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(54) **Title**: ARTICLE HAVING IMPROVED BREATHABILITY OR ANTISTATIC PROPERTY

(57) **Abstract**: This disclosure relates to an article comprising at least one ionomer layer that is formed of or consists essentially of a highly neutralized water dispersible ionomer, wherein the highly neutralized water dispersible ionomer is derived from a parent acid copolymer, the parent acid copolymer comprising copolymerized units of ethylene and about 18-30 weight % 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) of about 200-1000 g/10 min (measured in accordance with ASTM D1238 at 190°C with a 2160g load); and in which at least 85 % 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.

ARTICLE HAVING IMPROVED BREATHABILITY OR ANTISTATIC PROPERTY

TECHNICAL FIELD

The disclosure herein is related to an article comprising at least one ionomer layer, which possess improved breathability and/or antistatic properties.

BACKGROUND

Ionomers of ethylene copolymers with alpha, beta-ethylenically unsaturated carboxylic acids are known in the art. In these ionomers, at least a portion of the carboxylic acid groups of the copolymer are neutralized with metal ions to form carboxylate salts. See for example U.S. Pat. Nos. 3,264,272; 3,338,739; 3,355,319; 5,155,157; 5,244,969; 5,304,608; 5,688,869; 6,245,858; 6,518,365; and U.S. Patent Application Publication 2009/0297747.

In the past, certain ionomers have been used as materials to prepare breathable films or sheets (see for example Patent Application Publication WO 2004/043155). Ionomers also have been used as antistatic coating on various articles (see for example U.S. Pat. No. 5,179,168).

However, there is still a need to develop novel ionomers having even further improved breathability and/or antistatic properties.

SUMMARY OF THE INVENTION

Provided herein is an article comprising at least one ionomer layer that is formed of or consists essentially of a highly neutralized water dispersible ionomer, wherein the highly neutralized water dispersible ionomer is derived from a parent acid copolymer, the parent acid copolymer comprising copolymerized units of ethylene and about 18-30 weight% 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) of about 200-1000 g/10 min (measured in accordance with ASTM D1238 at 190°C with a 2160g load); and in which at least 85% 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. In one embodiment, the parent acid copolymer is an ethylene methacrylic acid dipolymer comprising about 18-25 weight% of copolymerized units of methacrylic acid.

In one embodiment, the article disclosed herein further comprises a substrate and the at least one ionomer layer is coated to at least one surface of the substrate. In a further embodiment, the substrate is formed of polymeric or paper materials. In a yet further embodiment, the article disclosed herein has a surface resistivity of less than 10^{12} Ω/sq.

In one embodiment, the at least one ionomer layer is substantially free of organic acid.

In one embodiment, the article disclosed herein is in the form of a monolayer film or sheet and the monolayer film or sheet is formed of or consisting essentially of the highly neutralized water dispersible ionomer.

In another embodiment, the article disclosed herein is in the form of a multilayer film or sheet, and wherein, at least one layer of the multilayer film or sheet is formed of or consisting essentially of the highly neutralized water dispersible ionomer and the multilayer film or sheet further comprises at least one additional layer. In a further embodiment, the at least one additional layer is formed of porous sheet or film. In a yet further embodiment, the article disclosed herein has a water vapor transmission rate value (WVTR) of at least 5000 g/m^2-day.

Further provided herein is a method for preparing the article described above comprising:

(a) dispersing the highly neutralized water dispersible ionomer in water heated to a temperature from 80-100°C under low shear conditions to provide an aqueous ionomer dispersion;

(b) optionally cooling the aqueous ionomer dispersion to a temperature of 20-30°C, wherein the highly neutralized water dispersible ionomer remains dispersed in the water;

(c) providing the substrate;

(d) applying the aqueous ionomer dispersion onto at least one surface of the substrate to form a wet coating layer; and

(e) drying the wet coating layer at a temperature of about 20-150°C to obtain the article.

Yet further provided herein is a method for preparing the monolayer film or sheet described above comprising:

(a) dispersing the highly neutralized water dispersible ionomer in water heated to a temperature from about 80-100°C under low shear conditions to provide an aqueous ionomer dispersion;

(b) optionally cooling the aqueous ionomer dispersion to a temperature of about 20-30°C, wherein the highly neutralized water dispersible ionomer remains dispersed in the water;

(c) providing a release substrate;

(d) applying the aqueous ionomer dispersion onto at least one surface of the release substrate to form a wet highly neutralized water dispersible ionomer layer;

(e) drying the wet highly neutralized water dispersible ionomer layer at a temperature of about 20-150°C to obtain a highly neutralized water dispersible ionomer film;

(f) peeling the highly neutralized water dispersible ionomer film away from the release substrate to obtain the monolayer film or sheet.

Yet further provided herein is a method for preparing the article disclosed herein comprising:

(a) dispersing the highly neutralized water dispersible ionomer in water heated to a temperature from about 80-100°C under low shear conditions to provide an aqueous ionomer dispersion;

(b) optionally cooling the aqueous ionomer dispersion to a temperature of about 20-30°C, wherein the highly neutralized water dispersible ionomer remains dispersed in the water;

(c) providing a release substrate;

(d) applying the aqueous ionomer dispersion onto at least one surface of the release substrate to form a wet highly neutralized water dispersible ionomer layer;

(e) drying the wet highly neutralized water dispersible ionomer layer at a temperature of about 20-150°C to obtain a highly neutralized water dispersible ionomer film;

(f) peeling the highly neutralized water dispersible ionomer film away from the release substrate;

(g) providing the additional layer; and

(h) laminating the highly neutralized water dispersible ionomer film onto the additional layer at a temperature from 50-150°C, and optionally with applied pressure to obtain the article.

Yet further provided herein is a method for preparing the article disclosed herein comprising:

(a) dispersing the highly neutralized water dispersible ionomer in water heated to a temperature from 80-100°C under low shear conditions to provide an aqueous ionomer dispersion;

(b) optionally cooling the aqueous ionomer dispersion to a temperature of 20-30°C, wherein the highly neutralized water dispersible ionomer remains dispersed in the water;

(c) providing the additional layer;

(d) applying the aqueous ionomer dispersion onto at least one surface of the additional layer to form a wet coating layer; and

(e) drying the wet coating layer at a temperature of about 20-150oC to obtain the article.

One embodiments is wherein (a) comprises (i) dispersing the highly neutralized water dispersible ionomer in water at room temperature (about 20-25°C) to form a mixture of solid blend and water, and subsequently (ii) heating the mixture to a temperature of about 80-100°C. Another embodiment is wherein (a) comprises dispersing the highly neutralized water dispersible ionomer in water preheated to a temperature of about 80-100°C.

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.

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. The terms “aqueous dispersion” and “dispersion” describe a transparent, free-flowing liquid with no solids visible to the human eye. No characterization is made regarding the interaction of the polymer molecules with the water molecules in such aqueous dispersions.

The materials, methods, and examples herein are illustrative only and, except as specifically stated, are not intended to be limiting. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present disclosure, suitable methods and materials are described herein.

The disclosure is described in detail herebelow.

Highly Neutralized Water Dispersible Ionomers

The water dispersible ionomers used herein are highly neutralized (at least about 85% neutralized) and are derived from certain parent acid copolymers comprising copolymerized units of ethylene and about 18-30 weight% of copolymerized units of an alpha,beta-ethylenically unsaturated carboxylic acid, such as acrylic acid or methacrylic acid. In certain embodiments, the parent acid copolymer used herein comprises about 18-25 weight% or about 19-23 weight%, of the alpha,beta-ethylenically unsaturated carboxylic acid, based on the total weight of the copolymer.

In one embodiment, the alpha,beta-ethylenically unsaturated carboxylic acid is methacrylic acid. 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 weight% of additional comonomers; that is, dipolymers of ethylene and the alpha,beta-ethylenically unsaturated carboxylic acid. In a further embodiment, the acid copolymers used herein are ethylene/methacrylic acid dipolymers.

The parent acid copolymers used herein may be polymerized as disclosed in U.S. Pat. Nos. 3,404,134; 5,028,674; 6,500,888; or 6,518,365, the disclosure of which is incorporated herein by references.

The parent acid copolymers used herein may have a melt flow rate (MFR) of about 200-1000 g/10 min as measured in accordance with ASTM D1238 at 190°C and a 2160 g load. A similar ISO test is ISO 1133. Alternatively, the parent acid copolymers may have a MFR ranging from a lower limit of about 200, 250, or 300 g/10 min to an upper limit of about 400, 500, 600, or 1000 g/10 min, such as from about 250-400 g/10 min. The 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-dispensability, while ionomers derived from parent acid copolymer with MFR of greater than about 1000 g/10 min may reduce the physical properties in the intended end use.

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 ethylene acid copolymers. For example, two ethylene/methacrylic acid dipolymers may be used such that the total weight% of methacrylic acid is about 18-30 weight% of the total polymeric material and the MFR of the blend is about 200-1000 g/10 min.

The highly neutralized water dispersible ionomers used herein may be produced from the parent acid copolymers, wherein at least about 85%, or at least about 90%, or about 100%, 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 sodium ions, potassium ions or mixtures thereof. In one embodiment, the highly neutralized water dispersible ionomers used herein is produced from the parent acid copolymers wherein the carboxylic acid groups of the parent acid copolymers are neutralized to form carboxylic acid salts with potassium ions. The parent acid copolymers may be neutralized using methods disclosed in, for example, U.S. Pat. No. 3,404,134. In one embodiment, the highly neutralized water dispersible ionomers used herein may be prepared by first dispersing low neutralized water dispersible ionomers (no more than 60% neutralized) in a suitable solvent, and then introducing suitable cations into the solution to further increase the neutralization level of the carboxylic acid groups.

The highly neutralized water dispersible ionomers used herein combine the properties of being self-dispersible in hot water along with being thermoplastic. The highly neutralized water dispersible ionomers used herein have a MFR of at least about 1 g/10 min, such as about 1-20 g/10 min, or about

1-10 g/10 min as measured in accordance with ASTM D1238 at 190°C and a 2160 g load. In certain embodiments, the highly neutralized water dispersible ionomers used herein 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.

Ionomer Film and Sheet

Disclosed herein is an ionomer film or sheet that is formed of or consisting essentially of the highly neutralized water dispersible ionomers described above. 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. The highly neutralized water dispersible ionomer film disclosed herein may have a thickness of about 0.1-100 μm, or about 1-50 μm, or about 5-25 μm.

In one embodiment, the ionomer film or sheet disclosed herein is formed of or consisting essentially of the highly neutralized water dispersible ionomers described above and substantially free of organic acid or salts thereof. By "substantially free", it is meant there is absolutely no or less than 0.1 weight% of organic acid or salts thereof. The organic acids used herein include, but are not limited to, caproic acid, caprylic acid, capric acid, lauric acid, stearic acid, behenic acid, erucic acid, oleic acid, and linoleic acid, naturally derived organic fatty acids such as palmitic, stearic, oleic, and mixtures thereof. The salts of organic acids used herein may be any of a wide variety, particularly including the barium, lithium, sodium, zinc, bismuth, potassium, strontium, magnesium or calcium salts of the organic acids.

Further, in addition to the highly neutralized water dispersible ionomers described above, the ionomer film or sheet may also contain any other additives known in the art, provided that such additives do not negatively affect the breathability, antistatic properties, and mechanical properties of the ionomer film or sheet. 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. In one embodiment, the ionomer film or sheet disclosed herein comprises about 0-30 weight% of polyhydric alcohol to further improve the antistatic property of the ionomer film or sheet, based on the total weight of the ionomer film or sheet.

The ionomer film or sheet disclosed herein may be prepared by any suitable process, such as extrusion coating, extrusion casting, extrusion film blowing, solution casting, solution coating, etc.

Article

Further disclosed herein are articles comprises at least one ionomer layer that is formed of or consisting essentially of the highly neutralized water dispersible ionomers described above. The ionomer layer disclosed herein may have a thickness of about 0.1-100 μm, or about 1-50 μm, or about 5-25 μm.

In one embodiment, the article disclosed herein is an article with an antistatic surface coating. That is, the article disclosed herein comprises a substrate and at least one surface of the substrate is coated with a coating layer that is formed of or consisting essentially of the highly neutralized water dispersible ionomers described above.

Such ionomer coating layer provides an antistatic surface to the article. The substrate may be formed of any suitable material. For example, the substrate may be formed of paper or polymeric materials. The paper materials used herein may be in the form of one or more layers of paper or paperboard. In accordance with the present disclosure, the paper layer or paperboard layer may have a thickness of about 30-600 μm and a basis weight of about 25-500 g/m^2, or 100-300 g/m^2. The polymeric materials used herein may 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, polycarbonate (PC), polyethylene terephthalate (PET), polybutylene terephthalate (PBT), polytrimethylene terephthalate (PTT), and combinations of two or more thereof. Suitable PA

include, without limitation, PA6, PA66, PA610, and combinations of two or more thereof. In one embodiment, the polymeric materials used herein are selected from polyesters, polyolefins, and combinations thereof. In a further embodiment, the polymeric materials used herein are selected from polyolefins, such as polyethylenes. The article disclosed herein may further comprise surface protective layer on the surface of the coating layer. The protective layer used herein comprises polyolefins, polyesters, PA, and combinations of two or more thereof. The protective layer used herein may have a thickness of less than 50 μm.

The articles with antistatic surface coating disclosed herein possess improved antistatic properties, compared to other articles with conventional ionomers known in the art. The term "antistatic property" as used herein refers to the ability of a coating layer to dissipate an electrical charge, such as a static electrical charge. The antistatic property is measured as surface resistivity in ohm per square (Ω/sq), in accordance with ASTM D257-07. Lower the surface resistivity represents better antistatic property. The article disclosed herein, which hasthe antistatic surface coating, has a surface resistivity of less than about 10^{12} Ω/sq.

Such articles possess good antistatic property, and can be used in a wide variety of applications. For example, the articles with antistatic surface can be used as containers for electronic devices or dried powder material; protective apparels; etc. Containers for electronic devices or dried powder material, include, but are not limited to, boxes, trays, bags, envelopes, pouches, sacks, cartons, wrapping or packaging films or sheets and fill sheets. Such containers can protect the electronic devices from being harmed by electrostatic discharge. The term "electronic device" as used herein refers to finished consumer products as well as modular devices, or electronic components to be incorporated into products. Electronic components can be any type of structure that is used as parts of an electronic device. They include, but are not limited to, printed wiring boards, chips, integrated circuits, discrete components, connectors, flex circuits, displays, I/O interfaces, keypads and other input devices, and housings. The

ionomer coating layers can dissipate the static electric charge resulted from frictions between dried powder materials and the container.

In a further embodiment, the article disclosed herein is a film or sheet with improved breathability.

The highly breathable film or sheet disclosed herein may be in the form of a monolayer film or sheet, and the monolayer film or sheet is formed of the at least one ionomer film or sheet layer described above.

Or, the highly breathable film or sheet may be in the form of a multilayer film or sheet and at least one layer of the multilayer film or sheet is formed of the at least one ionomer film or sheet layer described above.

In those embodiments, wherein the highly breathable films or sheets are in the form of a multilayer film or sheet, in addition to the at least one ionomer film or sheet layer that is formed or consists essentially of the highly neutralized water dispersible ionomer, the multilayer films or sheets also comprise at least one additional layer.

To maintain the breathability of the multilayer films or sheets, it is desirable that the additional layer is porous. Exemplary porous layers used herein include, but are not limited to woven fabrics, non-woven fabrics, scrims, and filters. Woven fabrics generally have a plurality of warp yarns running lengthwise in the machine direction, and a plurality of weft yarns running substantially perpendicularly to the warp yarns. Any weave construction or pattern of the woven fabrics may be used, for example, plain weave, twill weave, satin weave, basket weave, and the like. Non-woven fabrics are those formed of a structure of individual fibers or threads which are interlaid, but not in an identifiable manner as in a knitted or woven fabric. Non-woven fabrics can be prepared by many different processes, such as, melt blowing processes, spun bonding processes, hydro entangling, air-laid and bonded carded web processes. Scrims are lightweight fabrics that are often used as a backing material, such as, base fabric for coated or laminated products. Filters used herein are porous structures through which a liquid or gas can be passed through so that the suspended particulate matters are filtered out. The article disclosed herein may

further comprise surface protective layer on the surface of article. The protective layer used herein is formed of porous film or sheet.

The ionomer films or sheets disclosed herein possess improved breathability, compared to other conventional ionomer films or sheets known in the art. The term "breathability" as used herein is measured using the water vapor transmission rater (WVTR) value or the water vapor permeation value (WVPV) value of a film or sheet. The WVTR is the rate of water transmission through the entire thickness of a film or sheet and is inversely proportional to the thickness of the film or sheet. WVTR can be measured in grams of water vapor per square meter per day, in accordance with ASTMASTM F1249-13, at 37.8°C. The WVPV is calculated by normalizing the WVTR of a film or sheet to a thickness of 25.4 μm. That is, WVPV = WVTR × T/25.4, in which T is the thickness of the film or sheet in μm. WVTR values of film or sheet samples are reported in g/m^2-day, while WVPV values are reported in g-25.4 μm/m^2-day. The MVPV value of the ionomer films or sheets disclosed herein may be at least about 9000 g-25.4 μm/m^2-day. The MVTR value of the articles comprising additional porous layer may be at least of about 5000 g/m^2-day.

Such articles possess good breathability, and can be used in a wide variety of products such as personal hygiene articles, infection control products, protective covers, garments and the like. Personal hygiene articles include personal hygiene oriented items such as diapers, training pants, absorbent underpants, adult incontinence products, feminine hygiene products, and the like. In general, these are articles which are worn to contain bodily discharge(s) from the wearer. Infection control products include medically oriented items such as surgical gowns and drapes, face masks, head coverings like bouffant caps, surgical caps and hoods, footwear like shoe coverings, boot covers and slippers, wipers, garments like lab coats, coveralls, aprons and jackets, patient bedding, stretcher and bassinet sheets and the like. In general, these are articles are used to protect the user from bodily discharge(s) from other individuals. Other infection control products include wound dressings, bandages, sterilization wraps, and the like that contain bodily discharges and/or protect the wound from external

contamination. A protective cover includes a cover for vehicles such as cars, trucks, boats, airplanes, motorcycles, bicycles, golf carts, etc., covers for equipment often left outdoors like grills, yard and garden equipment and lawn furniture, as well as floor coverings, table cloths, picnic area covers, tents and the like.

The article disclosed herein may further comprise other suitable functional layers. Such additional functional layers may be included in the article in any position. In particular, adhesive layer(s) may be included in the article 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/metharylate copolymers, ethylene/ethyl acrylate copolymers, etc.), ethylene/monoalkyl maleate copolymers, polyurethane, epoxy, silane or combinations of two or more thereof.

The surface of the substrate made of polymeric materials may be treated, for example, by corona treatment, to improve adhesion of the adjacent layer to the substrate. Corona treatment is used to increase the surface energy of the substrate by generating therein carboxyl groups via oxidation of the polymers of the surface through electric discharge.

Moreover, printing information may be applied over one surface of the article. Preferably, the one surface of the article that carries the printing information is the surface that is positioned outward when the article is prepared into a container.

Method for preparing the article

Yet further disclosed herein are methods for preparing the articles described above.

The article with antistatic surface coatings may be prepared as follow:

(a) dispersing the highly neutralized water dispersible ionomer in water heated to a temperature from about 80-100°C under low shear conditions to provide an aqueous ionomer dispersion;

(b) optionally cooling the aqueous ionomer dispersion to a temperature of about 20-30°C, wherein the highly neutralized water dispersible ionomer remains dispersed in the water;

(c) providing the substrate;

(d) applying the aqueous ionomer dispersion onto at least one surface of the substrate to form a wet coating layer; and

(e) drying the wet coating layer at a temperature of about 20-150°C to obtain the article.

In step (a) of the process, the water is heated to a temperature of about 80-100°C or 85-95°C to ensure that the highly neutralized water dispersible is fully dispersed therein. In one embodiment, room temperature (about 20-25°C) water is used initially and then heated up to about 80-100°C to ensure full dispersion of the ionomer. In another embodiment, the highly neutralized water dispersible ionomer is mixed with water that is preheated to about 80-100°C under low shear condition. The aqueous ionomer dispersion may be produced in any suitable vessel, such as a tank, vat, pail and the like. Stirring is useful to provide effective contact of the highly neutralized water dispersible ionomer with water under low shear condition. The "low shear condition" used herein to refer to the shear rate of less than 1000 s^{-1}. The aqueous ionomer dispersion may be prepared in about 1 hour or less, such as in about 30 minutes or in about 20 minutes or less.

The aqueous ionomer dispersion may comprise from a lower limit of about 0.001 or about 1 weight% to an upper limit of about 10, about 20, about 30, or about 50 weight%, such as from about 1 to about 20 weight%, of the highly neutralized water dispersible ionomer, based on the total weight of the aqueous ionomer dispersion.

Once prepared, the aqueous ionomer dispersion is optionally cooled to a temperature of about 20-30°C. This may be accomplished by allowing the aqueous ionomer dispersion to cool under ambient conditions (temperatures of about 20-30°C. and atmospheric pressure) or by application of reduced temperatures, such as, by use of chill rolls or the like.

After cooling the aqueous ionomer dispersion, the aqueous ionomer dispersion is applied onto at least one surface of the substrate to form a wet coating layer.

The aqueous ionomer dispersion can be applied to the substrate surface in any suitable manner known in the art, including gravure coating, roll coating, wire rod coating, dip coating, flexographic printing, spray coating and the like. Excess aqueous dispersion coating composition can be removed by squeeze rolls, doctor knives and the like, if desired.

After applying the aqueous dispersion onto the substrate surface, the wet coating layer is dried to provide a solid coating layer on the substrate. During this drying step, water is removed from the aqueous dispersion, such as by evaporation, freeze drying, or the like. Drying may include allowing the dispersion to dry under ambient conditions (temperatures of about 20-30°C. and atmospheric pressure). Alternatively, drying may include application of elevated temperatures (such as up to 150°C. in an oven or heating tunnel) and/or reduced pressure. Freeze drying involves rapid freezing and drying in a high vacuum.

Further disclosed herein are methods for preparing the highly breathable films or sheets disclosed above.

In those embodiments wherein the highly breathable films or sheets are in the form of multilayer films or sheets, similar process described in reference to the article with antistatic surface coating may be used herein, with the exception that the substrate is replaced by the additional layer (e.g., porous sheet or film layer).

Or, the highly breathable multilayer films or sheets may be prepared by the following process:

(a) dispersing the highly neutralized water dispersible ionomer in water heated to a temperature from about 80-100°C under low shear conditions to provide an aqueous ionomer dispersion;

(b) optionally cooling the aqueous ionomer dispersion to a temperature of about 20-30°C, wherein the highly neutralized water dispersible ionomer remains dispersed in the water;

(c) providing a release substrate;

(d) applying the aqueous ionomer dispersion onto at least one surface of the release substrate to form a wet coating layer;

(e) drying the wet coating layer at a temperature of about 20-150°C to obtain a highly neutralized water dispersible ionomer film;

(f) peeling the highly neutralized water dispersible ionomer film away from the release substrate;

(g) providing the additional layer; and

(h) laminating the highly neutralized water dispersible ionomer film to the additional layer at a temperature from about 50-150°C, and optionally with pressure, to obtain breathable films or sheet.

The lamination process used in step (h) include, without limitation, nip roll lamination, vacuum lamination, etc. In one embodiment, the process may include providing all the component layers; aligning all the components in a certain order to form a pre-lamination assembly; and subjecting the pre-lamination assembly to lamination under heat and/or pressure.

The release substrates used herein include, without limitation, glass plate, polymeric plate, metal plate and the like.

While, in those embodiments wherein the highly breathable films or sheets are in the form of monolayer films or sheets, the following process may be used:

(a) dispersing the highly neutralized water dispersible ionomer in water heated to a temperature from about 80-100°C under low shear conditions to provide an aqueous ionomer dispersion;

(b) optionally cooling the aqueous ionomer dispersion to a temperature of about 20-30°C, wherein the highly neutralized water dispersible ionomer remains dispersed in the water;

(c) providing a release substrate;

(d) applying the aqueous ionomer dispersion onto at least one surface of the release substrate to form a wet coating layer;

(e) drying the wet coating layer at a temperature of about 20-150°C to obtain a highly neutralized water dispersible ionomer film;

(f) peeling the highly neutralized water dispersible ionomer film away from the release substrate to obtain the breathable film or sheet.

EXAMPLES

Materials:

- WDI (Water Dispersible Ionomer): a water dispersible ionomer derived from a parent acid copolymer, the parent acid copolymer comprising copolymerized units of ethylene and about 20 weight% of copolymerized units of methacrylic acid, based on the total weight of the parent acid copolymer, the parent acid copolymer having a MFR of 250 g/10min (measured in accordance to ASTM D1238 at 190 °C with a 2160g load); and in which 53.7% 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 potassium salts, obtained from E.I. du Pont de Nemours and Company (U.S.A.) (hereafter "DuPont");
- KOH: potassium hydroxide powder (CAS Number 1310-58-3) obtained from Sinopharm Chemical Reagent Co., Ltd.;
- SA Solution: 0.1 g/mL solution of stearic acid (CAS Number 57-11-4) in ethanol, obtained from Sinopharm Chemical Reagent Co., Ltd.

Comparative Examples CE1-CE7 and Examples E1-E5:

In each of CE1-CE7 and E1-E5, first, an aqueous ionomer dispersion was prepared as follows: a) WDI pellets were added into deionized water with a stirring speed of 400 rpm; b) heating up the mixture slowly to about 90-100°C; and c) maintaining the temperature and stirring speed for about 2 hours to ensure complete dispersion of the WDI pellets in the water. The dry content of the resulting aqueous ionomer dispersion was about 20 weight%. Thereafter, various amounts of KOH and optionally SA were added into the dispersion to further neutralize the WDI. Stirring of 400 rpm was applied to facilitate the dissolution of KOH. Compositions of the examples and comparative examples are shown in Table 1.

The resulting aqueous ionomer dispersion was coated onto a glass substrate by a Mayer rod to obtain a wet coating layer. The coated substrates were subsequently transferred into an oven and dried at 90°C for about 10-30 min. Finally, the ionomer films as such obtained were peeled off the from glass substrate.

Further, the thickness of the ionomer films were obtained by subtracting the thickness of the glass substrate from the total thickness of the coated glass substrate and tabulated in Table 1.

The MVTR value of the ionomer films were determined in accordance with ASTM F1249-13, at 37.8°C and tabulated in Table 1. WVPV was then calculated and tabulated in Table 1.

Finally, the tensile strain at break (%), tensile stress at maximum load (Mpa) and Energy at break (J/cm^2) of the ionomer films were determined in accordance with ASTM D882 and tabulated in Table 1.

From the results of Table 1, the following are evident.

When comparing E1-E4 versus CE1-CE4, it was found that the breathability of the ionomer film, as characterized by WVPV, increased as the neutralization level of the ionomer used therein increased. Moreover, it was found that an about 45% increase in WVPV was obtained when the neutralization level was increased from 80% to 85% (see E1 versus CE4).

Comparative Examples CE8-CE10 and Examples E6-E13:

The coated articles of CE8-CE10 and E6-E13 were prepared in the same manner as described in CE1-CE7 and E1-E4, except that corona treated low density polyethylene (LDPE) film with a thickness of about 120 μm were used as the substrate. Compositions of the examples and comparative examples are shown in Table 2.

Further, the thickness of the ionomer layers were obtained by subtracting the thickness of the LDPE substrate from the total thickness of the coated LDPE substrate and tabulated in Table 2.

The surface resistivity of the coated articles were measured by resistivity meter (Keithley 6517B) in accordance with ASTM D257-07 and tabulated in Table 2.

From the results of Table 2, the following are evident.

When comparing E6-E9 versus CE8-CE10, it was found that the surface resistivity of the ionomer coated film decreased as the neutralization level of the ionomer used herein increased. Moreover, it was found that an about 10^3 fold of reduction in surface resistivity was obtained when the neutralization level was increased from 75% to 85% (see E6 versus CE10).

While the invention has been illustrated and described in typical embodiments, it is not intended to be limited to the details shown, since various modifications and substitutions are possible without departing from the spirit of the present invention. As such, modifications and equivalents of the invention herein disclosed may occur to persons skilled in the art

Table 1

Materials	CE1	CE2	CE3	CE4	E1	E2	E3	E4	CE5	CE6	CE7	E5
WDI (weight%)	20	20	20	20	20	20	20	20	20	20	20	20
Deionized Water (weight%)	80	80	80	80	80	80	80	80	80	80	80	80
KOH (weight%)	-	0.28	0.53	0.65	0.78	0.9	1.02	1.15	0.9	0.9	0.9	0.9
SA solution(weight%)	-	-	-	-	-	-	-	-	2	6	20	-
Total (weight%)	100	100.28	100.53	100.65	100.78	100.9	101.02	101.15	102	106.9	120.9	100.9
Neutralization Level (%)	53.7	65	75	80	85	90	95	100	90	90	90	90
Property												
T (film thickness)[1] (μm)	15.2 (I) 7.6 (II)	16.5 (I) 15.2 (II)	16.5 (I) 25.4 (II)	41.9 (I) 54.6 (II)	48.3 (I) 54.6 (II)	20.3 (I) 22.9 (II)	21.6 (I) 24.1 (II)	25.4 (I) 25.4 (II)	15	17.8	15	12
WVTR[2] (g/m^2-day)	409 (I) 538 (II)	1115 (I) 1009 (II)	3044 (I) 2565 (II)	3778 (I) 3036 (II)	3973 (I) 5127 (II)	13527 (I) 10910 (II)	14432 (I) 11970 (II)	17826 (I) 26769 (II)	n/d[5]	n/d[5]	n/d[5]	n/d[5]
WVPV[3] (g-25.4 μm/m^2-day)	245 (I) 161 (II)	725 (I) 605 (II)	1979 (I) 2565 (II)	623 3(I) 6528 (II)	7548 (I) 11022 (II)	10821 (I) 9819 (II)	12268 (I) 11372 (II)	17826 (I) 26769 (II)	n/d[5]	n/d[5]	n/d[5]	n/d[5]
Averaged WVPV[4] (g-25.4 μm/m^2-day)	203	665	2272	6381	9285	10320	11820	22298	n/d[5]	n/d[5]	n/d[5]	n/d[5]
Tensile strain at break (%)	n/d[5]	n/d[5]	n/d[5]	n/d[5]	n/d[5]	n/d[5]	n/d[5]	n/d[5]	78	58.8	43	78
Tensile stress at maximum load (Mpa)	n/d[5]	n/d[5]	n/d[5]	n/d[5]	n/d[5]	n/d[5]	n/d[5]	n/d[5]	6.87	6.63	7.75	6.66
Energy at break (J/cm^2)	n/d[5]	n/d[5]	n/d[5]	n/d[5]	n/d[5]	n/d[5]	n/d[5]	n/d[5]	47.8	36.0	17.4	49.6

[1, 2, 3] Two samples (I and II) were prepared for each formulation and therefore two separate thickness measurements, WVTR measurements, and WVPV values are recorded herein; [4] The Averaged WVPV value recorded herein is an average of the two separate WVPV values from Samples I and II; [5] n/d: not determined.

Table 2

Materials	CE8	CE9	CE10	E6	E7	E8	E9	E10	E11	E12	E13
WDI (weight%)	20	20	20	20	20	20	20	20	20	20	20
Deionized Water (weight%)	80	80	80	80	80	80	80	80	80	80	80
KOH (weight%)	-	0.28	0.53	0.76	0.9	1.02	1.14	0.76	0.76	0.76	0.76
Total (weight%)	100	100.28	100.53	100.76	100.9	101.02	101.14	100.76	100.76	100.76	100.76
Neutralization Level (%)	53.7	65	75	85	90	95	100	85	85	85	85
Property											
T (film thickness) (μm)	20	20	20	20	20	20	20	0.8	1.5	3.2	6.5
Surface resistivity (Ω/sq)	10^{15}	10^{15}	10^{11}	10^{8}	10^{7}	10^{7}	10^{8}	10^{9}	10^{9}	10^{8}	10^{8}

WHAT IS CLAIMED IS:

1. An article comprising at least one ionomer layer that is formed of or consists essentially of a highly neutralized water dispersible ionomer, wherein the highly neutralized water dispersible ionomer is derived from a parent acid copolymer, the parent acid copolymer comprising copolymerized units of ethylene and about 18-30 weight% 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) of about 200-1000 g/10 min (measured in accordance with ASTM D1238 at 190°C with a 2160 g load); and in which at least 85% 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.

2. The article of Claim 1, wherein the parent acid copolymer is an ethylene methacrylic acid dipolymer comprising about 18-25 weight% of copolymerized units of methacrylic acid.

3. The article of Claim 1 or 2, which further comprises a substrate and the at least one ionomer layer is coated to at least one surface of the substrate.

4. The article of claim 3, wherein the substrate is formed of polymeric or paper materials.

5. The article of Claim 3 or 5, which has a surface resistivity of less than 10^{12} Ω/sq.

6. The article of Claim 1，wherein the at least one ionomer layer is substantially free of organic acid.

7. The article of any one of Claims 1, 2, and 6, which is in the form of a monolayer film or sheet and the monolayer film or sheet is formed of or consisting essentially of the highly neutralized water dispersible ionomer.

8. The article of any one of Claims 1, 2, and 6, which is in the form of a multilayer film or sheet, and wherein, at least one layer of the multilayer film or sheet is formed of or consisting essentially of the highly neutralized water

dispersible ionomer and the multilayer film or sheet further comprises at least one additional layer.

9. The article of Claim 8, wherein the at least one additional layer is formed of porous sheet or film.

10. The article of any one of Claims 6-9, which has a water vapor transmission rate of at least 5000 g/m^2-day.

11. A method for preparing the article of any one of Claims 3-4 comprising:

(a) dispersing the highly neutralized water dispersible ionomer in water heated to a temperature from 80-100°C under low shear conditions to provide an aqueous ionomer dispersion;

(b) optionally cooling the aqueous ionomer dispersion to a temperature of 20-30°C, wherein the highly neutralized water dispersible ionomer remains dispersed in the water;

(c) providing the substrate;

(d) applying the aqueous ionomer dispersion onto at least one surface of the substrate to form a wet coating layer; and

(e) drying the wet coating layer at a temperature of about 20-150°C to obtain the article.

12. A method for preparing the monolayer film or sheet of Claim 7 comprising:

(a) dispersing the highly neutralized water dispersible ionomer in water heated to a temperature from about 80-100°C under low shear conditions to provide an aqueous ionomer dispersion;

(b) optionally cooling the aqueous ionomer dispersion to a temperature of about 20-30°C, wherein the highly neutralized water dispersible ionomer remains dispersed in the water;

(c) providing a release substrate;

(d) applying the aqueous ionomer dispersion onto at least one surface of the release substrate to form a wet highly neutralized water dispersible ionomer layer;

(e) drying the wet highly neutralized water dispersible ionomer layer at a temperature of about 20-150°C to obtain a highly neutralized water dispersible ionomer film;

(f) peeling the highly neutralized water dispersible ionomer film away from the release substrate to obtain the monolayer film or sheet.

13. A method for preparing the article of any one of Claims 8-10 comprising:

(a) dispersing the highly neutralized water dispersible ionomer in water heated to a temperature from about 80-100°C under low shear conditions to provide an aqueous ionomer dispersion;

(b) optionally cooling the aqueous ionomer dispersion to a temperature of about 20-30°C, wherein the highly neutralized water dispersible ionomer remains dispersed in the water;

(c) providing a release substrate;

(d) applying the aqueous ionomer dispersion onto at least one surface of the release substrate to form a wet highly neutralized water dispersible ionomer layer;

(e) drying the wet highly neutralized water dispersible ionomer layer at a temperature of about 20-150°C to obtain a highly neutralized water dispersible ionomer film;

(f) peeling the highly neutralized water dispersible ionomer film away from the release substrate;

(g) providing the additional layer; and

(h) laminating the highly neutralized water dispersible ionomer film onto the additional layer at a temperature from 50-150°C, and optionally with applied pressure to obtain the article.

14. A method for preparing the article of any one of Claims 8-10 comprising:

(a) dispersing the highly neutralized water dispersible ionomer in water heated to a temperature from 80-100°C under low shear conditions to provide an aqueous ionomer dispersion;

(b) optionally cooling the aqueous ionomer dispersion to a temperature of 20-30°C, wherein the highly neutralized water dispersible ionomer remains dispersed in the water;

(c) providing the additional layer;

(d) applying the aqueous ionomer dispersion onto at least one surface of the additional layer to form a wet coating layer; and

(e) drying the wet coating layer at a temperature of about 20-150°C to obtain the article.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/079059

A. CLASSIFICATION OF SUBJECT MATTER

C08F 210/02(2006.01)i; C08F 8/44(2006.01)i; C08J 5/18(2006.01)i; C09D 123/08(2006.01)i; B32B 33/00(2006.01)i

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)

C08F210/-; C08F8/-; C08J5/-; C09D123/-; B32B33/-

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)

EPODOC,WPI,CNKI,CNPAT:Ionomer, methacrylic acid, salt, ethylene, +acrylic, layer, neutraliz+, resistivity, antistatic, film, carboxylic acid , MFR, potassium cations

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2013090406 A1 (E. I. DU PONT DE NEMOURS AND COMPANY) 20 June 2013 (2013-06-20) description, page 3 line 4 to page 4 line 8 and page 15 lines 31-37	1-14
Y	WO 2005075556 A1 (DU PONT-MITSUI POLYCHEMICALS CO., LTD. ET AL.) 18 August 2005 (2005-08-18) description, page 3 lines 24-27 and page 4 lines 1-5	1-14
Y	EP 2221322 A1 (DU PONT-MITSUI POLYCHEMICALS CO., LTD.) 25 August 2010 (2010-08-25) description, paragraphs [0009], [0010], [0017]-[0019], [0028] and [0034]	1-14
A	EP 2386592 A1 (DU PONT-MITSUI POLYCHEMICALS CO. LTD.) 16 November 2011 (2011-11-16) description, paragraphs [0062]-[0074]	1-14
A	WO 2007075775 A1 (E. I. DU PONT DE NEMOURS AND COMPANY ET AL.) 05 July 2007 (2007-07-05) description, page 2 line 25 to page 4 line 30	1-14

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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"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

"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

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"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

"&" 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 January 2016	**14 February 2016**

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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