

(10) International Publication Number
WO 2013/086950 A1(43) International Publication Date
20 June 2013 (20.06.2013)

- (51) **International Patent Classification:**
B32B 33/00 (2006.01) **C08L 23/08** (2006.01)
- (21) **International Application Number:**
PCT/CN20 12/086 195
- (22) **International Filing Date:**
7 December 2012 (07.12.2012)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
201 11041 1085.9 12 December 201 1 (12. 12.201 1) CN
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— with international search report (Art. 21(3))

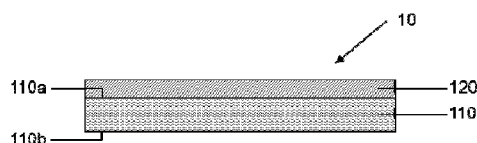
(54) **Title:** RECYCLABLE LAMINATED PACKAGING MATERIAL

Figure 1

(57) **Abstract:** Disclosed herein is a laminated packaging material, which comprises: (a) a base layer comprising non-plastic materials and having a first surface and a second surface; (b) a first separatory laminated to the first surface the base layer; and optionally (c) a first thermoplastic layer that is laminated to the first separatory layer or (c) a non-plastic layer that is laminated to the first separatory layer; wherein the first separatory layer has a thickness of about 1.8-50 μm and is formed of a water-dispersable ionomer composition.

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RECYCLABLE LAMINATED PACKAGING MATERIAL**TECHNICAL FIELD**

The disclosure is related to a laminated packaging material that is easy to recycle.

BACKGROUND

In the packaging industry, laminating paperboard and/or metal films (such as aluminum foils) with polymeric materials to form laminated packaging materials has been widely practiced. Containers prepared from such packaging materials can be used for storage of powder or liquid goods. For example, such containers can be used for storage of food, especially liquid food such as milk, juice, alcohol, and others.

However, in such laminated packaging materials, layers of non-plastic materials (such as paperboards, metal films, etc) are firmly bonded to layers of plastic materials. This presents a problem for recycling the containers, as the plastic and non-plastic materials cannot be readily separated and sorted into separate recycling streams.

Previously, due to its solubility in water, polyvinyl alcohol (PVOH) has been used in laminated packaging materials to allow the separation non-plastic materials from plastic materials. However, it is found that the bonding strength of PVOH to paper or aluminum foils is rather poor. Moreover, PVOH has a rather narrow processing window as degradation starts to occur when the melting temperature is reached. Thus, PVOH is not suitable for extrusion coating, a processing option commonly used in packaging industry. Accordingly, a need to develop a laminated packaging material that is easy to prepare and easy to recycle still exists.

SUMMARY

Provided herein is a laminated packaging material that can be easily recycled, which comprises:

- (a) a base layer that comprises non-plastic material and has a first surface and a second surface; and

(b) a first separatory layer that is laminated to the first surface of the base layer; and

wherein the first separatory layer is formed of a water-dispersable ionomer composition and has a thickness of 1.8-50 μm , and

wherein the water-dispersable ionomer composition comprises an ionomer that is derived from a parent acid copolymer, the parent acid copolymer comprising copolymerized units of ethylene and 18-30 wt% of copolymerized units of acrylic acid or methacrylic acid, based on the total weight of the parent acid copolymer, the parent acid copolymer having a melt flow rate (MFR) from 200-1000 g/10 min (measured according to ASTM D1238 at 190°C with a 2160 g load), and in which 50-70% of the carboxylic acid groups of the parent acid copolymer, based on the total carboxylic acid content of the parent acid copolymer as calculated for the non-neutralized parent acid copolymer, are neutralized to carboxylic acid salts comprising potassium cations, sodium cations or combinations thereof.

In one embodiment of the laminated packaging material, the base layer comprises at least one layer of paper, paperboard, or metal film, preferably, the metal film is aluminum foil.

In a further embodiment of the laminated packaging material, the base layer is formed of a monolayer of paperboard.

In a yet further embodiment of the laminated packaging material, the base layer is formed of a monolayer of aluminum foil.

In a yet further embodiment of the laminated packaging material, the base layer comprises at least one paperboard layer and at least one aluminum foil layer, the at least one paperboard layer and the at least one aluminum foil layer being laminated together by a second separatory layer in between, the second separatory layer being formed of the water-dispersable ionomer composition and having a thickness of 1.8-50 μm .

In a yet further embodiment of the laminated packaging material, the material further comprises: (c) a non-plastic layer that is laminated to the first separatory layer. In such embodiments, the non-plastic layer may comprise at

least one layer of paper, paperboard, or metal film (preferably aluminum film). Or, the laminated packaging material may further comprises: (c) a first thermoplastic layer that is laminated to the first separatory layer. In such embodiments, the laminated packaging material may yet further comprise: (d) a third separatory layer that is laminated to the second surface of the base layer, the third separatory layer being formed of the water-dispersable ionomer composition and has a thickness of 1.8-50 μm ; and (e) a second thermoplastic layer that is laminated to the third separatory layer. In such embodiments, each of the first and second thermoplastic layers may be independently formed of a same or different thermoplastic composition, the thermoplastic composition comprising a polymer selected from the group consisting of polyolefins, polyesters, polyamides, and combinations of two or more thereof, preferably, the polyolefins are selected from the group consisting of polyethylenes, polypropylenes, and combinations thereof, and the polyesters are selected from the group consisting of polyethylene terephthalate, polybutylene terephthalate, polytrimethylene terephthalate, and combinations of two or more thereof. Or, each of the thermoplastic compositions forming the first and second thermoplastic layers comprises a polyethylene. Or, the thermoplastic composition forming the first thermoplastic layer comprises a polyethylene and the thermoplastic composition forming the second thermoplastic layer comprises a polyethylene terephthalate.

Further provided herein is a container prepared from the laminated packaging material described above.

Yet further provided herein is a method for recycling a laminated packaging material, comprising: (i) providing the laminated packaging material described above; (ii) immersing the laminated packaging material in water that is heated to a temperature of 80°C or higher; (iii) maintaining the laminated packaging material in the heated water under low shear until the component layers laminated on each side of each of the separatory layers separate; and (iv) separating the non-plastic material from the plastic material that are comprised in the laminated packaging material.

In one embodiment of the method, in step (iii), the laminated packaging material is maintained in the heated water for 1 hour or less.

In accordance with the present disclosure, when a range is given with two particular end points, it is understood that the range includes any value that is within the two particular end points and any value that is equal to or about equal to any of the two end points.

BRIEF DISCRETION OF DRAWINGS

Figure 1 is a not-to-scale cross-sectional view of one embodiment of the laminated packaging material (10).

Figure 2 is a not-to-scale cross-sectional view of one embodiment of the base layer (110) that is comprised in the laminated packaging material (10).

Figure 3 is a not-to-scale cross-sectional view of another embodiment of the laminated packaging material (10').

Figure 4 is a not-to-scale cross-sectional view of yet another embodiment of the laminated packaging material (10").

DETAILED DESCRIPTION

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 disclosure belongs. In case of conflict, the 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 disclosure, 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 lower preferable values and upper preferable values, this is to be understood as specifically disclosing all ranges formed from any pair of any lower range limit or preferred value and any upper 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.

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

Use of "a" or "an" are employed to describe elements and components of the invention. This is 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 produce them or the amounts of the monomers used to produce the polymers. 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 and amounts should be interpreted to mean that the polymer comprises copolymerized units of those monomers or that amount of the monomers, and the corresponding polymers and compositions thereof.

The term "copolymer" is used to refer to polymers formed by copolymerization of two or more monomers. Such copolymers include dipolymers consisting essentially of two copolymerized comonomers.

As used herein, "disperse," "dispersing" and related terms refer to a process in which solid articles such as pellets of polymer are mixed with water and over a brief period of time disappear into the liquid phase.

Disclosed herein is a laminated packaging material (10, see Figure 1) used for making containers. The laminated packaging material (10) disclosed herein comprises both plastic and non-plastic materials that can be easily separated for recycling. The laminated packaging material (10) disclosed herein comprises: (a) a base layer (110) comprising non-plastic material and having a first surface (110a) and second surface (110b) and (b) a first separatory layer (120) laminated to the first surface of the base layer (110a), wherein the first separatory layer (120) has a thickness of about 1.8-50 μm and is formed of a water-dispersable ionomer composition.

The water-dispersable ionomer compositions disclosed herein comprise or consist essentially of ionomers that are derived from certain parent acid copolymers comprising copolymerized units of ethylene and about 18-30 wt% of copolymerized units of an alpha, beta-ethylenically unsaturated carboxylic acid such as acrylic acid or methacrylic acid. Preferably, the parent acid copolymers used herein comprise about 19-25 wt%, or more preferably about 19-23 wt%, of the alpha, beta-ethylenically unsaturated carboxylic acid, based on the total weight of the copolymer.

Of note are acid copolymers consisting essentially of copolymerized units of ethylene and copolymerized units of the alpha, beta-ethylenically unsaturated carboxylic acid and 0 wt% of additional comonomers; that is, dipolymers of ethylene and the alpha, beta-ethylenically unsaturated carboxylic acid. Preferred acid copolymers are ethylene/methacrylic acid dipolymers.

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

The parent acid copolymers used herein preferably have a melt flow rate (MFR) of about 200-1000 g/10 min as measured in accordance with ASTM D1238 at 190°C using a 2160 g load. A similar ISO test is ISO 1133. Alternatively, the parent acid copolymers have MFR from a lower limit of about 200, about 250 or about 300 to an upper limit of about 400, about 500, about 600 or about 1000. The preferred MFR of the parent acid copolymer provides ionomers with optimum physical properties in the final shaped article while still allowing for rapid self-dispersion in hot water. Ionomers derived from parent acid copolymers with MFR below about 200 g/10 min have minimal hot water self-dispersability, while ionomers derived from parent acid copolymer with MFR greater than about 1000 g/10 min may reduce the physical properties in the intended enduse.

In some embodiments, blends of two or more ethylene acid copolymers may be used, provided that the aggregate components and properties of the blend fall within the limits described above for the parent ethylene acid copolymers. For example, two ethylene/methacrylic acid dipolymers may be used such that the total wt% of methacrylic acid is about 18-30 wt% of the total polymeric material and the MFR of the blend is about 200-1000 g/10 min.

The ionomers used herein are produced from the parent acid copolymers, wherein from about 50-70%, or preferably from about 55-60%, such as about 60%, of the total carboxylic acid groups of the parent acid copolymers, as calculated for the non-neutralized parent acid copolymers, are neutralized to form carboxylic acid salts with potassium ions, sodium ions or combinations thereof. The parent acid copolymers may be neutralized using methods disclosed in, for example, U.S. Patent 3,404,134.

Importantly, the ionomers used in the water-dispersable ionomer compositions combine the properties of being self-dispersible in hot water along with being thermoplastic, allowing for melt fabrication into many articles of commerce. Preferably, the ionomers used herein have a MFR of at least about 1 g/10 min, such as about 1-20 g/10 min as measured by ASTM D1238 at 190°C using a 2160 g load. More preferably, the ionomer used herein has a MFR of

about 1-10 g/10 min. The combination of the above described parent acid copolymer MFR and the neutralization levels provides ionomers which combine the properties of being easily self-dispersible in hot water and easily melt fabricated into articles of commerce.

In certain embodiments, the ionomers used in the water-dispersable ionomer compositions may be blends of two or more ionomers, provided that the aggregate components and properties of the blends fall within the limits described above for the ionomers.

In addition to the ionomers described above, the water-dispersable ionomer compositions used herein may also contain other additives known in the art, provided that such additives do not negatively affect the water-dispersability of the water-dispersable ionomer composition. The additives may include, but are not limited to, processing aids, flow enhancing additives, lubricants, pigments, dyes, flame retardants, impact modifiers, nucleating agents, anti-blocking agents such as silica, thermal stabilizers, UV absorbers, UV stabilizers, surfactants, chelating agents, and coupling agents.

In accordance to the present disclosure, the first separatory layers (120) included in the laminated packaging material (10) is formed of the water-dispersable ionomer composition disclosed herein and has a thickness ranging from about 1.8 μm to about 50 μm , or from about 1.8 μm to about 30 μm .

As part of the laminated packing material disclosed herein, the base layer (110) may be in the form of a monolayer film or sheet or a laminated multi-layer film or sheet. The terms "film" and "sheet" are used interchangeably herein to refer to a continuous thin flat structure with a uniform thickness. In general, a sheet may have a thickness greater than about 100 μm , while a film may have a thickness of about 100 μm or less. In those embodiments where the base layer (110) is in the form of a monolayer film or sheet, the base layer (110) is formed of a non-plastic material. For example, the base layer (110) may be formed of a monolayer of paper or paperboard or a monolayer of a metal film (e.g., aluminum (Al) foil). While in those embodiments wherein the base layer (110) is in the form of a laminated multi-layer film or sheet, the base layer (110) may comprise

one or more component layers formed of non-plastic materials. For example, the base (110) may comprise at least one component layer of paper or paperboard or at least one component layer of a metal film (e.g., aluminum foil). Still, the base layer (110) may also comprise two or more non-plastic material layers, with each of the two or more non-plastic material layers being paper layers, paperboard layers, metal film layers, or combinations of two or more thereof. It is understood, however, that, within the laminated packing material, in order to allow the non-plastic material layers to be separable from the other plastic materials, separatory layers formed of the water-dispersable ionomer compositions disclosed above may also be laminated to one or both sides of each of the non-plastic material layers. Alternatively speaking, each of the non-plastic material layers is bonded to its adjacent layers via separatory layers.

In general, paperboards are thicker paper based materials. Typically, a paperboard is defined as a paper with a basis weight above 224 g/m².

In accordance with the present disclosure, the paper layer or paperboard layer used in the base layer (110) may have a thickness of about 30-600 μm and a basis weight of about 25-500 g/m², or 100-300 g/m².

The metal film (e.g., aluminum foil) layer(s) comprised in the base layer (110) may have a thickness of about 3-200 μm or about 3-100 μm , or about 3-50 μm .

However, in accordance with the present disclosure, the total thickness of the base layer (110) may be in the range of about 3 μm to about 600 μm .

In one embodiment, the base layer (110) is formed of a monolayer of paperboard.

In a further embodiment, the base layer (110) is formed of a monolayer of metal film (e.g., aluminum foil).

In a yet further embodiment, as illustrated in Figure 2, the base layer (110) is formed of a layer of paperboard (112) and a layer of aluminum foil (114), which are laminated together via a separatory layer of the water-dispersable ionomer composition disclosed above (120').

Preferably, the laminated packaging material (10', see Figure 3) may further comprise: (c) an additional non-plastic layer or a first thermoplastic layer (130) laminated to the first separatory layer (120).

In those embodiments wherein the additional non-plastic layer (130) is included, the non-plastic layer (130) may be formed of any suitable non-plastic material that is the same or different from the non-plastic material used in the base layer. The non-plastic layer (130) also may be in the form of a monolayer film or sheet or a laminated multi-layer film or sheet. For example, the non-plastic layer (130) may be formed of a monolayer of paper or paperboard or a monolayer of a metal film (e.g., aluminum (Al) foil), or, the non-plastic layer (130) also may be in the form of a laminated multi-layer film or sheet and comprises one or more component layers formed of non-plastic materials described above. The non-plastic layer (130) may comprise at least one component layer of paper or paperboard or at least one component layer of a metal film (e.g., aluminum foil). Still, the non-plastic layer (130) may also comprise two or more non-plastic material layers, with each of the two or more non-plastic material layers being paper layers, paperboard layers, metal film layers, or combinations of two or more thereof. And here again, when the non-plastic layer (130) is in the form of a laminated multi-layer film or sheet, additional separatory layer(s) formed of the water-dispersable ionomer composition may be included as well.

More preferably, a first thermoplastic layer (130) is included in the laminated packaging material and laminated to the first separatory layer. Yet more preferably, the laminated packaging material (10", see Figure 4) further comprises: (d) a third separatory layer (120") laminated to the second surface of the base layer (110b); and (e) a second thermoplastic layer (140) laminated to the third separatory layer (120"), with the third separatory layer (120") having a thickness of about 1.8-50 μm and being formed of the water-dispersable ionomer composition.

In accordance with the present disclosure, each of the one or more thermoplastic layers (130, 140, etc.) comprised in the laminated packaging material (10) may be formed of a same or different thermoplastic composition.

Suitable thermoplastic materials comprised in these thermoplastic compositions include, without limitation, polyolefins, polyesters, polyamides (PA), and combinations of two or more thereof. Suitable polyolefins include, without limitation, polyethylenes (PE), polypropylenes (PP), and combinations of two or more thereof. Suitable polyesters include, without limitation, polyethylene terephthalate (PET), polybutylene terephthalate (PBT), polytrimethylene terephthalate (PTT), and combinations of two or more thereof. In one embodiment, the thermoplastic materials used herein are selected from polyesters, polyolefins, and combinations thereof. In a further embodiment, the thermoplastic materials used herein are selected from polyolefins, such as polyethylenes. Also in accordance to the present disclosure, each of thermoplastic layers (130, 140, etc.) may independently have a thickness ranging from about 2 μm to about 200 μm .

It is understood, however, that, within the laminated packing material, in order to allow the non-plastic material layers to be separable from the other plastic materials, separatory layers formed of the water-dispersable ionomer compositions disclosed above may also be laminated to one or both sides of each of the non-plastic material layers. Alternatively speaking, each of the non-plastic material layers is bonded to its adjacent layers via separatory layers. In addition, within the laminated packaging material (10), when there are two adjacent layers, in which two distinct materials are used and each requires a distinct recycling stream, a separatory layer formed of the water-dispersable ionomer composition also may be laminated between the two adjacent layers. Moreover, within the laminated packaging material (10), there is no limitation on the number of separatory layers that could be included. Also, each of the separatory layers may have a same or different thickness from each other, and that the water-dispersable ionomer composition used in each of the separatory layers may be the same or distinct. Two water-dispersable ionomer compositions may be distinct because (i) different kind and/or level of additive(s) were included, or (ii) different ionomers (such as ionomers with different

neutralization levels, or ionomers derived from parent acid copolymers with different acid levels) were used.

It is also understood that, in addition to the above mentioned base layer (110), first separatory layer (120), the optional additional non-plastic layer or first thermoplastic layer (130), the optional third separatory layer (120"), and the optional second thermoplastic layer (140), the laminated packaging material (10) disclosed herein may further comprise other suitable functional layers. Such additional functional layers may be included in the laminated packaging material (10) in any position. That is, such additional functional layers may be laminated between the base layer (110) and the first thermoplastic layer (130); or between base layer (110) and the second thermoplastic layer (140); or over the first thermoplastic layer (130); or over the second thermoplastic layer (140).

Exemplary functional layers that could be included in the laminated packaging material (10) include, without limitation: gas-barrier layers, oil-proof layers, aroma-holding layers, and combinations of two or more thereof. In particular, adhesive layer(s) may be included in the laminated packaging material (10) to provide sufficient bonding between any pair of adjacent component layers. The adhesive layers used herein may be formed of any suitable polyolefins, which include, without limitation, maleic anhydride grafted polyolefins (e.g., maleic anhydride grafted polyethylenes, maleic anhydride grafted polypropylenes, etc.), ethylene/acrylate copolymers (e.g., ethylene/methacrylate copolymers, ethylene/ethyl acrylate copolymers, etc.), ethylene/monoalkyl maleate copolymers, and combinations of two or more thereof. Here again, if the material comprised in such additional layers can not go to the same recycling stream as the material comprised in its adjacent layer(s), a separatory layer formed of the water-dispersable ionomer composition may also be laminated therebetween.

Moreover, printing information may be applied over one surface of the base layer (110). Preferably, the one surface of the base layer that carries the printing information is the surface that is positioned outward when the laminated packaging material (10) is prepared into a container.

In particular, the laminated packing material disclosed herein may have a structure as one of the following:

- AI/WDI
- Paperboard/WDI/PE
- Paperboard/WDI/AI/WDI
- Paperboard/WDI/AI/WDI/PE
- PE/WDI/Paperboard/WDI/PE;
- PE/WDI/AI/WDI/PE;
- PE/WDI/AL/WDI/Paperboard/WDI/PE;
- PE/WDI/Paperboard/WDI/AI/WDI/PE
- PE/WDI/Paperboard/WDI/PE/WDI/AI/WDI/PE
- PET/WDI/AI/WDI
- PET/WDI/AI/WDI/PE
- PET/WDI/AI/WDI/PET/PE

with WDI representing a water-dispersable ionomer composition described herein.

Previously, due to its solubility in water, polyvinyl alcohol (PVOH) has been suggested as separatory materials in laminated packaging films to allow easy recycling. However, the poor bonding strength between PVOH and paper or aluminum foils limits its application. Moreover, PVOH has a rather narrow processing window as degradation starts to occur when the melting temperature is reached. On the other hand, though, the water-dispersable ionomer compositions used herein are suitable for extrusion processes and it is demonstrated that separatory layers formed of the water-dispersable ionomer compositions used herein have very much improved bonding strength to other thermoplastic films (e.g., polyethylene films) or inorganic materials (e.g., aluminum foils).

The laminated packaging material (10) may be prepared by any suitable lamination process, such as extrusion coating, extrusion lamination, nip roll lamination, vacuum laminations, etc.

For example, in one embodiment, the process may include providing all the component layers; aligning all the component layers in a certain order to form a pre-lamination assembly; and subjecting the pre-lamination assembly to lamination under heat and/or pressure.

It is also conceivable that certain adjacent plastic layers may be extrusion coated over the other component layer(s). For example, the first separatory layer (120) may be extrusion coated over the first surface of the base layer (110a). Or, in embodiment (10'), the first separatory layer (120) may be extrusion coated over the first surface of the base layer (110a) first, which is followed by extrusion coating the first thermoplastic layer (130) over the first separatory layer (120). The same two-step extrusion coating process can be repeated to apply the optional third separatory layer (120'') and the second thermoplastic layer (140) over the second surface of the base layer (110b). Alternatively, the first separatory layer (120) may be extrusion coated over the first surface of the base layer (110a) first, which is followed by laminating the first thermoplastic layer (130) over the first separatory layer (120) by a nip roll process. The same process can then be repeated to apply the optional third separatory layer (120'') and the second thermoplastic layer (140) over the second surface of the base layer (110b).

In a further embodiment, the laminated packaging material (10) may be prepared by co-extrusion coating the first thermoplastic layer (130) and the first separatory layer (120) over the first surface of the base layer (110a). Similarly, the optional second thermoplastic layer (140) and the optional third separatory layer (120'') may be further co-extrusion coated over the second surface of the base layer (110b).

Further, the process for preparing the laminated packaging material (10) also may include extrusion lamination. For example, the water-dispersable ionomer composition may be extruded between the first thermoplastic layer (130) and the base layer (110) to form the laminated packaging material (10'). Or, in those embodiments wherein the base layer (110) comprises two distinct material layers (such as a paperboard layer and an aluminum layer) bonded via a

separatory layer, the process may include extruding the water-dispersable ionomer composition between the two distinct material layers to form the base layer (110).

Yet further, the process also may include solution coating. For example, the first and/or the third separatory layer may be applied over the base layer (110) by solution coating first, which is followed by extrusion coating or lamination to bond to the first and/or second thermoplastic layer.

Further disclosed herein is a container prepared from the laminated packing material (10) disclosed herein. In such containers, the laminated packaging material (10) may be positioned in any direction. However, it is preferred that, when prepared into a container, the laminated packaging material (10) is positioned in a way such that the first surface of the base layer (110a) is positioned inward and facing to the inside of the container.

The containers disclosed herein may be in any forms, such as pouches or cartons. Preferably, the container is for storage of food. More preferably, the container is for storage of liquid food, such as milk, juice, alcohol, and others.

One advantage of the container disclosed herein is that it can be easily recycled after use. In particular, due to the inclusion of the separatory layers that are formed of the water-dispersable ionomer compositions, the non-plastic materials and the plastic materials comprised in a used container could be easily separated from each other and recycled.

Specifically, as is disclosed in U.S. Patent Application No. 61/59947, aqueous dispersion of the water-dispersable ionomer composition can be easily produced under very mild process conditions, such as low shear (e.g. simply stirring a mixture of hot water and the ionomer composition) and low temperature (less than the boiling point of water) at atmospheric pressure, requiring less energy than prior dispersion processes. Such dispersion process is inherently safer as it avoids the use of strong bases, such as aqueous sodium hydroxide (caustic), during the dispersion process. The dispersion conditions allow for convenient recycling of the packaging material described herein by exposing the packaging material to conditions that allow for the dispersion of the water-

dispersable ionomer composition, thereby separating the non-plastic material from the plastic materials.

The process for separating the non-plastic material from the plastic materials comprised in containers disclosed herein may include contacting the container with water at a temperature of as low as about 80°C. In some embodiments, the temperature of the water is in the range from about 80-90°C, or about 80-85°C, or about 85-90°C. However, one can appreciate that if the water-dispersable ionomer compositions can disperse in such temperatures, they can also be dispersed at temperatures above 90°C. Also, in some embodiments, the container may be cut into pieces before being contacted with water.

In normal circumstances, the water-dispersable ionomer compositions could be dispersed in warm water in about 1 hour or less, such as in about 30 minutes or less or in about 20 minutes or less. Once the water-dispersable ionomer composition is fully dispersed in the water, the component layers laminated to each side of the separatory layer that is formed of the water-dispersable ionomer composition will separate from each other. The non-plastic materials comprised in the container, such as paperboard or aluminum foil, could then be separated from the other plastic materials for recycling.

In one embodiment, to separate the non-plastic materials from the plastic materials, the container (preferably after use) disclosed herein is first mixed with water under low shear conditions at room temperature (about 20-25°C) and then the temperature of the mixture is raised to about 80-90°C.

In a further embodiment, to separate the non-plastic materials from the plastic materials, the container (preferably after use) disclosed herein is mixed with water under low shear conditions at room temperature and then the temperature of the mixture is raised to about 85-90°C.

In a yet further embodiment, to separate the non-plastic materials from the plastic materials, the container (preferably after use) disclosed herein is mixed with water that is preheated to a temperature of about 80-90°C under low shear conditions.

In a yet further embodiment, to separate the non-plastic materials from the plastic materials, the container (preferably after use) disclosed herein is mixed with water that is preheated to a temperature of about 85-90°C under low shear conditions.

EXAMPLES

Materials:

- WDI (Water-dispersable Ionomer): a water-dispersable ionomer derived from a parent acid copolymer, wherein the parent acid copolymer had a MFR of 250 g/10 min (measured according to ASTM D1238 at 190°C with a 2160 g load) and comprised copolymerized units of ethylene and 19 wt% of copolymerized units of methacrylic acid, based on the total weight of the parent acid copolymer; and wherein the water-dispersable ionomer had a MFR of 1.25 g/10 min and was prepared by neutralizing 60% of the carboxylic acid groups of the parent acid copolymer, based on the total carboxylic acid content of the parent acid copolymer as calculated for the non-neutralized parent acid copolymer, with sodium hydroxide to form sodium salts;
- NWDI (Non-water-dispersable Ionomer): an ionomer derived from a parent acid copolymer, wherein the parent acid copolymer comprised copolymerized units of ethylene and 10 wt% of copolymerized units of methacrylic acid, based on the total weight of the parent acid copolymer, and wherein the ionomer had a MFR of 1.3 g/10 min and was prepared by neutralizing 54% of the carboxylic acid groups of the parent acid copolymer, based on the total carboxylic acid content of the parent acid copolymer as calculated for the non-neutralized parent acid copolymer, with sodium hydroxide to form sodium salts;
- PVOHfPolvvinyl Alcohol): polyvinyl alcohol resin obtained from E.I. du Pont de Nemours and Company (U.S.A.) (hereafter "DuPont") under the trade name Elvanol®T-25, which had a viscosity of 28.0 mPa-s (measured using a 4% solids aqueous solution at 20°C);
- Al (Aluminum Foil): 7 μm thick aluminum foil;

- PE (Polyethylene): polyethylene resin obtained from Dow Chemical (U.S.A.) under the trade name Dow™ LDPE 722, which had a MFR of 8.0 g/10min.

Comparative Examples CE1-CE2 and Example E1:

In CE1, a bi-layer laminate of PE/Al was prepared by extrusion coating a 30 μm thick PE layer onto a layer of Aluminum Foil using a David Standard extrusion coating line with the processing temperature set at 300°C.

In CE2, first, a water solution containing 20 wt% of WDI was applied over one side of a layer of Aluminum Foil using a coating roller, followed by drying in a 90°C oven for about 10 minutes. The coated Aluminum Film as such obtained had one side coated with a 1.6 μm thick WDI coating layer. Subsequently, a tri-layer laminate of PE/WDI(1.6 μ)/Al was prepared by extrusion coating a 30 μm thick PE layer onto the coated side of the coated Aluminum Foil using a David Standard extrusion coating line with the processing temperature set at 300°C.

Similarly, in E1, a tri-layer laminate of PE/WDI(5 μ)/Al was prepared with the exception that the thickness of the WDI coating layer was 5 μm .

Thereafter, the laminates prepared in each of CE1, CE2, and E1 were cut into 2x20 mm strips and then immersed in 95°C water. The strips were kept in the water with stirring at 300 rpm for various periods of time before the integrity of the strips was visually inspected. The results are tabulated in Table 1.

As demonstrated herein, in order to allow the separation of the aluminum foils from the PE films, a layer of water-dispersable ionomer composition with a sufficient thickness (e.g., more than 1.6 μm) needs to be laminated therebetween.

Table 1

Samples	Structure	Time Kept in 95°C Water		
		3 min	15 min	30 min
CE1	PE/Al	No separation	No separation	No separation
CE2	PE/WDI(1.6 μ)/Al	No separation	No separation	No separation
E1	PE/WDI(5 μ)/Al	¹ Separation in about 15% of the entire area	¹ Separation in about 60% of the entire area	separation in about 90% of the entire area

¹The separation occurred between the PE and Al layers.

Comparative Example CE3 and Examples E2-E3:

In CE3, a tri-layer laminate of PE/NWDI(10 μ)/Al was prepared by co-extrusion coating a 10 μ m NWDI layer and a 40 μ m PE layer over one side of an Aluminum Foil using a David Standard extrusion coating line with the processing temperature set at 300 °C.

Similarly, a tri-layer laminate of PE/WDI(10 μ)/Al was prepared in E2 with the WDI layer having a thickness of 10 μ m and the PE layer having a thickness of 40 μ m.

Again, in E3, a tri-layer laminate of PE/WDI(25 μ)/Al was prepared with the WDI layer having a thickness of 25 μ m and the PE layer having a thickness of 25 μ m.

Thereafter, the tri-layer laminates prepared in each of CE3, E2, and E3 were cut into 2x20 mm strips and then immersed in 95°C water. The strips were kept in the water with stirring at 300 rpm for various periods of time before the integrity of the strips was visually inspected. The results are tabulated in Table 2

Table 2

Samples	Structure	Time Kept in 95°C Water		
		3 min	10 min	30 min
CE3	PE/NWDI(10 μ)/Al	No separation	No separation	No separation
E2	PE/WDI(10 μ)/Al	¹ Separation in about 75% of the entire area	¹ Separation in the entire area	² n/a
E3	PE/WDI(25 μ)/Al	¹ Separation in about 75% of the entire area	¹ Separation in the entire area	² n/a

¹the separation occurred between PE and Al;

²n/a: not applicable.

Comparative Example CE4 and Example E4:

First, in accordance with ASTM3418, the melting temperature for PVOH and WDI were measured using a differential Scanning Calorimeter (Q100 DSC manufactured by TA Instruments (U.S.A.)). The results showed that PVOH had a melting temperature of 200°C and WDI had a melting temperature of 84°C. Further, using a thermogravimetric analyzer (Q500 TGA manufactured by TA

Instruments) and in accordance with ASTM E1131, it was found that PVOH started to degrade at 200°C, while WDI started to degrade at 325°C. Such results demonstrated that PVOH is not suitable for extrusion coating processes.

And, similarly to the process used in E1, a tri-layer laminate of PE/WDI(2.5 μ)/Al was prepared by first applying a 2.5 μ m thick WDI coating over one side of a layer of Aluminum Foil and then extrusion coating a 50 μ m thick PE layer over the coated surface of the Aluminum Foil.

In CE4, a tri-layer laminate of PE/PVOH (2.5 μ)/Al was prepared by first applying a 2.5 μ m thick PVOH coating using a water solution containing 10 wt% of PVOH over one side of a layer of Aluminum Foil and then extrusion coating a 50 μ m thick PE layer over the coated surface of the Aluminum Foil.

Again, the tri-layer laminates prepared in each of E4 and CE4 were cut into 25.4x127 mm test strips and the peel strength were measured in accordance to ASTM F904-98 and the results are tabulated in Table 3.

The results demonstrate that separatory layers formed of WDI had very much improved bonding strength to PE or Al, compared to separatory layers formed of PVOH.

Table 3

Samples	Structure	Peel Strength (N/25.4mm)	Failure Mode
CE4	PE/PVOH(2.5 μ)/Al	0.16	Partially between PE and PVOH layers and partially between Al and PVOH layers
E4	PE/WDI(2.5 μ)/Al	1.1	Between PE and WDI layers

WHAT IS CLAIMED IS:

1. A laminated packaging material, which comprises:
 - (a) a base layer that comprises non-plastic material and has a first surface and a second surface; and
 - (b) a first separatory layer that is laminated to the first surface of the base layer;

wherein the first separatory layer is formed of a water-dispersable ionomer composition and has a thickness of 1.8-50 μm , and

wherein the water-dispersable ionomer composition comprises an ionomer that is derived from a parent acid copolymer, the parent acid copolymer comprising copolymerized units of ethylene and 18-30 wt% of copolymerized units of acrylic acid or methacrylic acid, based on the total weight of the parent acid copolymer, the parent acid copolymer having a melt flow rate (MFR) from 200-1000 g/10 min (measured according to ASTM D1238 at 190°C with a 2160 g load), and in which 50-70% of the carboxylic acid groups of the parent acid copolymer, based on the total carboxylic acid content of the parent acid copolymer as calculated for the non-neutralized parent acid copolymer, are neutralized to carboxylic acid salts comprising potassium cations, sodium cations or combinations thereof.
2. The laminated packaging material of Claim 1, wherein the base layer comprises at least one layer of paper, paperboard, or metal film, and wherein the metal film is preferably aluminum film.
3. The laminated packaging material of Claim 1, wherein the base layer is formed of a monolayer of paperboard.
4. The laminated packaging material of Claim 1, wherein the base layer is formed of a monolayer of aluminum foil.
5. The laminated packaging material of Claim 1, wherein the base layer comprises at least one paperboard layer and at least one aluminum foil layer, the at least one paperboard layer and the at least one aluminum foil layer being laminated together by a second separatory layer in between, the

second separatory layer being formed of the water-dispersable ionomer composition and having a thickness of 1.8-50 μm .

6. The laminated packaging material of any one of Claims 1-5, which further comprises: (c) a non-plastic layer that is laminated to the first separatory layer.
7. The laminated packaging material of Claim 6, wherein the non-plastic layer comprises at least one layer of paper, paperboard, or metal film, and wherein the metal film is preferably aluminum film.
8. The laminated packaging material of any one of Claims 1-5, which further comprises: (c) a first thermoplastic layer that is laminated to the first separatory layer.
9. The laminated packaging material of Claim 8, which further comprises:
 - (d) a third separatory layer that is laminated to the second surface of the base layer, and wherein the third separatory layer is formed of the water-dispersable ionomer composition and has a thickness of 1.8-50 μm ; and
 - (e) a second thermoplastic layer that is laminated to the third separatory layer.
10. The laminated packaging material of Claim 9, wherein each of the first and second thermoplastic layers is independently formed of a same or different thermoplastic composition, the thermoplastic composition comprising a polymer selected from the group consisting of polyolefins, polyesters, polyamides, and combinations of two or more thereof.
11. The laminated packaging material of Claim 10, wherein the polyolefins are selected from the group consisting of polyethylenes, polypropylenes, and combinations thereof, and the polyesters are selected from the group consisting of polyethylene terephthalate, polybutylene terephthalate, polytrimethylene terephthalate, and combinations of two or more thereof.
12. The laminated packaging material of Claim 10, wherein each of the thermoplastic compositions forming the first and second thermoplastic layers comprises a polyethylene.

13. The laminated packaging material of Claim 10, wherein the thermoplastic composition forming the first thermoplastic layer comprises a polyethylene and the thermoplastic composition forming the second thermoplastic layer comprises a polyethylene terephthalate.
14. A container prepared from the laminated packaging material recited in any one of Claims 1-13.
15. A method for recycling a laminated packaging material, comprising:
 - (i) providing the laminated packaging material recited in any one of Claim 1-13;
 - (ii) immersing the laminated packaging material in water that is heated to a temperature of 80°C or higher;
 - (iii) maintaining the laminated packaging material in the heated water under low shear until the layers in the laminated material separate; and
 - (iv) separating the non-plastic material from the plastic materials that are comprised in the laminated packaging material.
16. The method of Claim 15, wherein in step (iii), the laminated packaging material is maintained in the heated water for 1 hour or less.

FIGURES

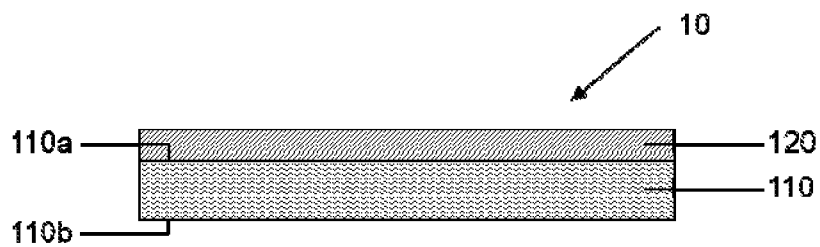


Figure 1

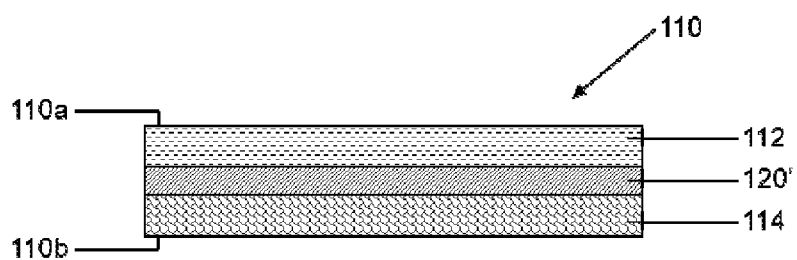


Figure 2

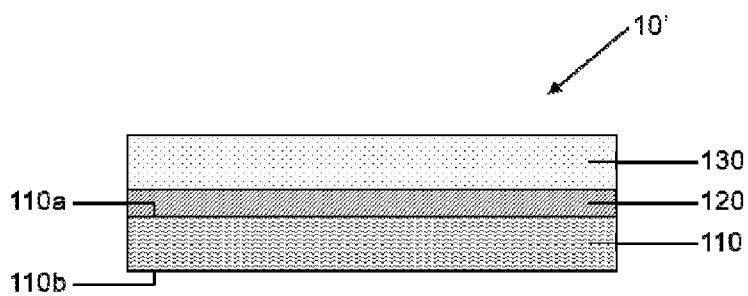


Figure 3

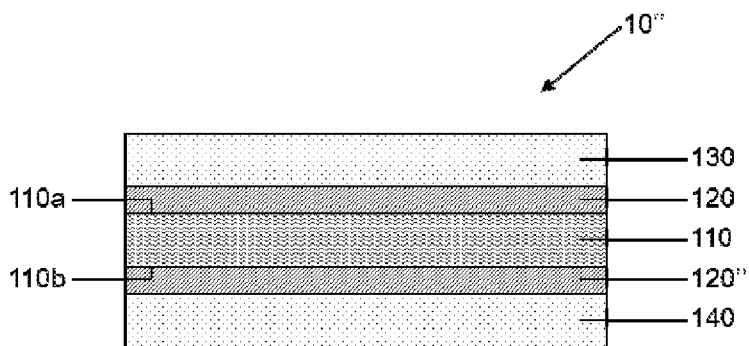


Figure 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2012/086195

A. CLASSIFICATION OF SUBJECT MATTER

See the extra sheet

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)

IPC: C08LJ332B

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

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

ICNPAT,WPI, EPODOC, CNKI : ionomer, composition, polymer, resin, acrylic, methacrylic, acid, parent, water, disperable, recycled

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US2009107553 A1 (DU PONT DE NEMOURS & CO E I) 30 April 2009(30.04.2009) claims 1-20	1-16
A	US6184281 B1(GLIDDEN CO) 6 Feb.2001 (06.02.2001) the whole document	1-16

1 Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 28 Feb.2013(28.02.2013)	Date of mailing of the international search report 14 Mar. 2013 (14.03.2013)
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer WANQYang Telephone No. (86-10)62084977

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN20 12/086 195

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
US2009107553 A 1	30.04.2009	CA2703162 A 1	07.05.2009
		CN1 01842226 A	22.09.2010
		RU2010121926A	10.12.2011
		CA2703162 C	11.09.2012
		WO2009059108 A 1	07.05.2009
		US2009107572A	30.04.2009
US6 184281 B1	06.02.2001	None	

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN20 12/086 195

CLASSIFICATION OF SUBJECT MATTER

B32B 33/00 (2006.01)i

C08L 23/08 (2006.01)i