002/0155302; WO 99/58334; and WO 2006/057771). For Example, US 5,759,698 discloses a glass laminate interlayer derived from an ionomer resin which has been thermoset with an organic peroxide and a silane agent.

The use of ionomeric compositions as solar cell encapsulant films or sheets has also been known within the art (see, e.g., US 5,476,553; US 5,478,402; US 5,733,382; US 5,762,720; US 5,986,203; US 6,114,046; US 6,187,448; US 6,660,930; US 2003/0000568; US 2005/0279401; JP 2000186114; and JP 2006032308).

However, the ionomeric resins being used in the art of safety laminates or solar cell modules generally have a low melt flow index (MI) of 15 g/10 min or less (2160 g, 190°C, ISO 1133, ASTM D1238). The use of such low melt flow ionomeric resins requires higher lamination temperatures (i.e., 130°C – 170°C) and therefore may complicate the lamination process.

Chou et al., in US 6,680,821, describe a method of coating a metallic surface using a resin powder comprising certain metal neutralized acid copolymers comprising an alpha-olefin and an alpha-beta

unsaturated carboxylic acid with a MI in the range of from about 20 to about 1,000 g/10 min. This patent does not describe use of such materials within safety glass or photovoltaic module laminates or additive packages that enhance the performance of the copolymers in such uses.

There is a need for polymeric film or sheet suitable for use as interlayers in glass laminate end-use applications, such as safety windows and solar cells, that do not have the shortcomings described above, as well as for compositions useful in forming such films or sheets. For instance, there is a desire to prepare useful compositions with a reduced extrusion compounding temperature. In addition, there is a desire to reduce the lamination temperature, preferably to about 100°C to about 120°C, or to reduce the lamination cycle time, or both, and therefore simplifying the lamination process. In addition, there is a desire for films or sheets that have enhanced adhesion strength under a wide variety of lamination temperatures, including such desirable lower temperatures, and to provide the laminates with improved shock resistance.

SUMMARY OF THE INVENTION

The invention is directed to a polymeric film or sheet comprising an ionomeric composition comprising ionomeric copolymer of an alpha olefin and about 1 to about 30 wt% of alpha,beta-ethylenically unsaturated carboxylic acid having 3 to 8 carbons, based on the total weight of the ionomeric copolymer, wherein the carboxylic acid is neutralized to a level of 1 to 100 mol%, with one or more metal ions, based on the total number of moles of carboxylate groups in the ionomeric copolymer, and wherein the ionomeric copolymer has a Melt Index of about 20 to about 300 g/10 min.

The invention is further directed to an article comprising an interlayer formed of the polymeric film or sheet described above and an additional layer selected from the group consisting of glass, other polymeric interlayer sheets, polymeric film layers, and metal films or sheets. In one embodiment, the article is a safety glass laminate wherein the additional layer is a glass sheet and the interlayer is laminated to the glass sheet. In another embodiment, the article is a solar cell pre-laminate

assembly and comprises a solar cell component comprising one or a plurality of solar cells.

The invention is yet further directed to a solar cell laminate prepared by the steps comprising (a) providing interlayer formed of the polymeric film or sheet described, (b) providing a solar cell component comprising one or a plurality of solar cells; and (c) encapsulating the solar cell component in a matrix comprising the ionomeric composition.

The invention is yet further directed to a process of manufacturing an article, wherein the article is a solar cell module, the process comprising: (i) providing a solar cell pre-laminate assembly as described above, and (ii) laminating the pre-laminate assembly to form the solar cell module.

The invention is yet further directed to a polymeric composition comprising an ionomeric composition and an additive, wherein (i) the ionomeric composition comprises a copolymer of an alpha olefin and about 1 to about 30 wt% of an alpha,beta-ethylenically unsaturated carboxylic acid having 3 to 8 carbons, based on the total weight of the ionomeric copolymer, wherein the carboxylic acid is neutralized to a level of 1 to 100 mol%, with one or more metal ions, based on the total number of moles of carboxylate groups in the ionomeric copolymer, (ii) the ionomeric copolymer has a Melt Index of about 20 to about 300 g/10 min and (iii) the additive is selected from the group consisting of silane coupling agent, organic peroxide, and combinations thereof.

DETAILED DESCRIPTION OF THE INVENTION

All publications, patent applications, patents, and other documents mentioned herein are incorporated by reference in their entirety. Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. In case of conflict, the present specification, including definitions, will control.

Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the invention, suitable methods and materials are described herein.

Unless stated otherwise, all percentages, parts, ratios, etc., are by weight.

When an amount, concentration, or other value or parameter is given as either a range, preferred range or a list of upper preferable values and lower preferable values, this is to be understood as specifically disclosing all ranges formed from any pair of any upper range limit or preferred value and any lower range limit or preferred value, regardless of whether ranges are separately disclosed. Where a range of numerical values is recited herein, unless otherwise stated, the range is intended to include the endpoints thereof, and all integers and fractions within the range. It is not intended that the scope of the invention be limited to the specific values recited when defining a range.

When the term "about" is used in describing a value or an end-point of a range, the disclosure should be understood to include the specific value or end-point referred to.

As used herein, the terms "comprises," "comprising," "includes," "including," "containing," "characterized by," "has," "having" or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. Further, unless expressly stated to the contrary, "or" refers to an inclusive or and not to an exclusive or. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

The transitional phrase "consisting of" excludes any element, step, or ingredient not specified in the claim, closing the claim to the inclusion of materials other than those recited except for impurities ordinarily associated therewith. When the phrase "consists of" appears in a clause of the body of a claim, rather than immediately following the preamble, it limits only the element set forth in that clause; other elements are not excluded from the claim as a whole.

The transitional phrase "consisting essentially of" limits the scope of a claim to the specified materials or steps and those that do not materially affect the basic and novel characteristic(s) of the claimed invention. "A 'consisting essentially of' claim occupies a middle ground between closed claims that are written in a 'consisting of' format and fully open claims that are drafted in a 'comprising' format."

Where applicants have defined an invention or a portion thereof with an open-ended term such as "comprising," it should be readily understood that (unless otherwise stated) the description should be interpreted to also describe such an invention using the terms "consisting essentially of" or "consisting of."

Use of "a" or "an" are employed to describe elements and components of the invention. This is done merely for convenience and to give a general sense of the invention. This description should be read to include one or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

In describing certain polymers it should be understood that sometimes applicants are referring to the polymers by the monomers used to make them, the amounts of the monomers used to make them, or by the monomer residues incorporated within them. While such a description may not include the specific nomenclature used to describe the final polymer or may not contain product-by-process terminology, any such reference to monomers, monomer residues, repeat units, and amounts should be interpreted to mean that the polymer is made from those monomers or that amount of the monomers, and the corresponding polymers and compositions thereof. In this regard, a reference to a copolymer containing residues of a monomer is referring to the fact that the copolymer contains repeat units from that monomer. When applicants refer to a copolymer containing a percentage of a monomer, it should be understood that this reference is to the copolymer containing repeat units from that monomer.

In describing and/or claiming this invention, the term "copolymer" is used to refer to polymers containing two or more monomers.

The terms "finite amount" and "finite value" are used to refer to an amount that is greater than zero.

The term "acid copolymer" is used to refer to a resin composition comprised of copolymerized residues of an alpha olefin and copolymerized residues of an alpha, beta-ethylenically unsaturated carboxylic acid having 3 to 8 carbons. The term "ionomer" is used herein to refer to a resin composition derived from a partially or fully neutralized "acid copolymer".

HIGH MELT FLOW IONOMERIC COMPOSITIONS

The invention is related to certain high melt flow ionomeric compositions that are useful in forming safety interlayer sheets or solar cell encapsulant films or sheets. Specifically, the high melt flow ionomeric composition is comprised of an ionomer copolymer having a MI of about 20 to about 300 g/10 min, as measured by ASTM D1238 at 190°C and a 2160 g load. (A similar ISO test is ISO 1133.)

Ionomeric Copolymers:

The high melt flow ionomeric copolymer is derived from certain parent acid copolymer comprising a finite amount of an alpha olefin and about 1 to about 30 wt% of an alpha,beta-ethylenically unsaturated carboxylic acid having 3 to 8 carbons, based on the total weight of the copolymer. Preferably, the parent acid copolymer comprises about 10 to about 25 wt%, or more preferably, about 15 to about 23 wt%, or yet more preferably, about 18 to about 23 wt%, of the alpha,beta-ethylenically unsaturated carboxylic acid, based on the total weight of the copolymer.

The alpha olefin comonomers typically incorporate from 2 to 10 carbon atoms. Preferable alpha olefins include, but are not limited to, ethylene, propylene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 3-methyl-1-butene, 4-methyl-1-pentene, and the like and mixtures thereof. More preferably, the alpha olefin is ethylene. The alpha,beta-ethylenically unsaturated carboxylic acid comonomers may include acrylic acid, methacrylic acid, itaconic acid, maleic acid, maleic anhydride, fumaric acid, monomethyl maleic acid, and mixtures thereof. Preferable alpha,beta-ethylenically unsaturated carboxylic acid comonomers include acrylic acid, methacrylic acid and mixtures thereof.

The parent acid copolymers may be polymerized as disclosed in US 3,404,134; US 5,028,674; US 6,500,888; and US 6,518,365.

To produce the high melt flow ionomeric copolymers, the parent acid copolymers are neutralized from about 1% to about 100%, or preferably, from about 1% to about 50%, or more preferably, from about 2% to about 40%, or yet more preferably, from about 2% to about 20%, with metallic ions, based on the total carboxylic acid content. The metallic ions may be monovalent, divalent, trivalent, multivalent, or mixtures therefrom. Useful monovalent metallic ions include, but are not limited to, sodium, potassium, lithium, silver, mercury, copper, and the like and mixtures thereof. Useful divalent metallic ions include, but are not limited to, beryllium, magnesium, calcium, strontium, barium, copper, cadmium, mercury, tin, lead, iron, cobalt, nickel, zinc, and the like and mixtures therefrom. Useful trivalent metallic ions include, but are not limited to, aluminum, scandium, iron, yttrium, and the like and mixtures therefrom. Useful multivalent metallic ions include, but are not limited to, titanium, zirconium, hafnium, vanadium, tantalum, tungsten, chromium, cerium, iron, and the like and mixtures therefrom. It is noted that when the metallic ion is multivalent, complexing agents, such as stearate, oleate, salicylate, and phenolate radicals are included, as disclosed within US 3,404,134. The metallic ions are preferably monovalent or divalent metallic ions. More preferably, the metallic ions are selected from the group consisting of sodium, lithium, magnesium, zinc, and mixtures therefrom. Yet more preferably, the metallic ions are selected from the group consisting of sodium, zinc, and mixtures therefrom. The parent acid copolymers of the invention may be neutralized as disclosed in US 3,404,134.

The high melt flow ionomeric copolymers have a MI of about 20 to about 300 g/10 min. Preferably, the ionomeric copolymers have a MI of about 30 to about 200 g/10 min. In general, to achieve the desirable high melt flow rates of the ionomeric copolymers, the parent acid copolymers should have a MI of about 50 to about 600 g/10 min, or preferably, about 50 to about 400 g/10 min, or more preferably, about 50 to about 200 g/10 min.

Such a high melt flow rate provides the ionomeric films or sheets derived therefrom with reduced lamination temperatures, or shorter cycle time, or both, when they are used in safety laminates or solar cell laminates. Moreover, when laminated under the lamination temperatures, films or sheets derived from such high melt flow ionomeric compositions possess higher adhesion strength than those derived from ionomeric compositions with relatively lower melt flow rates.

The high melt flow ionomeric copolymers may optionally contain other unsaturated comonomers. Specific examples of preferable other unsaturated comonomers include, but are not limited to, methyl acrylate, methyl methacrylate, ethyl acrylate, ethyl methacrylate, isopropyl acrylate, isopropyl methacrylate, butyl acrylate, butyl methacrylate and mixtures thereof. In general, the ionomeric copolymers may incorporate 0 to about 50 wt%, or preferably, 0 to about 30 wt%, or more preferably, 0 to about 20 wt%, of the other unsaturated comonomer(s), based on the total weight of the copolymer.

Additives:

The high melt flow ionomeric composition may further comprise one or more additives.

In one particular embodiment, the ionomeric composition further comprises one or more silane coupling agents to further enhance the adhesion strength of the films or sheets derived therefrom.

Exemplary silane coupling agents that are useful in the invention include, but are not limited to, gamma-chloropropylmethoxysilane, vinyltrimethoxysilane, vinyltriethoxysilane, vinyltris(beta-methoxyethoxy)silane,gamma-vinylbenzylpropyltrimethoxysilane, N-beta-(N-vinylbenzylaminoethyl)-gamma-aminopropyltrimethoxysilane, gamma-methacryloxypropyltrimethoxysilane, vinyltriacetoxysilane, gamma-glycidoxypropyltrimethoxysilane, gamma-glycidoxypropyltriethoxysilane, beta-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, vinyltrichlorosilane, gamma-mercaptopropylmethoxysilane, gamma-aminopropyltriethoxysilane, N-beta-(aminoethyl)-gamma-aminopropyltrimethoxysilane, and the like and mixtures thereof. The silane coupling agents are preferably incorporated in the ionomeric

compositions at a level of about 0.01 to about 5 wt%, or more preferably, about 0.05 to about 1 wt%, based on the total weight of the composition.

It is noted that the silane coupling agents can reduce the melt flow rate of the ionomeric compositions to which they are incorporated. Therefore, with a set level of silane, the high melt flow ionomeric compositions can maintain a certain level of viscosity than the prior art lower melt flow ionomeric compositions.

In another embodiment of the invention, the ionomeric compositions may further comprise additives which effectively reduce the melt flow of the resin, to the limit of thermosetting the films or sheets during lamination. The use of such additives will enhance the upper end-use temperature and reduce creep of the laminate interlayer sheets or solar cell encapsulant films or sheets derived therefrom. Typically, the end-use temperature may be enhanced up to about 20 to about 70°C. In addition, safety laminates and solar cell laminates produced from such materials will be fire resistant. Specifically, by thermosetting the ionomeric resins during lamination, the resins will have a reduced tendency to melt and flow out of the laminate, which in turn, may serve as additional fuel for a fire.

Typically, the effective melt flow reducing additives are organic peroxides, such as 2,5-dimethylhexane-2,5-dihydroperoxide, 2,5-dimethyl-2,5-di(tert-betylperoxy)hexane-3, di-tert-butyl peroxide, tert-butylcumyl peroxide, 2,5-dimethyl-2,5-di(tert-butylperoxy)hexane, dicumyl peroxide, alpha, alpha'-bis(tert-butyl-peroxyisopropyl)benzene, n-butyl-4,4-bis(tert-butylperoxy)valerate, 2,2-bis(tert-butylperoxy)butane, 1,1-bis(tert-butyl-peroxy)cyclohexane, 1,1-bis(tert-butylperoxy)-3,3,5-trimethyl-cyclohexane, tert-butyl peroxybenzoate, benzoyl peroxide, and the like and mixtures combinations thereof. Preferably the organic peroxides decompose at a temperature of about 100°C or higher to generate radicals. More preferably, the organic peroxides have a decomposition temperature which affords a half life of 10 hours at about 70°C or higher to provide improved stability for blending operations.

Moreover, the temperature gap between the ionomer composition compounding temperature and the organic peroxide decomposition temperature is critical to avoid premature crosslinking during the

compounding and film and sheet formation processes. In an extrusion process (which is the preferred process for manufacturing the high melt flow ionomeric films or sheets), the high melt flow ionomeric compositions require desirable reduced extrusion temperatures when compared to the otherwise lower melt flow ionomeric compositions and therefore effectively preventing premature crosslinking during extrusion compounding, film or sheet formation.

The organic peroxides are added at a level of about 0.01 to about 10 wt%, or preferably, about 0.5 to about 3 wt%, based on the total weight of the composition.

If desired, initiators, such as dibutyltin dilaurate, may also be contained in the ionomeric composition at a level of about 0.01 to about 0.05 wt%, based on the total weight of the composition. In addition, if desired, inhibitors, such as hydroquinone, hydroquinone monomethyl ether, p-benzoquinone, and methylhydroquinone, may be added for the purpose of enhancing control to the reaction and stability. Typically, the inhibitors would be added at a level of less than about 5 wt%, based on the total weight of the composition.

In yet another embodiment, the high melt flow ionomeric composition may further comprise any other suitable additive(s) known within the art. Such additives may include, but are not limited to, plasticizers, processing aides, flow enhancing additives, lubricants, pigments, dyes, flame retardants, impact modifiers, nucleating agents, antiblocking agents (e.g., silica), thermal stabilizers, UV absorbers, UV stabilizers, dispersants, surfactants, chelating agents, coupling agents, adhesives, primers, reinforcement additives (e.g., glass fiber), fillers, and the like. Generally, when used in solar cell encapsulant films or sheets, the additives that may reduce the optical clarity of the compositions, such as reinforcement additives and fillers, are reserved for those films or sheets used as the back encapsulant layers.

Thermal stabilizers can be used and have been widely disclosed within the art. Any known thermal stabilizer may find utility within the invention. Preferable general classes of thermal stabilizers include, but are not limited to, phenolic antioxidants, alkylated monophenols,

alkylthiomethylphenols, hydroquinones, alkylated hydroquinones, tocopherols, hydroxylated thiodiphenyl ethers, alkylidenebisphenols, O-, N- and S-benzyl compounds, hydroxybenzylated malonates, aromatic hydroxybenzyl compounds, triazine compounds, aminic antioxidants, aryl amines, diaryl amines, polyaryl amines, acylaminophenols, oxamides, metal deactivators, phosphites, phosphonites, benzylphosphonates, ascorbic acid (vitamin C), compounds that destroy peroxide, hydroxylamines, nitrones, thiosynergists, benzofuranones, indolinones, and the like and mixtures thereof. The high melt flow ionomeric compositions may contain any effective amount of thermal stabilizers. Use of a thermal stabilizer is optional and in some instances is not preferred. When used, the high melt flow ionomeric compositions contain at least about 0.05 wt%, and up to about 10 wt%, more preferably up to about 5 wt%, and most preferably up to about 1 wt%, of thermal stabilizers, based on the total weight of the composition.

UV absorbers can be used and have also been widely disclosed within the art. Any known UV absorber may find utility within the invention. Preferable general classes of UV absorbers include, but are not limited to, benzotriazoles, hydroxybenzophenones, hydroxyphenyl triazines, esters of substituted and unsubstituted benzoic acids, and the like and mixtures thereof. The high melt flow ionomeric compositions may contain any effective amount of UV absorbers. Use of an UV absorber is optional and in some instances is not preferred. When used, the high melt flow ionomeric compositions contain at least about 0.05 wt%, and up about 10 wt%, more preferably up to about 5 wt%, and most preferably up to about 1 wt%, of UV absorbers, based on the total weight of the composition.

Hindered amine light stabilizers (HALS) can be used and have also been widely disclosed within the art. Generally, hindered amine light stabilizers are disclosed to be secondary, tertiary, acetylated, N-hydrocarbyloxy substituted, hydroxy substituted N-hydrocarbyloxy substituted, or other substituted cyclic amines which further incorporate steric hindrance, generally derived from aliphatic substitution on the carbon atoms adjacent to the amine function. The high melt flow ionomeric compositions may contain any effective amount of hindered

amine light stabilizers. Use of hindered amine light stabilizers is optional and in some instances is not preferred. When used, the high melt flow ionomeric compositions contain at least about 0.05 wt%, and up to about 10 wt%, more preferably up to about 5 wt%, and most preferably, up to about 1 wt%, of hindered amine light stabilizers, based on the total weight of the composition.

HIGH MELT FLOW IONOMERIC FILMS OR SHEETS

The invention further provides shaped articles, such as, films or sheets comprising the high melt flow ionomeric compositions. These high melt flow ionomeric films and sheets may be produced by any suitable process. For example, the films and sheets may be formed through dipcoating, solution casting, compression molding, injection molding, melt extrusions, melt blowing, or any other procedures that are known to those of skill in the art. Preferably, the high melt flow ionomeric films and sheets are formed by melt extrusion, which is a particularly preferred process for formation of "endless" products.

As discussed above, the high melt flow ionomeric films or sheets are useful in forming the interlayer sheets in safety laminates or encapsulant films or sheets in solar cell laminates. Moreover, the high melt flow ionomeric films or sheets may take the form of single-layer or multilayer films or sheets. By single-layer, it is meant that the film or sheet has only one single layer and that the one single layer is made of the high melt flow ionomeric composition. By multilayer, it is meant that the high melt flow ionomeric film or sheet has two or more sub-layers and that at least one of the sub-layers is made of the high melt flow ionomeric composition. The other sub-layer(s) of the multilayer film or sheet may be made of any suitable polymeric compositions. Preferably, however, the other sub-layer(s) is made of polymeric compositions selected from the group consisting of acid copolymers and ionomers derived therefrom, poly(ethylene vinyl acetate), poly(vinyl acetal) (e.g., poly(vinyl butyral)), polyurethane, polyvinylchloride, polyethylenes (e.g., metallocene-catalyzed linear low density polyethylenes), polyolefin block elastomers, ethylene acrylate ester copolymers (e.g., poly(ethylene-co-methyl acrylate)

and poly(ethylene-co-butyl acrylate)), silicone elastomers and epoxy resins. More preferably, the other sub-layers are formed of polymeric compositions selected from the group consisting of acid copolymers and ionomers derived therefrom, poly(ethylene vinyl acetate), metallocene-catalyzed linear low density polyethylenes, polyolefin block elastomers, and ethylene acrylate ester copolymers. Moreover, to provide adequate adhesion strength, at least one, or preferably, both, of the surface sub-layers of the multilayer film or sheet are formed of the high melt flow ionomeric compositions. In one preferred embodiment, multilayer films and sheets with high flow ionomeric copolymer surfaces and low flow core layers provide the desirable low lamination temperatures and high adhesion of the invention.

The films or sheets of the invention preferably have a total thickness of about 0.1 mil (0.003 mm) to about 250 mils (6.35 mm). When used as a safety laminate interlayer sheet, the high melt flow ionomeric sheet preferably has a total thickness of about 10 mils (0.25 mm) to about 250 mils (6.35 mm), or more preferably, about 15 mils (0.38 mm) to about 90 mils (2.28 mm), or yet more preferably, about 30 mils (0.76 mm) to about 60 mils (1.52 mm). Also in accordance to the invention, for use as a solar cell encapsulant the sheet or film preferably has a thickness of about 0.1 mil (0.003 mm) to about 20 mils (0.51 mm). That is, when used in a flexible solar cell laminate as a solar cell encapsulant film, the high melt flow ionomeric film preferably has a total thickness of about 0.1 mil (0.003 mm) to about 10 mils (0.25 mm), or more preferably, about 1 mil (0.03 mm) to about 5 mils (0.13 mm), while when used in a rigid solar cell laminate as a solar cell encapsulant sheet, the high melt flow ionomeric sheet preferably has a total thickness of about 10 mils (0.25 mm) to about 20 mils (0.51 mm). The thickness of the individual sub-layers that make up the total multilayer ionomeric film or sheet is not critical and may be independently varied depending on the particular application. Preferably, however, the surface layers of a multilayer film or sheet should have a thickness of about 1 mil (0.03 mm) to about 5 mils (0.13 mm).

The high melt flow ionomeric films or sheets may have smooth or rough surfaces on one or both sides. Preferably, the high melt flow films

or sheets have rough surfaces to facilitate the de-airing of the laminates through the laminate process. Providing channels for the escape of air and removing air during lamination is a known method for obtaining laminates having acceptable appearance. Rough surfaces can be effected by mechanically embossing or by melt fracture during extrusion of the interlayer sheet or encapsulant film or sheet followed by quenching so that the roughness is retained during handling. The surface pattern can be applied to the high melt flow ionomeric film or sheet through common art processes. For example, the as extruded film or sheet may be passed over a specially prepared surface of a die roll positioned in close proximity to the exit of the die which imparts the desired surface characteristics to one side of the molten polymer. Thus, when the surface of such roll has minute peaks and valleys, film or sheet formed of polymer cast thereon will have a rough surface on the side which contacts the roll which generally conforms respectively to the valleys and peaks of the roll surface. Such die rolls are disclosed in, e.g., US 4,035,549.

If desired, one or both surfaces of the high melt flow ionomeric film or sheet may be treated to enhance the adhesion to other laminate layers. This treatment may take any form known within the art, including adhesives, primers, such as silanes, flame treatments (see, e.g., US 2,632,921; US 2,648,097; US 2,683,894; and US 2,704,382), plasma treatments (see e.g., US 4,732,814), electron beam treatments, oxidation treatments, corona discharge treatments, chemical treatments, chromic acid treatments, hot air treatments, ozone treatments, ultraviolet light treatments, sand blast treatments, solvent treatments, and the like and combinations thereof. For example, a thin layer of carbon may be deposited on one or both surfaces of the film or sheet through vacuum sputtering as disclosed in US 4,865,711. US 5,415,942, on the other hand, discloses a hydroxy-acrylic hydrosol primer coating that may serve as an adhesion-promoting primer for poly(ethylene terephthalate) films.

The adhesive layer preferably can take the form of a monolayer of an adhesive primer or of a coating. The adhesive/primer coating may be less than about 1 mil (0.03 mm), or preferably, less than about 0.5 mil (0.013 mm), or more preferably, less than about 0.1 mil (0.003 mm) thick.

The adhesives may be any adhesive or primer known within the art. Preferably, the adhesives or primers are silane coupling agents or poly(vinyl amine) or poly(allyl amine). The poly(allyl amine)-based primers and their application to poly(ethylene terephthalate) polymeric films are disclosed within US 5,411,845; US 5,770,312; US 5,690,994; and US 5,698,329.

SAFETY LAMINATES

The invention further provides safety laminates comprising a polymeric interlayer sheet formed of the high melt flow ionomeric composition. Specifically, the safety laminate comprises at least one rigid sheet layer and at least one layer of the high melt flow ionomeric sheet as an interlayer sheet.

As discussed above, at the lamination temperatures used herein, the high melt flow ionomeric interlayer sheets typically possess higher adhesion strength than those sheets derived from otherwise low melt flow ionomers, and therefore providing the safety laminate structures with improved shock resistance.

The rigid sheets may be glass or rigid plastic sheets, such as, polycarbonate, acrylics, polyacrylate, cyclic polyolefins (e.g., ethylene norbornene polymers), metallocene-catalyzed polystyrene, polyamides, polyesters, fluoropolymers and the like and combinations thereof. Metal sheets (such as, aluminum, steel or galvanized steel) or ceramic plates may be substituted for the rigid polymeric sheet or glass.

The term "glass" is meant to include not only window glass, plate glass, silicate glass, sheet glass, low iron glass, tempered glass, tempered CeO-free glass, and float glass, but also to include colored glass, specialty glass (such as those include ingredients to control, e.g., solar heating), coated glass (such as those sputtered with metals (e.g., silver or indium tin oxide) for solar control purposes), E-glass, Toroglass, Solex® glass (Solutia). Such specialty glasses are disclosed in, e.g., US 4,615,989; US 5,173,212; US 5,264,286; US 6,150,028; US 6,340,646; US 6,461,736; and US 6,468,934. It is understood, however, that the type

of glass to be selected for a particular laminate depends on the intended use.

One preferred embodiment of the invention is a safety laminate comprising at least one layer of glass, and at least one layer of the high melt flow ionomeric sheet. Preferably, the high melt flow ionomeric sheet is self-adhered to the glass. As used herein, when the polymeric sheet is said to be "self-adhered" to the glass, it is meant that there is no intermediate layer such as a primer or thin adhesive layer between the glass and the polymeric layer, nor has the surface of the glass or polymeric layer been specially treated. A more preferred embodiment of the invention is a laminate comprising two layers of glass and at least one layer of the high melt flow ionomeric sheets bonded in between. Preferably, the high melt flow ionomeric sheet is self-adhered to one or both of the glass layers.

The safety laminate of the invention may further comprise other optional interlayer sheets and/or film layers. The other optional interlayer sheets may be formed of any suitable materials, such as, acid copolymers and ionomers derived therefrom, poly(ethylene vinyl acetate), poly(vinyl acetal) (e.g., poly(vinyl butyral)), polyurethane, polyvinylchloride, polyethylenes (e.g., metallocene-catalyzed linear low density polyethylenes), polyolefin block elastomers, ethylene acrylate ester copolymers (e.g., poly(ethylene-co-methyl acrylate) and poly(ethylene-co-butyl acrylate)), silicone elastomers and epoxy resins. In one preferred embodiment, the other interlayer is a second polymeric film or sheet comprising an ionomeric composition. The thickness of the other optional interlayer sheet(s) is not critical and may be independently varied depending on the particular application. The values provided above for the acid copolymer layer are preferred in many instances.

The film layers used in the safety laminates may be metal, such as aluminum foil, or polymeric. Preferable polymeric film materials include, but are not limited to, polyesters (e.g., poly(ethylene terephthalate) (PET)), poly(ethylene naphthalate), polycarbonate, polyolefins (e.g., polypropylene, polyethylene, and cyclic polyloefins), norbornene polymers, polystyrene (including syndiotactic polystyrene), styrene-acrylate

copolymers, acrylonitrile-styrene copolymers, polysulfones (e.g., polyethersulfone, polysulfone, etc.), nylons, poly(urethanes), acrylics, cellulose acetates (e.g., cellulose acetate, cellulose triacetates, etc.), cellophane, vinyl chloride polymers (e.g., polyvinylidene chloride, vinylidene chloride copolymers, etc.), fluoropolymers (e.g., polyvinyl fluoride, polyvinylidene fluoride, polytetrafluoroethylene, ethylene-tetrafluoroethylene copolymers, etc.) and the like. More preferably, the polymeric film is a biaxially oriented poly(ethylene terephthalate) film.

The thickness of the polymeric film is not critical and may be varied depending on the particular application. In general, however, the thickness of the polymeric film may range from about 0.1 mils (0.003 mm) to about 10 mils (0.26 mm), or preferably, from about 1 mil (0.025 mm) to about 7 mils (0.18 mm).

In addition, the polymeric films are sufficiently stress-relieved and shrink-stable under the coating and lamination processes. Preferably, the polymeric films are heat stabilized to provide low shrinkage characteristics when subjected to elevated temperatures (i.e. less than 2% shrinkage in both directions after 30 min at 150°C).

The films may also be coated if desired. For example, the films may be coated with organic infrared absorbers and sputtered metal layers, such as silver, coatings and the like. Metal coated polymeric films are disclosed in, e.g., US 3,718,535; US 3,816,201; US 4,465,736; US 4,450,201; US 4,799,745; US 4,846,949; US 4,954,383; US 4,973,511; US 5,071,206; US 5,306,547; US 6,049,419; US 6,104,530; US 6,204,480; US 6,255,031; and US 6,565,982. For example, the coating may function as oxygen and moisture barrier coatings, such as the metal oxide coating disclosed within US 6,521,825; US6,818,819; and EP 1 182 710.

If desired, one or both surfaces of laminate layers, such as the ionomeric interlayer sheet(s), the optional other interlayer sheet(s) or film layer(s), or the rigid sheet(s), may be treated to enhance their adhesion strength, as described above.

The safety laminate of the invention may take any form known within the art. Preferable specific glass laminate constructions include, for

example, wherein "ION" means the preferable high melt flow ionomer comprising interlayer sheet, as described above,

- glass/ION;
- glass/ION/film;
- glass/ION/glass;
- glass/ION/film/ION/glass;
- glass/ION/film/ION/film;

and the like.

The safety laminates of the invention may be produced by any of the lamination process that are described below in detail, or by other processes.

SOLAR CELL PRE-LAMINATE ASSEMBLIES AND SOLAR CELL LAMINATES

The invention further provides a solar cell pre-laminate assembly which comprises a solar cell component formed of one or a plurality solar cells and at least one layer of the high melt flow ionomeric film or sheet that is described above.

Solar cells are commonly available on an ever increasing variety as the technology evolves and is optimized. Within the invention, a "solar cell" is meant to include any article which can convert light into electrical energy. Typical art examples of the various forms of solar cells include, for example, single crystal silicon solar cells, polycrystal silicon solar cells, microcrystal silicon solar cells, amorphous silicon based solar cells, copper indium selenide solar cells, compound semiconductor solar cells, dye sensitized solar cells, and the like. The most common types of solar cells include multi-crystalline solar cells, thin film solar cells, compound semiconductor solar cells and amorphous silicon solar cells due to relatively low cost manufacturing ease for large scale solar cells.

Thin film solar cells are typically produced by depositing several thin film layers onto a substrate, such as glass or a flexible film, with the layers being patterned so as to form a plurality of individual cells which are electrically interconnected to produce a suitable voltage output.

Depending on the sequence in which the multi-layer deposition is carried out, the substrate may serve as the rear surface or as a front window for the solar cell module. By way of example, thin film solar cells are disclosed in US 5,512,107; US 5,948,176; US 5,994,163; US 6,040,521; US 6,137,048; and US 6,258,620. Examples of thin film solar cell modules are those that comprise cadmium telluride or CIGS, (Cu(In-Ga)(SeS)2), thin film cells.

In one particular embodiment, the solar cell pre-laminate assembly comprises one layer of the high melt flow ionomeric film or sheet, which is positioned next to the solar cell component and serves as one of the encapsulant layers, or preferably, the high melt flow ionomeric film or sheet is positioned next to the solar cell component at the light-receiving side and serves as the front encapsulant layer.

In accordance with the invention, besides the at least one high melt flow ionomeric film or sheet, the solar cell pre-laminate assembly may optionally further comprise encapsulant layers formed of other polymeric materials, such as, acid copolymers and ionomers derived therefrom, poly(ethylene vinyl acetate), poly(vinyl acetal) (e.g., poly(vinyl butyral), including acoustic grades of poly(vinyl butyral)), polyurethane, poly vinyl chloride, polyethylenes (e.g., linear low density metallocene-catalyzed polyethylenes), polyolefin block elastomers, ethylene acrylate ester copolymers (e.g., poly(ethylene-co-methyl acrylate) and poly(ethylene-co-butyl acrylate)), silicone elastomers and epoxy resins.

In a further embodiment, the solar cell pre-laminate assembly comprises two layers of the high melt flow ionomeric film or sheet, wherein each of the two high melt flow ionomeric films or sheets are laminated to each of the two sides of the solar cell component and serve as the front and back encapsulant layers.

The thickness of the individual encapsulant layers other than the high melt flow ionomeric film(s) or sheet(s) is not critical and may be independently varied depending on the particular application. Preferably, the thickness of each of these encapsulant layers may independently range from about 1 mil (0.026 mm) to about 120 mils (3.00 mm), or more preferably, from about 1 mil to about 40 mils (1.02 mm), or most

preferably, from about 1 mil to about 20 mils (0.51 mm). In addition, all the encapsulant layer(s) comprised in the solar cell pre-laminate assemblies, may have smooth or rough surfaces. Preferably, however, the encapsulant layer(s) have rough surfaces to facilitate the de-airing of the laminates through the lamination process.

In yet a further embodiment, the solar cell pre-laminate assembly may further comprise an incident layer and/or a backing layer serving as the outer layers of the assembly at the light-receiving side and the back side, respectively.

The outer layers of the solar cell pre-laminate assemblies, i.e., the incident layers and the backing layer, may be derived from any suitable sheets or films. Suitable sheets may be glass or plastic sheets, such as, polycarbonate, acrylics, polyacrylate, cyclic polyolefins (e.g., ethylene norbornene polymers), metallocene-catalyzed polystyrene, polyamides, polyesters, fluoropolymers and the like and combinations thereof. In addition, metal sheets, such as aluminum, steel, galvanized steel, or ceramic plates may be utilized in forming the back-sheet.

Suitable film layers may be polymeric. Preferred polymers used to form the polymeric films, include but are not limited to, polyesters (e.g., poly(ethylene terephthalate)), poly(ethylene naphthalate), polycarbonate, polyolefins (e.g., polypropylene, polyethylene, and cyclic polyloefins), norbornene polymers, polystyrene (including syndiotactic polystyrene), styrene-acrylate copolymers, acrylonitrile-styrene copolymers, polysulfones (e.g., polyethersulfone, polysulfone, etc.), nylons, poly(urethanes), acrylics, cellulose acetates (e.g., cellulose acetate, cellulose triacetates, etc.), cellophane, vinyl chloride polymers (e.g., polyvinylidene chloride, vinylidene chloride copolymers, etc.), fluoropolymers (e.g., polyvinyl fluoride, polyvinylidene fluoride, polytetrafluoroethylene, ethylene-tetrafluoroethylene copolymers, etc.) and the like. Most preferably, the polymeric film is biaxially oriented polyester film (preferably poly(ethylene terephthalate) film) or a fluoropolymer film (e.g., Tedlar®, Tefzel®, and Teflon® films, from E. I. du Pont de Nemours and Company, Wilmington, DE). Fluoropolymer-polyester-fluoropolymer

("TPT") films are also preferred for some applications. Metal films, such as aluminum foil may also be used herein as the back-sheet.

The solar cell pre-laminate assembly of the invention, may optionally further comprise other functional film or sheet layers (e.g., dielectric layers or barrier layers) embedded within the assembly. Such functional layers may be derived from any of the above mentioned polymeric films or those that are coated with additional functional coatings. For example, poly(ethylene terephthalate) films coated with a metal oxide coating, such as those disclosed within US 6,521,825; US 6,818,819; and EP 1 182 710, may function as oxygen and moisture barrier layers in the laminates.

If desired, a layer of non-woven glass fiber (scrim) may also be included in the solar cell laminates to facilitate de-airing during the lamination process or to serve as reinforcement for the encapsulant layer(s). The use of such scrim layers within solar cell laminates is disclosed within, e.g., US 5,583,057; US 6,075,202; US 6,204,443; US 6,320,115; US 6,323,416; and EP 0 769 818.

In addition, it is understood that all the film or sheet layers positioned to the light-receiving side of the solar cell layer are made of transparent material to allow efficient transmission of sunlight into the solar cell component. In some instances, a special film or sheet may be included to serve both the function of an encapsulant layer and an outer layer. It is also conceivable that any of the film or sheet layers included in the assembly may be in the form of a pre-formed single-layer or multi-layer film or sheet.

If desired, one or both surfaces of the laminate layers of the solar cell pre-laminate assemblies may be treated to enhance the adhesion strength, as described above.

The solar cell pre-laminate assemblies may take any form known within the art. Preferable specific solar cell pre-laminate constructions (top (light incident) side to back side) include, for example, wherein "ION" means the preferable high melt flow ionomeric encapsulant film or sheet of the invention, as described above,

- glass/ION/solar cell/ION/glass;

- glass/ION/solar cell/ION/ fluoropolymer film;
- fluoropolymer film/ION/solar cell/ION/glass;
- fluoropolymer film/ION/solar cell/ION/ fluoropolymer film;
- glass/ION/solar cell/ION/polyester film;
- fluoropolymer film/ION/solar cell/ION/polyester film;
- glass/ION/solar cell/ION/barrier coated film/ION/glass;
- fluoropolymer film/ION/barrier coated film/ION/solar cell/ION/barrier coated film/ION/fluoropolymer film;
- glass/ION/solar cell/ION/aluminum stock;
- fluoropolymer film/ION/solar cell/ION/aluminum stock;
- glass/ION/solar cell/ION/galvanized steel sheet;
- glass/ION/solar cell/ION/polyester film/ION/aluminum stock;
- fluoropolymer film/ION/solar cell/ION/polyester film/ION/aluminum stock;
- glass/ION/solar cell/ION/polyester film/ION/galvanized steel sheet;
- fluoropolymer film/ION/solar cell/ION/polyester film/ION/galvanized steel sheet;
- glass/ION/solar cell/acoustic poly(vinyl butyral) encapsulant layer/glass;
- glass/ION/solar cell/poly(vinyl butyral) encapsulant layer/fluoropolymer film;
- fluoropolymer film/ION/solar cell/acid copolymer encapsulant layer/Tedlar® film;
- glass/ION/solar cell/ethylene vinyl acetate encapsulant layer/polyester film;
- fluoropolymer film/ION/solar cell/poly(ethylene-co-methyl acrylate) encapsulant layer/polyester film;
- glass/poly(ethylene-co-butyl acrylate) encapsulant layer/solar cell/ION/barrier coated film/poly(ethylene-co-butyl acrylate) encapsulant layer/glass;

and the like.

The preferred fluoropolymer film in each of the above examples is a Tedlar® fluoropolymer film or a fluoropolymer-polyester-fluoropolymer

trilayer film. The preferred polyester film in each of the above examples is a poly(ethylene terephthalate) film. The term "glass" is intended to refer to sheets of any of the aforementioned types of glass or glass alternatives.

The invention further provides solar cell laminates produced from the solar cell pre-laminate assemblies disclosed above. Specifically the solar cell laminates are formed by subjecting the solar cell pre-laminate assemblies to further lamination process, as provided below in detail.

Moreover, as discussed above, under the lamination temperature used herein, the high melt flow ionomeric encapsulant films or sheets possess higher adhesion strength than those encapsulant films or sheets derived from otherwise low melt flow ionomers, and therefore providing the solar cell laminate structures at the reduced lamination conditions described herein; and therefore provide solar cell laminate structures with a simplified production process.

LAMINATION PROCESS

The invention further provides a simplified process for producing the safety laminates or solar cell laminates. Specifically, as provided above, the incorporation of the high melt flow ionomeric interlayer sheets or high melt flow ionomeric solar cell encapsulant films or sheets requires reduced lamination temperatures , or cycle time, or both compared to those used in the process involving low melt flow ionomers.

The lamination process may be an autoclave or non-autoclave process.

In an exemplary process, a glass sheet, a front encapsulant layer, a solar cell component, a back encapsulant layer and a backing layer (e.g., Tedlar® film), and a cover glass sheet are laid up and laminated together under heat and pressure and a vacuum (for example, in the range of about 27-28 inches (689-711 mm) Hg) to remove air. Preferably, the glass sheet has been washed and dried. A typical glass type is 90 mil thick annealed low iron glass. In an exemplary procedure, the pre-laminate assembly of the invention is placed into a bag capable of sustaining a vacuum ("a vacuum bag"), drawing the air out of the bag using a vacuum line or other means of pulling a vacuum on the bag, sealing the bag while maintaining

the vacuum, placing the sealed bag in an autoclave at a temperature of about 100°C to about 180°C, at a pressure of about 150 to about 250, preferably about 200 psig (about 15 bar), for about 10 to about 50 minutes. Preferably the bag is autoclaved at a temperature of about 100°C to about 120°C for about 20 to about 45 minutes. More preferably the bag is autoclaved at a temperature of about 110°C to about 120°C for about 20 to about 40 minutes. A vacuum ring may be substituted for the vacuum bag. One type of vacuum bags is disclosed within US 3,311,517. The high melt flow ionomeric films and sheets of the invention provide the desirable advantage of lower lamination temperatures and/or faster lamination cycle times, depending on the laminator's choice.

Any air trapped within the pre-laminate assembly may be removed through a nip roll process. For example, the pre-laminate assembly may be heated in an oven at a temperature of about 80°C to about 120°C, or preferably, at a temperature of between about 90°C and about 100°C, for about 15 to about 60 (preferably about 30) minutes. Thereafter, the heated pre-laminate assembly is passed through a set of nip rolls so that the air in the void spaces between the solar cell outside layers, the solar cell component, and the encapsulant layers may be squeezed out, and the edge of the assembly sealed. This process may provide the final solar cell module or may provide what is referred to as a pre-press assembly, depending on the materials of construction and the exact conditions utilized.

The pre-press assembly may then be placed in an air autoclave where the temperature is raised to about 100°C to about 160°C, or preferably between about 110°C and about 120°C, and pressure to between about 100 psig and about 300 psig, or preferably, about 200 psig (14.3 bar). These conditions are maintained for about 15 minutes to about 1 hour, or preferably, about 20 to about 50 minutes, after which, the air is cooled while no more air is added to the autoclave. After about 10 to about 30 (preferably about 20) minutes of cooling, the excess air pressure is vented and the solar cell laminates are removed from the autoclave. This should not be considered limiting. Essentially any lamination process known within the art may be used herein.

A non-autoclave lamination process has been disclosed, e.g., within US 3,234,062; US 3,852,136; US 4,341,576; US 4,385,951; US 4,398,979; US 5,536,347; US 5,853,516; US 6,342,116; US 5,415,909; US 2004-0182493; US 2003-0148114 A1; EP 1 235 683 B1; WO 91/01880; and WO 03/057478 A1. Generally, the non-autoclave process includes heating the pre-laminate assembly or the pre-press assembly and, optionally, the application of vacuum, pressure or both. For example, the pre-press may be successively passed through heating ovens and nip rolls. A commercial example of a photovoltaic lamination process includes the Icolam vacuum laminating systems of Meier Vakuumtechnik GmbH, Bocholt, Germany.

In producing solar cell laminates, if desired, the edges of the laminates may be sealed to reduce moisture and air intrusion and the potential degradation effect on the efficiency and lifetime of the solar cell(s) by any means disclosed within the art. Suitable edge seal materials include, but are not limited to, butyl rubber, polysulfide, silicone, polyurethane, polypropylene elastomers, polystyrene elastomers, block elastomers, styrene-ethylene-butylene-styrene (SEBS), and the like.

EXAMPLES

The following Examples and are intended to be illustrative of the invention, and are not intended in any way to limit the scope of the invention.

METHODS

The following methods are used in the Examples presented hereafter.

Melt Index

Melt Index (MI) is measured by ASTM D1238 at 190°C using a 2160 g load. A similar ISO test is ISO 1133.

I. Lamination Process 1:

The laminate layers described below are stacked (laid up) to form the pre-laminate assembly described within the examples. For the assembly containing a film layer as the incident or back-sheet layer, a cover glass sheet is placed over the film layer. The pre-laminate assembly is then placed within a Meier ICOLAM 10/ 08 laminator, (Meier Vakuumtechnik GmbH, Bocholt, Germany). The lamination cycle includes an evacuation step (vacuum of 3 in. Hg) of 5.5 minutes and a pressing stage (pressure of 2 bar) of 5.5 minutes at a temperature of 115°C. For Examples 11, 16, 20, 52, 57 and 60 only, an additional step at 145°C for 5 minutes while maintaining the pressing conditions is incorporated to cure the composition. The laminate is then removed.

II. Lamination Process 2:

The laminate layers described below are stacked (laid up) to form the pre-laminate assemblies described within the examples. For the assembly containing a film layer as the incident or back-sheet layer, a cover glass sheet is placed over the film layer. The pre-laminate assembly is then placed within a vacuum bag, the vacuum bag is sealed and a vacuum is applied to remove the air from the vacuum bag. The bag is placed into an oven and heated to 90-100°C for 30 minutes to remove any air contained between the assembly. The pre-press assembly is then subjected to autoclaving at 115°C for 30 minutes in an air autoclave to a pressure of 200 psig (14.8 bar), as described above. The air is then cooled while no more air is added to the autoclave. After 20 minutes of cooling when the air temperature reaches less than about 50°C, the excess pressure is vented, and the laminate is removed from the autoclave.

EXAMPLES 1-20

The 12x12 in (305x305 mm) laminate structures described below in Table 1 are assembled and laminated by Lamination Process 1.

Table 1

	Laminate Structures				
Example	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
1, 21	Glass 1	ION 1	ION 1	Glass 1	
2, 22	Glass 1	ION 2	Glass 1		
3, 23	Glass 1	ION 2	ION 2	Glass 1	
4, 24	Glass 2	ION 3	PET 1	ION 3	Glass 2
5, 25	Glass 3	ION 4	EBA	ION 4	Glass 1
6, 26	Glass 1	ION 5	ION 5	PET 2	
7, 27	Glass 2	ION 6	PET 3	EVA	Glass 2
8, 28	Glass 1	ION 7	PET 1		
9, 29	Glass 1	ION 8	PET 4	PVB A	Glass 1
10, 30	Glass 2	ION 9	PET 5	PVB	PET 1
11, 31	Glass 1	ION 10	ION 11	ION 10	Glass 1
12, 32	Glass 2	ION 12	ION 12	PET 1	
13, 33	Glass 1	ION 13	PET 6	ION 13	Glass 1
14, 34	Glass 1	ION 14	ION 11	ION 14	Glass 1
15, 35	Glass 3	ION 15	PET 1	ION 15	Glass 2
16, 36	Glass 1	ION 16	ION 11	ION 16	Glass 1
17, 37	Glass 1	ION 17	PET 2	ION 17	Glass 1
18, 38	Glass 2	ION 18	PET 4	ION 18	Glass 2
19, 39	Glass 3	ION 19	ION 19	Glass 1	
20, 40	Glass 1	ION 20	Glass 1		

- ION 1 is a 20 mil (0.51 mm) thick embossed sheet of Ionomer A, a poly(ethylene-co-methacrylic acid) containing 15 wt% of polymerized residues of methacrylic acid that is 20% neutralized with zinc ion and having a MI of 30 g/10 min.
- ION 2 is a 60 mil (1.52 mm) thick embossed tri-layer sheet having (i) two (2) 2 mil (0.06 mm) thick surface layers formed of a blend of Ionomer B, a poly(ethylene-co-methacrylic acid) containing 18 wt% of polymerized residues of methacrylic acid that is 10% neutralized with sodium ion and having a MI of 50 g/10 min, and 0.15 wt% of TINUVIN 328 (Ciba Specialty Chemicals Company), based on the total weight of the blend, and (ii) a core layer formed of a poly(ethylene-co-methacrylic acid) containing 18

wt% of polymerized residues of methacrylic acid that is 35% neutralized with sodium ion and having a MI of 1 g/10 min.

- ION 3 is a 15 mil (0.38 mm) thick embossed tri-layer sheet having (i) two (2) 1 mil (0.03 mm) thick surface layers of Ionomer C, a poly(ethylene-co-methacrylic acid) containing 19 wt% of polymerized residues of methacrylic acid that is 7.5% neutralized with zinc ion and having a MI of 100 g/10 min and (ii) a core layer of a poly(ethylene-co-isobutyl acrylate-co-methacrylic acid) containing 10 wt% of polymerized residues of isobutyl acrylate and 10 wt% of polymerized residues of methacrylic acid that is 70% neutralized with zinc ions and having a MI of 1 g/10 min.
- ION 4 is a 1 mil (0.03 mm) thick film of Ionomer D, a poly(ethylene-co-methacrylic acid) containing 19 wt% of polymerized residues of methacrylic acid that is 5% neutralized with zinc ion and having a MI of 200 g/10 min.
- ION 5 is a 20 mil (0.51 mm) thick embossed sheet of Ionomer E, a poly(ethylene-co-methacrylic acid) containing 22 wt% of polymerized residues of methacrylic acid that is 7.5% neutralized with zinc ion and having a MI of 75 g/10 min.
- ION 6 is a 20 mil (0.51 mm) thick embossed sheet of Ionomer F, a composition comprising 99.5 wt% of Ionomer A and 0.5 wt% of N-beta-(aminoethyl)-gamma-aminopropyltrimethoxysilane, based on the total weight of the composition.
- ION 7 is a 90 mil (2.25 mm) thick embossed tri-layer sheet having (i) two (2) 1 mil (0.03 mm) thick surface layers of Ionomer G, a composition comprising 99.25 wt% of Ionomer B and 0.25 wt% of N-beta-(aminoethyl)-gamma-aminopropyltrimethoxysilane, based on the total weight of the composition, and (ii) a core layer of a poly(ethylene-co-n-butyl acrylate) containing 35 wt% of polymerized residues of n-butyl acrylate and having a MI of 3 g/10 min.
- ION 8 is a 20 mil (0.51 mm) thick embossed tri-layer sheet having (i) two (2) 2 mil (0.06 mm) thick surface layers of Ionomer H, a composition comprising 99.875 wt% of Ionomer C and 0.125 wt% of N-beta-(aminoethyl)-gamma-aminopropyltrimethoxysilane, based on the total weight of the composition, and (ii) a core layer of a poly(ethylene-co-methacrylic acid) containing 22 wt% of polymerized residues of

methacrylic acid that is 35% neutralized with sodium ion and having a MI of 1.5 g/10 min.

- ION 9 is a 15 mil (0.38 mm) thick embossed sheet of Ionomer I, a composition comprising 99.875 wt% of Ionomer D and 0.125 wt% of gamma-glycidoxypropyltriethoxysilane, based on the total weight of the composition.
- ION 10 is a 1 mil (0.03 mm) thick film of Ionomer J, a composition comprising 99.875 wt% of Ionomer E, 0.30 wt% of TINUVIN 1577, 0.30 wt% of CHIMASSORB 944, (products of the Ciba Specialty Chemicals Company), and 0.125 wt% of gamma-methacryloxypropyltrimethoxysilane, based on the total weight of the composition.
- ION 11 is a 90 mil (2.25 mm) thick embossed sheet of Ionomer K, a composition comprising 98.5 wt% of Ionomer A and 1.5 wt% of 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, based on the total weight of the composition.
- ION 12 is a 15 mil (0.38 mm) thick embossed sheet of Ionomer L, a composition comprising 98.0 wt% of Ionomer B and 2.0 wt% of 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, based on the total weight of the composition.
- ION 13 is a 20 mil (0.51 mm) thick embossed sheet of Ionomer M, a composition comprising 97.5 wt% of Ionomer C, 0.5 wt% of CYASORB UV-1164 (Cytec Industries), and 2.5 wt% of 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, based on the total weight of the composition.
- ION 14 is a 1 mil (0.03 mm) thick film of Ionomer N, a composition comprising 93.0 wt% of Ionomer D, 5.0 wt% of triallyl isocyanurate and 2.0 wt% of 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, based on the total weight of the composition.
- ION 15 is a 20 mil (0.51 mm) thick embossed tri-layer sheet having (i) two (2) 1 mil (0.03 mm) thick surface layers of Ionomer O, a composition comprising 95.0 wt% of Ionomer E, 3 wt% of trimethylolpropane triacrylate and 2.0 wt% of 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, based on the total weight of the composition and (ii) a core layer of poly(ethylene-co-methyl acrylate) containing 25 wt% of polymerized residues of methyl acrylate and having a MI of 5 g/10 min.

- ION 16 is a 1 mil (0.03 mm) thick film of Ionomer P, a composition comprising 98.0 wt% of Ionomer A, 0.5 wt% of vinyltrimethoxysilane, and 1.5 wt% of 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, based on the total weight of the composition.
- ION 17 is a 20 mil (0.51 mm) thick embossed sheet of Ionomer Q, a composition comprising 97.75 wt% of Ionomer B, 0.25 wt% of gamma-methacryloxypropyltrimethoxysilane, and 2.0 wt% of 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, based on the total weight of the composition.
- ION 18 is a 15 mil (0.38 mm) thick embossed tri-layer sheet having (i) two (2) 1 mil (0.03 mm) thick surface layers of Ionomer R, a composition comprising 97.375 wt% of Ionomer C, 0.125 wt% of N-beta-(N-vinylbenzylaminoethyl)-gamma-aminopropyltrimethoxysilane, and 2.5 wt% of 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, based on the total weight of the composition and (ii) a core layer of a poly(ethylene-co-methacrylic acid) containing 18 wt% of polymerized residues of methacrylic acid that is 70% neutralized with sodium ion and having a MI of 1.5 g/10 min.
- ION 19 is a 20 mil (0.51 mm) thick embossed tri-layer sheet having (i) two (2) 2 mil (0.06 mm) thick surface layers of Ionomer S, a composition comprising 92.875 wt% of Ionomer D, 5.0 wt% of triallyl isocyanurate, 0.125 wt% of gamma-methacryloxypropyltrimethoxysilane, and 2.0 wt% of 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, based on the total weight of the composition and (ii) a core layer of a poly(ethylene-co-methacrylic acid) containing 22 wt% of polymerized residues of methacrylic acid that is 35% neutralized with zinc ion and having a MI of 0.5 g/10 min.
- ION 20 is a 90 mil (2.25 mm) thick embossed sheet of Ionomer T, a composition comprising 94.875 wt% of Ionomer E, 3 wt% of trimethylolpropane triacrylate, 0.125 wt% of N-beta-(N-vinylbenzylaminoethyl)-gamma-aminopropyltrimethoxysilane, CYASORB UV-1164, TINUVIN 123, and 2.0 wt% of 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, based on the total weight of the composition.
- PVB A is a 40 mil (1.02 mm) thick acoustic poly(vinyl butyral) sheet containing 100 parts per hundred (pph) poly(vinyl butyral) with a hydroxyl number of 15 and plasticized with 48.5 pph plasticizer tetraethylene glycol

diheptanoate, prepared in a way similar to those disclosed in PCT Patent Application No. WO 2004/039581.

EXAMPLES 21-40

The 12x12 in (305x305 mm) solar cell laminate structures described above in Table 1 are assembled and laminated by Lamination Process 2, above.

EXAMPLES 41-60

The 12x12 in (305x305 mm) solar cell pre-laminate structures described below in Table 2 are assembled and laminated by Lamination Process 1, above. Layers 1 and 2 constitute the incident layer and the front-sheet encapsulant layer, respectively, and Layers 4 and 5 constitute the back-sheet encapsulant layer and the backing layer, respectively.

Table 2

Solar Cell Pre-Lamination Structures

Example	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
41, 61	Glass 4	ION 1	Solar Cell 1	ION 1	FPF
42, 62	Glass 4	EVA	Solar Cell 2	ION 2	Glass 1
43, 63	Glass 4	ION 3	Solar Cell 3	ION 2	AL
44, 64	Glass 2	ION 3	Solar Cell 4	ION 3	Glass 2
45, 65	FPF	ION 4	Solar Cell 1	ION 4	FPF
46, 66	Glass 1	ION 5	Solar Cell 2	ION 5	PET 1
47, 67	Glass 4	ION 6	Solar Cell 3	ION 6	FPF
48, 68	Glass 4	ION 6	Solar Cell 4	ION 7	PET 1
49, 69	Glass 4	ION 8	Solar Cell 1	ION 8	Glass 1
50, 70	Glass 4	ION 9	Solar Cell 2	ION 9	FPF
51, 71	FPF	ION 10	Solar Cell 3	ION 10	FPF
52, 72	Glass 2	ION 12	Solar Cell 4	ION 11	Glass 2
53, 73	Glass 4	ION 13	Solar Cell 1	ION 13	FPF
54, 74	FPF	ION 14	Solar Cell 2	ION 14	PET 1
55, 75	Glass 4	ION 15	Solar Cell 3	ION 15	AL
56, 76	FPF	ION 16	Solar Cell 4	ION 16	FPF
57, 77	Glass 4	ION 17	Solar Cell 1	ION 17	Glass 1
58, 78	Glass 4	ION 18	Solar Cell 2	ION 18	FPF
59, 79	FPF	ION 19	Solar Cell 3	ION 19	AL
60, 80	Glass 4	ION 19	Solar Cell 4	ION 20	

EXAMPLES 61-80

The 12x12 in (305x305 mm) solar cell pre-laminate structures described above in Table 2 are assembled and laminated by Lamination Process 2, above. Layers 1 and 2 constitute the incident layer and the front-sheet encapsulant layer, respectively, and Layers 4 and 5 constitute the back-sheet encapsulant layer and the backing layer, respectively.

COMPARATIVE EXAMPLE CE1 EXAMPLE 81

In Comparative Example CE1, 50 grams of a low melt flow ionomer, which was a poly(ethylene-co-methacrylic acid) copolymer containing 15

wt% polymerized residues of methacrylic acid that is 23% neutralized with zinc ions and having a MI of 5 g/10 min, was added to a 90°C preheated Brabender Rheometer (C. W. Brabender Instruments, Inc., So. Hackensack, NJ) equipped with a 50 cc mixing head over 1 minute, while the speed of the mixing blades was set at 8 rpm. The speed of the mixing blades was then increased to 30 rpm and the polymer resin was further mixed for 1 minute, after which the shear pin sheared due to high torque and the mixing motor was at 5 amps. The process was then shut down.

In Example 81, 50 grams of a high melt flow ionomer, which was a poly(ethylene-co-methacrylic acid) copolymer containing 15 wt% polymerized residues of methacrylic acid that is 11.9% neutralized with zinc ions and having a MI of 100 g/10 min, was added to a 90°C preheated Brabender Rheometer equipped with a 50 cc mixing head over 1 minute, while the speed of the mixing blades was set at 8 rpm. The speed of the mixing blades was then increased to 30 rpm and the polymer resin was further mixed for 5 minutes, after which a homogeneous polymer melt was achieved with the mixing motor at 1 amp and the polymer melt temperature at 101°C. The process was shut down.

These results demonstrated that high melt flow ionomers (Example 81) can be compounded at temperatures low enough (about 90°C) for the incorporation of organic peroxides through commercially-viable and scalable extrusion compounding equipment while the corresponding low melt flow ionomers (Comparative Example CE1) can not.

WHAT IS CLAIMED IS:

1. A polymeric film or sheet comprising an ionomeric composition comprising ionomeric copolymer of an alpha olefin and about 1 to about 30 wt% of alpha,beta-ethylenically unsaturated carboxylic acid having 3 to 8 carbons, based on the total weight of the ionomeric copolymer, wherein the carboxylic acid is neutralized to a level of 1 to 100 mol%, with one or more metal ions, based on the total number of moles of carboxylate groups in the ionomeric copolymer, and wherein the ionomeric copolymer has a Melt Index of about 20 to about 300 g/10 min.

2. The polymeric film or sheet of claim 1 wherein the ionomeric composition further comprises an additive selected from the group consisting of silane coupling agent, organic peroxide, and combinations thereof.

3. An article comprising an interlayer formed of the polymeric film or sheet of claim 1 or 2 and an additional layer selected from the group consisting of glass, other polymeric interlayer sheets, polymeric film layers, and metal films or sheets.

4. The polymeric film or sheet of claim 1 or 2 or article of claim 3, wherein (a) the alpha olefin is ethylene; (b) the alpha,beta-ethylenically unsaturated carboxylic acid is selected from the group consisting of acrylic acid, methacrylic acid, itaconic acid, maleic acid, maleic anhydride, fumaric acid, monomethyl maleic acid, and mixtures thereof; (c) the ionomeric copolymer comprises about 10 to about 25 wt% of the alpha,beta-ethylenically unsaturated carboxylic acid; (d) the carboxylic acid is neutralized to a level of 2 to 40 mol%, with one or more metal ions, based on the total number of moles of carboxylate groups in the ionomeric copolymer; (e) the ionomeric copolymer has a Melt Index of about 30 to about 200 g/10 min, and (f) the interlayer has a thickness of about 0.1 to about 250 mils (about 0.003 to about 6.35 mm).

5. The polymeric film or sheet of claim 2 or article of claim 3 or 4, wherein the ionomeric composition contains about 0.01 to about 5 wt% of the silane coupling agent, based on the total weight of the ionomeric composition, and the silane coupling agent is selected from the group consisting of gamma-chloropropylmethoxysilane, vinyltrimethoxysilane,

vinyltriethoxysilane, vinyltris(beta-methoxyethoxy)silane,gamma-vinylbenzylpropyltrimethoxysilane, N-beta-(N-vinylbenzylaminoethyl)-gamma-aminopropyltrimethoxysilane, gamma-methacryloxypropyltrimethoxysilane, vinyltriacetoxysilane, gamma-glycidoxypropyltrimethoxysilane, gamma-glycidoxypropyltriethoxysilane, beta-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, vinyltrichlorosilane, gamma-mercaptopropylmethoxysilane, gamma-aminopropyltriethoxysilane, N-beta-(aminoethyl)-gamma-aminopropyltrimethoxysilane, and mixtures thereof.

6. The polymeric film or sheet of claim 2 or article of claim 3 or 4, wherein the ionomeric composition contains about 0.01 to about 10 wt% of the organic peroxide, based on the total weight of the ionomeric composition, and the organic peroxide is selected from the group consisting of 2,5-dimethylhexane-2,5-dihydroperoxide, 2,5-dimethyl-2,5-di(tert-betylperoxy)hexane-3, di-tert-butyl peroxide, tert-butylcumyl peroxide, 2,5-dimethyl-2,5-di(tert-butylperoxy)hexane, dicumyl peroxide, alpha, alpha'-bis(tert-butyl-peroxyisopropyl)benzene, n-butyl-4,4-bis(tert-butylperoxy)valerate, 2,2-bis(tert-butylperoxy)butane, 1,1-bis(tert-butyl-peroxy)cyclohexane, 1,1-bis(tert-butylperoxy)-3,3,5-trimethyl-cyclohexane, tert-butyl peroxybenzoate, benzoyl peroxide and mixtures thereof.

7. The article of any of claims 3-6, which is a safety glass laminate wherein the additional layer is a glass sheet and the interlayer has a thickness of about 10 to about 250 mils (about 0.25 to about 6.35 mm) and is laminated to the glass sheet.

8. The article of any of claims 3-6, which is a solar cell pre-laminate assembly and wherein the assembly comprises a solar cell component comprising one or a plurality of solar cells the polymeric film or sheet has a thickness of about 0.1 to about 20 mils (about 0.003 to about 0.5 mm).

9. The article of claim 8, further comprising a second polymeric layer that is positioned next to the solar cell component on the opposite side from the polymeric film or sheet, wherein the second polymeric layer comprises a polymeric composition selected from the group consisting of poly(vinyl acetal), ethylene vinyl acetate, polyurethane, polyvinylchloride,

polyethylenes, polyolefin block elastomers, ethylene acrylate ester copolymers, copolymer of alpha olefin and alpha,beta-ethylenically unsaturated carboxylic acid and ionomers thereof, silicone elastomers and epoxy resins.

10. The article of claim 8 or 9, further comprising (A) an incident layer that is formed of a transparent material and serves as an outer layer at the light-receiving side of the assembly, and/or (B) a backing layer that is formed of glass, a plastic film or sheet, or a metal film or sheet and serves as an outer layer at the back side of the assembly.

11. A process of manufacturing an article, wherein the article is a solar cell module, the process comprising: (i) providing a solar cell pre-laminate assembly as described in any of claims 8-10, and (ii) laminating the pre-laminate assembly to form the solar cell module.

12. The process of claim 13, wherein the step (ii) of lamination is conducted by subjecting the assembly to heat and, optionally, vacuum.

13. An article prepared by the process of claim 11 or 12.

14. A polymeric composition comprising an ionomeric composition and an additive, wherein (i) the ionomeric composition comprises a copolymer of an alpha olefin and about 1 to about 30 wt% of an alpha,beta-ethylenically unsaturated carboxylic acid having 3 to 8 carbons, based on the total weight of the ionomeric copolymer, wherein the carboxylic acid is neutralized to a level of 1 to 100 mol%, with one or more metal ions, based on the total number of moles of carboxylate groups in the ionomeric copolymer, (ii) the ionomeric copolymer has a Melt Index of about 20 to about 300 g/10 min and (iii) the additive is selected from the group consisting of silane coupling agent, organic peroxide, and combinations thereof.

15. The polymeric composition of claim 15, wherein (A) the ionomeric copolymer has a Melt Index of about 30 to about 200 g/10 min, (B) the alpha olefin is ethylene, (C) the alpha,beta-ethylenically unsaturated carboxylic acid is selected from the group consisting of acrylic acid, methacrylic acid, itaconic acid, maleic acid, maleic anhydride, fumaric acid, monomethyl maleic acid, and mixtures thereof, (D) the ionomeric composition comprises about 10 to about 25 wt% of repeat units

from the alpha,beta-ethylenically unsaturated carboxylic acid, based on the total weight of the ionomeric copolymer, and (E) the carboxylic acid is neutralized to a level of 2 to 40 mol%, with one or more metal ions, based on the total number of moles of carboxylate groups in the ionomeric copolymer.

16. The polymeric composition of claim 15 or 16, wherein the polymeric composition comprises, based on the total weight of the composition, about 0.01 to about 5 wt% of a silane coupling agent selected from the group consisting of gamma-chloropropylmethoxysilane, vinyltrimethoxysilane, vinyltriethoxysilane, vinyltris(beta-methoxyethoxy)silane,gamma-vinylbenzylpropyltrimethoxysilane, N-beta-(N-vinylbenzylaminoethyl)-gamma-aminopropyltrimethoxysilane, gamma-methacryloxypropyltrimethoxysilane, vinyltriacetoxysilane, gamma-glycidoxypropyltrimethoxysilane, gamma-glycidoxypropyltriethoxysilane, beta-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, vinyltrichlorosilane, gamma-mercaptopropylmethoxysilane, gamma-aminopropyltriethoxysilane, N-beta-(aminoethyl)-gamma-aminopropyltrimethoxysilane, and mixtures thereof.

17. The polymeric composition of claim 15 or 16, wherein the polymeric composition comprises, based on the total weight of the polymeric composition, about 0.01 to about 10 wt% of an organic peroxide selected from the group consisting of 2,5-dimethylhexane-2,5-dihydroperoxide, 2,5-dimethyl-2,5-di(tert-betylperoxy)hexane-3, di-tert-butyl peroxide, tert-butylcumyl peroxide, 2,5-dimethyl-2,5-di(tert-butylperoxy)hexane, dicumyl peroxide, alpha, alpha'-bis(tert-butyl-peroxyisopropyl)benzene, n-butyl-4,4-bis(tert-butylperoxy)valerate, 2,2-bis(tert-butylperoxy)butane, 1,1-bis(tert-butyl-peroxy)cyclohexane, 1,1-bis(tert-butylperoxy)-3,3,5-trimethyl-cyclohexane, tert-butyl peroxybenzoate, benzoyl peroxide and mixtures thereof.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/002094

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08J5/18

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C08J

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/121219 A1 (SHELBY MARCUS D [US] ET AL) 8 June 2006 (2006-06-08) claims 1-40; examples 1-12	1-17
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X	WO 03/064166 A (3M INNOVATIVE PROPERTIES CO [US]) 7 August 2003 (2003-08-07) claims 1-46; examples 1-19	1-17
X	WO 03/054260 A (3M INNOVATIVE PROPERTIES CO [US]) 3 July 2003 (2003-07-03) claims 1-33; examples 1-15	1-17

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 May 2008	30/05/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Glomm, Bernhard

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/002094

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 5 037 875 A (DEGARAVILLA JAMES R [US]) 6 August 1991 (1991-08-06) claims 1-9; examples 1-3	1-17

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Information on patent family members

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