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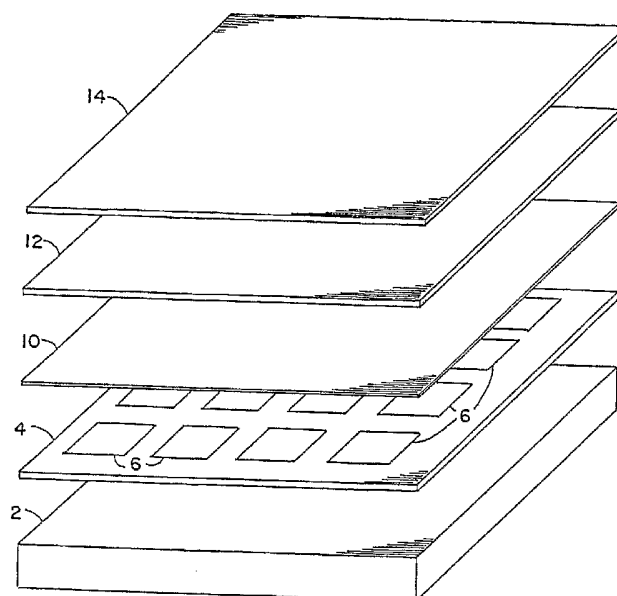
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(54) Title: SOLAR ENCAPSULANTS WITH PROTECTIVE ADDITIVES



(57) Abstract: The ability of solar cell encapsulant materials comprising an ionomer, EVA or a block polymer composition of the type described in U.S. Patents Nos. 4,749,430 and 4,692,557 to withstand discoloration and degradation from exposure to UV radiation is improved by incorporating in the encapsulant material a selected triazine UV absorber that does not react with the metals that interconnect the solar cells. A preferred embodiment of the invention involves the addition of a metal deactivator. An anti-oxidant may be added to augment the ability of the metal deactivator to reduce the metal reactivity of the ionomer, EVA or block polymer composition.

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Solar Encapsulants With Protective Additives

This application claims the benefit of my copending U.S. Provisional Patent Application No. 60/657,289, filed March 1, 2005 for "Solar Encapsulants Based On Block Polymers With Protective Additives"; Provisional Patent Application No. 60/662,401, filed March 16, 2005 for "EVA Solar Encapsulants With Protective Additives; and Provisional Patent Application No. 60/662,425, filed March 16, 2005 for "Ionomer Solar Encapsulants With Protective Additives".

Field of the Invention

This invention relates to the manufacture of photovoltaic solar cell modules and more particularly to an improved encapsulant material for encapsulating the solar cells in the modules.

Background of the Invention

Most photovoltaic solar cells, e.g., silicon solar cells, are relatively small and hence conventional industry practice is to electrically interconnect a row of cells in series to form a string, and to electrically interconnect several strings together in a selected series and/or parallel arrangement so as to form a physically integrated module with a correspondingly greater power output. The solar cells typically have a first grid contact on their front side that comprises silver and collects current from across the width of the cells, and a second contact on their back side that typically comprises aluminum and/or silver. Electrical interconnection of the cells is typically accomplished by copper tabbing. Those conductors are commonly arranged to form stress relief loops to compensate for expansion and contractions caused by temperature changes. Two or more modules may be connected together in a selected series and/or parallel arrangement to form a larger array with correspondingly greater power output.

An essential aspect of solar cell modules is the need to mechanically support and protect the cells against environmental degradation. Accordingly the typical module arrangement comprises disposing the cells between a transparent front (top) protective support sheet or superstrate (usually a glass plate) and a back (bottom) support sheet or substrate, with the cells being encapsulated by a transparent or light-transmitting polymeric encapsulant that is bonded to the front and back support sheets. The back support sheet may be in the form of glass plate or a flexible polymeric sheet (commonly called the "backskin") such as, but not limited to, Tedlar/Polyester/Tedlar ("TPT"), Tedlar/Polyester/EVA ("TPE"), and Polyester/Silicon Dioxide/Polyester. By way of example but not limitation the modules may take the form of the modules described and illustrated in U.S. Patents Nos. 4,692,557, 5,733,382, 5,994,641, and 6,660,930. The disclosures of those patents are incorporated herein by reference.

The light-transmitting encapsulant serves three functions: it allows sunlight to impinge on the solar cells; it bonds together the front and back support sheets so as to form a laminated structure with the solar cells disposed between those sheets; and it provides protection for the cells against environmental degradation. A large number of materials have been considered for use as solar cell encapsulants, including ionomers (as disclosed in U. S. Patents Nos. 5,478,402, 5,476,553, and 6,353,042), ethylene vinyl acetate copolymer, commonly known as "EVA" (as disclosed in U.S. Patents Nos. 6,586,271 and 6,093,757), block polymers (as disclosed in U.S. Patents 4,749,430 and 4,692,557), and thermoplastic polyurethane (TPU) polymers. The conventional practice is to incorporate an ultraviolet (UV) absorber and other additives in the encapsulant composition to protect the encapsulant against degradation and/or improve performance of the module. However, the foregoing encapsulant materials have suffered from the limitation that they still tend to degrade, albeit at different rates, under the influence of UV radiation, with the degradation being evidenced by discoloration of the encapsulant. For example, EVA gets progressively darker as it decomposes under sunlight, and its decomposition releases acetic acid, which in turn promotes further

degradation, particularly in the presence of heat and/or oxygen. The tendency of a given encapsulant to degrade will be evidenced by discoloration occurring within the first year following daily exposure of the solar modules to sunlight.

The present invention stems from my discovery of a weakness in the additives commonly used for preventing degradation of the encapsulants over the course of the product lifetimes of the solar modules. Testing of some encapsulant materials provided by a manufacturer and comprising a thermoplastic polyurethane (TPU) polymer plus a UV absorber and two other additives revealed that rapid yellowing occurred when the encapsulant materials were exposed to accelerated testing conditions of heat, humidity and UV radiation. Some of these materials were quite stable when tested between sheets of glass without the presence of any solar cells, but discolored fairly rapidly when solar cells were incorporated in the test samples. Moreover, the discoloration was most pronounced in the regions of the solar cell where silver electrical conductors were present. I also learned that similar problems had been observed when TPU polymers were similarly stressed in the presence of copper, and that the polymer was not at fault, but rather one or more of the additives. This cause was known because elimination of all of the additives from their encapsulant formulation eliminated the discoloration effect.

The foregoing knowledge lead to further experimentation with different TPU polymer samples each containing only one of the three additives contained in the original test. That experimentation resulted in the determination that only one of the three additives was at fault in causing the discoloration, and that was the UV absorber. Although the manufacturer of the TPU polymer samples did not disclose the identity of the three additives, I made the assumption that the absorber used in the TPU sample could be similar to the UV absorbers used in EVA solar encapsulants which years earlier had been found to undergo accelerated degradation in the presence of metals.

The block copolymers described in U.S. Patents 4,749,430 and 4,692,557 offer certain advantages with respect to serving as a solar cell encapsulant. Those block polymers are thermoplastic and, in comparison to EVA, they do not expand or

contract as much, absorb less moisture, and become softer at lower temperatures. The latter aspect is advantageous with respect to forming a laminated solar module as described above. However, use of block polymer formulations as solar cell encapsulants has not been successful due to discoloration and deterioration occurring after exposure to sunlight for a relatively short period. U.S. Patents Nos. 4,749,430 and 4,692,557 describe an encapsulant formulation as containing a benzotriazole UV absorber (Tinuvin 327 sold by Ciba Specialty Chemicals Corporation) that is similar to those used in EVA formulations. Based on my experimental work, I concluded that the too rapid degradation of the block polymer encapsulant formulations might be due to the sensitivity to metals as had been seen in EVA and TPU encapsulant formulations.

Further investigation into the phenomenon of deterioration of polymer encapsulants in the presence of a metal such as silver confirmed that polymer degradation had been observed in the case of use of benzophenone UV absorbers as well as benzotriazole UV absorbers in EVA encapsulation formulations. As a consequence of additional investigation of UV absorbers and other additives for solar cell encapsulants, I learned that another class of UV absorbers that do not appear to lead to reactions with metals in contact with polymer metals are the hydroxylphenyl triazines. One such compound, 2-(4,6-Diphenyl-1,3,5-triazin-2-yl)-5-hexyloxy-phenol, marketed by Ciba Specialty Chemicals Corporation under the tradename Tinuvin 1577, was known to be effective as a UV absorber, relatively easy to incorporate into many polymers and more stable to UV radiation than benzophenone and benzotriazole UV absorbers. It would, therefore, be expected to protect any polymer containing it against UV-induced discoloration and degradation for a longer period than those other absorbers. Subsequently, test samples were constructed using as an encapsulant a block polymer of the type disclosed and claimed in said U.S. Patents Nos. 4,749,430 and 4,692,557, plus Tinuvin 1577, and exposed to a variety of testing conditions, including UV exposure. The block polymer was the product marketed by Kraton Polymers under the trade name Kraton G1726. The test samples containing Tinuvin 1577 did not fare well, showing

relatively rapid onset of discoloration, even in the case of samples that did not contain silver.

However, in comparison to benzotriazole and benzophenone UV absorbers, triazine UV absorbers tend to have a lesser tendency toward causing encapsulant degradation in the presence of metals. Accordingly there existed the possibility that another triazine UV absorber compound could be found that would not promote or cause accelerated polymer degradation due to the presence of metal conductors in the solar cell module.

Objects and Summary of the Invention.

The primary object of this invention is to provide a new solar cell encapsulating material that is characterized by improved photothermal and photochemical stability.

Another primary object of this invention is to provide a solar cell module characterized by a new solar cell encapsulating material that exhibits improved photothermal and photochemical stability.

A more specific object of this invention is to provide a new solar cell encapsulant formulation comprising an ionomer, EVA, or a block polymer composition as disclosed and claimed in U.S. Patents Nos. 4,749,430 and 4,692,557 and a UV absorber that provides improved resistance to discoloration and deterioration under the influence of UV radiation.

Another specific object is to provide a solar cell module with a novel solar cell encapsulant formulation that comprises a polymeric encapsulant from the group consisting of an ionomer, EVA, or a block polymer composition as disclosed and claimed in U.S. Patents Nos. 4,749,430 and 4,692,557 and a UV absorber, and which is characterized by an improved resistance to discoloration and deterioration under the influence of UV radiation.

Still another object is to provide a UV absorber/additives package for use in improving the resistance to discoloration and deterioration of encapsulant formulations wherein an ionomer, EVA or a block polymer composition as disclosed

and claimed in U.S. Patents Nos. 4,749,430 and 4,692,557 serves as the cell-encapsulating polymer.

A more specific object is to provide a new and improved encapsulant composition that essentially comprises a block polymer of the type disclosed and claimed in U.S. Patents Nos. 4,749,430 and 4,692,557 and is characterized by improved resistance to discoloration and deterioration from exposure to UV radiation.

Still another specific object of this invention is to provide an encapsulating material comprising a block polymer, a tackifying resin, UV absorber, and hindered amine light stabilizer that exhibits enhanced stability against moisture and thermal decomposition.

The foregoing objects are achieved by using in combination with the encapsulating polymer the UV absorber sold under the trade name Cyasorb UV-1164. A preferred embodiment of the invention includes addition of metal deactivator and anti-oxidant to maximize resistance to reaction.

Other objects features and advantages of the invention will be obvious to persons skilled in the art from the following specific description of the invention which is to be considered together with the accompanying drawing.

The Drawings

Figs. 1 and 2 schematically illustrate components of a conventional form of solar cell module which is modified to incorporate the present invention.

Specific Description of the Invention

With respect to cell encapsulants that comprise a block polymer composition and a tackifying resin as disclosed in U.S. Patents Nos. 4,749,430 and 4,692,557 (which patents are incorporated herein by reference), the invention is practiced by adding to those components a UV absorber in the form of Cyasorb UV-1164 or Cyasorb THT-6460, and a hindered amine light stabilizer (HALS). In another embodiment, the block polymer-based encapsulant is further modified by the

addition of an anti-oxidant. A preferred embodiment includes the addition of a metal deactivator and an anti-oxidant.

More specifically, the block polymer-based encapsulant compositions provided by this invention utilize as the polymer encapsulant a blend of:

about 65 to 75 parts by weight of a selectively hydrogenated two-block polymer wherein one polymer block is designated by A and a second polymer block is designated by B such that prior to hydrogenation,

(1) each A is a polymer block of a monovinyl or alpha alkyl monovinyl arene having a number average molecular weight in the range of from about 5,000 to about 75,000, said A blocks comprising from about 10 to about 40% by weight of the total block copolymer, and

(2) each B is a polymer block having a number average molecular weight in the range of from about 10,000 to about 150,000 and is formed by polymerizing a conjugated diene having from 4 to 10 carbon atoms per molecule, and said B blocks comprising from about 90 to about 60% by weight of the total block copolymer, and

about 25 to about 35 parts by weight of a selectively hydrogenated multiblock copolymer which contains at least two kinds of polymer blocks wherein one polymer block is designated by A and a second polymer block is designated by B such that:

(1) each A is a polymer endblock of a monovinyl or alpha alkyl monovinyl arene having a number average molecular weight in the range of from about 5,000 to about 75,000, said A blocks comprising from about 10 to about 90% by weight of the total block copolymer, and

(2) each B is a polymer midblock having a number average molecular weight in the range of from about 10,000 to about 150,000 and is formed by polymerizing a conjugated diene having from 4 to 10 carbon atoms per molecule, and said B blocks comprising from about 90 to about 10% by weight of the total block copolymer.

In practice of the invention using block copolymers, it is preferred to use the block polymer composition product sold by Kraton Polymers US LLC under the

tradename Kraton G1726. The composition of that product is set forth in U.S. Patent No. 4,692,557. It is further characterized by its manufacturer as a clear, linear triblock polymer based on styrene and ethylene/butylene, with a polystyrene content of 30%.

The tackifying resin is required to assure that the block polymer-based encapsulant material will adhere strongly to the adjacent components of a solar module. Preferably the tackifying resin is Regalrez 1094, a product of Eastman Chemical Company. Regalrez 1094 is a hydrogenated alpha-methyl styrene polymer. As an alternative, the Regalrez 1094 may be replaced by some other tackifying resin, e.g., the resin marketed by Arakawa Chemical Company under the trade name Arkon P85. Still other tackifying resins compatible with the block-polymer may be used.

Cyasorb UV-1164 is the tradename for the following: 2-[4,6-Bis(2,4-dimethylphenyl)-1,3,5-triazin-2-yl]-5-(octyloxy)phenol, with a melting point in the range of 88.0 to 91.0 °C. Cyasorb THT-6460 contains the foregoing Cyasorb UV-1164 compound plus other ingredients, including a hindered amine light stabilizer believed to be 1,6-hexanediamine, N, N'-bis(1,2,2,6,6-pentamethyl-4-piperidiny)-, polymers with morpholine-2,4,6-trichloro-1,3,5-triazine.

One suitable hindered amine light stabilizer (HALS) is Chimassorb 119, manufactured by Ciba Specialty Chemicals. Chimassorb 119 is the trade name for 1,3,5-triazine-2,4,6-triamine, N,N'''-[1,2-ethane-diyl-bis [[4,6-bis-[butyl (1,2,2,6,6-pentamethyl-4-piperidiny)amino] -1,3,5-triazine-2-yl] imino]-3,1-propanediyl]] bis [N',N''- dibutyl-N,N''-bis (1,2,2,6,6-pentamethyl-4-piperdiny)-. Other hindered amine light stabilizers may be used in combination with the Cyasorb UV-1164 light absorber. No hindered amine light stabilizer compound need be added if the light absorber is Cyasorb THT-6460, since that material already includes a HALS.

A block polymer-type encapsulant material is prepared by blending together a block polymer composition as described above, a tackifying resin, Cyasorb UV-1164 absorber, and a hindered amine light stabilizer (HALS) in the following proportions by weight: between about 80 to about 90 % block polymer composition,

between about 10 to about 20 % tackifying resin, between about 0.2 to about 1.0 % absorber, and between about 0.3 and about 0.6 % HALS. The step of adding the hindered amine light stabilizer may be omitted if the Cyasorb UV-1164 is replaced by Cyasorb THT-6460 since the latter contains a HALS. The resultant composition may be formed into flat sheets and used as a cell encapsulant in the manufacture of solar modules.

By way of example, a solar module comprising an encapsulant material formed by blending together 80 wt. % Kraton G 1726, about 19 wt. % Regalrez 1094, 0.4 wt.% Cyasorb UV-1164 and 0.4 wt.% Chimassorb 119 will exhibit an improved resistance to discoloration and degradation of the encapsulant under intensive exposure to UV radiation notwithstanding the encapsulant being in contact with metal conductors in the modules, such resistance being significantly better than that of prior encapsulants based on the block polymers described above.

In my investigations of UV absorbers as detailed above I also conceived the idea of using another additive to further suppress degradation mechanisms involving the presence of metals. Accordingly an alternative embodiment of this invention comprises adding the metal deactivator product sold by Ciba Specialty Chemicals under the trade name Irganox MD 1024 to the encapsulant formulation. The chemical name for Irganox MD 1024 is 2',3-bis[[3-[3,5-di-tert-butyl-4-hydroxyphenyl] propionyl]] propionohydrazide (also known as 1,2-bis(3,5-di-tert-butyl-4-hydroxyhydrocinnamoyl) hydrazine), CAS No. 32687-78-8. This deactivator enhances the lifetime of solar modules in that it suppresses degeneration of the absorber-containing encapsulant due to the presence of the conductors that interconnect the solar cells. The amount of this additive added to the encapsulant composition is between about 0.1 and about 1.0 % by weight, preferably between about 0.1 and 0.5 %.

As an optional measure an anti-oxidant may be added to the encapsulant composition, with or without the presence of the Irganox MD 1024. However, it has been observed that the MD 1024 works well in combination with Irganox 1010, a commonly used antioxidant, to prolong polymer lifetime. Irganox 1010 has been

identified by its manufacturer, Ciba Specialty Chemicals, as tetrakis-[methylene-(3,5-di-terbutyl-4-hydrocinnamate)] methane (CAS No. 6683-19-8). More specifically, prior to my invention it was known that the combination of Irganox MD 1024 and Irganox 1010, when provided in the proper proportions, increases the time to failure (by an unspecified criterion, possibly mechanical in nature) of polyethylene in contact with copper by as much as a factor of two, over the time to failure of a formulation containing Irganox 1010 without any Irganox MD 1024. Hence I concluded and confirmed that, by utilizing the synergistic combination of Irganox MD 1024 and Irganox 1010, the preservation of encapsulant polymer properties, such as light transmission, may be extended by a similar factor.

Accordingly for this invention it is preferred to include both Irganox MD 1024 and Irganox 1010 in the encapsulant composition, with the Irganox MD 1024 serving to significantly prolong the useful lifetime of the encapsulant, both by means of its primary activity in reducing metal reactivity with polymers, and also through the synergistic effect between the Irganox 1010 and Irganox MD 1024 described in the preceding paragraph. The Irganox 1010 may be replaced by another anti-oxidant, e.g. the compound sold by Ciba Specialty Chemicals under the tradename Irganox 3114. As indicated above, the MD 1024 is added to the encapsulant composition in an amount ranging from about 0.1 wt. % to about 1.0 wt. %, preferably not more than about 0.5 wt. %. The anti-oxidant, e.g. Irganox 1010 or Irganox 3114, may be added in an amount ranging from about 0.1 wt. % to about 2.0 wt. %.

Figs. 1 and 2 schematically illustrate components of a conventional form of solar cell module which is modified to incorporate the present invention. In Fig. 2, the thicknesses of the components are not intended to be to scale. The components used to construct the solar cell module comprise a transparent front panel or superstrate 2, a first layer 4 of a light transmitting encapsulant, an array of separately formed crystalline solar cells 6 interconnected by conductors 8 (Fig. 2), a porous scrim sheet 10, a second layer 12 of a transparent encapsulant, and a protective back panel or backskin 14. The front panel is usually made of glass

while the back panel may be made of glass or some other material, e.g., Tedlar®. Preferably, to improve adherence of the encapsulant, the glass is subjected to a silane pretreatment, e.g., as set forth in said U.S. Patent No. 4,749,430. Although not shown in Fig. 2, it is to be understood that some, and preferably all, of the individual conductors 8 that connect adjacent solar cells or strings of cells are oversized in length for stress relief and may form individual loops between the cells. Each cell has a first electrode or contact (not shown) on its front radiation-receiving surface and a second electrode or contact (also not shown) on its back surface, with the conductors 8 being soldered to those contacts to establish the desired electrical circuit configuration. By way of example but not limitation, each cell may have contacts as disclosed in U.S. Patent No. 5,733,382, which is incorporated herein by reference. Each of the layers 4 and 12 may comprise one or more sheets of encapsulant material, depending upon the thickness in which the encapsulant is commercially available. Although not shown, it is to be understood that the solar cells are oriented so that their front contacts face the front panel 2, and also the cells are arranged in rows, i.e., strings, with the several strings being connected by other conductors similar to conductors 8 and with the whole array having terminal leads (not shown) that extend out through a side of the assembly of components. The foregoing components are assembled in sandwich fashion, starting with the front panel 2 on the bottom.

After the sandwich has been assembled, it is transferred to a laminating apparatus (not shown) where its components are subjected to the laminating process. The laminating apparatus is essentially a vacuum press having heating means and a flexible wall or bladder member that coacts with a wall member or platen to compress the components together when the press is closed and evacuated. The sandwich is positioned within the press and then the closed press is operated so as to heat the sandwich in vacuum to a selected temperature at which the encapsulant will melt enough to flow around the cells, usually a temperature of at least 120°C, with the pressure applied to the components increasing at a selected rate to a maximum level, usually in the range of about 390

to about 410 torr minimum. These temperature and pressure conditions are maintained long enough, typically for about 3 to 10 minutes, to assure that the encapsulant has melted or softened enough to flow around and fully encapsulate the interconnected cells and fully contact the front and back panels, after which the pressure is maintained at or near the foregoing minimum level while the assembly is allowed to cool to about 80°C or less so as to cause the encapsulant to form a solid bond with the adjacent components of the module. The pressure exerted on the sandwich of module components reaches its maximum level only after the assembled components have reached the desired maximum temperature in order to allow the encapsulant to flow as required and also to assure full removal of air and moisture.

In accordance with the preferred embodiment of this invention, test sample modules were made according to the foregoing procedure wherein each of the encapsulant layers 4 and 12 had the following composition by weight: about 80% Kraton G 1726 block polymer, 18.2% RegalRez tackifying agent, 0.3 Cyasorb UV-1164, 0.3% Chimassorb, 0.55% Irganox 3114, and 0.3% Irganox MD 1024. Those test modules were subjected to accelerated UV testing that involved repetitive temperature and humidity cycling equivalent to ½ year of daily exposure to sunlight. These test results revealed that the encapsulant did not discolor and exhibited substantially no loss in light transmittance.

The foregoing invention is not limited to the Kraton G 1726 block polymer product but may be practiced with other block polymer encapsulants encompassed by the blend composition described hereinabove.

The invention also is not limited to block polymers but is also applicable to providing stable EVA-based and ionomer-based encapsulants formulations that are free of benzotriazole and benzophenone UV absorbers, with the amount of each additive being within the range set forth above in relation to the block polymer encapsulants. The invention is applicable to any EVA copolymer composition known in the art for use as an encapsulant. By way of example, but not limitation, the EVA copolymer may have a vinyl acetate content between about 25% and 35% by

weight. The EVA encapsulant formulation may also comprise an organosilane primer to enhance adherence of the encapsulant to the solar cells and adjacent components of the module, e.g., glass front and back panels. Examples of suitable primers are set forth in U.S. Patent No. 5,447,576. Alternatively the glass components of the module may be subjected to an organosilane pretreatment as noted above in connection with the description of the method used to manufacture a module as illustrated in Figs. 1 and 2.

One example of an EVA-based encapsulant composition embodying the invention comprises EVA modified by 0.3 wt. % Cyasorb UV-1164 and 0.3 wt. % Chimassorb 119. An alternative and preferred EVA encapsulant composition comprises modifying EVA with 0.3 wt. % Cyasorb UV-1164, 0.3 wt. % Chimassorb, 0.5 wt. % Irganox 3114 and 0.3 wt. % Irganox MD 1024. The foregoing EVA encapsulant composition provided by this invention may be formed into sheets whereby it may be used to form a solar module according to the method and structure herein described and illustrated. The Chimassorb 119 may be replaced by some other hindered amine light stabilizer.

With regard to providing ionomer-based encapsulant formulations, the ionomer component may be any ionomer composition known in the art for use as a solar cell encapsulant, e.g., the Surlyn®1601 and 1705 products of DuPont. As used herein the term "ionomer" includes sodium and zinc-based ionomers and has the meaning attributed to it in U.S. Patents Nos. 5,478,402 and 5,476,553, issued respectively to J. Hanoka and J. Hanoka et al.

An example of application of the invention to produce sheets of ionomer-based encapsulant is a composition comprising Surlyn®1601 or 1705 ionomer, 0.3 wt. % Cyasorb UV-1164 and 0.3 wt. % Chimassorb 119. An alternative and preferred ionomer encapsulant composition comprises modifying the selected ionomer with 0.3 wt. % Cyasorb UV-1164, 0.3 wt. % Chimassorb 119, 0.5 wt. % Irganox 3114 and 0.3 wt. % Irganox MD 1024. The foregoing additive-modified ionomer encapsulant composition provided by this invention may be formed into sheets whereby it may be used to form a solar module according to the method and

structure herein described and illustrated. The ionomer encapsulant also may include an organosilane primer to enhance adherence of the encapsulant to the solar cells and adjacent components of the solar module, e.g., glass front and back panels. It is to be noted that the Chimassorb 119 may be replaced by some other hindered amine light stabilizer.

WHAT IS CLAIMED IS:

1. An encapsulant composition for use in encapsulating photovoltaic cells comprising;

- (a) a polymeric encapsulant;
- (b) Cyasorb UV-1164 UV absorber as herein identified; and
- (c) a hindered amine light stabilizer,

with the absorber being present in the composition in an amount ranging from about between about 0.2 wt. % to about 1.0 % and the light stabilizer being present in an amount ranging from about 0.3 wt. % to about 0.6 wt. %.

2. An encapsulant composition according to claim 1 wherein said hindered amine light stabilizer is the product_Chimassorb 119 as herein identified,

3. An encapsulant composition according to claim 1 wherein the polymeric encapsulant is EVA.

4. An encapsulant composition according to claim 3 further including an anti-oxidant.

5. An encapsulant composition according to claim 3 further including a metal deactivator.

6. An encapsulant composition according to claim 5 wherein said metal deactivator is Irganox MD 1024 as herein described.

7. An encapsulant composition according to claim 6 further including an anti-oxidant.

8. An encapsulant composition according to claim 5 wherein said metal deactivator is present in an amount ranging from about 0.1 wt. % to about 1.0 wt. %.
9. An encapsulant composition according to claim 8 wherein further including an anti-oxidant in an amount ranging from about 0.1 wt. % to about 2.0 wt. %.
10. An encapsulant composition according to claim 9 wherein said anti-oxidant is Irganox 1010 or Irganox 3114 as herein identified.
11. An encapsulant composition according to claim 1 wherein the polymeric encapsulant is an ionomer.
12. An encapsulant composition according to claim 11 further including an anti-oxidant.
13. An encapsulant composition according to claim 11 further including a metal deactivator.
14. An encapsulant composition according to claim 13 wherein said metal deactivator is Irganox MD 1024 as herein described.
15. An encapsulant composition according to claim 13 wherein said metal deactivator is present in an amount ranging from about 0.1 wt. % to about 1.0 wt. %.
16. An encapsulant composition according to claim 15 wherein further including an anti-oxidant in an amount ranging from about 0.1 wt. % to about 2.0 wt. %.
17. An encapsulant composition according to claim 16 wherein said anti-oxidant is Irganox 1010 or Irganox 3114 as herein identified.

18. An encapsulant composition according to claim 1 wherein the polymeric encapsulant is a block polymer-based compositions comprising a blend of:
about 65 to 75 parts by weight of a selectively hydrogenated two-block polymer wherein one polymer block is designated by A and a second polymer block is designated by B such that prior to hydrogenation,

(1) each A is a polymer block of a monovinyl or alpha alkyl monovinyl arene having a number average molecular weight in the range of from about 5,000 to about 75,000, said A blocks comprising from about 10 to about 40% by weight of the total block copolymer, and

(2) each B is a polymer block having a number average molecular weight in the range of from about 10,000 to about 150,000 and is formed by polymerizing a conjugated diene having from 4 to 10 carbon atoms per molecule, and said B blocks comprising from about 90 to about 60% by weight of the total block copolymer, and

about 25 to about 35 parts by weight of a selectively hydrogenated multiblock copolymer which contains at least two kinds of polymer blocks wherein one polymer block is designated by A and a second polymer block is designated by B such that:

(1) each A is a polymer endblock of a monovinyl or alpha alkyl monovinyl arene having a number average molecular weight in the range of from about 5,000 to about 75,000, said A blocks comprising from about 10 to about 90% by weight of the total block copolymer, and

(2) each B is a polymer midblock having a number average molecular weight in the range of from about 10,000 to about 150,000 and is formed by polymerizing a conjugated diene having from 4 to 10 carbon atoms per molecule, and said B blocks comprising from about 90 to about 10% by weight of the total block copolymer; and

further wherein said encapsulant composition comprises a tackifying resin.

19. An encapsulant composition according to claim 18 wherein said polymeric encapsulant is present in an amount ranging from about 80 wt. % to about 90 wt. %

and said tackifying resin is present in an amount ranging from about between about 10 wt. % to about 20 wt. %.

20. An encapsulant composition according to claim 19 further including a metal deactivator.

21. A photovoltaic module comprising a transparent front support sheet made of glass, a back sheet, an array of photovoltaic cells with front and back electrical contacts disposed between said front support sheet and said back sheet, a plurality of electrical conductors interconnecting said cells, said conductors being physically and electrically connected to said contacts by solder, and an encapsulant extending between and bonded to said front support sheet and said back sheet and surrounding and bonded to said cells and said conductors, — characterized in that said encapsulant comprises a polymer material from the class consisting of (a) ionomers, (b) EVA, and (c) a block polymer-based composition comprising a tackifying resin and a blend of: about 65 to 75 parts by weight of a selectively hydrogenated two-block polymer wherein one polymer block is designated by A and a second polymer block is designated by B such that prior to hydrogenation, (1) each A is a polymer block of a monovinyl or alpha alkyl monovinyl arene having a number average molecular weight in the range of from about 5,000 to about 75,000, said A blocks comprising from about 10 to about 40% by weight of the total block copolymer, and (2) each B is a polymer block having a number average molecular weight in the range of from about 10,000 to about 150,000 and is formed by polymerizing a conjugated diene having from 4 to 10 carbon atoms per molecule, and said B blocks comprising from about 90 to about 60% by weight of the total block copolymer, and about 25 to about 35 parts by weight of a selectively hydrogenated multiblock copolymer which contains at least two kinds of polymer blocks wherein one polymer block is designated by A and a second polymer block is designated by B such that: (1) each A is a polymer endblock of a monovinyl or alpha alkyl monovinyl arene having a number average

molecular weight in the range of from about 5,000 to about 75,000, said A blocks comprising from about 10 to about 90% by weight of the total block copolymer, and (2) each B is a polymer midblock having a number average molecular weight in the range of from about 10,000 to about 150,000 and is formed by polymerizing a conjugated diene having from 4 to 10 carbon atoms per molecule, and said B blocks comprising from about 90 to about 10% weight of the total block copolymer; Cyasorb UV-1164 UV absorber as herein identified; and a hindered amine light stabilizer.

22. A photovoltaic module according to claim 21 wherein said encapsulant also includes a metal deactivator and an anti-oxidant.

23. A photovoltaic module according to claim 22 wherein said metal deactivator is Irganox MD 1024 as herein described.

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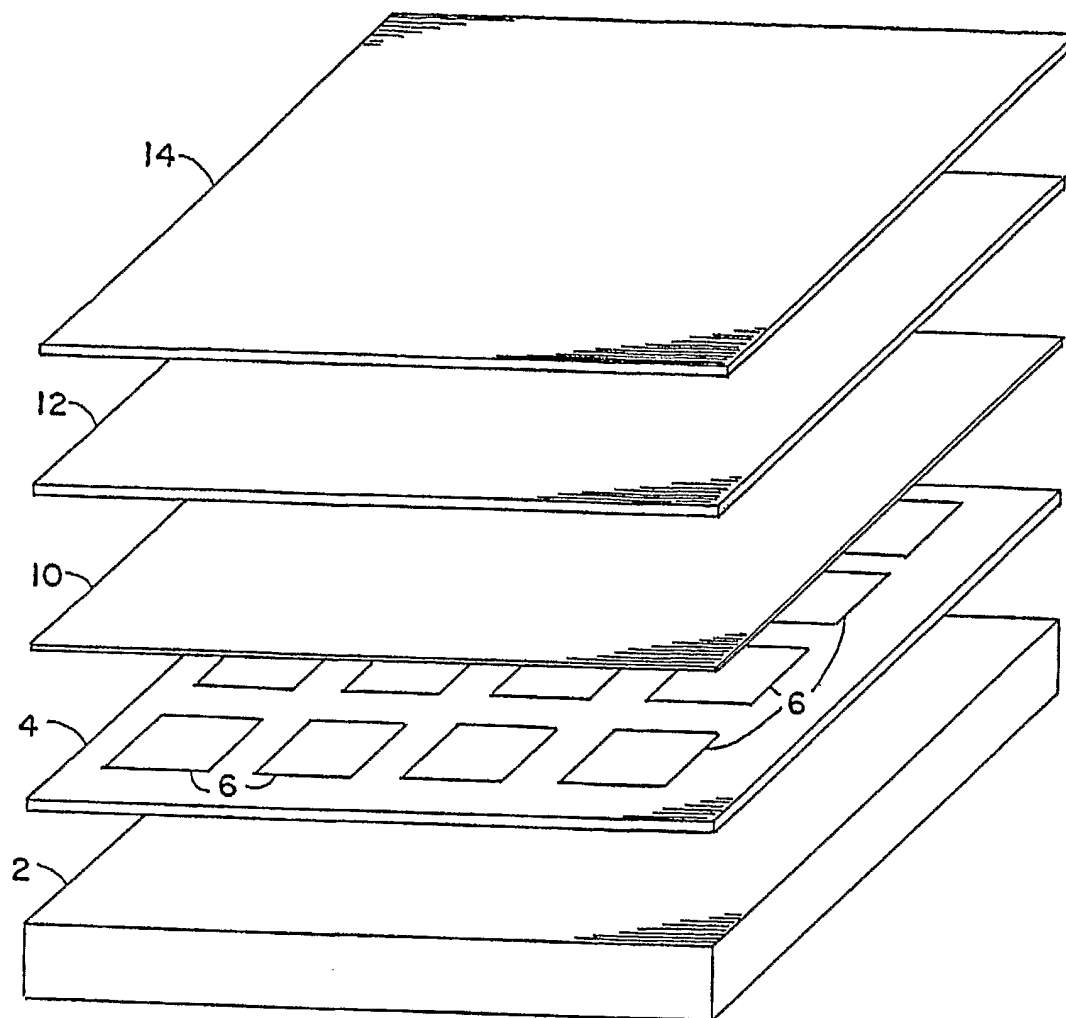


FIG. 1

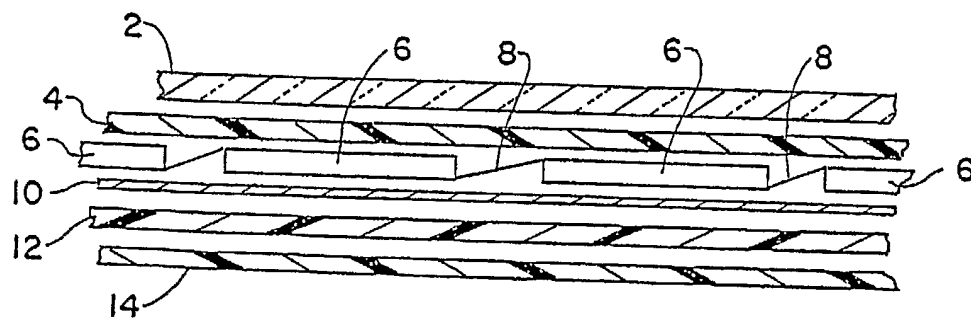


FIG. 2