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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 December 2014 (11.12.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/197415 A1

(51) International Patent Classification:
C08J 5/12 (2006.01) ***B32B 27/30*** (2006.01)
C09J 5/00 (2006.01)

(21) International Application Number:
PCT/US2014/040593

(22) International Filing Date:
3 June 2014 (03.06.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/830,969 4 June 2013 (04.06.2013) US

(71) Applicant: MONOSOL LLC [US/US]; 707 E. 80th Place, Suite 301, Merrillville, IN 46410 (US).

(72) Inventors: KUMAR, Sumeet; 12741 Connecticut Street, Crown Point, IN 46307 (US). **BROMBY, Percy**; 3440 W. 85th Place, Chicago, IL 60652 (US). **LEE, David, M.**; 707 E. 80th Place, Suite 301, Merrillville, IN 46410 (US).

(74) Agents: PARKS, Steven, M. et al.; Marshall, Gerstein & Borun LLP, 233 S. Wacker Drive, 6300 Willis Tower, Chicago, IL 60606-6357 (US).

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

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

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: WATER-SOLUBLE FILM SEALING SOLUTIONS, RELATED METHODS, AND RELATED ARTICLES

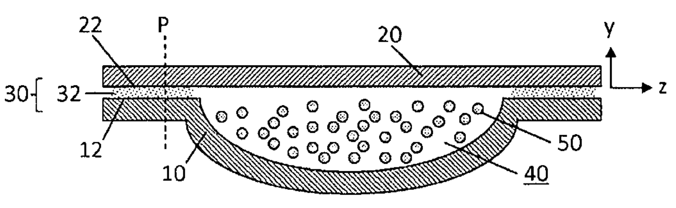


Figure 1

(57) **Abstract**: Disclosed herein are sealing solutions for sealing water-soluble films, in particular aqueous mixtures including one or more polymeric solvents such as polyols. Aqueous sealing solutions including a relatively dilute solvent for one or more polymeric components of the water-soluble film (e.g., water-soluble polymeric components thereof, such as polyvinyl alcohol (PVOH)) can exhibit one or more benefits, including a reduction in dissolution of the film by the sealing solution and an increase in seal strength. Also disclosed are sealed articles formed with the sealing solutions, for example water-soluble packets containing various liquid or solid compositions.

WO 2014/197415 A1

WATER-SOLUBLE FILM SEALING SOLUTIONS, RELATED METHODS, AND RELATED ARTICLES

Cross Reference To Related Application

[0001] Priority is claimed to U.S. Provisional Application No. 61/830,969 (filed on June 4, 2013), which is incorporated herein by reference in its entirety.

Field of the Disclosure

[0002] The present disclosure relates generally to water-soluble films. More particularly, the disclosure relates to sealing solutions for sealing water-soluble films, in particular low-viscosity aqueous mixtures including one or more polymeric solvents such as polyols, which solutions can be used to form sealed water-soluble articles containing various compositions.

Background

[0003] Water-soluble films are well known in the art. Water-soluble films have many applications, including non-edible forms, such as packaging, and edible forms, wherein the film itself is or contains an edible article. Edible films are known for uses such as delivery of therapeutic agents, breath freshening agents, food ingredients including but not limited to baking ingredients such as dough modifiers and flavors. The films can be formed into water-soluble packets for storing or delivering various compositions, edible or non-edible.

[0004] Common methods for sealing water-soluble films formed into packets or pouches include heat sealing and solution sealing. With heat sealing, pouches may be formed by placing two sheets of water-soluble film together, heat-sealing three edges, filling with a suitable composition, and then heat sealing the forth edge to form a sealed pouch. In a solution sealing process, solvent is applied to the film material to form a seal between the solvated film and another film. Water is a common solvent for solution sealing of water-soluble pouches because it is low cost, non-toxic, and readily available such that, when applied at appropriate levels, it can result in strong seals which prevent solid/liquid leakage from the resulting pouch.

[0005] While solution sealing can have advantages over heat sealing, solution sealing has been found unsuitable for many water-soluble films. Some water-soluble films may form solution seals with insufficient strength to maintain structural integrity during their useful lives. In other cases, the water-soluble film may be relatively susceptible to rapid dissolution by the sealing solution, thus destroying the film and/or preventing seal formation with sufficient strength. For example, on rapidly dissolving water-soluble films such as polyvinyl alcohol, water can be too aggressive in dissolving the film, resulting in film burn-through and preventing quality seal formation. For some water-soluble films, in particular for thin films such as 1.5 mil-thick films, there is no known method or corresponding sealing solution for effectively sealing the films.

Summary

[0006] The disclosure generally relates to sealing solutions for sealing water-soluble films, in particular aqueous mixtures including one or more polymeric solvents such as polyols. It has been found that aqueous sealing solutions including a relatively dilute solvent for one or more polymeric components of the water-soluble film (e.g., water-soluble polymeric components thereof, such as polyvinyl alcohol (PVOH)) can exhibit one or more benefits, including a reduction in dissolution of the film by the sealing solution (e.g., relative to water alone, such as represented by an increased characteristic burn-through time), an increase in seal strength (e.g., relative to a seal formed by water alone, such as represented by a characteristic peel strength), and embodiments including a combination of such benefits.

[0007] One aspect of the disclosure relates to a method for sealing a water-soluble film, the method including:(a) applying a sealing solution to a first surface of a water-soluble film, the sealing solution including (i) water, and (ii) a polyol having 3 or more hydroxyl groups, wherein the sealing solution has a dynamic viscosity (μ_S) less than 1.5 cP as measured at 20°C; and (b) contacting a second surface of a water-soluble film with the sealing solution on the first surface for a time sufficient to form a seal between the first surface and the second surface.

[0008] Another aspect of the disclosure relates to a method for sealing a water-soluble film, the method including: (a) applying a sealing solution to a first surface of a water-soluble film having an initial thickness less than about 50 μm and including a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units, the sealing solution including (i) water, and (ii) a polyol present in the sealing solution in an amount ranging from about 2 wt.% to about 15 wt.%, the polyol being selected from the group consisting of glycerol, erythritol, threitol, arabitol, xylitol, ribitol, mannitol, sorbitol, galactitol, fucitol, iditol, inositol, volemitol, isomalt, maltitol, lactitol, and combinations thereof, wherein the sealing solution has a dynamic viscosity (μ_s) less than 1.5 cP as measured at 20°C; and (b) contacting a second surface of a water-soluble film having an initial thickness less than about 50 μm and including a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units with the sealing solution on the first surface for a time sufficient to form a seal between the first surface and the second surface.

[0009] Another aspect of the disclosure relates to a method for sealing a water-soluble film, the method including: (a) applying a sealing solution to a first surface of a water-soluble film, the sealing solution including (i) water, and (ii) a solvent for at least one polymeric component of the water-soluble film, wherein (A) the solvent and the polymeric component have a solubility radius (Ra) of about 5 or less as defined by equation (I):

$$(Ra)^2 = 4(\delta_{D,S} - \delta_{D,P})^2 + (\delta_{P,S} - \delta_{P,P})^2 + (\delta_{H,S} - \delta_{H,P})^2 \qquad (I)$$

where $\delta_{D,S}$ is the solvent dispersive force, $\delta_{D,P}$ is the polymeric component dispersive force, $\delta_{P,S}$ is the solvent polar force, $\delta_{P,P}$ is the polymeric component polar force, $\delta_{H,S}$ is the solvent hydrogen bonding force, and $\delta_{H,P}$ is the polymeric component hydrogen bonding force, each of which is determined by a consistent method of Hansen solubility parameter evaluation, and (B) the sealing solution has a dynamic viscosity (μ_s) less than 1.5 cP as measured at 20°C; and (b) contacting a second surface of a water-soluble film with the sealing solution on the first surface for a time sufficient to form a seal between the first surface and the second surface.

[0010] In another aspect, the disclosure relates to a method for forming a sealed water-soluble packet containing a composition, the method including: performing a method for sealing a water-soluble film according to any of the disclosed embodiments, wherein (i) the water-soluble film of at least one of the first surface and the second surface defines a volume at least partially enclosing a composition, and (ii) forming the seal creates the sealed water-soluble packet containing the composition.

[0011] In another aspect, the disclosure relates to an article such as a sealed water-soluble packet, the article including: (a) a first surface of a water-soluble film sealed to a second surface of a water-soluble film at an interfacial region between the first surface and the second surface; and (b) a polyol having 3 or more hydroxyl groups present in the interfacial region at a local concentration substantially higher than a bulk concentration of the polyol in the water-soluble film and outside of the interfacial region.

[0012] In another aspect, the disclosure relates to an article such as a sealed water-soluble packet, the article including: (a) a first surface of a water-soluble film sealed to a second surface of a water-soluble film at an interfacial region between the first surface and the second surface, wherein the water-soluble film for each of the first surface and the second surface has an initial thickness less than about 50 μm and includes a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units; and (b) a polyol present in the interfacial region at a local concentration substantially higher than a bulk concentration of the polyol in the water-soluble film and outside of the interfacial region, the polyol being selected from the group consisting of glycerol, erythritol, threitol, arabitol, xylitol, ribitol, mannitol, sorbitol, galactitol, fucitol, iditol, inositol, volemitol, isomalt, maltitol, lactitol, and combinations thereof.

[0013] In another aspect, the disclosure relates to an article such as a sealed water-soluble packet, the article including: (a) a first surface of a water-soluble film sealed to a second surface of a water-soluble film at an interfacial region between the first surface and the second surface; and (b) a solvent for at least one polymeric component of the water-soluble film present in the interfacial region at a local concentration substantially higher than a bulk concentration of the solvent in the water-soluble film and outside of the interfacial region, wherein the solvent and the polymeric component have a solubility radius (Ra) of about 5 or less as defined by equation (I):

$$(Ra)^2 = 4(\delta_{D,S} - \delta_{D,P})^2 + (\delta_{P,S} - \delta_{P,P})^2 + (\delta_{H,S} - \delta_{H,P})^2 \qquad \text{(I)}$$

where $\delta_{D,S}$ is the solvent dispersive force, $\delta_{D,P}$ is the polymeric component dispersive force, $\delta_{P,S}$ is the solvent polar force, $\delta_{P,P}$ is the polymeric component polar force, $\delta_{H,S}$ is the solvent hydrogen bonding force, and $\delta_{H,P}$ is the polymeric component hydrogen bonding force, each of which is determined by a consistent method of Hansen solubility parameter evaluation.

[0014] Optionally, the water-soluble films of each aspect can be formed (e.g., thermoformed) into a pouch, for example so that the pouch can be filled with a suitable composition and subsequently sealed into a water-soluble packet containing the composition using the disclosed solvent sealing solutions and related methods.

[0015] Further aspects and advantages will be apparent to those of ordinary skill in the art from a review of the following detailed description and accompanying drawings. While the compositions and methods are susceptible of embodiments in various forms, the description hereafter includes specific embodiments with the understanding that the disclosure is illustrative, and is not intended to limit the invention to the specific embodiments described herein.

Description of the Drawings

[0016] The following detailed description of the various disclosed methods, processes, compositions, and articles refers to the accompanying drawings in which:

[0017] Figure 1 is a side cross-sectional view of a sealed water-soluble packet, which illustrates corresponding methods for sealing a water-soluble film according to the disclosure.

[0018] Figure 2 is a qualitative concentration profile along line P of Figure 1 illustrating local concentrations of sealing solution components and water-soluble film components in bulk and seal-interfacial regions of a sealed water-soluble film.

[0019] Figure 3 includes graphs and tables illustrating (a) the burn-through time and (b) the seal peel strength for PVOH copolymer Film A as a function of glycerin concentration for glycerin-in-water sealing solutions according to the disclosure.

[0020] Figure 4 includes graphs and tables illustrating (a) the burn-through time and (b) the seal peel strength for PVOH copolymer Film B as a function of glycerin concentration for glycerin-in-water sealing solutions according to the disclosure.

[0021] Figure 5 includes graphs and tables illustrating (a) the burn-through time and (b) the seal peel strength for PVOH copolymer Film C as a function of glycerin concentration for glycerin-in-water sealing solutions according to the disclosure.

[0022] Figure 6 includes graphs and tables illustrating (a) the burn-through time and (b) the seal peel strength for PVOH homopolymer Film D as a function of glycerin concentration for glycerin-in-water sealing solutions according to the disclosure.

[0023] Figure 7 includes graphs and tables illustrating (a) the burn-through time and (b) the seal peel strength for PVOH homopolymer Film E as a function of glycerin concentration for glycerin-in-water sealing solutions according to the disclosure.

[0024] Figure 8 includes graphs illustrating the burn-through time and the seal peel strength for PVOH homopolymer Film F for glycerin-in-water sealing solutions according to the disclosure (a) at low concentrations and (b) and high concentrations.

[0025] Figure 9 includes graphs illustrating the burn-through time and the seal peel strength for PVOH homopolymer Film F for 2-methyl-1,3-propanediol (MP diol)-in-water sealing solutions according to the disclosure (a) at low concentrations and (b) and high concentrations.

[0026] Figure 10 includes graphs illustrating the burn-through time and the seal peel strength for PVOH homopolymer Film F for propylene glycol-in-water sealing solutions according to the disclosure (a) at low concentrations and (b) and high concentrations.

[0027] Figure 11 includes a graph illustrating the burn-through time and the seal peel strength for PVOH homopolymer Film F for mannitol-in-water sealing solutions according to the disclosure (a) at low concentrations.

[0028] Figure 12 includes graphs illustrating the burn-through time and the seal peel strength for PVOH homopolymer Film F for sorbitol-in-water sealing solutions according to the disclosure (a) at low concentrations and (b) and high concentrations.

[0029] Figure 13 includes graphs illustrating the burn-through time and the seal peel strength for PVOH homopolymer Film F for xylitol-in-water sealing solutions according to the disclosure (a) at low concentrations and (b) and high concentrations.

Detailed Description

[0030] Disclosed herein are sealing solutions for sealing water-soluble films. The sealing solutions include water and a solvent for one or more polymeric components of the water-soluble film to be sealed. As used in the context of the sealing solution, a "solvent" refers to a compound generally capable of forming a liquid or solid solution with the polymeric component of the film. As described below, an extent of solubility between the solvent and polymeric component can be characterized by a solubility radius parameter. The solvent need not necessarily be a liquid at room temperature or seal-forming temperature (e.g., it can be a liquid or solid at such temperatures). The solvent suitably is soluble in water at the concentration used in the sealing solution. Examples of suitable solvents include polyols having 3 or more hydroxyl (-OH) groups, for example for soluble films including polyvinyl alcohol or other water-soluble polymer components.

[0031] The aqueous sealing solution suitably includes one or more such solvents at relatively dilute concentrations, generally resulting in a sealing solution viscosity at or near (e.g., slightly above) that of water. Even at a relatively dilute solvent concentration, the aqueous sealing solution can exhibit one or more benefits relative to water alone as a sealant, including a reduction in dissolution of the film by the sealing solution and an increase in seal strength. In some cases, the sealing solution can permit the formation of seal for a particular film where no solution seal would otherwise be possible using water alone (e.g., providing a sufficient increase in burn-though time to permit the formation of a complete seal, even though such seal might have a relatively low absolute seal strength limiting its use in certain applications). The disclosed sealing solutions and corresponding methods can be used to form various sealed articles, for example sealed water-soluble packets containing various compositions such as human and animal ingestible items, personal care compositions and cleaning compositions.

[0032] The sealing solution, sealed films, and related methods are contemplated to include embodiments including any combination of one or more of the additional optional elements, features, and steps further described below (including those shown in the figures and Examples), unless stated otherwise.

[0033] As used herein, the term "homopolymer" generally includes polymers having a single type of monomeric repeating unit (e.g., a polymeric chain consisting of or consisting essentially of a single monomeric repeating unit). For the particular case of PVOH, the term "homopolymer" (or "PVOH homopolymer") further includes copolymers having a distribution of vinyl alcohol monomer units and vinyl acetate monomer units, depending on the degree of hydrolysis (e.g., a polymeric chain consisting of or consisting essentially of vinyl alcohol and vinyl acetate monomer units). In the limiting case of 100% hydrolysis, a PVOH homopolymer can include a true homopolymer having only vinyl alcohol units.

[0034] As used herein, the term "copolymer" generally includes polymers having two or more types of monomeric repeating units (e.g., a polymeric chain consisting of or consisting essentially of two or more different monomeric repeating units, whether as random copolymers, block copolymers, etc.). For the particular case of PVOH, the term "copolymer" (or "PVOH copolymer") further includes copolymers having a distribution of vinyl alcohol monomer units and vinyl acetate monomer units, depending on the degree of hydrolysis, as well as at least one other type of monomeric repeating unit (e.g., a ter- (or higher) polymeric chain consisting of or consisting essentially of vinyl alcohol monomer units, vinyl acetate monomer units, and one or more other monomer units). In the limiting case of 100% hydrolysis, a PVOH copolymer can include a copolymer having vinyl alcohol units and one or more other monomer units, but no vinyl acetate units.

[0035] As used herein, the term "comprising" indicates the potential inclusion of other agents, elements, steps, or features, in addition to those specified.

[0036] As used herein, "favorable solubility" refers to a film according to the disclosure herein that, at about 2.0 mils thick, completely dissolves in less than 50 seconds, preferably less than 40 and most preferably less than 30 seconds in water at 23 °C.

[0037] As used herein and unless specified otherwise, the terms "wt.%" and "wt%" are intended to refer to the composition of the identified element in "dry" (non water) parts by weight of the entire film (when applicable) or parts by weight of the entire composition enclosed within a pouch (when applicable). As used herein and unless specified otherwise, the term "phr" is intended to refer to the composition of the identified element in parts per one hundred parts water-soluble polymer (or resin; whether PVOH or otherwise) in the water-soluble film.

[0038] All ranges set forth herein include all possible subsets of ranges and any combinations of such subset ranges. By default, ranges are inclusive of the stated endpoints, unless stated otherwise. Where a range of values is provided, it is understood that each intervening value between the upper and lower limit of that range and any other stated or intervening value in that stated range, is encompassed within the disclosure. The upper and lower limits of these smaller ranges may independently be included in the smaller ranges, and are also encompassed within the disclosure, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either or both of those included limits are also contemplated to be part of the disclosure.

Sealing Solution

[0039] The sealing solution includes water and a solvent for one or more polymeric components of the water-soluble film, generally in the form of an aqueous solution. In one type of embodiment, the sealing solution includes water and a solvent for the primary polymeric component of the water-soluble film (e.g. highest concentration polymeric component, by weight, based on the entire weight of the film). As noted above, the solvent can be a liquid or solid in its natural state at typical sealing temperatures, and it is capable of forming a liquid or solid solution with its corresponding polymeric component(s) of the water-soluble film. The sealing solution can include more than one solvent, for example where multiple solvents are selected for their compatibility with a particular polymeric component. Alternatively or additionally, multiple solvents can be used when the water-soluble film has multiple polymeric components (e.g., where different solvents are selected for their solubility characteristics with respect to different polymeric components).

[0040] The sealing solution has been found to be effective as a relatively dilute aqueous solvent solution, both in terms of its ability to increase burn-through resistance and increase seal strength. For example, solvent concentration ranges of about 2 wt.% to about 15 wt.% or about 5 wt.% to about 10 wt.% in the sealing solution can be effective. More generally, the solvent can be present at levels of at least about 2, 4, 5, 8, or 10 wt.% and/or up to about 8, 10, 12, 15, 20, 30, 40, or 50 wt.% relative to the total sealing solution. The foregoing amounts and ranges can apply individually to specific solvents or collectively to all solvents when more than one type of solvent is included in the sealing solution. Analogous to the solvent, water concentration ranges of about 85 wt.% to about 95 wt.% or about 90 wt.% to about 95 wt.% in the sealing solution can be effective. More generally, water can be present at levels of at least about 50, 60, 70, 80, 88, 90, or 92 wt.% and/or up to about 90, 92, 95, 96, or 98 wt.% relative to the total sealing solution. Alternatively or additionally, the relatively dilute nature of the sealing solution can be reflected by the dynamic viscosity of the sealing solution (μ_s), which is generally at or near (e.g., slightly above) the viscosity of water at a corresponding temperature. For example, a suitable sealing solution viscosity at a 20°C reference temperature can be less than 1.5 cP or range from about 1 cP to about 1.4 cP or 1.45 cP (e.g., more generally being at least about 0.5, 1, 1.1, or 1.2 cP and/or up to about 1.1, 1.2, 1.3, 1.4, or 1.45 cP). At different reference temperatures (T_{ref}), the sealing solution viscosity (μ_S) relative to the corresponding water viscosity (μ_w) can alternatively be expressed as a ratio (μ_s/μ_w) of less than 1.5 (e.g., more generally being at least about 0.5, 1, 1.1, or 1.2 and/or up to about 1.1, 1.2, 1.3, 1.4, or 1.45).

[0041] The specific solvents of the sealing solution are not particularly limited, and they generally include small organic molecules having one or more (e.g., at least 2 or 3 or more) polar functional groups (e.g., oxygen- or nitrogen-containing groups, such as hydroxyl groups or (1°, 2°, or 3°) amino groups) which promote the solvent's compatibility with the aqueous sealing solution medium and polar functional groups of the polymeric component in the water-soluble film, where such polymeric functional groups can be the same or different from those in the solvent. A specific solvent can contain 2 to 12 carbon atoms (e.g., 3 to 6, 8, or 10 carbon atoms, such as 3, 4, 5, or 6 carbon atoms). Alternatively or additionally the solvent can contain 2 or 3 to 12 polar functional groups (e.g., 2 or 3 to 6, 8, or 10 polar groups, such as 3, 4, 5, or 6 polar groups), whether hydroxyl, amino, otherwise, or a combination thereof. In certain embodiments, the solvent can be a suitable plasticizer for the polymeric component(s) of the water-soluble film, whether or not the selected solvent is present as such in a particular film to be sealed.

[0042] Polyols having 3 or more hydroxyl groups (-OH) represent a suitable class of solvents for various water-soluble films. For example, polyols are suitable for water-soluble films containing PVOH (e.g., homopolymers thereof) as the sole or major polymeric component (e.g., at least about 50, 60, 75, 85, or 95 wt.% relative to the film as a whole or all polymeric components thereof). Examples of suitable polyols include various sugar alcohols including glycerin (glycerol), erythritol, threitol, arabitol, xylitol, ribitol, mannitol, sorbitol, galactitol, fucitol, iditol, inositol, volemitol, isomalt, maltitol, lactitol, and combinations thereof. Such polyols at relatively low concentrations in water (e.g., about 2 wt.% to about 15 wt.%. or about 5 wt.% to about 10 wt.%) generally exhibit low sealing solution viscosities. For example, 5 wt.% and 10 wt.% glycerin-in-water solutions have viscosities of about 1.2 cP and about 1.3 cP, respectively. Examples of suitable amino-functional solvents for various water-soluble films (e.g., with amino-functional components or otherwise) include linear (poly)ethyleneamines including ethylenediamine, diethylenetriamine (DETA), and triethylenetetramine (TETA).

[0043] As illustrated in the examples below, in one class of embodiments, a solvent can be selected and characterized based on its polymeric compatibility in terms of a Hansen solubility radius (Ra) parameter. Hansen solubility parameters (HSP) are a recognized tool for understanding and identifying relatively good and poor solvents for many materials, including polymers. The solubility characteristics of a material can be characterized by three individual forces: dispersive forces (δ_D), polar forces (δ_P), and hydrogen bonding forces (δ_H). The individual forces can be combined into a total cohesive energy value (δ_T) as shown in Equation 1:

$$(\delta_T)^2 = (\delta_D)^2 + (\delta_P)^2 + (\delta_H)^2. \tag{1}$$

In addition to representative solubility parameters for a single component, a solubility radius (Ra) can be used to characterize the relative solubility of two materials with respect to each other. For the specific case of sealing solution solvent (S) and a water-soluble film polymeric component (P), the solubility radius (Ra) can be expressed as shown in Equation 2:

$$(Ra)^2 = 4(\delta_{D,S} - \delta_{D,P})^2 + (\delta_{P,S} - \delta_{P,P})^2 + (\delta_{H,S} - \delta_{H,P})^2. \qquad (2)$$

In Equation 2, $\delta_{D,S}$ is the solvent dispersive force, $\delta_{D,P}$ is the polymeric component dispersive force, $\delta_{P,S}$ is the solvent polar force, $\delta_{P,P}$ is the polymeric component polar force, $\delta_{H,S}$ is the solvent hydrogen bonding force, and $\delta_{H,P}$ is the polymeric component hydrogen bonding force. If the solubility radius (or distance) between two materials is 0, then they have the same δ_D, δ_P, and δ_H coordinates, and they are soluble in each other. The further apart they are, the less likely they are to be soluble in each in each other. Calculations for evaluating the various HSP values can be performed using a commercially available software package such as HSPIP (available from the Hansen Solubility Parameters internet site, currently in the 4th edition). Experimentally good solvents and poor solvents can be tested, and the HSP coordinates δ_D, δ_P, and δ_H for a material can be experimentally determined. Alternatively, the individual HSP coordinates δ_D, δ_P, and δ_H can be computed using the Y-MB methodology (included in the HSPIP software). Regardless of the method selected for HSP parameter estimation, a consistent method is suitably used for all solvents and polymeric components of interest.

[0044] The solubility radius between the sealing solution solvent and at least one (water-soluble) polymeric component in the water-soluble film is suitably small, for example about 5 or less. In various embodiments, the solubility radius suitably ranges from about 1 to about 5, or, more generally, can be at least about 1, 2, or 3 and/or up to about 4, 4.5, or 5. In cases where the sealing solution includes more than one solvent, each of the solvents suitably has a solubility radius of about 5 or less with respect to a water-soluble polymeric component in the water-soluble film. In cases where the water-soluble film includes more than one water-soluble polymeric component, the solvent suitably has a solubility radius of about 5 or less with respect to at least one of the water-soluble polymeric components and optionally with respect to the primary water-soluble polymeric component. In embodiments, the solvent can have a solubility radius of about 5 or less with respect to the majority of the water-soluble polymeric components. In embodiments, the solvent can have a solubility radius of about 5 or less with respect to all water-soluble polymeric components. Where there are multiple solvents and water-soluble polymeric components, individual solvents can be selected for solubility compatibility with at least one water-soluble polymeric component. For example, in one type of embodiment all water-soluble polymeric components have at least one corresponding compatible solvent in the sealing solution. While the foregoing values and ranges for the solubility radius may be used independently of the particular solvent and water-soluble polymeric component to characterize the compatibility of a particular solvent-polymer pair, suitable HSP coordinate values for PVOH/polyol systems include (a) a $\delta_{P,S}$ value of at least about 10 and/or up to about 12 or 15, and/or (b) a $\delta_{H,S}$ value of at least about 22 or 25 and/or up to about 30 or 33.

[0045] The sealing solution is suitably a mixture including water and the solvent(s) as its only or major components. In optional embodiments, additional additives may be present in small amounts (e.g., up to about 1 wt.% or 2 wt.%, such as about 0.01 wt.% to about 2 wt.% or about 0.1 wt.% to about 1 wt.%). For example, a surfactant (e.g., those described below for inclusion in the water-soluble film) may be added to improve the wetting properties of the sealing solution as it is applied to a film surface prior to sealing. The sealing solution can be free of added water-soluble polymers (e.g., whether as water-soluble film-forming polymers, as components of the water-soluble film, or otherwise); however, some resin or polymer may be present at equilibrium or contamination values based on the accumulation of residual amounts of the resin or polymer in the forming and/or sealing equipment during film processing. In other, non-exclusive optional embodiments, the sealing solution can further include a plasticizing additive other than the solvents (e.g., polyols) described above, for example at levels less than and/or comparable to those for the solvent. Examples include various organic diols and/or glycols such as 1,2-ethanediol (ethylene glycol), 1,3-propanediol, 1,2-propanediol, 1,4-butanediol (tetramethylene glycol), 1,5-pantanediol (pentamethylene glycol), 1,6-hexanediol (hexamethylene glycol), 2,3-butanediol, 1,3-butanediol, 2-methyl-1,3-propanediol, various polyethylene glycols (e.g., diethylene glycol, triethylene glycol), and combinations thereof.

Water-Soluble Films

[0046] Water-soluble films, optional ingredients for use therein, and methods of making the same are well known in the art. In one class of embodiments, the water-soluble film includes polyvinyl alcohol (PVOH), including homopolymers thereof (e.g., including substantially only vinyl alcohol and vinyl acetate monomer units) and copolymers thereof (e.g., including one or more other monomer units in addition to vinyl alcohol and vinyl acetate units). PVOH is a synthetic resin generally prepared by the alcoholysis, usually termed hydrolysis or saponification, of polyvinyl acetate. Fully hydrolyzed PVOH, wherein virtually all the acetate groups have been converted to alcohol groups, is a strongly hydrogen-bonded, highly crystalline polymer which dissolves only in hot water -- greater than about 140 °F (60 °C). If a sufficient number of acetate groups are allowed to remain after the hydrolysis of polyvinyl acetate, the PVOH polymer then being known as partially hydrolyzed, it is more weakly hydrogen-bonded and less crystalline and is soluble in cold water -- less than about 50 ° F (10 ° C). An intermediate cold or hot water soluble film can include, for example, intermediate partially-hydrolyzed PVOH (*e.g.*, with degrees of hydrolysis of about 94% to about 98%), and is readily soluble only in warm water— *e.g.*, rapid dissolution at temperatures of about 40 °C and greater. Both fully and partially hydrolyzed PVOH types are commonly referred to as PVOH homopolymers although the partially hydrolyzed type is technically a vinyl alcohol-vinyl acetate copolymer.

[0047] The degree of hydrolysis (DH) of the PVOH included in the water-soluble films of the present disclosure can be about 75% to about 99%. As the degree of hydrolysis is reduced, a film made from the resin will have reduced mechanical strength but faster solubility at temperatures below about 20°C. As the degree of hydrolysis increases, a film made from the resin will tend to be mechanically stronger and the thermoformability will tend to decrease. The degree of hydrolysis of the PVOH can be chosen such that the water-solubility of the resin is temperature dependent, and thus the solubility of a film made from the resin, compatibilizer polymer, and additional ingredients is also influenced. In one class of embodiments the film is cold water-soluble. A cold water-soluble film, soluble in water at a temperature of less than 10 °C, can include PVOH with a degree of hydrolysis in a range of about 75% to about 90%, or in a range of about 80% to about 90%, or in a range of about 85% to about 90%. In another class of embodiments the film is hot water-soluble. For example, a hot water-soluble film is advantageous for edible applications such as water-soluble packets enclosing a hot food item, e.g. oatmeal, cocoa, or soup mix. A hot water-soluble film, soluble in water at a temperature of at least about 60 °C, can include PVOH with a degree of hydrolysis of at least about 98%. In some embodiments, the film is intended to by edible, for example by humans. In such cases, the particular degree of hydrolysis may be selected to conform with local, state, or federal laws or regulations relating to approved degrees of hydrolysis for human or other animal consumption. For example, the skilled artisan will recognize that PVOH film approved for human consumption (currently) includes those with nominally an 88% degree of hydrolysis, for example a degree of hydrolysis of about 86.5% to about 89%.

[0048] Other film-forming, water soluble resins for use in addition to or in an alternative to PVOH can include, but are not limited to modified polyvinyl alcohols, polyacrylates, water-soluble acrylate copolymers, polyvinyl pyrrolidone, polyethyleneimine, pullulan, water-soluble natural polymers including, but not limited to, guar gum, xanthan gum, carrageenan, and starch, water-soluble polymer derivatives including, but not limited to, ethoxylated starch and hydroxypropylated starch, copolymers of the forgoing and combinations of any of the foregoing. Yet other water-soluble polymers can include polyalkylene oxides, polyacrylamides, polyacrylic acids and salts thereof, celluloses, cellulose ethers, cellulose esters, cellulose amides, polyvinyl acetates, polycarboxylic acids and salts thereof, polyaminoacids, polyamides, gelatines, methylcelluloses, carboxymethylcelluloses and salts thereof, dextrins, ethylcelluloses, hydroxyethyl celluloses, hydroxypropyl methylcelluloses, maltodextrins, and polymethacrylates. Such water-soluble, film-forming resins, whether PVOH or otherwise are commercially available from a variety of sources. In general, the water-soluble film can include copolymers and/or blends of the foregoing resins.

[0049] The water-soluble, film-forming polymers can be included in the film composition in an amount in a range of about 30 wt.% to about 90 wt.%, for example. The weight ratio of the amount of the water-soluble polymer as compared to the combined amount of all plasticizers, compatibilizing agents, and secondary additives can be in a range of about 0.5 to about 9, about 0.5 to about 5, or about 1 to 3, or about 1 to 2, for example.

[0050] Water-soluble polymers for use in the films described herein (including, but not limited to PVOH polymers) can be characterized by a viscosity in a range of about 3.0 to about 27.0 cP, or about 3.0 cP to about 15 cP, or about 6.0 to about 10.0 cP. The viscosity of a PVOH polymer is determined by measuring a freshly made solution using a Brookfield LV type viscometer with UL adapter as described in British Standard EN ISO 15023-2:2006 Annex E Brookfield Test method. It is international practice to state the viscosity of 4% aqueous polyvinyl alcohol solutions at 20 °C. Polymeric viscosities specified herein in cP should be understood to refer to the viscosity of a 4% aqueous water-soluble polymer solution at 20 °C, unless specified otherwise.

[0051] It is well known in the art that the viscosity of a water-soluble polymer (PVOH or otherwise) is correlated with the weight-average molecular weight $\left(\overline{Mw}\right)$ of the same polymer, and often the viscosity is used as a proxy for $\overline{Mw}$. Thus, the weight-average molecular weight of the water-soluble, film-forming polymer can be in a range of about 30,000 to about 175,000, or about 30,000 to about 100,000, or about 55,000 to about 80,000.

[0052] The water-soluble film can contain other auxiliary agents and processing agents, such as, but not limited to, plasticizers, plasticizer compatibilizers, lubricants, release agents, fillers, extenders, cross-linking agents, antiblocking agents, antioxidants, detackifying agents, antifoams, nanoparticles such as layered silicate-type nanoclays (e.g., sodium montmorillonite), bleaching agents (e.g., sodium metabisulfite, sodium bisulfite or others), and other functional ingredients, in amounts suitable for their intended purposes. Embodiments including plasticizers are preferred. The amount of such agents can be up to about 50 wt. %, 20 wt %, 15 wt %, 10 wt %, 5 wt. %, 4 wt % and/or at least 0.01 wt. %, 0.1 wt %, 1 wt %, or 5 wt %, individually or collectively.

[0053] The plasticizer can include, but is not limited to, glycerin, diglycerin, ethylene glycol, diethylene glycol, triethylene glycol, tetraethylene glycol, propylene glycol, polyethylene glycols up to 400 MW, neopentyl glycol, trimethylolpropane, polyether polyols, 2-methyl-1,3-propanediol, lactic acid, ethanolamines, and a mixture thereof. Such plasticizers (e.g., whether in liquid form at room temperature or otherwise) can be included in the water-soluble films in amounts ranging from about 25 phr to about 50 phr, about 30 phr to about 45 phr, or about 35 phr to about 40 phr, whether for a single plasticizer or a combination of plasticizers. In various embodiments, the water-soluble film can alternatively or additionally include sugar alcohol plasticizers that are solid at room temperature, for example including isomalt, maltitol, sorbitol, xylitol, erythritol, adonitol, dulcitol, pentaerythritol, mannitol and combinations thereof. The sugar alcohol plasticizers can be included in the water-soluble films in amounts ranging from about 5 phr to about 35 phr, about 5 phr to about 25 phr, about 10 phr to about 20 phr, or about 10 phr to about 15 phr, whether for a single sugar alcohol plasticizer or a combination of sugar alcohol plasticizers. The total amount of the plasticizer (e.g., liquid, solid, sugar alcohol, or otherwise) can be in a range of about 10 wt. % to about 40 wt. %, or about 15 wt. % to about 35 wt. %, or about 20 wt. % to about 30 wt. %, for example about 25 wt. %.

[0054] Water-soluble films of the present disclosure can include a compatibilizing agent for the sugar alcohol plasticizer that is a solid at room temperature. The compatibilizing agent can be included in the water-soluble films in amounts ranging from about 10 phr to about 25 phr, about 13 phr to about 22 phr, or about 15 phr to about 20 phr, whether for a single compatibilizing agent or a combination of compatibilizing agents. The amount of compatibilizing agent alternatively or additionally can be expressed as ratio ranging from about 2:1 to about 1:2 relative to the sugar alcohol plasticizer. Suitable compatibilizers include, but are not limited to, cellulose ethers such as methylcellulose, hydroxypropyl methylcellulose, carboxymethyl cellulose, salts thereof, polysaccharides of pectin, polysaccharides of sodium alginate, modified starches such as acid-modified, hydroxypropylated starches (e.g., Pure-Cote B760 or B790 available from Grain Processing Corporation, Muscatine, Iowa), hydroxyethyl starches (e.g., Ethylex 2035 available from Tate & Lyle Ingredients Americas LLC, 2200 E. Eldorado Street, Decater, IL), and combinations of any of the foregoing. In one class of embodiments, the compatibilizer comprises sodium carboxymethyl cellulose (CMC). The degree of substitution of the CMC can be from about 0.60 to about 0.95, for example. As used herein, "degree of substitution" refers to the number of hydroxyl groups that have been substituted with a sodium carboxymethyl group (CH_2COO (Na)) per monomer unit. In one type of embodiment, the viscosity of a 2% aqueous solution of CMC is in a range of about 20 to about 80 cP, as measured at 25 °C on a Brookfield LVT viscometer. In another class of embodiments, the compatibilizer comprises a hydroxypropylated starch. In one type of embodiment, the hydroxypropylated starch can have a 9.1% moisture content, a pH of about 6.3, an ash content of 0.20 wt.% and a protein content of 0.173 wt.%. In another class of embodiments, the compatibilizing agent comprises a hydroxyethyl starch. The level of ethoxylation can be from about 2 wt.% to about 3 wt.%, for example, as the total weight of the substituent units divided by the total weight of the polymer.

[0055] Suitable surfactants can include the nonionic, cationic, anionic and zwitterionic classes. Suitable surfactants include, but are not limited to, polyoxyethylenated polyoxypropylene glycols, alcohol ethoxylates, alkylphenol ethoxylates, tertiary acetylenic glycols and alkanolamides (nonionics), polyoxyethylenated amines, quaternary ammonium salts and quaternized polyoxyethylenated amines (cationics), and amine oxides, N-alkylbetaines and sulfobetaines (zwitterionics). Other suitable surfactants include dioctyl sodium sulfosuccinate, lactylated fatty acid esters of glycerol and propylene glycol, lactylic esters of fatty acids, sodium alkyl sulfates, polysorbate 20, polysorbate 60, polysorbate 65, polysorbate 80, lecithin, acetylated fatty acid esters of glycerol and propylene glycol, and acetylated esters of fatty acids, and combinations thereof. In various embodiments, the amount of surfactant in the water-soluble film is in a range of about 0.1 wt % to 2.5 wt %, optionally about 1.0 wt % to 2.0 wt %.

[0056] The water-soluble film can further have a residual moisture content of at least 4 wt. %, for example in a range of about 4 to about 10 wt. %, as measured by Karl Fischer titration.

[0057] Other features of water-soluble films may be found in U.S. Publication No. 2011/0189413 and U.S. Application No. 13/740,053, both of which are incorporated by reference herein in their entireties.

[0058] A class of embodiments of the water-soluble films according to the present disclosure is characterized by the water-soluble film being edible, for example when including sugar alcohol plasticizers and compatibilizers therefor. In this class of embodiments the water-soluble polymers can include, can consist essentially of, or can consist of one or more of PVOH, modified PVOH, water-soluble natural polymers including, but not limited to, guar gum, xanthan gum, carrageenan, and starch, water-soluble polymer derivatives including, but not limited to, ethoxylated starch and hydroxypropylated starch, copolymers of the forgoing, and combinations of the forgoing. Optional ingredients for inclusion in water-soluble films according to the disclosure include one or more of plasticizers that are liquid at room temperature, surfactants, compatibilizers, co-polymers, and co-film formers, for example. Liquid plasticizers can include, consist essentially of, or consist of one or more of glycerol, diglycerol, propylene glycol, low molecular weight polyethylene glycol (e.g., having a liquid consistency, for example having a molecular weight such as 200, 300, and 600), monoacetin, triacetin, triethyl citrate, and 1,3-butanediol. Surfactants can include, consist essentially of, or consist of dioctyl sodium sulfosuccinate, lactylated fatty acid esters of glycerol and propylene glycol, lactylic esters of fatty acids, sodium alkyl sulfates, polysorbate 20, polysorbate 60, polysorbate 65, polysorbate 80, lecithin, acetylated fatty acid esters of glycerol and propylene glycol, and acetylated esters of fatty acids, for example. Film formers can include, consist essentially of, or consist of one or more of pullulan, pectin, starch, gelatin, sodium alginates and modified starches. Other optional ingredients will be apparent to one of ordinary skill in the art in view of the present disclosure. Components for inclusion in edible water soluble films can be those designated as "Generally Recognized as Safe" (GRAS) by the United States Food and Drug Administration, and/or components with assigned, allowable E-numbers in the European Union, and/or components that are not yet designated as GRAS or E-numbered but have gone through proper testing and have been demonstrated as safe for human consumption in the amounts proposed for use in the film.

Shaping and Sealing

[0059] The disclosed sealing solution can be used to seal to water-soluble film surfaces with or without the application of heat and/or pressure thereto, for example according to conventional film processing techniques. Prior to sealing, the water-soluble film(s) can be shaped according to various processes known in the art, such as by using heat in a thermoforming process. The heat may be applied using any suitable means. For example, the film may be heated directly by passing it under a heating element or through hot air, prior to feeding it onto a surface or once on a surface. Alternatively, it may be heated indirectly, for example by heating the surface or applying a hot item onto the film. In some embodiments, the film is heated using an infrared light. The film may be heated to a temperature of about 50 to about 150°C, about 50 to about 120°C, about 60 to about 130°C, about 70 to about 120°C, or about 60 to about 90°C. Alternatively, the film can be wetted by any suitable means, for example directly by spraying a wetting agent (including water, a solution of the film composition, a plasticizer for the film composition, or any combination of the foregoing) onto the film, prior to feeding it onto the surface or once on the surface, or indirectly by wetting the surface or by applying a wet item onto the film.

[0060] Once a film has been heated and/or wetted, it may be drawn into an appropriate mold, preferably using a vacuum. The filling of the molded film with a suitable composition can be accomplished by utilizing any suitable means. In some embodiments, the most preferred method will depend on the product form and required speed of filling. In some embodiments, the molded film is filled by in-line filling techniques. The filled, open packets are then closed forming the pouches, using a second film, by any suitable method. This may be accomplished while in horizontal position and in continuous, constant motion. The closing may be accomplished by continuously feeding a second film, preferably water-soluble film, over and onto the open packets and then preferably sealing the first and second film together, typically in the area between the molds and thus between the packets.

[0061] Methods according to the disclosure utilize the sealing solution in any of its various embodiments to form a seal between two film surfaces. Other forms of sealing, including heat sealing, can be used in addition to solution sealing. Typically, only the film area which is to form the seal (including some optional excess margin) is treated with heat or sealing solution. The heat or sealing solution can be applied by any method, typically on the closing film material, and typically only on the areas which are to form the seal. Solution sealing methods preferably include selectively applying the sealing solution onto the area between the molds (e.g., matching mold surfaces), or on the closing film material, for example by spraying or printing this onto these areas, and then applying pressure onto these areas, to form the seal. Sealing rolls and belts as described above (optionally also providing heat) can be used.

[0062] The formed water-soluble packets or pouches may then be cut by a cutting device. Cutting can be accomplished using any suitable method. It may be preferred that the cutting is also done in continuous manner, and preferably with constant speed and preferably while in horizontal position. The cutting device can, for example, be a sharp item or a hot item, whereby in the latter case, the hot item `burns` through the film/sealing area in addition to or in the alternative to slicing. The different compartments of multi-compartment pouches may be made together in a side-by-side style wherein the resulting, conjoined pouches may or may not be separated by cutting. Alternatively, the compartments can be made separately. It should be understood that by the use of appropriate feed stations, it may be possible to manufacture multi-compartment pouches incorporating a number of different or distinctive compositions and/or different or distinctive liquid, gel or paste compositions.

[0063] Figure 1 illustrates a cross-sectional view of a sealed water-soluble packet 100 formed according to the disclosure using a sealing solution as described above in any of its embodiments. A first water-soluble film 10 includes a first surface 12. As shown, the first water-soluble film 10 has been shaped (e.g., thermoformed) such that a portion of the film 10 defines a volume (or compartment) 40 into which a suitable composition 50 can be placed prior to sealing the packet 100. In the illustrated embodiment, the first surface 12 generally corresponds to an upper or top (e.g., relative to gravity or filling direction of the compartment 40) circumferential surface of the first water-soluble film 10 around the compartment 40. The sealing solution can be applied to the first surface 12 by any suitable means (e.g., spraying, printing), for example before or after shaping of the first water-soluble film 10 and/or adding of the composition 50 to the compartment 40. A second water-soluble film 20 is thereafter contacted with the first water-soluble film 10 to enclose the compartment 40 (e.g., completely around the circumference of compartment 40, although embodiments wherein the compartment is thereby enclosed only partially are also contemplated). As illustrated, a second surface 22 of the second water-soluble film 20 (e.g., bottom or lower surface thereof) contacts the first surface 12 where the sealing solution is present at an interfacial region 30 between the two surfaces 12, 22. The two surfaces 12, 22 are held in contact (e.g., via pressure) for a time sufficient to form a seal 32 between the two films 10, 20 and surfaces 12, 22, thus creating the sealed water-soluble packet 100. The sealing time is selected to dissolve surface portions of the two films 10, 20 in the interfacial region 30, whereupon subsequent evaporation and/or diffusive mass transport of the water component of the sealing solution away from the interfacial region 30 permits the film 10, 20 components and sealing solution solvent to re-solidify into the seal 32.

[0064] In the embodiment illustrated in Figure 1, the first surface 12 and the second surface 22 are from two separate water-soluble films 10, 20, respectively (e.g., separate pieces of film sealed together, which films can be formed from the same or different components). In another embodiment (not shown), the first surface 12 and the second surface 22 can be distinct regions from the same water-soluble film 10 (e.g., separate regions of same piece of film folded and sealed onto each other). Similarly, the embodiment of Figure 1 is described with the sealing solution being applied to the first surface 12. In other embodiments, the sealing solution can be applied additionally or alternatively to the second surface 22 prior to contacting the two surfaces 12, 22 and forming the seal 32. In cases where the sealing solution is applied to multiple film surfaces, the sealing solution can be the same for all surfaces or different for different surfaces (e.g., sealing solutions and their corresponding solvent(s) can be selected depending on the particular film to which they are to be applied).

[0065] Figure 2 illustrates qualitative spatial profiles for local concentrations of representative film and sealing solution components (C_1-C_4) in the bulk film regions 10, 20 and in the interfacial region 30 of the water-soluble packet 100 and the seal 32. The profiles are illustrated along line P of Figure 1 for water-soluble films 10, 20 with a nominal thickness T, but more generally apply along a reference line generally normal to the first and second surfaces 12, 22 and passing through the interfacial region 30. As described below, the sealing solution solvent (e.g., polyol or otherwise) is generally present in the interfacial region 30 at a local concentration substantially higher than a bulk concentration of the polyol in the water-soluble film and outside of the interfacial region 30. For example, a local solvent concentration of at least 40, 50, 60, 70, 80, or 90 wt.% and/or up to 60, 70, 80, 90, or 100 wt.% may be observed in the interfacial region 30 (e.g., as an average concentration in the interfacial region 30 or as a peak value in the concentration profile passing through the interfacial region). Complementarily to the sealing solution solvent, one or more components of the water-soluble film may be present in the interfacial region 30 at a local concentration substantially lower than the bulk concentration of the particular component in the water-soluble film and outside of the interfacial region (e.g., bulk film components (other than the sealing solution solvent) such as polymer, plasticizer, etc. may diffuse into the interfacial region 30 but be present at correspondingly lower concentrations due to dilution with the more concentrated sealing solution solvent).

[0066] By way of non-limiting example, the representative concentration profiles in Figure 2 can illustrate the article 100 and seal 32 resulting from the use of a dilute glycerin-in-water sealing solution (e.g., 5 wt.% to 10 wt.% glycerin) to seal a PVOH film plasticized with glycerin and propylene glycol (e.g., in a film containing 60 wt.% PVOH, 20 wt.% glycerin, 15 wt.% propylene glycol as added components and 5 wt.% water as an illustrative equilibrium environmental moisture content). In Figure 2, the illustrated components are glycerin (C_1, as a sealing solution solvent and film plasticizer), water (C_2, as environmental moisture), PVOH (C_3, as a film water-soluble polymer), and propylene glycol (C_4, as a film plasticizer). Although relatively dilute for solvent glycerin, evaporation and diffusive mass transport of water added from the sealing solution away from the interfacial region 30 during the sealing process may yield a region where the solvent glycerin is locally highly concentrated in the seal 32. Because the sealing solution acts to dissolve boundary regions of the first and second water-soluble films 10, 20, the PVOH resin and propylene glycol plasticizer components thereof may be transported into the interfacial region 30, albeit at lower concentrations than in the bulk film 10, 20, owing to the diluting effect of the sealing solution solvent in the interfacial region 30.

[0067] As described above, the sealing solution is particularly effective at providing one or more benefits, including: a reduction in dissolution time for the water-soluble films 10, 20 by the sealing solution and an increase in the strength of the resulting seal 32 formed with the sealing solution, both relative to the use of water alone as a reference sealant. The benefits may be realized for a variety of film thicknesses, including those having an initial thickness ranging from about 10 μm to about 150 μm or about 30 μm to about 60 μm (e.g., an initial thickness of at least 10, 20, 30, 35, or 40 μm and/or up to 40, 50, 60, 70, 80, 100, or 150 μm, where the initial thickness refers to nominal film thickness prior to potential (local) stretching or thinning of film during a forming or sealing process).

[0068] The sealing solution is particularly useful for water-soluble films of a given thickness having a relatively short burn-through time (as defined below) for water, insofar as such short times can result in substantial film destruction when using water alone as a sealant. In some embodiments, water-soluble films 10, 20 are selected which have burn-through times of about 45 sec or about 50 sec or less using water alone as a test solvent. With a sealing solution according to the disclosure, however, the film burn-through times are increased relative to the water reference, and are generally about 45 sec or about 50 sec or more. More generally, in other embodiments, the water-only burn-through times can be at least about 10, 20, or 30 sec and/or up to about 20, 30, 40, 45, 50, or 60 sec, and sealing solution burn-through times can be at least about 45, 50, 60, 80, or 100 sec and/or up to about 60, 80, 100, 150, 200, or 500 sec, also with an increase relative to the corresponding water-only times.

[0069] The seal 32 resulting from the sealing solution can be characterized as having an increased peel strength or load (as defined below) for water-soluble films of a given thickness, for example relative to a seal formed with water alone. In various embodiments, the seal 32 exhibits a peel strength of at least about 30% greater than that of a corresponding seal formed with water alone (e.g., at least about 30%, 40%, 50%, or 60% and/or up to about 50%, 60%, 80%, 100%, 150%, or 200% increase relative to a water-only seal). Alternatively or additionally, the strength of the seal can be characterized as a minimum relative peel strength, or peel strength ratio, defined as the ratio of the absolute peel strength or load (e.g., measured in N for films of a given thickness) to the film peak load (e.g., also measured in N for films of the same thickness as a tensile strength measurement described below). For example, the seal 32 can have a peel strength ratio (expressed as a percent) of at least 12%, 15%, 20%, or 30% and/or up to 40%, 60%, 80%, or 100%.

[0070] The water-soluble packets may contain various compositions. A multi-compartment pouch may contain the same or different compositions in each separate compartment. This feature of the disclosure may be utilized to keep compositions containing incompatible ingredients (e.g., bleach and enzymes) physically separated or partitioned from each other. Such partitioning may provide aesthetic benefits, expand the useful life and/or decrease physical instability of the pouch contents.

[0071] Non-limiting examples of useful compositions include human and animal ingestible items, personal care compositions and cleaning compositions. Representative human and animal ingestible items include dehydrated or instant beverages (coffee, tea, juice), dried foods (e.g., starch-based foods such as pasta, rice, oatmeal, etc.), pet foods and nutritional or exercise supplements (e.g., protein supplements, vitamin supplements). Representative personal compositions include lotions (for example moisturizing and/or sun screen), protective emollients and similar compositions, Suitable cleaning compositions include light duty and heavy duty liquid detergent compositions, hard surface cleaning compositions, detergent gels commonly used for laundry, and bleach and laundry additives, shampoos, body washes, and similar compositions. Compositions of use in the present pouches may take the form of a liquid, gel, paste, solid or a powder. Liquid compositions may comprise a solid. Solids may include powder or agglomerates, such as micro-capsules, beads, noodles or one or more pearlized balls or mixtures thereof. Such a solid element may provide a technical benefit, through the wash or as a pre-treat, delayed or sequential release component; additionally or alternatively, it may provide an aesthetic effect.

[0072] Specific contemplated aspects of the disclosure are herein described in the following numbered paragraphs.

[0073] 1. A method for sealing a water-soluble film, the method comprising:
(a) applying a sealing solution to a first surface of a water-soluble film, the sealing solution comprising (i) water, and (ii) a polyol having 3 or more hydroxyl groups, wherein the sealing solution has a dynamic viscosity (μ_S) less than 1.5 cP as measured at 20°C; and (b) contacting a second surface of a water-soluble film with the sealing solution on the first surface for a time sufficient to form a seal between the first surface and the second surface.

[0074] 2. The method of paragraph 1, wherein the polyol is present in the sealing solution in an amount ranging from about 2 wt.% to about 15 wt.%.

[0075] 3. The method of any of the preceding paragraphs, wherein the sealing solution consists essentially of water and one or more polyols each having 3 or more hydroxyl groups

[0076] 4. The method of any of the preceding paragraphs, wherein the polyol contains 2 to 12 carbon atoms and 3 to 12 hydroxyl groups

[0077] 5. The method of any of the preceding paragraphs, wherein the polyol is selected from the group consisting of glycerol, erythritol, threitol, arabitol, xylitol, ribitol, mannitol, sorbitol, galactitol, fucitol, iditol, inositol, volemitol, isomalt, maltitol, lactitol, and combinations thereof.

[0078] 6. A method for sealing a water-soluble film, the method comprising:
(a) applying a sealing solution to a first surface of a water-soluble film having an initial thickness less than about 50 μm and comprising a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units, the sealing solution comprising (i) water, and (ii) a polyol present in the sealing solution in an amount ranging from about 2 wt.% to about 15 wt.%, the polyol being selected from the group consisting of glycerol, erythritol, threitol, arabitol, xylitol, ribitol, mannitol, sorbitol, galactitol, fucitol, iditol, inositol, volemitol, isomalt, maltitol, lactitol, and combinations thereof, wherein the sealing solution has a dynamic viscosity (μ_s) less than 1.5 cP as measured at 20°C; and (b) contacting a second surface of a water-soluble film having an initial thickness less than about 50 μm and comprising a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units with the sealing solution on the first surface for a time sufficient to form a seal between the first surface and the second surface.

[0079] 7. The method of paragraph 6, wherein the water-soluble film for each of the first surface and the second surface: (i) has a degree of hydrolysis ranging from about 86.5% to about 89%; and (ii) further comprises: (A) a sugar alcohol plasticizer selected from the group consisting of isomalt, maltitol, sorbitol, xylitol, erythritol, adonitol, dulcitol, pentaerythritol, mannitol, and combinations thereof, (B) a liquid plasticizer selected from the group consisting of glycerin, diglycerin, ethylene glycol, diethylene glycol, triethylene glycol, tetraethylene glycol, propylene glycol, polyethylene glycols up to 400 MW, 2-methyl-1,3-propanediol, and combinations thereof, and (C) a compatibilizing agent selected from the group consisting of cellulose ethers, polysaccharides of pectin, polysaccharides of sodium alginate, modified starches, and combinations thereof.

[0080] 8. A method for sealing a water-soluble film, the method comprising:
(a) applying a sealing solution to a first surface of a water-soluble film, the sealing solution comprising (i) water, and (ii) a solvent for at least one polymeric component of the water-soluble film, wherein (A) the solvent and the polymeric component have a solubility radius (Ra) of about 5 or less as defined by equation (I):

$$(Ra)^2 = 4(\delta_{D,S} - \delta_{D,P})^2 + (\delta_{P,S} - \delta_{P,P})^2 + (\delta_{H,S} - \delta_{H,P})^2 \qquad \text{(I)}$$

where $\delta_{D,S}$ is the solvent dispersive force, $\delta_{D,P}$ is the polymeric component dispersive force, $\delta_{P,S}$ is the solvent polar force, $\delta_{P,P}$ is the polymeric component polar force, $\delta_{H,S}$ is the solvent hydrogen bonding force, and $\delta_{H,P}$ is the polymeric component hydrogen bonding force, each of which is determined by a consistent method of Hansen solubility parameter evaluation, and (B) the sealing solution has a dynamic viscosity (μ_s) less than 1.5 cP as measured at 20°C; and (b) contacting a second surface of a water-soluble film with the sealing solution on the first surface for a time sufficient to form a seal between the first surface and the second surface.

[0081] 9. The method of paragraph 8, wherein the solubility radius ranges from about 1 to about 5.

[0082] 10. The method of any one of paragraphs 8 to 9, wherein (i) the polymeric component comprises polyvinyl alcohol; (ii) $\delta_{P,S}$ is at least about 10; and (iii) $\delta_{H,S}$ is at least about 22.

[0083] 11. The method of any one of paragraphs 8 to 10, wherein the solvent is present in the sealing solution in an amount ranging from about 2 wt.% to about 15 wt.%.

[0084] 12. The method of any one of paragraphs 8 to 11, wherein the sealing solution consists essentially of water and one or more solvents each having a solubility radius of about 5 or less relative to the polymeric component.

[0085] 13. The method of any of the preceding paragraphs, wherein the dynamic viscosity ranges from about 1 cP to about 1.45 cP.

[0086] 14. The method of any of the preceding paragraphs, wherein: (i) the water-soluble film has a burn-through time of about 45 sec or less using water alone as a test solvent; and (ii) the water-soluble film has a burn-through time (A) of about 45 sec or more using the sealing solution as a test solvent and (B) greater than the burn-through time using water alone as a test solvent.

[0087] 15. The method of any of the preceding paragraphs, wherein the seal exhibits a peel strength of at least about 12% relative to the peak load of the water-soluble film.

[0088] 16. The method of any of the preceding paragraphs, wherein the seal exhibits a peel strength of at least about 30% greater than that of a corresponding seal formed with water alone.

[0089] 17. The method of any of the preceding paragraphs, wherein the first surface and the second surface each independently have an initial thickness ranging from about 10 μm to about 150 μm.

[0090] 18. The method of any of the preceding paragraphs, wherein the water-soluble film comprises a water-soluble polymer selected from the group consisting of polyvinyl alcohols, polyethyleneimines, polyacrylates, water-soluble acrylate copolymers, polyvinyl pyrrolidones, pullulans, guar gums, xanthan gums, carrageenans, starches, ethoxylated starches, hydroxypropylated starches, polyalkylene oxides, polyacrylamides, polyacrylic acids and salts thereof, celluloses, cellulose ethers, cellulose esters, cellulose amides, polyvinyl acetates, polycarboxylic acids and salts thereof, polyaminoacids, polyamides, gelatines, methylcelluloses, carboxymethylcelluloses and salts thereof, dextrins, ethylcelluloses, hydroxyethyl celluloses, hydroxypropyl methylcelluloses, maltodextrins, polymethacrylates, copolymers thereof, blends thereof, and combinations thereof.

[0091] 19. The method of paragraph 18, wherein the water-soluble polymer has a 4% solution viscosity ranging from about 3 cP to about 27 cP at 20°C.

[0092] 20. The method of any of the preceding paragraphs, wherein the water-soluble film comprises a water-soluble polymer comprising polyvinyl alcohol.

[0093] 21. The method of paragraph 20, wherein the water-soluble polymer comprises a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units.

[0094] 22. The method of any one of paragraphs 20 to 21, wherein the polyvinyl alcohol has a degree of hydrolysis ranging from about 75% to about 99%.

[0095] 23. The method of any one of paragraphs 20 to 21, wherein the polyvinyl alcohol has a degree of hydrolysis ranging from about 86.5% to about 89%.

[0096] 24. The method of any of the preceding paragraphs, wherein the first surface and the second surface are from the same water-soluble film.

[0097] 25. The method of any of the preceding paragraphs, wherein the first surface and the second surface are from different water-soluble films.

[0098] 26. The method of any of the preceding paragraphs, wherein contacting the second surface with the first surface comprises at least one of applying pressure to the first surface and the second surface and applying heat to the first surface and the second surface to form the seal.

[0099] 27. The method of any of the preceding paragraphs, wherein the second surface comprises a second sealing solution thereon to be contacted with the first surface when forming the seal.

[0100] 28. The method of any of the preceding paragraphs, wherein: (i) the water-soluble film of at least one of the first surface and the second surface defines a volume at least partially enclosing a composition, and (ii) forming the seal creates a sealed water-soluble packet containing the composition.

[0101] 29. The method of paragraph 28, wherein the composition is selected from the group consisting of human and animal ingestible items, personal care compositions and cleaning compositions.

[0102] 30. An article comprising a sealed water-soluble film formed according to any of the preceding paragraphs.

[0103] 31. An article comprising: (a) a first surface of a water-soluble film sealed to a second surface of a water-soluble film at an interfacial region between the first surface and the second surface; and (b) a polyol having 3 or more hydroxyl groups present in the interfacial region at a local concentration substantially higher than a bulk concentration of the polyol in the water-soluble film and outside of the interfacial region.

[0104] 32. An article comprising: (a) a first surface of a water-soluble film sealed to a second surface of a water-soluble film at an interfacial region between the first surface and the second surface, wherein the water-soluble film for each of the first surface and the second surface has an initial thickness less than about 50 μm and comprises a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units; and (b) a polyol present in the interfacial region at a local concentration substantially higher than a bulk concentration of the polyol in the water-soluble film and outside of the interfacial region, the polyol being selected from the group consisting of glycerol, erythritol, threitol, arabitol, xylitol, ribitol, mannitol, sorbitol, galactitol, fucitol, iditol, inositol, volemitol, isomalt, maltitol, lactitol, and combinations thereof.

[0105] 33. An article comprising: (a) a first surface of a water-soluble film sealed to a second surface of a water-soluble film at an interfacial region between the first surface and the second surface; and (b) a solvent for at least one polymeric component of the water-soluble film present in the interfacial region at a local concentration substantially higher than a bulk concentration of the solvent in the water-soluble film and outside of the interfacial region, wherein the solvent and the polymeric component have a solubility radius (Ra) of about 5 or less as defined by equation (I):

$$(Ra)^2 = 4(\delta_{D,S} - \delta_{D,P})^2 + (\delta_{P,S} - \delta_{P,P})^2 + (\delta_{H,S} - \delta_{H,P})^2 \quad (I)$$

where $\delta_{D,S}$ is the solvent dispersive force, $\delta_{D,P}$ is the polymeric component dispersive force, $\delta_{P,S}$ is the solvent polar force, $\delta_{P,P}$ is the polymeric component polar force, $\delta_{H,S}$ is the solvent hydrogen bonding force, and $\delta_{H,P}$ is the polymeric component hydrogen bonding force, each of which is determined by a consistent method of Hansen solubility parameter evaluation.

[0106] 34. The article of any one of paragraphs 31 to 33, wherein one or more components of the water-soluble film are present in the interfacial region at a local concentration substantially lower than a bulk concentration of the one or more components in the water-soluble film and outside of the interfacial region.

[0107] 35. A method for sealing a water-soluble film, the method comprising: (a) applying a sealing solution to a first surface of a water-soluble film having an initial thickness less than about 50 µm or about 40 µm and comprising a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units, the sealing solution comprising (i) water and (ii) a polyol having 3 or more hydroxyl groups; and (b) contacting a second surface of a water-soluble film having an initial thickness less than about 50 µm or about 40 µm and comprising a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units with the sealing solution on the first surface for a time sufficient to form a seal between the first surface and the second surface.

Examples

Burn-Through Time Measurements

[0108] The time required for a given test solvent to dissolve through a water-soluble film of a given thickness is determined by the following "burn-through" measurement procedure. A test film of specified thickness is affixed to a piece of paper using tape. A drop of about 50 microliters of a test solvent (e.g., water or a sealing solution as disclosed herein) is applied to the test film using a dropper. The test solvent suitably has a food coloring additive or other visual indicator to facilitate observation of the test solvent's action upon the test film. The burn-through time is measured as the time at which the paper underlying the test film becomes damp and/or changes color according to the added visual indicator for the test solvent (i.e., the area around which the drop was placed turns the color of the food coloring or other indicator after the test film has been dissolved ("burned through") by the test solvent).

Film Tensile and Seal Peel Strength Measurements

[0109] This methodology is used to determine the tensile force required to tear or peel a water-soluble film (tensile strength) or solution-sealed water-soluble films (seal peel strength). The procedure includes the determination of tensile force and strength. An INSTRON tensile testing apparatus or equivalent is used for the collection of film data. An ESIPROOF proofing apparatus or equivalent with an anilox roller 140/10 is used to secure two sheets of film with solvent (e.g., water or a sealing solution as disclosed herein). A minimum of three test specimens, each cut with reliable cutting tools to ensure dimensional stability and reproducibility, are tested in the machine direction (MD) (where applicable) for each measurement. Tests conducted in the standard laboratory atmosphere of 23 ± 2.0°C and 35 ± 5 % relative humidity.

[0110] For peel strength determination, test specimens are prepared by cutting four 4" × 12" (10.2 cm × 30.5 cm) film sheets with the 12" (30.5 cm) dimension in the machine direction (MD) (where applicable). For two sheets, the four corners are taped to a surface with the film matte surface facing upward (or cast-opposite surface, where applicable). One sheet is overlaid on top of one of the taped sheets so that the matte surfaces are in contact. On top of the other taped sheet, the remaining sheet on is placed top so that the gloss side is contacted with the matte surface. One 4" (10.2 cm) end of each top sheet is taped to secure it to the bottom sheet. The loose end of each top sheet is threaded through the ESIPROOF proofing roller using the 140/10 anilox roller. An amount of 0.5 mL of the test sealing solution (e.g., water or an aqueous solvent solution) is applied to the doctor blade. The roller is pulled at a constant speed (3" per second) to coat the upper film and to secure it to the lower sheet. The film is allowed to weld for a period of about 10 minutes to 15 minutes, thereby forming a seal but leaving two unsealed (free) film flaps on one end of the test specimen for subsequent peel testing. For tensile strength determination, 1"-wide (2.54 cm) samples of a single (unsealed) film sheet having the same thickness as that for the peel strength films are prepared. The sealed or unsealed sample is then transferred to the

INSTRON tensile testing machine to proceed with testing while minimizing exposure in the 35% relative humidity environment. The tensile testing machine is prepared according to the manufacturer instructions, equipped with a 500 N load cell, and calibrated. The correct grips and faces are fitted.

[0111] For the peel test, there is a 0.50" (1.27 cm) separation between the rubber grips, all four of which are flat and square. Three (or more) 1"-wide (2.54 cm) samples are cut in the machine direction (MD). The unsealed flaps of each sample is placed in the grips of the testing machine, taking care to ensure that the specimen is aligned with the grips and parallel to them, and that the specimen is not pulled too tightly in the tester's jaws. The load is balanced and the test is initiated according to the instructions of the equipment manufacturer. At the end of the test, the tensile force (in N) required to tear or separate the layers is recorded as the peel strength. Similarly, for tensile strength, three (or more) 1"-wide (2.54 cm) single sheet samples are mounted into the tensile testing machine and analyzed to determine the film peak strength (in N).

Examples 1-5

[0112] A common technique for high speed converting of water-soluble films is the use of rotary drum style converting equipment where water is typically used as a sealing solution to slightly wet the lidding film as it is applied and the seal is formed under slight pressure using rollers. Important properties for the sealing solution include a combination of burn-through resistance (i.e., to prevent damage to and/or dissolution of the water-soluble film) and the ability to form a good seal as represented by sealing strength measured by seal peak strength (or load) or seal peak load ratio (as a ratio of the film peak strength). The burn-through resistance becomes more important in smaller gauge films (e.g., 1.5 mil thickness films) typically used to deliver solids (e.g., powder) products. Desirably, a film-sealing solution combination attains a minimum suitable burn-through time and a maximum seal strength.

[0113] Examples 1-5 evaluate five different PVOH-based water-soluble films as a function of sealing solution concentration, using water alone as a control sealant and variable-concentration glycerin-in-water solutions (generally spanning 2.5 wt. % to 50 wt. %) according to the disclosure. For each film-sealing solution combination, burn-through times and seal peel strength were tested for 1.5 mil thickness films. Result graphs and data are shown in Figures 3-7 and Tables 1-5 for Examples 1-5, respectively. A summary of the specific results for the different test films is provided below. In particular, the PVOH-based films exhibited improved (increased) burn-through times with increasing glycerin concentration. Moreover, the PVOH homopolymer films exhibited substantial improvement in seal peel strength using glycerin-in-water sealing solutions while simultaneously achieving a burn-through time increase sufficient to exceed a minimum desirable threshold of about 45-50 sec.

[0114] Example 1 (1.5 mil Film A including PVOH copolymer A): Burn-through time increased with increasing glycerin concentration. No statistical difference for the peel strength was observed in the range of 0% to 35% glycerin solution. This range is where the maximum seal peak load is observed. There is data at 25% where it is statistically different from the range of 0 to 35%. However, this is a single point and not a trend. Hence, a sealing solution using only water can be used to obtain a good seal. Water alone also has an acceptable minimum burn-through resistance of about 79 seconds.

Table 1. Burn-Through Time and Peel Strength for Film A

Sealing Solution	Burn Through, sec (95% CI)	Peel Strength, N (95% CI)	Film Peak Load, N	Seal Peak Load, N	Peak Load Ratio
100% Water	78.85 (5.45)	14.63 (1.00)	33.86	14.63	0.43
2.5% Glycerin	77.10 (4.12)	13.51 (1.86)	33.86	13.51	0.40
5% Glycerin	94 (9.67)	12.96 (1.46)	33.86	12.96	0.38
10% Glycerin	115 (8.18)	14.79 (1.14)	33.86	14.79	0.44
15% Glycerin	212 (14.73)	13.30 (1.41)	33.86	13.30	0.39
20% Glycerin	295 (22.99)	16.15 (1.60)	33.86	16.15	0.48
25% Glycerin	399 (29.99)	12.91 (1.07)	33.86	12.91	0.38
30% Glycerin	652 (26.90)	13.30 (1.09)	33.86	13.30	0.39
35% Glycerin		13.46 (1.39)	33.86	13.46	0.40
40% Glycerin		12.45 (0.61)	33.86	12.45	0.37
45% Glycerin		12.95 (0.67)	33.86	12.95	0.38
50% Glycerin		12.65 (0.76)	33.86	12.65	0.37

[0115] Example 2 (1.5 mil Film B including PVOH copolymer B): Burn-through time increased with increasing glycerin concentration. No statistical difference for the peel strength was observed in the range of 0% to 25% glycerin solution. This range is where the maximum seal peak load is observed. There is data at 10% where it is statistically different from the range of 0 to 35%. However, this is a single point and not a trend. Hence, a sealing solution using only water can be used to obtain a good seal. Water alone also has an acceptable minimum burn-through resistance of about 80 seconds.

Table 2. Burn-Through Time and Peel Strength for Film B

Sealing Solution	Burn Through, sec (95% CI)	Peel Strength, N (95% CI)	Film Peak Load, N	Seal Peak Load, N	Peak Load Ratio
100% Water	79.5 (7.13)	10.16 (1.43)	32.81	10.16	0.31
2.5% Glycerin	92.30 (7.58)	11.47 (2.01)	32.81	11.47	0.35
5% Glycerin	111 (9.82)	11.19 (1.97)	32.81	11.19	0.34
10% Glycerin	122 (10.92)	14.31 (1.85)	32.81	14.31	0.44
15% Glycerin	268.5 (17.76)	11.55 (1.85)	32.81	11.55	0.35
20% Glycerin		11.67 (1.01)	32.81	11.67	0.36
25% Glycerin		9.67 (1.48)	32.81	9.67	0.29
30% Glycerin		7.43 (0.70)	32.81	7.43	0.23
35% Glycerin		9.77 (0.67)	32.81	9.77	0.30
40% Glycerin		5.20 (0.75)	32.81	5.20	0.16
45% Glycerin		3.14 (0.75)	32.81	3.14	0.10
50% Glycerin		2.12 (0.57)	32.81	2.12	0.06

[0116] Example 3 (1.5 mil Film C including PVOH copolymer C): Burn-through time increased with increasing glycerin concentration. No statistical difference for the peel strength was observed in the range of 0% to 20% glycerin solution. This is where the maximum seal peak load is observed. There is data at 15% where it is statistically different from the range of 0 to 35%. However, this is a single point and not a trend. Hence, a sealing solution using only water can be used to obtain a good seal. Water alone also has an acceptable minimum burn-through resistance of about 95 seconds.

Table 3. Burn-Through Time and Peel Strength for Film C

Sealing Solution	Burn Through, sec (95% CI)	Peel Strength, N (95% CI)	Film Peak Load, N	Seal Peak Load, N	Peak Load Ratio
100% Water	95.4 (4.74)	10.83 (1.79)	48.79	10.83	0.22
2.5% Glycerin	106.6 (7.85)	10.55 (2.34)	48.79	10.55	0.22
5% Glycerin	153 (8.79)	11.05 (1.63)	48.79	11.05	0.23
10% Glycerin	253 (14.21)	12.96 (1.23)	48.79	12.96	0.27
15% Glycerin		13.61 (1.38)	48.79	13.61	0.28
20% Glycerin		9.80 (1.60)	48.79	9.80	0.20
25% Glycerin		3.29 (0.42)	48.79	3.29	0.07

30% Glycerin		2.55 (0.36)	48.79	2.55	0.05
35% Glycerin		0.99 (0.11)	48.79	0.99	0.02
40% Glycerin		0.26 (0.04)	48.79	0.26	0.01
45% Glycerin		0.86 (0.30)	48.79	0.86	0.02
50% Glycerin		0.71 (0.09)	48.79	0.71	0.01

[0117] Example 4 (1.5 mil Film D including PVOH homopolymer D): Burn-through time increased with increasing glycerin concentration. Unlike the various copolymer PVOH films of Examples 1-3, 0% glycerin (or 100% water) does not exhibit the maximum seal peak load. The maximum seal strength is observed in a range from about 10 to 40% glycerin-in-water. This range is where the maximum seal peak load is observed. Importantly, for this homopolymer film, a 100% water sealing solution is not an option for forming a solution seal. While the minimum burn-though resistance at 100% water of 88 seconds is acceptable and a seal can be formed using water alone as the sealant, the peak seal strength is not at its maximum when using 100% water.

Table 4. Burn-Through Time and Peel Strength for Film D

Sealing Solution	Burn Through, sec (95% CI)	Peel Strength, N (95% CI)	Film Peak Load, N	Seal Peak Load, N	Peak Load Ratio
100% Water	87.7 (6.30)	11.34 (1.78)	42.26	11.34	0.27
2.5% Glycerin	117.60 (9.12)	9.77 (1.49)	42.26	9.77	0.23
5% Glycerin	127 (12.53)	10.19 (0.73)	42.26	10.19	0.24
10% Glycerin	138 (12.36)	14.79 (1.89)	42.26	14.79	0.35
15% Glycerin	305.4 (20.05)	12.07 (1.30)	42.26	12.07	0.29
20% Glycerin	531 (23.48)	15.50 (1.33)	42.26	15.50	0.37
25% Glycerin	1006 (29.92)	14.32 (1.90)	42.26	14.32	0.34
30% Glycerin		15.65 (1.22)	42.26	15.65	0.37
35% Glycerin		13.81 (1.15)	42.26	13.81	0.33
40% Glycerin		14.14 (1.02)	42.26	14.14	0.33
45% Glycerin		11.16 (0.93)	42.26	11.16	0.26
50% Glycerin		6.87 (1.10)	42.26	6.87	0.16

[0118] Example 5 (1.5 mil Film E including PVOH homopolymer E): Film E is a water-soluble, edible film including (i) a PVOH homopolymer as a water-soluble polymer (nominal 23 cP solution viscosity and 88% degree of hydrolysis; 100 weight parts per hundred resin (phr)), (ii) xylitol as a sugar alcohol plasticizer (8.52 phr), (iii) sorbitol as a sugar alcohol plasticizer (6.53 phr), (iv) carboxymethylcellulose ether as a sugar alcohol compatibilizer (17.04 phr), (v) glycerin and propylene glycol as liquid plasticizers (36.98 phr combined), and (vi) a surfactant process aid (1.43 phr). Burn-through time increased with increasing glycerin concentration. Unlike the copolymer PVOH films of Examples 1-3, 0% glycerin (or 100% water) does not exhibit the maximum seal peak load. The maximum seal strength is observed in a range from 5 to 20% glycerin solution. This range is where the maximum seal peak load is observed. Importantly, for this homopolymer film, a 100% water sealing solution is not an option for forming a solution seal. Also, the minimum burn-though resistance at 100% water of about 34 seconds is not acceptable. However, at glycerin levels of 5% and above, a minimum burn-through time of 54 seconds or higher is obtained.

Table 5. Burn-Through Time and Peel Strength for Film E

Sealing Solution	Burn Through, sec (95% CI)	Peel Strength, N (95% CI)	Film Peak Load, N	Seal Peak Load, N	Peak Load Ratio
100% Water	34.55 (2.04)	2.44 (0.81)	19.92	2.44	0.12
2.5% Glycerin	51.10 (5.02)	2.10 (0.87)	19.92	2.10	0.11
5% Glycerin	54 (3.09)	4.16 (0.92)	19.92	4.16	0.21
10% Glycerin	62 (4.56)	3.77 (0.95)	19.92	3.77	0.19
15% Glycerin	74.5 (6.64)	4.95 (0.32)	19.92	4.95	0.25
20% Glycerin	112 (9.91)	4.93 (0.86)	19.92	4.93	0.25
25% Glycerin	218 (23.37)	2.95 (0.38)	19.92	2.95	0.15
30% Glycerin	443 (27.01)	0.61 (0.16)	19.92	0.61	0.03
35% Glycerin	972 (36.34)	0.65 (0.11)	19.92	0.65	0.03
40% Glycerin		1.29 (0.14)	19.92	1.29	0.06
45% Glycerin		0.75 (0.24)	19.92	0.75	0.04
50% Glycerin		0.69 (0.05)	19.92	0.69	0.03

Examples 6-11

[0119] Analogous to Examples 1-5, Examples 6-11 evaluate a PVOH-based water-soluble film (Film F including PVOH homopolymer F) as a function of sealing solution concentration, using water alone as a control sealant and variable-concentration sealing solutions (generally spanning 2.5 wt.% to 50 wt.%) using diol and polyol solvents. Film F is a water-soluble, edible film with a film peak load of about 20.0 N and including (i) a PVOH homopolymer as a water-soluble polymer (nominal 8 cP solution viscosity and 88% degree of hydrolysis; 100 weight parts per hundred resin (phr)), (ii) xylitol as a sugar alcohol plasticizer (8.52 phr), (iii) sorbitol as a sugar alcohol plasticizer (6.53 phr), (iv) carboxymethylcellulose ether as a sugar alcohol compatibilizer (17.04 phr), (v) glycerin and propylene glycol as liquid plasticizers (36.98 phr combined), and (vi) a surfactant process aid (1.43 phr). The specific solvents used were glycerin (Example 6), 2-methyl-1,3-propanediol (Example 7), propylene glycol (Example 8), mannitol (Example 9), sorbitol (Example 10), and xylitol (Example 11). For each film-sealing solution combination, burn-through times and seal peel strength were tested for 1.5 mil thickness films. Result graphs and data are shown in Figures 8-13 and Tables 6-11 for Examples 6-11, respectively.

Table 6. Burn-Through Time and Peel Strength for Film F – Glycerin

Sealing Solution	Burn Through, sec (95% CI)	Peel Strength, N (95% CI)
100% Water	43 (1.52)	4.18 (0.48)
2.5% Glycerin	47 (2.48)	3.73 (0.53)
5% Glycerin	51 (2.41)	6.80 (0.46)
10% Glycerin	61 (1.98)	4.39 (0.75)
15% Glycerin	67 (2.70)	4.61 (0.90)
20% Glycerin	113 (5.91)	4.91 (0.58)
25% Glycerin	171 (10.27)	3.97 (0.42)
30% Glycerin	250 (15.29)	3.74 (0.23)

Table 7. Burn-Through Time and Peel Strength for Film F – MP Diol

Sealing Solution	Burn Through, sec (95% CI)	Peel Strength, N (95% CI)
100% Water	43 (1.52)	4.18 (0.48)
2.5% MP Diol	50 (1.78)	5.14 (0.96)
5% MP Diol	52 (1.79)	5.20 (0.60)
10% MP Diol	57 (2.17)	5.22 (0.60)
15% MP Diol	84 (3.27)	4.50 (0.32)
20% MP Diol	97 (3.39)	3.24 (1.69)
25% MP Diol	156 (7.23)	3.43 (1.06)
30% MP Diol	200 (9.53)	3.07 (1.12)
35% MP Diol	320 (23.35)	1.80 (1.02)
40% MP Diol	432 (17.51)	3.61 (1.37)
45% MP Diol	608 (31.30)	3.93 (1.19)
50% MP Diol	654 (28.18)	2.99 (0.76)

Table 8. Burn-Through Time and Peel Strength for Film F – Propylene Glycol

Sealing Solution	Burn Through, sec (95% CI)	Peel Strength, N (95% CI)
100% Water	43 (1.52)	4.18 (0.48)
2.5% Propylene Glycol	51 (1.75)	2.91 (0.30)
5% Propylene Glycol	53 (1.60)	4.70 (0.37)
10% Propylene Glycol	61 (3.01)	4.81 (0.65)
15% Propylene Glycol	97 (3.87)	4.58 (0.58)
20% Propylene Glycol	111 (3.43)	4.34 (0.14)
25% Propylene Glycol	175 (7.27)	4.81 (0.62)
30% Propylene Glycol	211 (9.25)	4.45 (0.68)
35% Propylene Glycol	449 (25.41)	4.23 (0.85)
40% Propylene Glycol	434 (16.62)	3.41 (1.00)

Table 9. Burn-Through Time and Peel Strength for Film F – Mannitol

Sealing Solution	Burn Through, sec (95% CI)	Peel Strength, N (95% CI)
100% Water	43 (1.52)	4.18 (0.48)
2.5% Mannitol	42 (2.01)	3.01 (0.95)
5% Mannitol	55 (1.51)	5.59 (0.95)
10% Mannitol	67 (3.76)	4.61 (0.54)
15% Mannitol	91 (5.10)	2.91 (0.34)

Table 10. Burn-Through Time and Peel Strength for Film F – Sorbitol

Sealing Solution	Burn Through, sec (95% CI)	Peel Strength, N (95% CI)
100% Water	43 (1.52)	4.18 (0.48)
2.5% Sorbitol	51 (2.84)	3.92 (0.99)
5% Sorbitol	50 (2.70)	6.97 (0.62)
10% Sorbitol	72 (3.08)	6.10 (0.34)
15% Sorbitol	87 (3.87)	3.50 (0.41)
20% Sorbitol	107 (4.87)	3.70 (0.14)
25% Sorbitol	225 (18.21)	2.16 (0.58)
30% Sorbitol	539 (52.46)	2.04 (0.58)

Table 11. Burn-Through Time and Peel Strength for Film F – Xylitol

Sealing Solution	Burn Through, sec (95% CI)	Peel Strength, N (95% CI)
100% Water	43 (1.52)	4.18 (0.48)

2.5% Xylitol	46 (2.59)	4.58 (0.36)
5% Xylitol	48 (2.46)	5.84 (0.59)
10% Xylitol	63 (3.41)	5.63 (0.39)
15% Xylitol	73 (3.20)	4.76 (0.37)
20% Xylitol	126 (5.46)	4.94 (0.27)
25% Xylitol	199 (11.70)	4.25 (0.58)

[0120] Notably, the polyol solvents containing 3, 5, or 6 hydroxyl groups all exhibited substantial improvement in seal peel strength while simultaneously achieving a burn-through time increase sufficient to exceed a minimum desirable threshold of at least about 45-50 sec. In contrast, the diol solvents containing 2 hydroxyl groups, although achieving a burn-through time above an acceptable minimum, did not exhibit improvement in seal peel strength relative to water to the same degree as the polyol solvents.

[0121] Table 12 below presents an HSP analysis of the various solvents tested in Examples 6-11 for their solubility radius (Ra) in relation to a PVOH homopolymer as the corresponding polymeric component in the water-soluble film (see Equation (2) above). The values in Table 12 were computed using the Y-MB methodology and the commercially available HSPIP software for implementing the same. From Table 12, it is seen that the polyol solvents observed to have better solution sealing properties as compared to diol solvents similarly have smaller solubility radii relative to PVOH.

Table 12. HSP Analysis: PVOH-Solvent Solubility Radii

	HSP Parameter			
Component	δ_D	δ_P	δ_H	Ra
PVOH	19.3	10.4	26.5	-
Glycerin	18.3	11.3	28.5	3.0
Mannitol	17.6	12.3	28.6	4.4
Sorbitol	17.6	12.3	28.6	4.4
Xylitol	18.0	11.9	29.2	4.0
2-Methyl-1,3-Propanediol	17.3	9.3	21.4	6.6
Propylene Glycol	17.4	8.8	21.7	6.3

[0122] The foregoing description is given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications within the scope of the invention may be apparent to those having ordinary skill in the art.

[0123] Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise" and variations such as "comprises" and "comprising" will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

[0124] Throughout the specification, where compositions are described as including components or materials, it is contemplated that the compositions can also consist essentially of, or consist of, any combination of the recited components or materials, unless described otherwise. Likewise, where methods are described as including particular steps, it is contemplated that the methods can also consist essentially of, or consist of, any combination of the recited steps, unless described otherwise. The invention illustratively disclosed herein suitably may be practiced in the absence of any element or step which is not specifically disclosed herein.

[0125] The practice of a method disclosed herein, and individual steps thereof, can be performed manually and/or with the aid of or automation provided by electronic equipment. Although processes have been described with reference to particular embodiments, a person of ordinary skill in the art will readily appreciate that other ways of performing the acts associated with the methods may be used. For example, the order of various of the steps may be changed without departing from the scope or spirit of the method, unless described otherwise. In addition, some of the individual steps can be combined, omitted, or further subdivided into additional steps.

[0126] All patents, publications and references cited herein are hereby fully incorporated by reference. In case of conflict between the present disclosure and incorporated patents, publications and references, the present disclosure should control.

What is Claimed:

1. A method for sealing a water-soluble film, the method comprising:
(a) applying a sealing solution to a first surface of a water-soluble film, the sealing solution comprising
(i) water, and
(ii) a polyol having 3 or more hydroxyl groups,
wherein the sealing solution has a dynamic viscosity (μ_s) less than 1.5 cP as measured at 20°C; and
(b) contacting a second surface of a water-soluble film with the sealing solution on the first surface for a time sufficient to form a seal between the first surface and the second surface.

2. The method of claim 1, wherein the polyol is present in the sealing solution in an amount ranging from about 2 wt.% to about 15 wt.%.

3. The method of any one of the preceding claims, wherein the sealing solution consists essentially of water and one or more polyols each having 3 or more hydroxyl groups.

4. The method of any one of the preceding claims, wherein the polyol contains 2 to 12 carbon atoms and 3 to 12 hydroxyl groups.

5. The method of any one of the preceding claims, wherein the polyol is selected from the group consisting of glycerol, erythritol, threitol, arabitol, xylitol, ribitol, mannitol, sorbitol, galactitol, fucitol, iditol, inositol, volemitol, isomalt, maltitol, lactitol, and combinations thereof.

6. A method for sealing a water-soluble film, the method comprising:
(a) applying a sealing solution to a first surface of a water-soluble film having an initial thickness less than about 50 μm and comprising a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units, the sealing solution comprising
(i) water, and
(ii) a polyol present in the sealing solution in an amount ranging from about 2 wt.% to about 15 wt.%, the polyol being selected from the group consisting of glycerol, erythritol, threitol, arabitol, xylitol, ribitol, mannitol,

sorbitol, galactitol, fucitol, iditol, inositol, volemitol, isomalt, maltitol, lactitol, and combinations thereof,

wherein the sealing solution has a dynamic viscosity (μ_s) less than 1.5 cP as measured at 20°C; and

(b) contacting a second surface of a water-soluble film having an initial thickness less than about 50 μm and comprising a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units with the sealing solution on the first surface for a time sufficient to form a seal between the first surface and the second surface.

7. The method of claim 6, wherein the water-soluble film for each of the first surface and the second surface:

(i) has a degree of hydrolysis ranging from about 86.5% to about 89%; and

(ii) further comprises: (A) a sugar alcohol plasticizer selected from the group consisting of isomalt, maltitol, sorbitol, xylitol, erythritol, adonitol, dulcitol, pentaerythritol, mannitol, and combinations thereof, (B) a liquid plasticizer selected from the group consisting of glycerin, diglycerin, ethylene glycol, diethylene glycol, triethylene glycol, tetraethylene glycol, propylene glycol, polyethylene glycols up to 400 MW, 2-methyl-1,3-propanediol, and combinations thereof, and (C) a compatibilizing agent selected from the group consisting of cellulose ethers, polysaccharides of pectin, polysaccharides of sodium alginate, modified starches, and combinations thereof.

8. A method for sealing a water-soluble film, the method comprising:

(a) applying a sealing solution to a first surface of a water-soluble film, the sealing solution comprising

(i) water, and

(ii) a solvent for at least one polymeric component of the water-soluble film,

wherein

(A) the solvent and the polymeric component have a solubility radius (Ra) of about 5 or less as defined by equation (I):

$$(Ra)^2 = 4(\delta_{D,S} - \delta_{D,P})^2 + (\delta_{P,S} - \delta_{P,P})^2 + (\delta_{H,S} - \delta_{H,P})^2 \quad \text{(I)}$$

where $\delta_{D,S}$ is the solvent dispersive force, $\delta_{D,P}$ is the polymeric component dispersive force, $\delta_{P,S}$ is the solvent polar force, $\delta_{P,P}$ is the polymeric component polar force, $\delta_{H,S}$ is the solvent hydrogen bonding force, and $\delta_{H,P}$ is the polymeric component hydrogen bonding force, each of which is determined by a consistent method of Hansen solubility parameter evaluation, and

(B) the sealing solution has a dynamic viscosity (μ_s) less than 1.5 cP as measured at 20°C; and

(b) contacting a second surface of a water-soluble film with the sealing solution on the first surface for a time sufficient to form a seal between the first surface and the second surface.

9. The method of claim 8, wherein the solubility radius ranges from about 1 to about 5.

10. The method of any one of claims 8 to 9, wherein:
(i) the polymeric component comprises polyvinyl alcohol;
(ii) $\delta_{P,S}$ is at least about 10; and
(iii) $\delta_{H,S}$ is at least about 22.

11. The method of any one of claims 8 to 10, wherein the solvent is present in the sealing solution in an amount ranging from about 2 wt.% to about 15 wt.%.

12. The method of any one of claims 8 to 11, wherein the sealing solution consists essentially of water and one or more solvents each having a solubility radius of about 5 or less relative to the polymeric component.

13. The method of any one of claims 1 to 12, wherein the dynamic viscosity ranges from about 1 cP to about 1.45 cP.

14. The method of any one of claims 1 to 13, wherein:
(i) the water-soluble film has a burn-through time of about 45 sec or less using water alone as a test solvent; and
(ii) the water-soluble film has a burn-through time (A) of about 45 sec or more using the sealing solution as a test solvent and (B) greater than the burn-through time using water alone as a test solvent.

15. The method of any one of claims 1 to 14, wherein the seal exhibits a peel strength of at least about 12% relative to the peak load of the water-soluble film.

16. The method of any one of claims 1 to 15, wherein the seal exhibits a peel strength of at least about 30% greater than that of a corresponding seal formed with water alone.

17. The method of any one of claims 1 to 16, wherein the first surface and the second surface each independently have an initial thickness ranging from about 10 μm to about 150 μm.

18. The method of any one of claims 1 to 17, wherein the water-soluble film comprises a water-soluble polymer selected from the group consisting of polyvinyl alcohols, polyethyleneimines, polyacrylates, water-soluble acrylate copolymers, polyvinyl pyrrolidones, pullulans, guar gums, xanthan gums, carrageenans, starches, ethoxylated starches, hydroxypropylated starches, polyalkylene oxides, polyacrylamides, polyacrylic acids and salts thereof, celluloses, cellulose ethers, cellulose esters, cellulose amides, polyvinyl acetates, polycarboxylic acids and salts thereof, polyaminoacids, polyamides, gelatines, methylcelluloses, carboxymethylcelluloses and salts thereof, dextrins, ethylcelluloses, hydroxyethyl celluloses, hydroxypropyl methylcelluloses, maltodextrins, polymethacrylates, copolymers thereof, blends thereof, and combinations thereof.

19. The method of claim 18, wherein the water-soluble polymer has a 4% solution viscosity ranging from about 3 cP to about 27 cP at 20°C.

20. The method of any one of claims 1 to 19, wherein the water-soluble film comprises a water-soluble polymer comprising polyvinyl alcohol.

21. The method of claim 20, wherein the water-soluble polymer comprises a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units.

22. The method of any one of claims 20 to 21, wherein the polyvinyl alcohol has a degree of hydrolysis ranging from about 75% to about 99%.

23. The method of any one of claims 20 to 21, wherein the polyvinyl alcohol has a degree of hydrolysis ranging from about 86.5% to about 89%.

24. The method of any one of claims 1 to 23, wherein the first surface and the second surface are from the same water-soluble film.

25. The method of any one of claims 1 to 23, wherein the first surface and the second surface are from different water-soluble films.

26. The method of any one of claims 1 to 25, wherein contacting the second surface with the first surface comprises at least one of applying pressure to the first surface and the second surface and applying heat to the first surface and the second surface to form the seal.

27. The method of any one of claims 1 to 26, wherein the second surface comprises a second sealing solution thereon to be contacted with the first surface when forming the seal.

28. The method of any one of claims 1 to 27, wherein:
(i) the water-soluble film of at least one of the first surface and the second surface defines a volume at least partially enclosing a composition, and
(ii) forming the seal creates a sealed water-soluble packet containing the composition.

29. The method of claim 28, wherein the composition is selected from the group consisting of human and animal ingestible items, personal care compositions and cleaning compositions.

30. An article comprising a sealed water-soluble film formed according to any one of claims 1 to 29.

31. An article comprising:
(a) a first surface of a water-soluble film sealed to a second surface of a water-soluble film at an interfacial region between the first surface and the second surface; and
(b) a polyol having 3 or more hydroxyl groups present in the interfacial region at a local concentration substantially higher than a bulk concentration of the polyol in the water-soluble film and outside of the interfacial region.

32. An article comprising:

(a) a first surface of a water-soluble film sealed to a second surface of a water-soluble film at an interfacial region between the first surface and the second surface, wherein the water-soluble film for each of the first surface and the second surface has an initial thickness less than about 50 µm and comprises a polyvinyl alcohol copolymer consisting essentially of vinyl alcohol monomeric repeat units and vinyl acetate monomeric repeat units; and

(b) a polyol present in the interfacial region at a local concentration substantially higher than a bulk concentration of the polyol in the water-soluble film and outside of the interfacial region, the polyol being selected from the group consisting of glycerol, erythritol, threitol, arabitol, xylitol, ribitol, mannitol, sorbitol, galactitol, fucitol, iditol, inositol, volemitol, isomalt, maltitol, lactitol, and combinations thereof.

33. An article comprising:

(a) a first surface of a water-soluble film sealed to a second surface of a water-soluble film at an interfacial region between the first surface and the second surface; and

(b) a solvent for at least one polymeric component of the water-soluble film present in the interfacial region at a local concentration substantially higher than a bulk concentration of the solvent in the water-soluble film and outside of the interfacial region,

wherein the solvent and the polymeric component have a solubility radius (Ra) of about 5 or less as defined by equation (I):

$$(Ra)^2 = 4(\delta_{D,S} - \delta_{D,P})^2 + (\delta_{P,S} - \delta_{P,P})^2 + (\delta_{H,S} - \delta_{H,P})^2 \qquad (I)$$

where $\delta_{D,S}$ is the solvent dispersive force, $\delta_{D,P}$ is the polymeric component dispersive force, $\delta_{P,S}$ is the solvent polar force, $\delta_{P,P}$ is the polymeric component polar force, $\delta_{H,S}$ is the solvent hydrogen bonding force, and $\delta_{H,P}$ is the polymeric component hydrogen bonding force, each of which is determined by a consistent method of Hansen solubility parameter evaluation.

34. The article of any one of claims 31 to 33, wherein one or more components of the water-soluble film are present in the interfacial region at a local

concentration substantially lower than a bulk concentration of the one or more components in the water-soluble film and outside of the interfacial region.

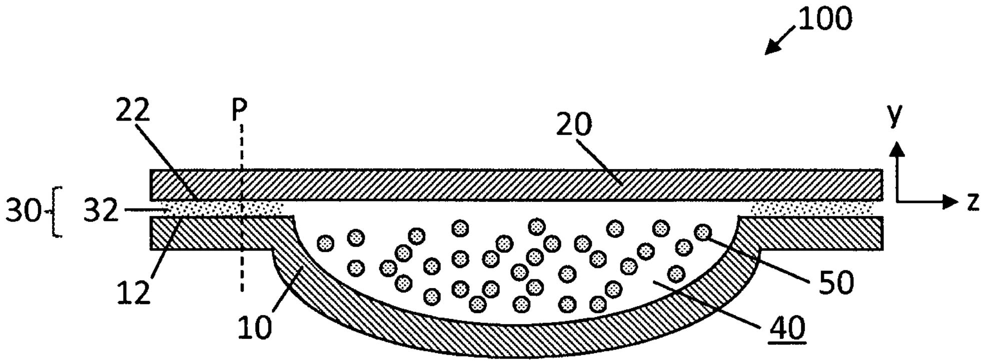


Figure 1

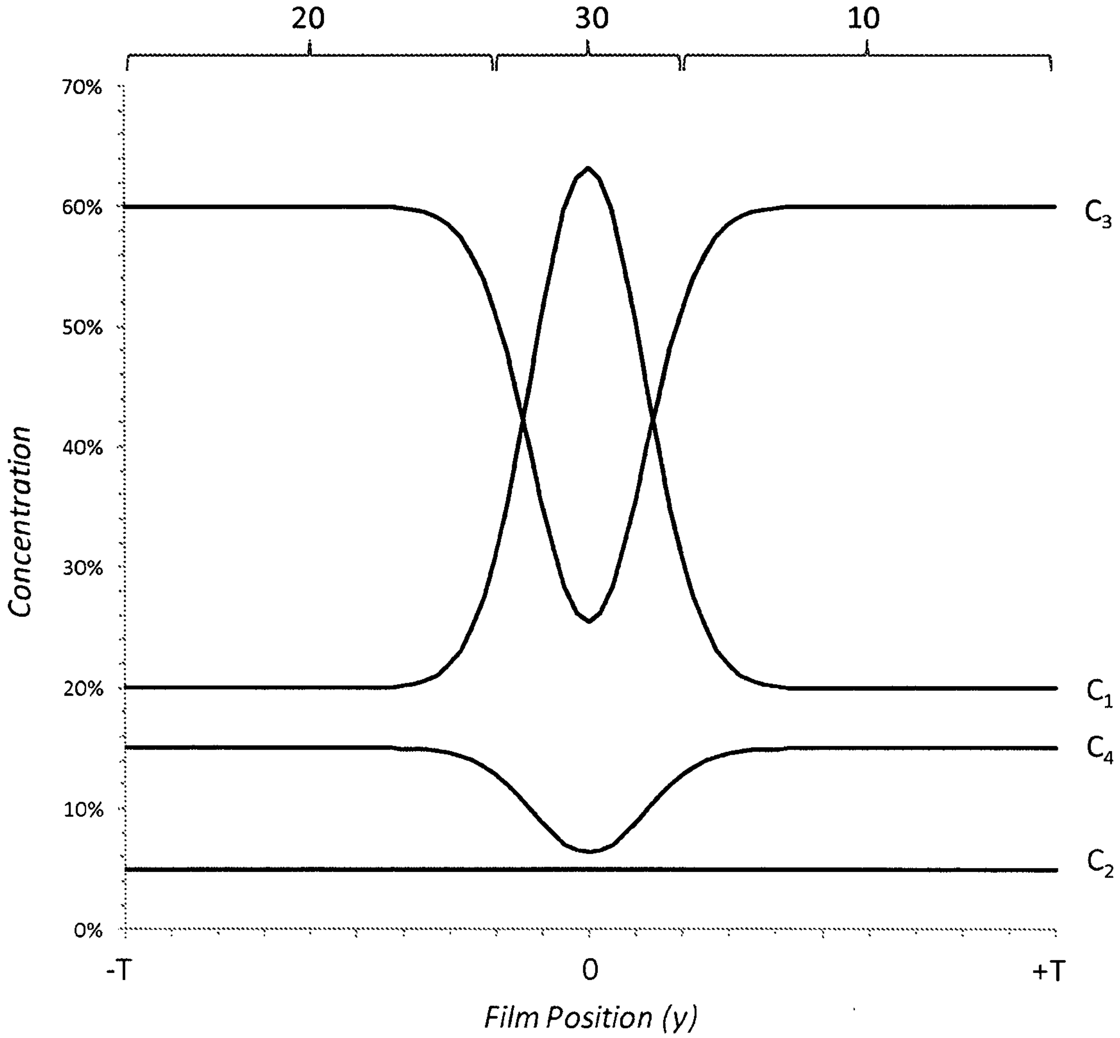


Figure 2

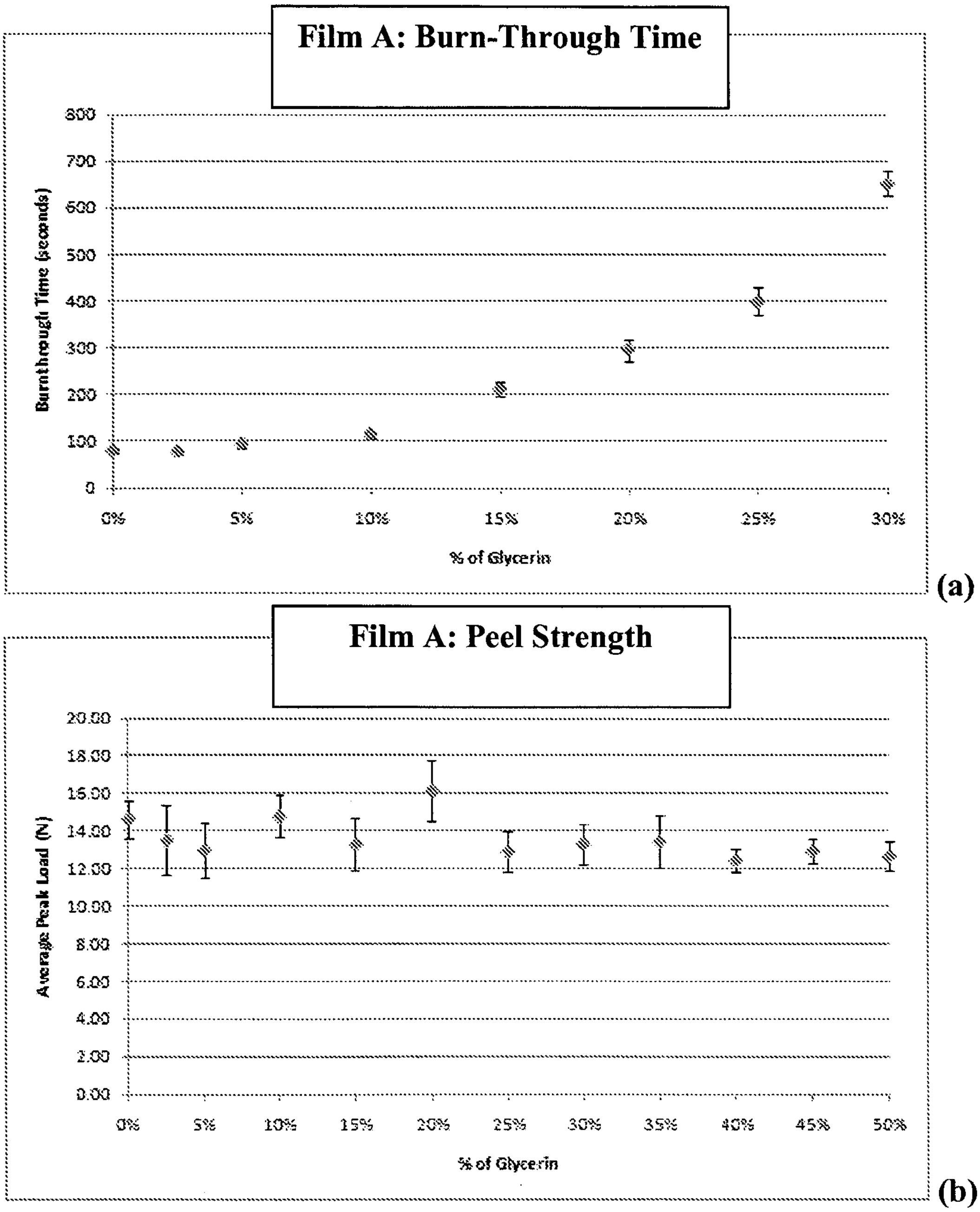
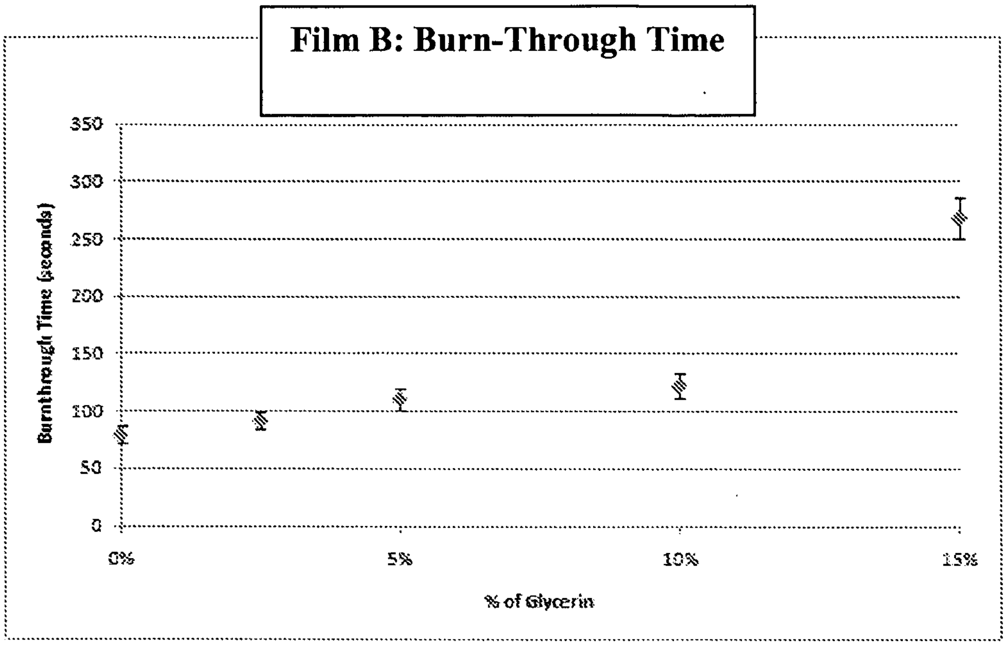
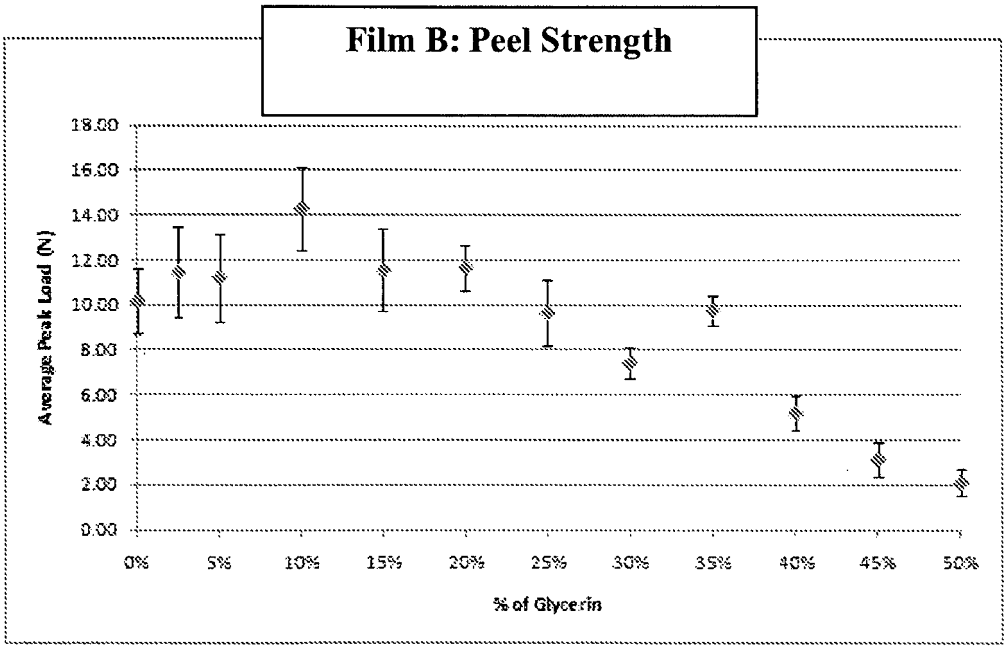

Film A: Burn-Through Time
Burnthrough Time (seconds)
800
700
600
500
400
300
200
100
0
0%
5%
10%
15%
20%
25%
30%
% of Glycerin
(a)
Film A: Peel Strength
Average Peak Load (N)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
% of Glycerin
(b)

Figure 3


Film B: Burn-Through Time
Burnthrough Time (seconds)
350
300
250
200
150
100
50
0
0%
5%
10%
15%
% of Glycerin

(a)


Film B: Peel Strength
Average Peak Load (N)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
% of Glycerin

(b)

Figure 4

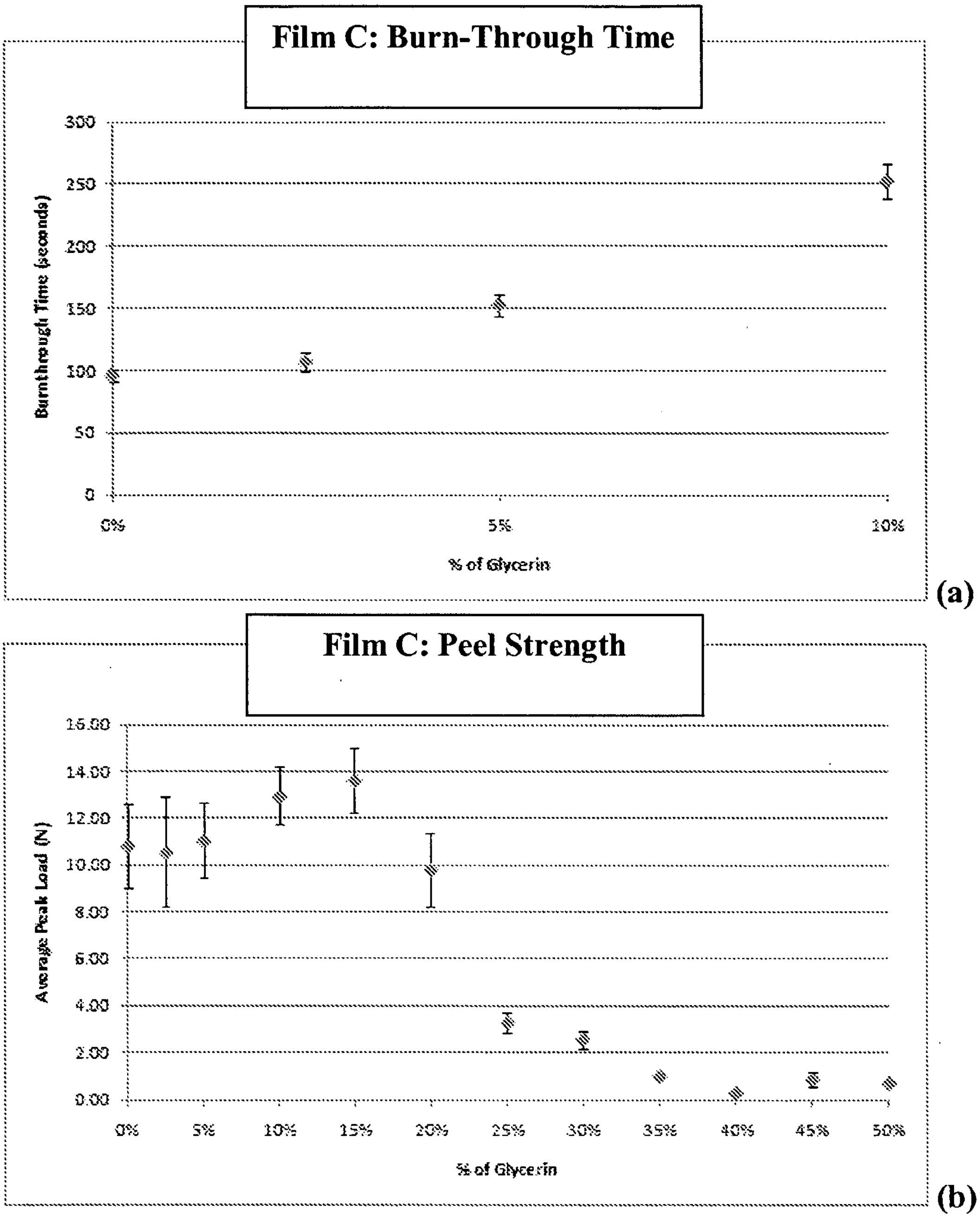
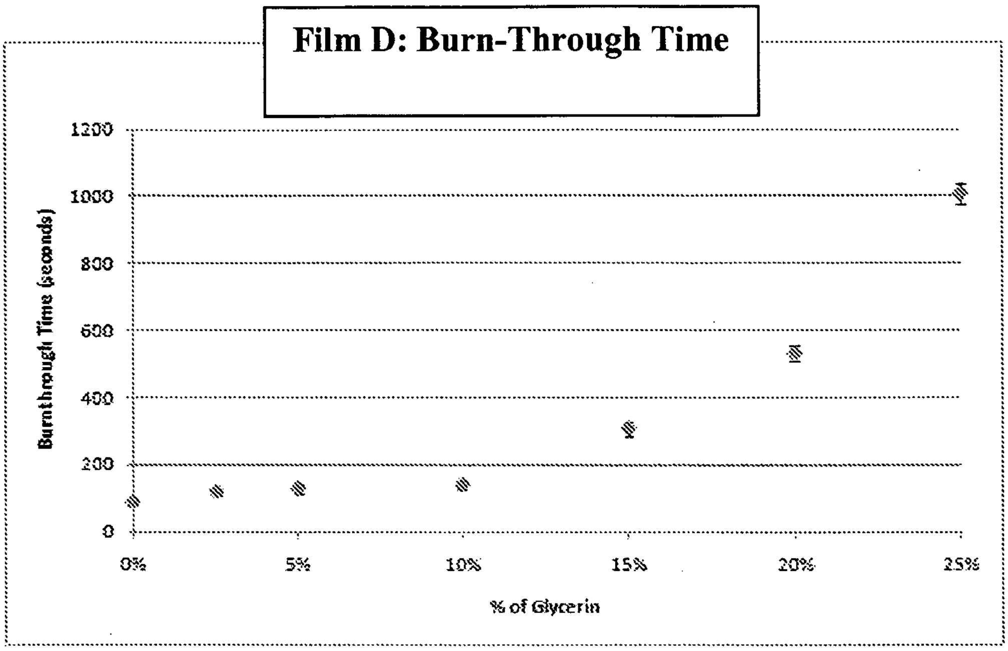
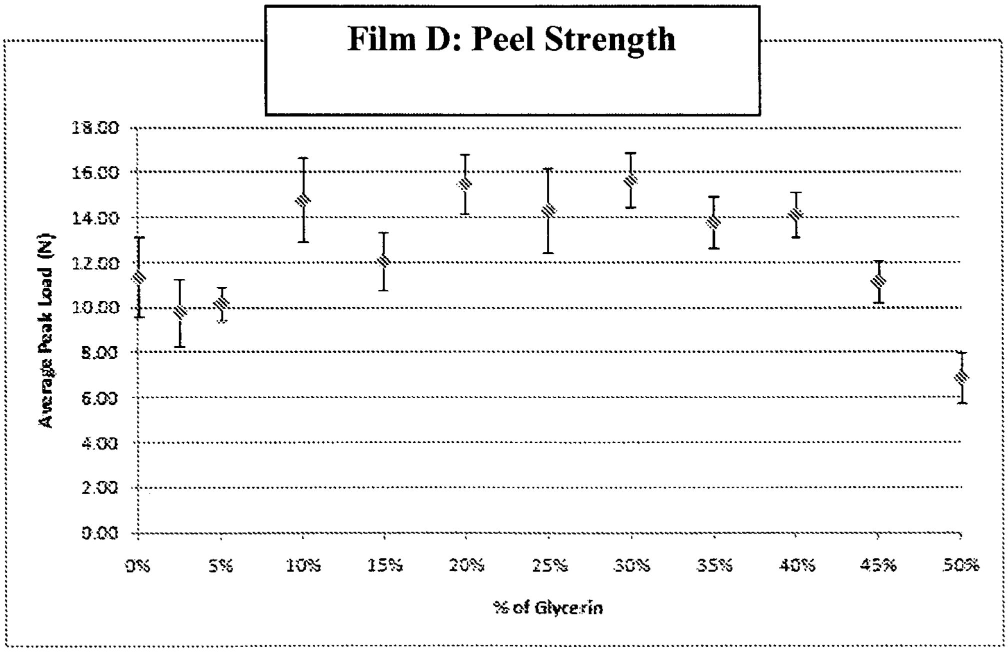

Film C: Burn-Through Time
Burnthrough Time (seconds)
300
250
200
150
100
50
0
0%
5%
10%
% of Glycerin
(a)
Film C: Peel Strength
Average Peak Load (N)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
% of Glycerin
(b)

Figure 5


Film D: Burn-Through Time
Burnthrough Time (seconds)
1200
1000
800
600
400
200
0
0%
5%
10%
15%
20%
25%
% of Glycerin

(a)


Film D: Peel Strength
Average Peak Load (N)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
% of Glycerin

(b)

Figure 6

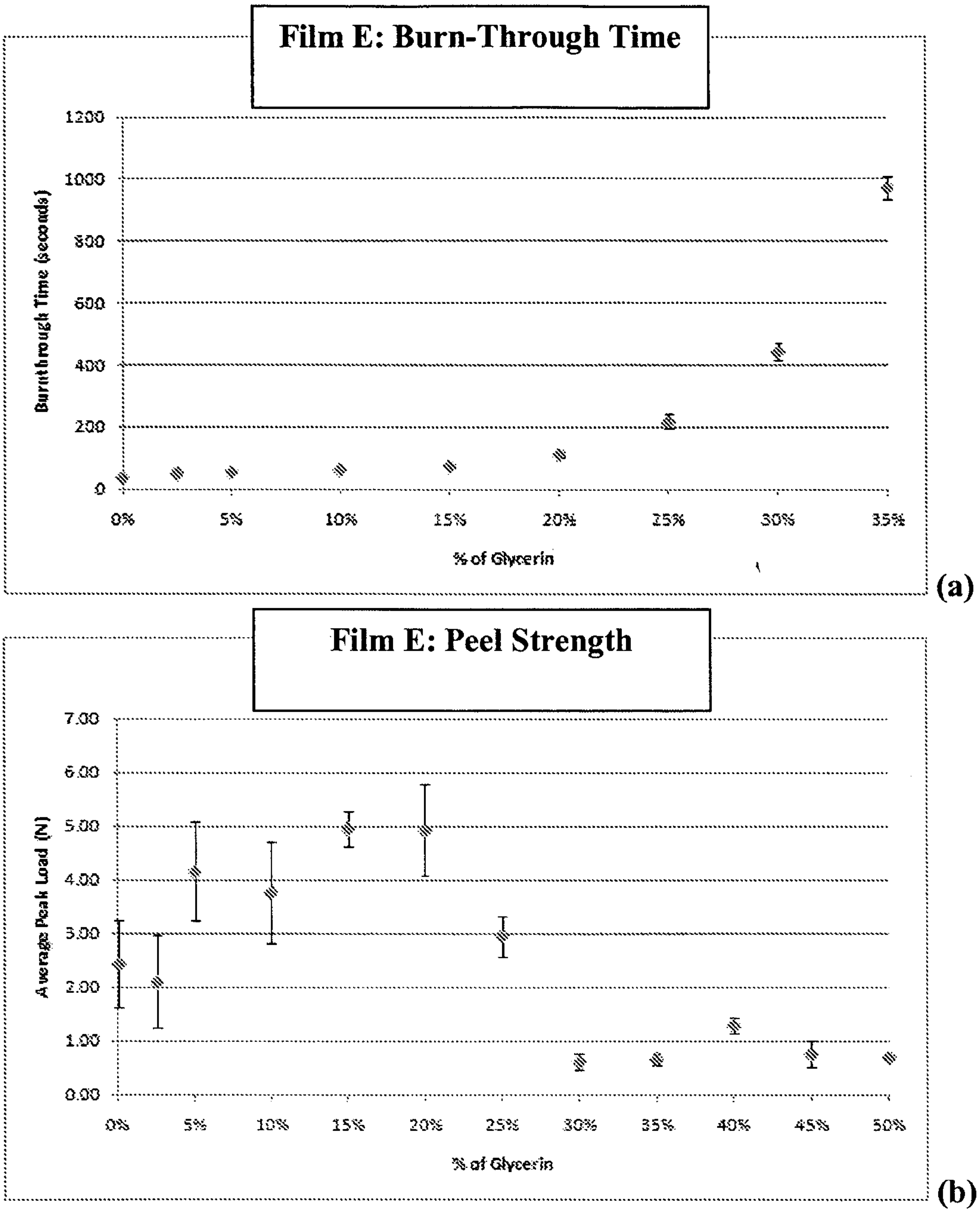

Film E: Burn-Through Time
Burnthrough Time (seconds)
1200
1000
800
600
400
200
0
0%
5%
10%
15%
20%
25%
30%
35%
% of Glycerin
(a)
Film E: Peel Strength
Average Peak Load (N)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
% of Glycerin
(b)

Figure 7

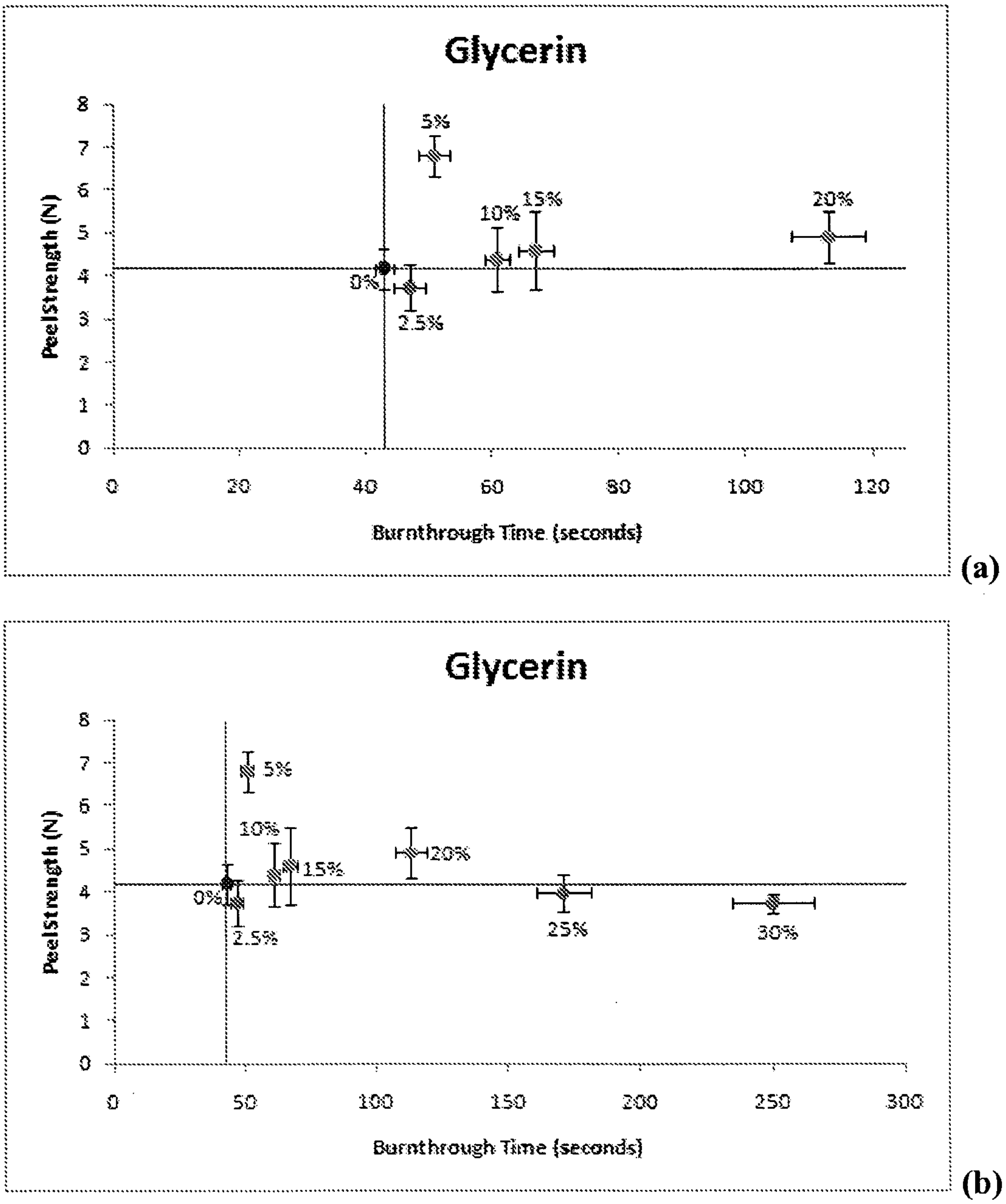

Glycerin
PeelStrength (N)
0
1
2
3
4
5
6
7
8
Burnthrough Time (seconds)
0
20
40
60
80
100
120
0%
2.5%
5%
10%
15%
20%
(a)
Glycerin
PeelStrength (N)
0
1
2
3
4
5
6
7
8
Burnthrough Time (seconds)
0
50
100
150
200
250
300
0%
2.5%
5%
10%
15%
20%
25%
30%
(b)

Figure 8

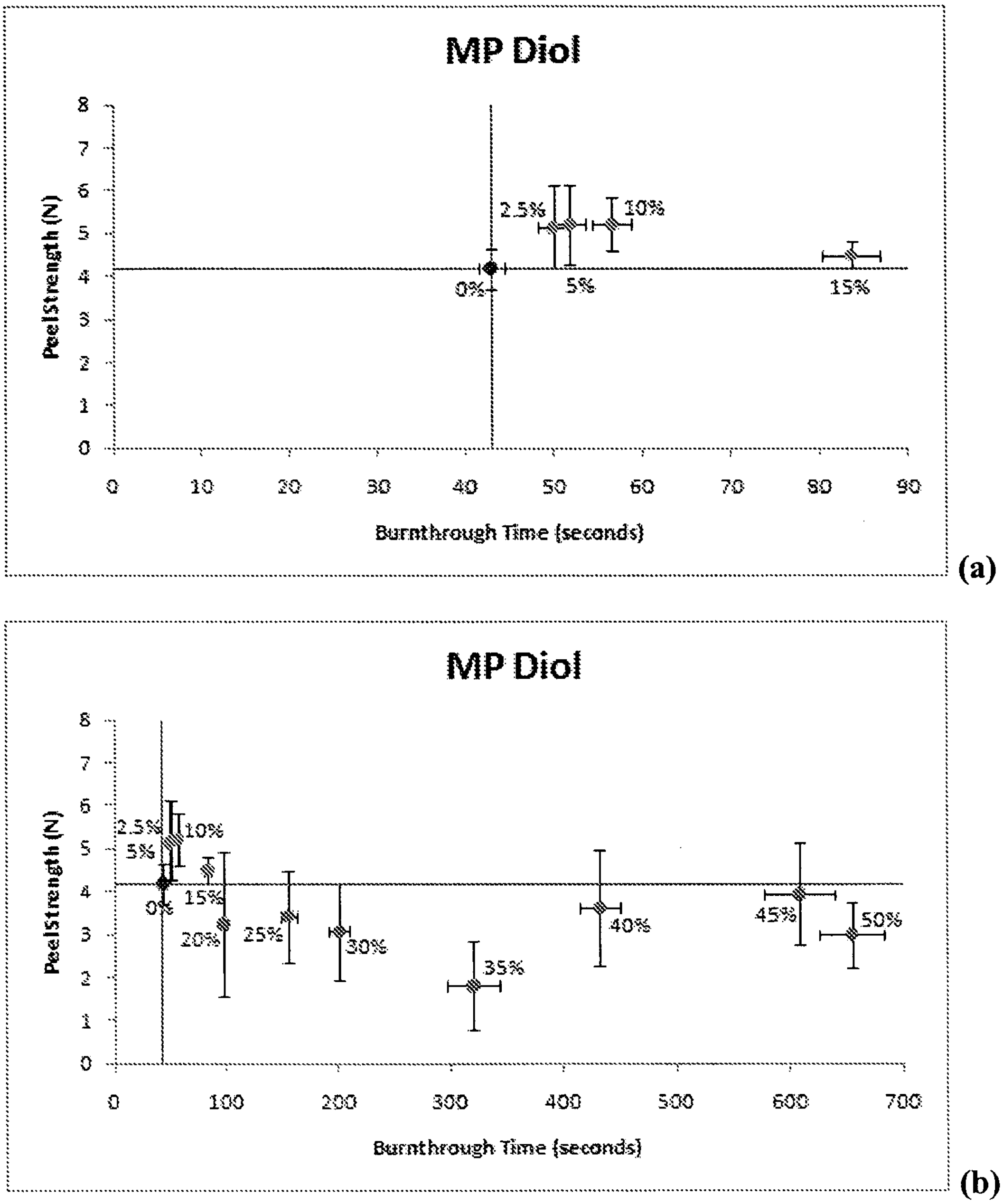

MP Diol
8
7
6
5
4
3
2
1
0
Peel Strength (N)
2.5%
10%
0%
5%
15%
0
10
20
30
40
50
60
70
80
90
Burnthrough Time (seconds)
(a)
MP Diol
8
7
6
5
4
3
2
1
0
Peel Strength (N)
2.5%
10%
5%
0%
15%
20%
25%
30%
35%
40%
45%
50%
0
100
200
300
400
500
600
700
Burnthrough Time (seconds)
(b)

Figure 9

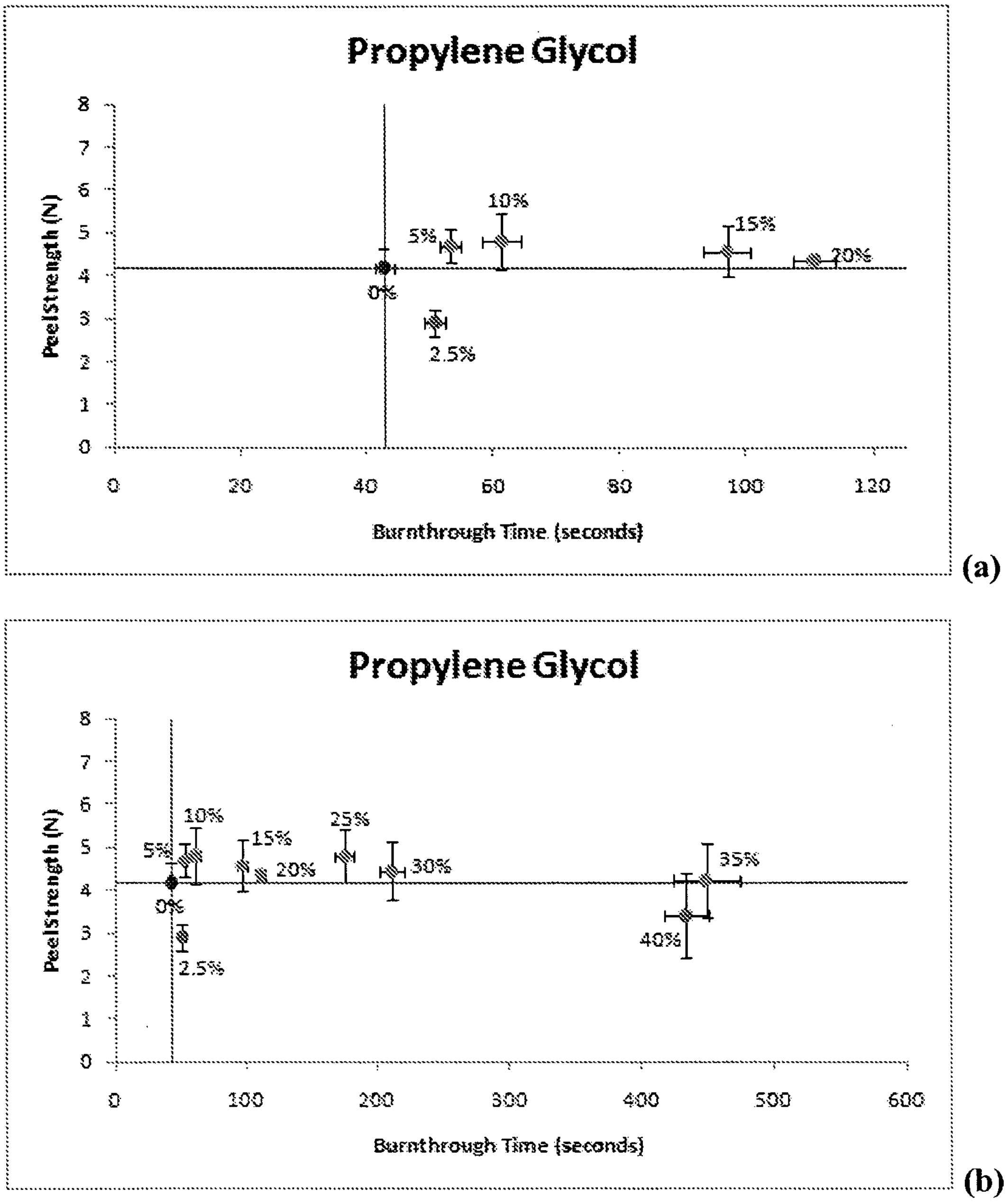
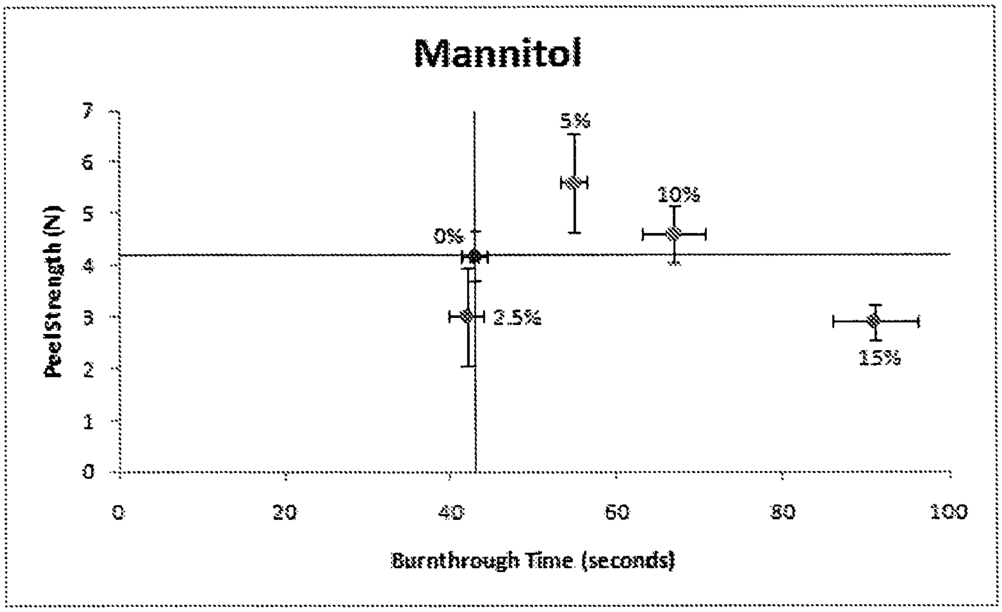
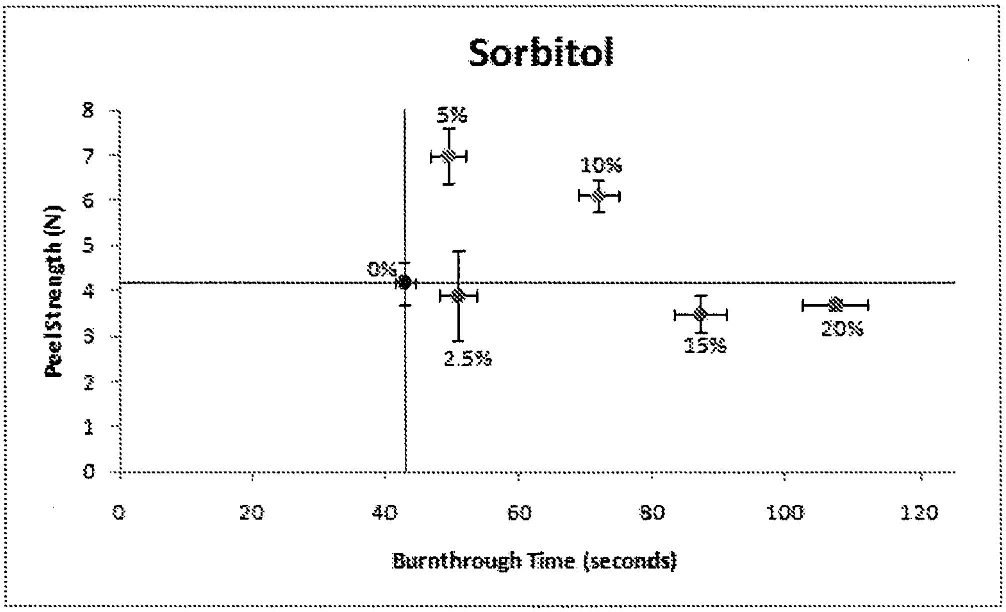

Propylene Glycol
Peel Strength (N)
0
1
2
3
4
5
6
7
8
Burnthrough Time (seconds)
0
20
40
60
80
100
120
0%
2.5%
5%
10%
15%
20%
(a)
Propylene Glycol
Peel Strength (N)
0
1
2
3
4
5
6
7
8
Burnthrough Time (seconds)
0
100
200
300
400
500
600
0%
2.5%
5%
10%
15%
20%
25%
30%
35%
40%
(b)

Figure 10

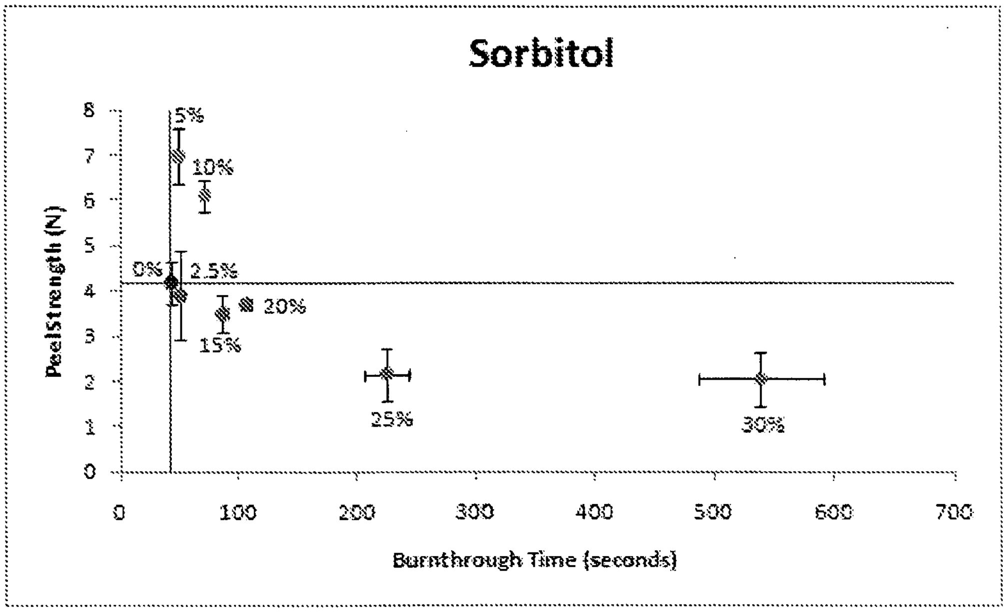

Mannitol
Peel Strength (N)
Burnthrough Time (seconds)
0
1
2
3
4
5
6
7
0
20
40
60
80
100
0%
2.5%
5%
10%
15%

(a)

Figure 11

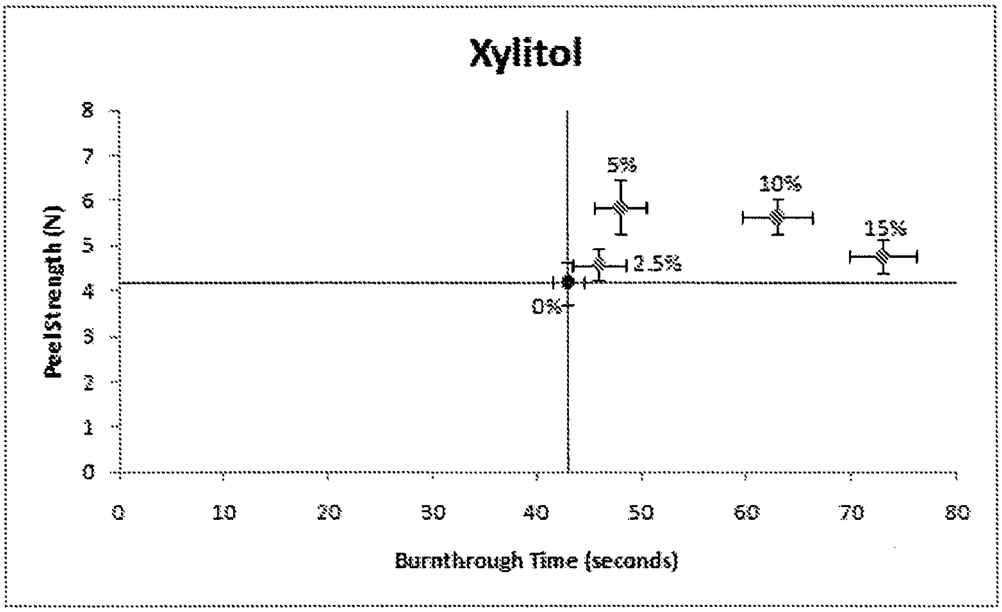

Sorbitol
PeelStrength (N)
Burnthrough Time (seconds)
0
1
2
3
4
5
6
7
8
0
20
40
60
80
100
120
0%
2.5%
5%
10%
15%
20%

(a)

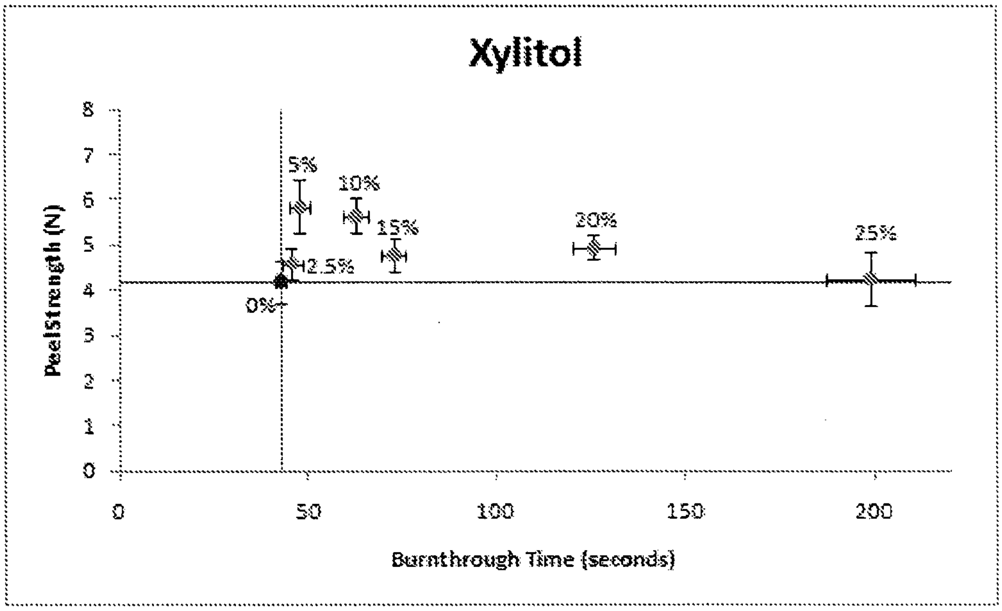

Sorbitol
PeelStrength (N)
Burnthrough Time (seconds)
0
1
2
3
4
5
6
7
8
0
100
200
300
400
500
600
700
5%
10%
0%
2.5%
20%
15%
25%
30%

(b)

Figure 12


Xylitol
Peel Strength (N)
0
1
2
3
4
5
6
7
8
Burnthrough Time (seconds)
0
10
20
30
40
50
60
70
80
0%
2.5%
5%
10%
15%

(a)


Xylitol
Peel Strength (N)
0
1
2
3
4
5
6
7
8
Burnthrough Time (seconds)
0
50
100
150
200
0%
2.5%
5%
10%
15%
20%
25%

(b)

Figure 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/040593

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08J5/12 C09J5/00 B32B27/30
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C08J C09J B32B

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 03/008513 A2 (PROCTER & GAMBLE [US]) 30 January 2003 (2003-01-30) page 3 - page 7; claims 1,4,5,7; example 1 -----	1-34
Y	WO 2005/121225 A1 (RECKITT BENCKISER UK LTD [GB]; DUFFIELD PAUL JOHN [GB]; EDWARDS DAVID) 22 December 2005 (2005-12-22) abstract page 7, line 1 - line 6; claims 1,6,7,12,13,15,16,23 -----	1-34
Y	US 2011/189413 A1 (DENOME FRANK W [US] ET AL) 4 August 2011 (2011-08-04) cited in the application paragraph [0055]; claims 1,6,7 -----	1-34

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

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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)

"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

"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

"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 15 October 2014	Date of mailing of the international search report 23/10/2014
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Meier, Stefan

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2014/040593

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 03008513 A2	30-01-2003	AU 2002322556 A1	03-03-2003
		CA 2449043 A1	30-01-2003
		EP 1406953 A2	14-04-2004
		ES 2456049 T3	21-04-2014
		US 2003036494 A1	20-02-2003
		WO 03008513 A2	30-01-2003
WO 2005121225 A1	22-12-2005	AT 461240 T	15-04-2010
		AU 2004318293 A1	08-12-2005
		CA 2536207 A1	03-11-2004
		EP 1641865 A1	05-04-2006
		ES 2342286 T3	05-07-2010
		GB 2401345 A	10-11-2004
		US 2007079454 A1	12-04-2007
		WO 2005121225 A1	22-12-2005
US 2011189413 A1	04-08-2011	AR 080093 A1	14-03-2012
		AR 080094 A1	14-03-2012
		AU 2011210549 A1	16-08-2012
		AU 2011210776 A1	09-08-2012
		CA 2786735 A1	04-08-2011
		CA 2786739 A1	04-08-2011
		CA 2788079 A1	04-08-2011
		CA 2788152 A1	04-08-2011
		CN 102725390 A	10-10-2012
		CN 102762612 A	31-10-2012
		CN 102781978 A	14-11-2012
		CN 102858639 A	02-01-2013
		EP 2528822 A1	05-12-2012
		EP 2528954 A1	05-12-2012
		EP 2528955 A1	05-12-2012
		EP 2529002 A1	05-12-2012
		JP 2013518008 A	20-05-2013
		JP 2013518009 A	20-05-2013
		JP 2013518010 A	20-05-2013
		JP 2013518173 A	20-05-2013
		RU 2012129690 A	10-03-2014
		RU 2012130029 A	10-03-2014
		RU 2012136783 A	10-03-2014
		RU 2012136830 A	20-03-2014
		US 2011186467 A1	04-08-2011
		US 2011186468 A1	04-08-2011
		US 2011188784 A1	04-08-2011
		US 2011189413 A1	04-08-2011
		WO 2011094470 A1	04-08-2011
		WO 2011094472 A1	04-08-2011
		WO 2011094687 A1	04-08-2011
		WO 2011094690 A1	04-08-2011

(19)中华人民共和国国家知识产权局

(12)发明专利申请

(10)申请公布号 CN 105377965 A
(43)申请公布日 2016.03.02

(21)申请号 201480038075.7

(22)申请日 2014.06.03

(30)优先权数据
61/830,969 2013.06.04 US

(85)PCT国际申请进入国家阶段日
2015.12.31

(86)PCT国际申请的申请数据
PCT/US2014/040593 2014.06.03

(87)PCT国际申请的公布数据
WO2014/197415 EN 2014.12.11

(71)申请人 蒙诺苏尔有限公司
地址 美国印地安那州

(72)发明人 S·库马尔 P·布罗姆比
大卫·M·李

(74)专利代理机构 北京德琦知识产权代理有限公司 11018
代理人 康泉 王珍仙

(51)Int.Cl.
C08J 5/12(2006.01)
C09J 5/00(2006.01)
B32B 27/30(2006.01)

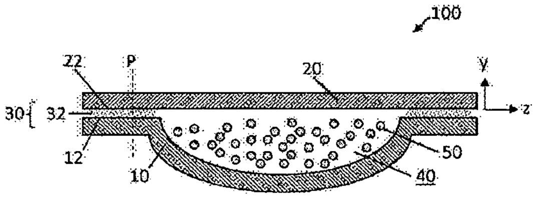
权利要求书4页 说明书25页 附图12页

(54)发明名称

水溶性膜密封溶液、相关方法和相关物品

(57)摘要

本文披露用于密封水溶性膜的密封溶液，具体来说包括一种或多种聚合溶剂（例如多元醇）的水性混合物。水性密封溶液包括用于所述水溶性膜的一种或多种聚合组分（例如其水溶性聚合组分，例如聚乙烯醇（PVOH））的相对稀溶剂，所述溶液可展现一种或多种益处，包括降低所述密封溶液对所述膜的溶解以及提高密封强度。还披露用所述密封溶液形成的密封物品，例如含有多种液体或固体组合物的水溶性小包。



1.一种用于密封水溶性膜的方法，所述方法包含：

(a) 向水溶性膜的第一表面施加密封溶液，所述密封溶液包含

(i) 水，以及

(ii) 具有3个或更多个羟基的多元醇，

其中如在20℃下所测量，所述密封溶液的动态粘度（μ_s）小于1.5cP；以及

(b) 使水溶性膜的第二表面与所述第一表面上的所述密封溶液接触足以在所述第一表面和所述第二表面之间形成密封的时间。

2.根据权利要求1所述的方法，其中所述多元醇以约2重量％到约15重量％范围内的量存在于所述密封溶液中。

3.根据前述权利要求中任一项所述的方法，其中所述密封溶液基本上由水和一种或多种各自具有3个或更多个羟基的多元醇组成。

4.根据前述权利要求中任一项所述的方法，其中所述多元醇含有2到12个碳原子和3到12个羟基。

5.根据前述权利要求中任一项所述的方法，其中所述多元醇选自由以下各者组成的群组：丙三醇、赤藓糖醇、苏糖醇、阿糖醇、木糖醇、核糖醇、甘露糖醇、山梨糖醇、半乳糖醇、岩藻糖醇、艾杜糖醇（iditol）、肌醇、庚七醇、异麦芽酮糖醇、麦芽糖醇、乳糖醇以及其组合。

6.一种用于密封水溶性膜的方法，所述方法包含：

(a) 向水溶性膜的第一表面施加密封溶液，所述水溶性膜的初始厚度小于约50μm并且包含基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物，所述密封溶液包含

(i) 水，以及

(ii) 以约2重量％到约15重量％范围内的量存在于所述密封溶液中的多元醇，所述多元醇选自由以下组成的群组：丙三醇、赤藓糖醇、苏糖醇、阿糖醇、木糖醇、核糖醇、甘露糖醇、山梨糖醇、半乳糖醇、岩藻糖醇、艾杜糖醇、肌醇、庚七醇、异麦芽酮糖醇、麦芽糖醇、乳糖醇以及其组合，

其中如在20℃下所测量，所述密封溶液的动态粘度（μ_s）小于1.5cP；以及

(b) 使水溶性膜的第二表面与所述第一表面上的所述密封溶液接触足以在所述第一表面和所述第二表面之间形成密封的时间，所述水溶性膜的初始厚度小于约50μm并且包含基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物。

7.根据权利要求6所述的方法，其中所述第一表面和所述第二表面中每一个的所述水溶性膜：

(i) 具有在约86.5％到约89％范围内的水解度；以及

(ii) 进一步包含：(A) 选自由以下组成的群组的糖醇塑化剂：异麦芽酮糖醇、麦芽糖醇、山梨糖醇、木糖醇、赤藓糖醇、福寿草醇、半乳糖醇、季戊四醇、甘露糖醇以及其组合，(B) 选自由以下组成的群组的液体塑化剂：丙三醇、二甘油、乙二醇、二乙二醇、三乙二醇、四乙二醇、丙二醇、高达400MW的聚乙二醇、2-甲基-1,3-丙二醇以及其组合，以及 (C) 选自由以下组成的群组的相容剂：纤维素醚、果胶多糖、海藻酸钠多糖、改性淀粉以及其组合。

8.一种用于密封水溶性膜的方法，所述方法包含：

(a) 向水溶性膜的第一表面施加密封溶液，所述密封溶液包含

(i) 水，以及

(ii) 用于所述水溶性膜的至少一种聚合组分的溶剂，

其中

(A) 如等式 (I) 所定义，所述溶剂和所述聚合组分具有约 5 或更低的溶解度半径 (Ra)：

$(Ra)^2 = 4(\delta_{D,S} - \delta_{D,P})^2 + (\delta_{P,S} - \delta_{P,P})^2 + (\delta_{H,S} - \delta_{H,P})^2$ (I)

其中 $\delta_{D,S}$为溶剂色散力，$\delta_{D,P}$为聚合组分色散力，$\delta_{P,S}$为溶剂极性力，$\delta_{P,P}$为聚合组分极性力，$\delta_{H,S}$为溶剂氢键力，并且 $\delta_{H,P}$为聚合组分氢键力，其各自通过汉森溶解度参数评估的自洽法 (consistent method of Hansen solubility parameter evaluation) 测定，以及

(B) 如在 20℃下所测量，所述密封溶液的动态粘度 (μ_s) 小于 1.5cP；以及

(b) 使水溶性膜的第二表面与所述第一表面上的所述密封溶液接触足以在所述第一表面和所述第二表面之间形成密封的时间。

9. 根据权利要求 8 所述的方法，其中所述溶解度半径在约 1 到约 5 范围内。

10. 根据权利要求 8 到 9 中任一项所述的方法，其中：

(i) 所述聚合组分包含聚乙烯醇；

(ii) $\delta_{P,S}$为至少约 10；以及

(iii) $\delta_{H,S}$为至少约 22。

11. 根据权利要求 8 到 10 中任一项所述的方法，其中所述溶剂以约 2 重量%到约 15 重量%范围内的量存在于所述密封溶液中。

12. 根据权利要求 8 到 11 中任一项所述的方法，其中所述密封溶液基本上由水和一种或多种各自具有相对于所述聚合组分约 5 或更低的溶解度半径的溶剂组成。

13. 根据权利要求 1 到 12 中任一项所述的方法，其中所述动态粘度在约 1cP 到约 1.45cP 范围内。

14. 根据权利要求 1 到 13 中任一项所述的方法，其中：

(i) 使用单独的水作为测试溶剂，所述水溶性膜具有约 45 秒或更短的烧穿时间；以及

(ii) 所述水溶性膜的烧穿时间 (A) 使用所述密封溶液作为测试溶剂时为约 45 秒或更长并且 (B) 大于使用单独的水作为测试溶剂时的所述烧穿时间。

15. 根据权利要求 1 到 14 中任一项所述的方法，其中所述密封呈现相对于所述水溶性膜的峰值负荷至少约 12%的剥离强度。

16. 根据权利要求 1 到 15 中任一项所述的方法，其中所述密封呈现比单独的水形成的相应密封大至少约 30%的剥离强度。

17. 根据权利要求 1 到 16 中任一项所述的方法，其中所述第一表面和所述第二表面各自独立地具有约 10μm 到约 150μm 范围内的初始厚度。

18. 根据权利要求 1 到 17 中任一项所述的方法，其中所述水溶性膜包含选自由以下组成的群组的水溶性聚合物：聚乙烯醇、聚乙烯亚胺、聚丙烯酸酯、水溶性丙烯酸酯共聚物、聚乙烯吡咯烷酮、支链淀粉、瓜尔胶 (guar gum)、黄原胶 (xanthan gum)、角叉菜胶、淀粉、乙氧基化淀粉、羟丙基化淀粉、聚氧化烯、聚丙烯酰胺、聚丙烯酸和其盐、纤维素、纤维素醚、纤维素酯、纤维素酰胺、聚乙酸乙烯酯、聚羧酸和其盐、聚氨基酸、聚酰胺、明胶、甲基纤维素、羧甲基纤维素和其盐、糊精、乙基纤维素、羟基乙基纤维素、羟基丙基甲基纤维素、麦芽糊精、

聚甲基丙烯酸酯、其共聚物、其掺合物以及其组合。

19. 根据权利要求 18 所述的方法，其中所述水溶性聚合物在 20℃下具有约 3cP 到约 27cP 范围内的 4％溶液粘度。

20. 根据权利要求 1 到 19 中任一项所述的方法，其中所述水溶性膜包含水溶性聚合物，其包含聚乙烯醇。

21. 根据权利要求 20 所述的方法，其中所述水溶性聚合物包含基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物。

22. 根据权利要求 20 到 21 中任一项所述的方法，其中所述聚乙烯醇具有约 75％到约 99％范围内的水解度。

23. 根据权利要求 20 到 21 中任一项所述的方法，其中所述聚乙烯醇具有约 86.5％到约 89％范围内的水解度。

24. 根据权利要求 1 到 23 中任一项所述的方法，其中所述第一表面和所述第二表面来自同一水溶性膜。

25. 根据权利要求 1 到 23 中任一项所述的方法，其中所述第一表面和所述第二表面来自不同水溶性膜。

26. 根据权利要求 1 到 25 中任一项所述的方法，其中所述第二表面与所述第一表面的接触包含向所述第一表面和所述第二表面施加压力以及向所述第一表面和所述第二表面施加热中的至少一个来形成所述密封。

27. 根据权利要求 1 到 26 中任一项所述的方法，其中所述第二表面上包含第二密封溶液，所述溶液在形成所述密封时与所述第一表面接触。

28. 根据权利要求 1 到 27 中任一项所述的方法，其中：

(i) 所述第一表面和所述第二表面中的至少一个的所述水溶性膜界定至少部分包围组合物的体积，以及

(ii) 形成所述密封产生含有所述组合物的密封水溶性小包。

29. 根据权利要求 28 所述的方法，其中所述组合物选自由以下各者组成的群组：人类和动物可摄取物品、个人护理组合物和清洁组合物。

30. 一种物品，其包含根据权利要求 1 到 29 中任一项形成的密封水溶性膜。

31. 一种物品，其包含：

(a) 水溶性膜的第一表面和水溶性膜的第二表面，其在所述第一表面与所述第二表面之间的界面区处密封；以及

(b) 具有 3 个或更多个羟基的多元醇，其在所述界面区中的局部浓度实质上高于所述多元醇在所述水溶性膜中以及所述界面区之外的整体浓度。

32. 一种物品，其包含：

(a) 水溶性膜的第一表面和水溶性膜的第二表面，其在所述第一表面与所述第二表面之间的界面区处密封，其中所述第一表面和所述第二表面中的每一个的所述水溶性膜具有小于约 50μm 的初始厚度并且包含基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物；以及

(b) 多元醇，其在所述界面区中的局部浓度实质上高于所述多元醇在所述水溶性膜中以及所述界面区之外的整体浓度，所述多元醇选自由以下组成的群组：丙三醇、赤藓糖醇、

苏糖醇、阿糖醇、木糖醇、核糖醇、甘露糖醇、山梨糖醇、半乳糖醇、岩藻糖醇、艾杜糖醇、肌醇、庚七醇、异麦芽酮糖醇、麦芽糖醇、乳糖醇以及其组合。

33. 一种物品，其包含：

(a) 水溶性膜的第一表面和水溶性膜的第二表面，其在所述第一表面与所述第二表面之间的界面区处密封；以及

(b) 用于所述水溶性膜的至少一种聚合组分的溶剂，所述溶剂在所述界面区中的局部浓度实质上高于所述溶剂在所述水溶性膜中以及所述界面区之外的整体浓度，

其中如等式 (I) 所定义，所述溶剂和所述聚合组分具有约5或更低的溶解度半径(Ra)：

$$(Ra)^2 = 4(\delta_{D,S} - \delta_{D,P})^2 + (\delta_{P,S} - \delta_{P,P})^2 + (\delta_{H,S} - \delta_{H,P})^2 \quad (I)$$

其中 $\delta_{D,S}$为溶剂色散力，$\delta_{D,P}$为聚合组分色散力，$\delta_{P,S}$为溶剂极性力，$\delta_{P,P}$为聚合组分极性力，$\delta_{H,S}$为溶剂氢键力，并且 $\delta_{H,P}$为聚合组分氢键力，其各自通过汉森溶解度参数评估的自洽法测定。

34. 根据权利要求31到33中任一项所述的物品，其中所述水溶性膜的一种或多种组分在所述界面区中的局部浓度实质上低于所述一种或多种组分在所述水溶性膜中以及所述界面区之外的整体浓度。

水溶性膜密封溶液、相关方法和相关物品

[0001] 相关申请的交叉引用

[0002] 要求美国临时申请案第61/830,969号(2013年6月4日申请)的优先权,所述申请案以全文引用的方式并入本文中。。

技术领域

[0003] 本发明大体上涉及水溶性膜。更具体来说,本发明涉及用于密封水溶性膜的密封溶液,具体来说包括一种或多种聚合溶剂(例如多元醇)的低粘度水性混合物,所述溶液可用于形式含有多种组合物的密封水溶性物品。

背景技术

[0004] 水溶性膜在所属领域中是众所周知的。水溶性膜具有许多应用,包括不可食性形式,例如包装,以及可食性形式,其中所述膜本身为可食性物品或含有可食性物品。可食性膜已知用于例如传递治疗剂、呼吸清新剂、包括(但不限于)烘培成分(例如面团改性剂和调味剂)的食物成分。所述膜可形成用于储存或传递多种可食性或不可食性组合物的水溶性小包。

[0005] 密封水溶性膜形成小包或袋的常见方法包括热密封和溶液密封。使用热密封,可以通过将两个水溶性膜薄片放在一起,热密封三个边缘,用适合组合物填充并且接着热密封第四边缘形成密封袋,来形成袋。在溶液密封方法中,向膜材料施加溶剂在溶剂化膜和另一膜之间形成密封。水为用于溶液密封水溶性袋的常见溶剂,因为其成本低,无毒并且容易获得,使得当以适当含量施加时,其可产生强效密封,防止固体/液体从所得袋泄漏。

[0006] 尽管溶液密封可具有优于热密封的优势,但已发现溶液密封不适于许多水溶性膜。一些水溶性膜形成的溶液密封的强度可能不足以在其使用寿命期间维持结构完整性。在其它情况下,水溶性膜可能相对容易被密封溶液快速溶解,因此破坏膜和/或阻碍形成足够强度的密封。举例来说,在快速溶解水溶性膜(例如聚乙烯醇)时,水在溶解膜时可能太激进,导致膜烧穿并且阻碍形成高质量的密封。对于一些水溶性膜,尤其对于例如1.5mil膜厚度的薄膜,不存在有效密封所述膜的已知方法或相应密封溶液。

发明内容

[0007] 本发明大体上涉及用于密封水溶性膜的密封溶液,具体来说包括一种或多种聚合溶剂(例如多元醇)的水性混合物。已发现水性密封溶液包括用于水溶性膜的一种或多种聚合组分(例如其水溶性聚合组分,例如聚乙烯醇(PVOH))的相对稀溶剂,所述溶液可展现一种或多种益处,包括降低所述密封溶液对所述膜的溶解(例如相对于单独的水,例如由增加的特征烧穿时间表示),提高密封强度(例如相对于单独的水形成的密封,例如由特征剥离强度表示),以及包括此类益处的组合的实施例。

[0008] 本发明的一个方面涉及一种用于密封水溶性膜的方法,所述方法包括:(a)向水溶性膜的第一表面施加密封溶液,所述密封溶液包括(i)水,和(ii)具有3个或更多个羟

基的多元醇，其中所述密封溶液在20℃下测量的动态粘度（μ_s）小于1.5cP；以及（b）使水溶性膜的第二表面与第一表面上的密封溶液接触足以在第一表面和第二表面之间形成密封的时间。

[0009] 本发明的另一方面涉及一种用于密封水溶性膜的方法，所述方法包括：（a）向水溶性膜的第一表面施加密封溶液，所述水溶性膜的初始厚度小于约50μm并且包括基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物，所述密封溶液包括（i）水，和（ii）以约2重量%到约15重量%范围内的量存在于密封溶液中的多元醇，所述多元醇选自由以下组成的群组：丙三醇、赤藓糖醇、苏糖醇、阿糖醇、木糖醇、核糖醇、甘露糖醇、山梨糖醇、半乳糖醇、岩藻糖醇、艾杜糖醇、肌醇、庚七醇、异麦芽酮糖醇、麦芽糖醇、乳糖醇以及其组合，其中密封溶液在20℃测量的动态粘度（μ_s）小于1.5cP；以及（b）使水溶性膜的第二表面与第一表面上的密封溶液接触足以在第一表面和第二表面之间形成密封的时间，所述水溶性膜的初始厚度小于约50μm并且包括基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物。

[0010] 本发明的另一方面涉及一种用于密封水溶性膜的方法，所述方法包括：（a）向水溶性膜的第一表面施加密封溶液，所述密封溶液包括（i）水，和（ii）用于水溶性膜的至少一种聚合组分的溶剂，其中（a）如等式（I）所定义，溶剂和聚合组分具有约5或更低的溶解度半径（Ra）：

[0011] $(Ra)^2 = 4(\delta_{D,S} - \delta_{D,P})^2 + (\delta_{P,S} - \delta_{P,P})^2 + (\delta_{H,S} - \delta_{H,P})^2$ （I）

[0012] 其中$\delta_{D,S}$为溶剂色散力，$\delta_{D,P}$为聚合组分色散力，$\delta_{P,S}$为溶剂极性力，$\delta_{P,P}$为聚合组分极性力，$\delta_{H,S}$为溶剂氢键力，并且$\delta_{H,P}$为聚合组分氢键力，其各自通过汉森溶解度参数评估的自洽法（consistent method of Hansen solubility parameter evaluation）测定，以及（B）如在20℃下所测量，密封溶液的动态粘度（μ_s）小于1.5cP；以及（b）使水溶性膜的第二表面与第一表面上的密封溶液接触足以在第一表面和第二表面之间形成密封的时间。

[0013] 在另一方面，本发明涉及一种用于形成含有组合物的密封水溶性小包的方法，所述方法包括：根据任何披露的实施例进行密封水溶性膜的方法，其中（i）第一表面和第二表面中的至少一个的水溶性膜界定至少部分包围组合物的体积，以及（ii）形成密封产生含有组合物的密封水溶性小包。

[0014] 在另一方面，本发明涉及一种物品，例如密封水溶性小包，所述物品包括：（a）水溶性膜的第一表面和水溶性膜的第二表面，其在所述第一表面与所述第二表面之间的界面区处密封；以及（b）具有3个或更多个羟基的多元醇，其在所述界面区中的局部浓度实质上高于所述多元醇在所述水溶性膜中以及所述界面区之外的整体浓度。

[0015] 在另一方面，本发明涉及一种物品，例如密封水溶性小包，所述物品包括：（a）水溶性膜的第一表面和水溶性膜的第二表面，其在所述第一表面与所述第二表面之间的界面区处密封，其中第一表面和第二表面中的每一个的水溶性膜具有小于约50μm的初始厚度并且包含基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物；以及（b）多元醇，其在所述界面区中的局部浓度实质上高于所述多元醇在所述水溶性膜中以及所述界面区之外的整体浓度，所述多元醇选自由以下组成的群组：丙三醇、赤藓糖醇、苏糖醇、阿糖醇、木糖醇、核糖醇、甘露糖醇、山梨糖醇、半乳糖醇、岩藻糖醇、艾杜糖醇、

肌醇、庚七醇、异麦芽酮糖醇、麦芽糖醇、乳糖醇以及其组合。

[0016] 在另一方面，本发明涉及一种物品，例如密封水溶性小包，所述物品包括：(a) 水溶性膜的第一表面和水溶性膜的第二表面，其在所述第一表面与所述第二表面之间的界面区处密封；以及 (b) 用于水溶性膜的至少一种聚合组分的溶剂，所述溶剂在所述界面区中的局部浓度实质上高于所述溶剂在所述水溶性膜中以及所述界面区之外的整体浓度，其中如等式 (I) 所定义，所述溶剂和所述聚合组分具有约 5 或更低的溶解度半径 (Ra)：

[0017] $(Ra)^2 = 4(\delta_{D,S} - \delta_{D,P})^2 + (\delta_{P,S} - \delta_{P,P})^2 + (\delta_{H,S} - \delta_{H,P})^2$ (I)

[0018] 其中 $\delta_{D,S}$为溶剂色散力，$\delta_{D,P}$为聚合组分色散力，$\delta_{P,S}$为溶剂极性力，$\delta_{P,P}$为聚合组分极性力，$\delta_{H,S}$为溶剂氢键力，并且 $\delta_{H,P}$为聚合组分氢键力，其各自通过汉森溶解度参数评估的自洽法测定。

[0019] 任选地，各方面的水溶性膜可形成（例如热成型）袋，例如使得所述袋可用适合组合物填充并且随后使用所披露的溶剂密封溶液和相关方法密封成含有组合物的水溶性小包。

[0020] 所属领域普通技术人员从以下详细描述和附图的评述显而易知其它方面和优点。虽然组合物和方法容许有多种形式的实施例，但下文的描述包括具体实施例，其中应理解本发明是说明性的并且并不打算将本发明限制于本文所描述的具体实施例。

附图说明

[0021] 各种所披露方法、工艺、组合物以及物品的以下详细描述涉及随附图式，其中：

[0022] 图 1 为密封水溶性小包的侧视横截面图，其示出了根据本发明密封水溶性膜的相应方法。

[0023] 图 2 为沿图 1 的线 P 的定性浓度分布，其示出了密封水溶性膜的整体和密封界面区中的密封溶液组分和水溶性膜组分的局部浓度。

[0024] 图 3 包括曲线和表，其示出了根据本发明的水包丙三醇密封溶液的 PVOH 共聚物膜 A 随丙三醇浓度而变化的 (a) 烧穿时间和 (b) 密封剥离强度。

[0025] 图 4 包括曲线和表，其示出了根据本发明的水包丙三醇密封溶液的 PVOH 共聚物膜 B 随丙三醇浓度而变化的 (a) 烧穿时间和 (b) 密封剥离强度。

[0026] 图 5 包括曲线和表，其示出了根据本发明的水包丙三醇密封溶液的 PVOH 共聚物膜 C 随丙三醇浓度而变化的 (a) 烧穿时间和 (b) 密封剥离强度。

[0027] 图 6 包括曲线和表，其示出了根据本发明的水包丙三醇密封溶液的 PVOH 均聚物膜 D 随丙三醇浓度而变化的 (a) 烧穿时间和 (b) 密封剥离强度。

[0028] 图 7 包括曲线和表，其示出了根据本发明的水包丙三醇密封溶液的 PVOH 均聚物膜 E 随丙三醇浓度而变化的 (a) 烧穿时间和 (b) 密封剥离强度。

[0029] 图 8 包括曲线，其示出了根据本发明的水包丙三醇密封溶液的 PVOH 均聚物膜 F 在 (a) 低浓度和 (b) 高浓度下的烧穿时间和密封剥离强度。

[0030] 图 9 包括曲线，其示出了根据本发明的水包 2- 甲基 -1,3- 丙二醇（MP 二醇）密封溶液的 PVOH 均聚物膜 F 在 (a) 低浓度和 (b) 高浓度下的烧穿时间和密封剥离强度。

[0031] 图 10 包括曲线，其示出了根据本发明的水包丙二醇密封溶液的 PVOH 均聚物膜 F 在 (a) 低浓度和 (b) 高浓度下的烧穿时间和密封剥离强度。

[0032] 图 11 包括曲线,其示出了根据本发明的水包甘露糖醇密封溶液的 PVOH 均聚物膜 F 在 (a) 低浓度下的烧穿时间和密封剥离强度。

[0033] 图 12 包括曲线,其示出了根据本发明的水包山梨糖醇密封溶液的 PVOH 均聚物膜 F 在 (a) 低浓度和 (b) 高浓度下的烧穿时间和密封剥离强度。

[0034] 图 13 包括曲线,其示出了根据本发明的水包木糖醇密封溶液的 PVOH 均聚物膜 F 在 (a) 低浓度和 (b) 高浓度下的烧穿时间和密封剥离强度。

具体实施方式

[0035] 本文披露用于密封水溶性膜的密封溶液。密封溶液包括水和用于打算密封的水溶性膜的一种或多种聚合组分的溶剂。如密封溶液的情况中所用,“溶剂”指的是一般能够与膜的聚合组分形成液体或固体溶液的化合物。如下文所述,溶剂和聚合组分之间的溶解度程度可以通过溶解度半径参数来表征。溶剂在室温下或密封形成温度下并非必需为液体(例如其在此类温度下可为液体或固体)。溶剂适合地在密封溶液所用的浓度下在水中可溶。适合溶剂的实例包括具有 3 个或更多个羟基 (-OH) 的多元醇,例如用于包括聚乙烯醇或其它水溶性聚合物组分的可溶性膜。

[0036] 水性密封溶液适合地包括一种或多种相对稀浓度的此类溶剂,一般导致密封溶液粘度为水粘度或几乎为水粘度(例如略高)。甚至在相对稀溶剂浓度下,水性密封溶液相对于单独水作为密封剂可呈现一种或多种益处,包括降低密封溶液对膜的溶解以及提高密封强度。在一些情况下,密封溶液可允许形成用于使用单独水不能形成溶液密封的具体膜的密封(例如使烧穿时间充分提高以形成完整密封,尽管此类密封可具有相对低绝对密封强度而限制其在某些应用中的使用)。所披露的密封溶液和相应方法可用于形式多种密封物品,例如含有多种组合物(例如人类和动物可摄取的物品、个人护理组合物和清洁组合物)的密封水溶性小包。

[0037] 除非另外说明,否则密封溶液、密封膜和相关方法预期包括如下实施例,其包括下文进一步描述的其它任选元件、特征和步骤中的一个或多个的任何组合(包括图和实例中所示的那些)。

[0038] 如本文中所使用,术语“均聚物”一般包括具有单一类型的单体重复单元的聚合物(例如由单一单体重复单元组成或基本上由其组成的聚合链)。对于 PVOH 的具体情形,术语“均聚物”(或“PVOH 均聚物”)进一步包括具有乙烯醇单体单元和乙酸乙烯酯单体单元的分布的共聚物,其取决于水解度(例如由乙烯醇和乙酸乙烯酯单体单元组成或基本上由其组成的聚合链)。在 100%水解的极限情况下,PVOH 均聚物可包括仅具有乙烯醇单元的真实均聚物。

[0039] 如本文中所使用,术语“共聚物”一般包括具有两种或更多种类型的单体重复单元的聚合物(例如由两种或更多种不同单体重复单元组成或基本上由其组成的聚合链,呈无规共聚物、嵌段共聚物等形式)。对于 PVOH 的具体情况,术语“共聚物”(或“PVOH 共聚物”)进一步包括如下共聚物,其具有视水解度而定的乙烯醇单体单元和乙酸乙烯酯单体单元的分布以及至少一种其它类型的单体重复单元(例如由乙烯醇单体单元、乙酸乙烯酯单体单元和一种或多种其它单体单元组成或基本上由其组成的三元(或更高)聚合链)。在 100%水解的极限情况下,PVOH 共聚物可包括具有乙烯醇单元和一个或多个其它单体单元,

但无乙酸乙烯酯单元的共聚物。

[0040] 如本文中所用，术语“包含”表示除指定的那些以外，还可能包括其它药剂、要素、步骤或特征。

[0041] 如本文中所使用，“有利的溶解度”指的是约 2.0mil 厚的根据本发明的膜在 23℃下，在 50 秒内，优选 40 秒内并且最优选 30 秒内完全溶解于水中。

[0042] 如本文中所用并且除非另外规定，否则术语“重量％（wt.％）”和“重量％（wt％）”打算指以整个膜的“干式”（非水）重量份（适当时）或包围于袋内的全部组合物的重量份（适当时）计，所鉴别要素的组成。如本文所用并且除非另外规定，否则术语“phr”打算指水溶性膜中每一百份水溶性聚合物（或树脂；PVOH 或其它）的份数的鉴别要素的组成。

[0043] 本文所阐述的所有范围包含范围的所有可能子集和此类子集范围的任何组合。除非另外说明，否则默认地，范围包含陈述的端点。当提供值的范围时，应理解，所述范围的上限与下限之间的各中间值和任何其它陈述值或所陈述范围内的中间值涵盖于本发明内。这些较小范围的上限和下限可以独立地包括在所述较小范围内并且也涵盖于本发明内，从属于在规定范围内的任何特定地排除的界限。在所述范围包括界限值中的一个或两个的情况下，排除所包括的界限值中的任一个或两个的范围也预期成为本发明的部分。

[0044] 密封溶液

[0045] 密封溶液包括水和用于水溶性膜的一种或多种聚合组分的溶剂，一般为水溶液形式。在一种类型的实施例中，密封溶液包括水和用于水溶性膜的主要聚合组分（例如按膜的总重量计，以重量为单位的最高浓度聚合组分）的溶剂。如上文所述，在典型密封温度下，溶剂的天然状态可为液体或固体，并且其能够与其水溶性膜的相应聚合组分形成液体或固体溶液。密封溶液可包括一种以上溶剂，例如其中多种溶剂因其与具体聚合组分的相容性而被选择。替代或另外地，当水溶性膜具有多种聚合组分时，可使用多种溶剂（例如其中不同溶剂因其关于不同聚合组分的溶解度特征而被选择）。

[0046] 已发现密封溶液因其提高耐烧穿性和提高密封强度的能力而有效用作相对稀水性溶剂溶液。举例来说，密封溶液中约 2 重量％到约 15 重量％或约 5 重量％到约 10 重量％的溶剂浓度范围可能有效。更一般来说，相对于总密封溶液，溶剂可按至少约 2、4、5、8 或 10 重量％和／或高达约 8、10、12、15、20、30、40 或 50 重量％的含量存在。当密封溶液中包括一种以上类型的溶剂时，前述量和范围可独立地应用于具体溶剂或整体应用于全部溶剂。与溶剂类似，密封溶液中约 85 重量％到约 95 重量％或约 90 重量％到约 95 重量％的水浓度范围可能有效。更一般来说，相对于总密封溶液，水可按至少约 50、60、70、80、88、90 或 92 重量％和／或高达约 90、92、95、96 或 98 重量％的含量存在。替代或另外地，密封溶液的相对稀释性质可以通过密封溶液的动态粘度（μ_s）反映，其一般为相应温度下水的粘度或几乎为水的粘度（例如略高）。举例来说，在 20℃参考温度下的适合密封溶液粘度可小于 1.5cP 或在约 1cP 到约 1.4cP 或 1.45cP 的范围内（例如更一般为至少约 0.5、1、1.1 或 1.2cP 和／或高达约 1.1、1.2、1.3、1.4 或 1.45cP）。在不同参考温度（T_{ref}）下，密封溶液粘度（μ_S）相对于相应水粘度（μ_w）可替代地表示为小于 1.5 的比率（μ_s/μ_w）（例如更一般为至少约 0.5、1、1.1 或 1.2 和／或高达约 1.1、1.2、1.3、1.4 或 1.45）。

[0047] 密封溶液的具体溶剂不受特别限制，并且其一般包括具有一个或多个（例如至少 2 个或 3 个或更多个）极性官能团（例如含氧或含氮基团，例如羟基或（1 个、2 个或 3 个）

氨基）的小有机分子，所述极性官能团提高溶剂与水性密封溶液介质以及水溶性膜中的聚合组分的极性官能团的相容性，其中此类聚合官能团与溶剂中的官能团可相同或不同。具体溶剂可含有 2 到 12 个碳原子（例如 3 到 6 个、8 个或 10 个碳原子，例如 3、4、5 或 6 个碳原子）。替代或另外地，溶剂可含有 2 个或 3 个到 12 个极性官能团（例如 2 个或 3 个到 6 个、8 个或 10 个极性基团，例如 3、4、5 或 6 个极性基团），即羟基、氨基或其组合。在某些实施例中，溶剂可为适于水溶性膜的聚合组分的塑化剂，不管所选溶剂是否原样存在于待密封的具体膜中。

[0048] 具有 3 个或更多个羟基 (-OH) 的多元醇代表适于多种水溶性膜的类别的溶剂。举例来说，多元醇适于含有 PVOH（例如其均聚物）作为唯一或主要聚合组分（例如相对于膜整体或其全部聚合组分至少约 50、60、75、85 或 95 重量％）的水溶性膜。适合多元醇的实例包括多种糖醇，包括丙三醇 (glycerin/glycerol)、赤藓糖醇、苏糖醇、阿糖醇、木糖醇、核糖醇、甘露糖醇、山梨糖醇、半乳糖醇、岩藻糖醇、艾杜糖醇、肌醇、庚七醇、异麦芽酮糖醇、麦芽糖醇、乳糖醇以及其组合。水中相对低浓度（例如约 2 重量％到约 15 重量％，或约 5 重量％到约 10 重量％）的此类多元醇一般呈现低密封溶液粘度。举例来说，5 重量％和 10 重量％水包丙三醇溶液分别具有约 1.2cP 和约 1.3cP 的粘度。用于多种水溶性膜的适合氨基功能性溶剂（例如具有氨基官能组分或其它）的实例包括线性（聚）亚乙基胺（包括乙二胺）、二亚乙基三胺 (DETA) 和三亚乙基四胺 (TETA)。

[0049] 如下文实例中所示，在一种类别的实施例中，可根据汉森溶解度半径 (Ra) 参数基于聚合相容性选择和表征溶剂。汉森溶解度参数 (HSP) 为用于理解和鉴别针对许多材料（包括聚合物）相对好和差溶剂的鉴别工具。材料的溶解度特征可由三个个别力表征：色散力（δ_D）、极性力（δ_P）以及氢键力（δ_H）。个别力可如等式 1 中所示组合成总内聚能值（δ_T）：

[0050] $(\delta_T)^2=(\delta_D)^2+(\delta_P)^2+(\delta_H)^2$。 (1)

[0051] 除了单个组分的代表性溶解度参数之外，可使用溶解度半径 (Ra) 来表征两种材料相对于彼此的相对溶解度。对于密封溶液溶剂和水溶性膜聚合组分 (P) 的具体情况，溶解度半径 (Ra) 可如等式 2 中所示表示：

[0052] $(Ra)^2=4(\delta_{D,S}-\delta_{D,P})^2+(\delta_{P,S}-\delta_{P,P})^2+(\delta_{H,S}-\delta_{H,P})^2$。 (2)

[0053] 在等式 2 中，$\delta_{D,S}$为溶剂色散力，$\delta_{D,P}$为聚合组分色散力，$\delta_{P,S}$为溶剂极性力，$\delta_{P,P}$为聚合组分极性力，$\delta_{H,S}$为溶剂氢键力，且 $\delta_{H,P}$为聚合组分氢键力。如果两种材料之间的溶解度半径（或距离）为 0，那么其具有相同 δ_D、δ_P和 δ_H坐标，并且其彼此可溶解。它们之间的距离越远，它们彼此可溶解的可能性越低。用于评估多个 HSP 值的计算可使用可商购的软件包（例如 HSPIP，获自汉森溶解度参数互联网网站，目前为第 4 版）进行。可测试实验上的好溶剂和差溶剂，并且可使用实验方式测定材料的 HSP 坐标 δ_D、δ_P和 δ_H。或者，可使用 Y-MB 方法（包括于 HSPIP 软件中）计算个别 HSP 坐标 δ_D、δ_P和 δ_H。不管选择哪种方法用于 HSP 参数估算，自洽法都适用于所关注的全部溶剂和聚合组分。

[0054] 水溶性膜中的密封溶液溶剂和至少一种（水溶性）聚合组分之间的溶解度半径适当地较小，例如约 5 或更低。在各种实施例中，溶解度半径适合地在约 1 到约 5 范围内，或更一般来说，可以是至少约 1、2 或 3 和／或高达约 4、4.5 或 5。在密封溶液包括一种以上溶剂的情况中，每一种溶剂适合地具有约关于水溶性膜中的水溶性聚合组分 5 或更低的溶解

度半径。在水溶性膜包括一种以上水溶性聚合组分的情况下，溶剂适合地具有关于水溶性聚合组分中的至少一个以及任选地关于主要水溶性聚合组分约 5 或更低的溶解度半径。在实施例中，溶剂可具有关于大多数水溶性聚合组分约 5 或更低的溶解度半径。在实施例中，溶剂可具有关于全部水溶性聚合组分约 5 或更低的溶解度半径。如果存在多种溶剂和水溶性聚合组分，那么可选择与至少一种水溶性聚合组分溶解度相容性的个别溶剂。举例来说，在一种实施例中，全部水溶性聚合组分在密封溶液中具有至少一种相应相容溶剂。尽管溶解度半径的前述值和范围可独立于具体溶剂和水溶性聚合组分用于表征具体溶剂 - 聚合物对的相容性，PVOH/ 多元醇系统的适合 HSP 坐标值包括 (a) 至少约 10 和 / 或高达约 12 或 15 的 $\delta_{P,S}$值，和 / 或 (b) 至少约 22 或 25 和 / 或高达约 30 或 33 的 $\delta_{H,S}$值。

[0055] 密封溶液适合地为包括水和溶剂作为其仅有或主要组分的混合物。在任选实施例中，可存在少量其它添加剂（例如高达约 1 重量％或 2 重量％，例如约 0.01 重量％到约 2 重量％或约 0.1 重量％到约 1 重量％）。举例来说，可添加表面活性剂（例如下文所述用于纳入水溶性膜中的那些）来改进密封溶液在密封之前施加到膜表面时的湿润特性。密封溶液可未添加水溶性聚合物（例如作为水溶性成膜聚合物、水溶性膜的组分或其它成分）；然而，一些树脂或聚合物按膜处理期形成和 / 或密封设备中的树脂或聚合物的累计残余量计可以平衡或污染值存在。在其它非排他性任选实施例中，密封溶液可进一步包括除上文所述的溶剂（例如多元醇）之外的塑化添加剂，例如其含量与溶剂含量相比较低和 / 或相当。实例包括多种有机二醇 (diol 和 / 或 glycol)，例如 1,2- 乙二醇（乙二醇）、1,3- 丙二醇、1,2- 丙二醇、1,4- 丁二醇（丁二醇）、1,5- 戊二醇（戊二醇）、1,6- 己二醇（己二醇）、2,3-丁二醇、1,3-丁二醇、2-甲基 -1,3- 丙二醇、多种聚乙二醇（例如二乙二醇、三乙二醇）以及其组合。

[0056] 水溶性膜

[0057] 水溶性膜、其中所用的任选成分以及其制备方法在所属领域中是众所周知的。在一类实施例中，水溶性膜包括聚乙烯醇 (PVOH)，包含其均聚物（例如仅实质上包括乙烯醇和乙酸乙烯酯单体单元）和其共聚物（例如包括除乙烯醇和乙酸乙烯酯单元以外的一种或多种其它单体单元）。PVOH 为通常通过聚乙酸乙烯酯的醇解制备的合成树脂，所述醇解通常称为水解或皂化。其中几乎所有乙酸酯基已转化成醇基的完全水解 PVOH 为强氢键结的高度结晶聚合物，其仅溶解于超过约 140 ℉ (60℃) 的热水中。如果允许在聚乙酸乙烯酯的水解之后保留足够数目的乙酸酯基，那么 PVOH 聚合物称为部分水解，其更微弱地氢键结并且较少结晶，并且可溶于低于约 50 ℉ (10℃) 的冷水中。中间冷水溶性膜或热水溶性膜可包括例如中间部分水解 PVOH（例如具有约 94％到约 98％的水解度），并且仅容易溶于温水中 - 例如快速溶解于约 40℃和更高的温度下。完全水解和部分水解的 PVOH 类型通常都称为 PVOH 均聚物，但技术角度上，部分水解类型为乙烯醇 - 乙酸乙烯酯共聚物。

[0058] 本发明水溶性膜中所包括的 PVOH 的水解度 (DH) 可为约 75％到约 99％。随着水解度降低，由所述树脂制成的膜的机械强度将降低，但在低于约 20℃的温度下的溶解加快。当水解度增加时，由所述树脂制成的膜在机械方面将变强并且热成形性将降低。可选择 PVOH 的水解度以使得树脂的水溶解度为温度依赖性的，并且因此也影响由树脂制成的膜的溶解度、增容剂聚合物以及额外成分。在一类实施例中，所述膜为冷水溶性膜。冷水溶性膜可溶于低于 10℃的温度的水中，可包括水解度在约 75％到约 90％范围内或在约 80％到约 90％

范围内或在约 85％到约 90％范围内的 PVOH。在另一类实施例中，所述膜为热水溶性膜。举例来说，热水溶性膜适宜可食性应用，例如包封食物物品，例如燕麦片、可可或汤混合物的水溶性小包。热水溶性膜可溶于至少约 60℃的温度的水中，可包括水解度为至少约 98％的 PVOH。在一些实施例中，膜打算被例如人类食用。在此类情况中，可选择具体水解度来符合与针对人类或其它动物食用的批准水解度有关的地方、州或联邦法律或法规。举例来说，熟练技术人员将了解批准用于人类食用的 PVOH 膜（目前）包括具有标称 88％水解度，例如约 86.5％到约 89％水解度的那些。

[0059] 除 PVOH 之外或作为 PVOH 替代使用的其它成膜水溶性树脂可包括（但不限于）改性聚乙烯醇；聚丙烯酸酯；水溶性丙烯酸酯共聚物；聚乙烯吡咯烷酮；聚乙二亚胺；普鲁兰；水溶性天然聚合物，包括（但不限于）瓜尔豆胶、黄原胶、角叉菜胶和淀粉；水溶性聚合物衍生物包括（但不限于）乙氧基化淀粉和羟丙基化淀粉；前述的共聚物和前述任一个的组合。其它水溶性聚合物可包括聚氧化烯、聚丙烯酰胺、聚丙烯酸和其盐、纤维素、纤维素醚、纤维素酯、纤维素酰胺、聚乙酸乙烯酯、聚羧酸和其盐、聚氨基酸、聚酰胺、明胶、甲基纤维素、羧甲基纤维素和其盐、糊精、乙基纤维素、羟乙基纤维素、羟丙基甲基纤维素、麦芽糊精以及聚甲基丙烯酸酯。此类水溶性成膜树脂 (PVOH 或其它）可商购自多种来源。一般来说，水溶性膜可包括前述树脂的共聚物和／或掺合物。

[0060] 水溶性成膜聚合物可按例如约 30 重量％到约 90 重量％范围内的量包括于膜组合物中。水溶性聚合物的量相较于全部塑化剂、相容剂和辅助添加剂的组合量的重量比可在例如约 0.5 到约 9、约 0.5 到约 5 或约 1 到 3，或约 1 到 2 的范围内。

[0061] 用于本文所述的膜的水溶性聚合物（包括（但不限于）PVOH 聚合物）特征为粘度在约 3.0 到约 27.0cP，或约 3.0cP 到约 15cP，或约 6.0 到约 10.0cP 范围内。PVOH 聚合物的粘度通过使用具有 UL 转接器的布洛克菲尔德 LV(Brookfield LV) 型粘度计，如英国标准 EN ISO 15023-2:2006 附件 E 布洛克菲尔德测试方法中所述测量新制溶液来测定。国际惯例是声明 20℃下的 4％聚乙烯醇水溶液的粘度。除非另外规定，否则本文中以 cP 指定的聚合粘度应理解为指 4％水溶性聚合物水溶液在 20℃下的粘度。

[0062] 所属领域中众所周知水溶性聚合物 (PVOH 或其它）的粘度与同一聚合物的重量平均分子量$\left(\overline{Mw}\right)$有关，并且粘度通常用作$\overline{Mw}$的代表。因此，水溶性成膜聚合物的重量平均分子量可在约 30,000 到约 175,000，或约 30,000 到约 100,000，或约 55,000 到约 80,000 范围内。

[0063] 水溶性膜可含有适于其预期目的的量的其它助剂和处理剂，例如（但不限于）塑化剂、塑化剂增容剂、润滑剂、脱模剂、填充剂、增量剂、交联剂、防粘连剂、抗氧化剂、防粘剂、消泡剂、纳米粒子（例如层化硅酸盐型纳米粘土，例如蒙脱石钠）、漂白剂（例如偏亚硫酸氢钠、亚硫酸氢钠或其它）以及其它功能性成分。包括塑化剂的实施例为优选的。单独或共同地，此类试剂的量可为至多约 50 重量％、20 重量％、15 重量％、10 重量％、5 重量％、4 重量％和／或至少 0.01 重量％、0.1 重量％、1 重量％或 5 重量％。

[0064] 塑化剂可包括（但不限于）丙三醇、二丙三醇、乙二醇、二乙二醇、三乙二醇、四乙二醇、丙二醇、高达 400MW 的聚乙二醇、新戊二醇、三羟甲基丙烷、聚醚多元醇、2- 甲基 -1,3- 丙二醇、乳酸、乙醇胺以及其混合物。此类塑化剂（例如在室温下呈液体形式或其

它）可按约 25phr 到约 50phr，约 30phr 到约 45phr，或约 35phr 到约 40phr 范围内的量包括于水溶性膜中，不管是单一塑化剂还是塑化剂的组合。在各种实施例中，水溶性膜可替代或另外地包括在室温下为固体的糖醇塑化剂，例如包括异麦芽酮糖醇、麦芽糖醇、山梨糖醇、木糖醇、赤藓糖醇、福寿草醇、半乳糖醇、季戊四醇、甘露糖醇以及其组合。糖醇塑化剂可按约 5phr 到约 35phr，约 5phr 到约 25phr，约 10phr 到约 20phr 或约 10phr 到约 15phr 范围内的量包括于水溶性膜中，不管是单一糖醇塑化剂还是糖醇塑化剂的组合。塑化剂（例如液体、固体、糖醇或其它）的总量可在约 10 重量％到约 40 重量％，或约 15 重量％到约 35 重量％，或约 20 重量％到约 30 重量％范围内，例如约 25 重量％。

[0065] 本发明的水溶性膜可包括糖醇塑化剂的相容剂，其在室温下为固体。相容剂可按约 10phr 到约 25phr，约 13phr 到约 22phr，或约 15phr 到约 20phr 范围内的量包括于水溶性膜中，不管是单一相容剂还是相容剂组合。相容剂的量替代或另外地可表示为相对于糖醇塑化剂约 2:1 到约 1:2 的范围内的比率。适合增容剂包括（但不限于）纤维素醚，例如甲基纤维素、羟丙基甲基纤维素、羧甲基纤维素、其盐；果胶的多糖；海藻酸钠的多糖；例如酸改性的改性淀粉；羟丙基化淀粉（例如纯 Cote B760 或 B790，获自谷物加工公司 (Grain Processing Corporation)，马斯卡廷 (Muscatine)，爱荷华 (Iowa)）；羟基乙基淀粉（例如 Ethylex 2035，获自泰莱成分美国 LLC(Tate&Lyle Ingredients Americas LLC)，2200E. 埃尔多拉多街 (Eldorado Street)，德坎特 (Decater)，伊利诺斯州 (IL)）以及前述任一个的组合。在一类实施例中，增容剂包含羧甲基纤维素钠 (CMC)。CMC 的取代程度可为例如约 0.60 到约 0.95。如本文中所使用，“取代程度”指的是每个单体单元经钠羧基甲基基团 ($CH_2COO(Na)$) 取代的羟基数目。在一种实施例中，如在 25℃下在布洛克菲尔德 LVT 粘度计上所测量，CMC 的 2％水溶液的粘度在约 20 到约 80cP 的范围内。在另一类实施例中，增容剂包含羟丙基化淀粉。在一种实施例中，羟丙基化淀粉可具有 9.1％水分含量，约 6.3pH，0.20 重量％灰分含量以及 0.173 重量％蛋白质含量。在另一类实施例中，相容剂包含羟基乙基淀粉。乙氧基化含量例如按取代基单元总重量除以聚合物总重量计可为约 2 重量％到约 3 重量％。

[0066] 适合表面活性剂可包括非离子、阳离子、阴离子以及两性离子类别。适合表面活性剂包括（但不限于）聚氧乙烯化聚氧丙二醇、醇乙氧基化物、烷基苯酚乙氧基化物、叔炔二醇以及烷醇酰胺（非离子）、聚氧乙烯化胺、季铵盐以及季铵化聚氧乙烯化胺（阳离子）以及胺氧化物、N- 烷基甜菜碱以及磺基甜菜碱（两性离子）。其它适合表面活性剂包括磺基丁二酸钠二辛酯、丙三醇和丙二醇的乳酰化脂肪酸酯、脂肪酸的乳酰酯、烷基硫酸钠、聚山梨醇酯 20、聚山梨醇酯 60、聚山梨醇酯 65、聚山梨醇酯 80、卵磷脂、丙三醇和丙二醇的乙酰化脂肪酸酯以及脂肪酸的乙酰化酯，以及其组合。在各种实施例中，水溶性膜中的表面活性剂的量在约 0.1 重量％到 2.5 重量％，任选地约 1.0 重量％到 2.0 重量％范围内。

[0067] 如通过卡尔费歇尔滴定 (Karl Fischer titration) 所测量，水溶性膜可另外具有至少 4 重量％，例如约 4 重量％到约 10 重量％范围内的残余水分含量。

[0068] 水溶性膜的其它特征可见于美国公开案第 2011/0189413 号和美国申请案第 13/740,053 号中，其都以全文引用的方式并入本文中。

[0069] 根据本发明的水溶性膜的一类实施例的特征在于水溶性膜可食用，例如当包括糖醇塑化剂和其增容剂时。在这一类实施例中，水溶性聚合物可包括以下各物中的一个或多

个，可基本上由以下各物中的一个或多个组成或可由以下各物中的一个或多个组成：PVOH；改性 PVOH；水溶性天然聚合物，包括（但不限于）瓜尔豆胶、黄原胶、角叉菜胶以及淀粉；水溶性聚合物衍生物，包括（但不限于）乙氧基化淀粉和羟丙基化淀粉；前述的共聚物以及前述的组合。用于纳入根据本发明的水溶性膜的任选成分包括在室温下为液体的塑化剂中的一个或多个，例如表面活性剂、增容剂、共聚物以及辅助成膜剂。液体塑化剂可包括以下各物中的一个或多个，可基本上由以下各物中的一个或多个组成或可由以下各物中的一个或多个组成：丙三醇、二丙三醇、丙二醇、低分子量聚乙二醇（例如具有液体稠度，例如具有例如 200、300 和 600 的分子量）、单乙酸丙三醇酯、三醋精、柠檬酸三乙酯以及 1,3- 丁二醇。表面活性剂可例如包括以下各物，基本上由以下各物组成或由以下各物组成：磺基丁二酸钠二辛酯、丙三醇和丙二醇的乳酰化脂肪酸酯、脂肪酸的乳酰酯、烷基硫酸钠、聚山梨醇酯 20、聚山梨醇酯 60、聚山梨醇酯 65、聚山梨醇酯 80、卵磷脂、丙三醇和丙二醇的乙酰化脂肪酸酯以及脂肪酸的乙酰化酯。成膜剂可包括以下各物中的一个或多个，基本上由以下各物中的一个或多个组成或由以下各物中的一个或多个组成：普鲁兰、果胶、淀粉、明胶、海藻酸钠以及改性淀粉。所属领域的一般技术人员考虑本发明将显而易知其它任选成分。用于纳入可食性水溶性膜中的组分可为美国食品和药物管理局 (United States Food and Drug Administration) 指定为“公认为安全 (Generally Recognized as Safe)”(GRAS)，和 / 或组分在欧盟指定为容许 E 数值，和 / 或组分尚未指定为 GRAS 或 E 数值，但已经通过适当测试并且已证实为建议用于膜中的量的情况下对人类消耗来说安全的那些。

[0070] 成形和密封

[0071] 所披露的密封溶液可用于例如根据常规膜处理技术在施加或不施加热量和 / 或压力的情况下密封于水溶性膜表面。在密封之前，水溶性膜可根据所属领域中已知的多种工艺成形，例如通过在热成形方法中加热。可使用任何适合手段施加热量。举例来说，可通过以下步骤直接加热所述膜：在将膜馈入到表面上之前或当膜在表面上时，使膜穿过加热元件下方或通过热空气。或者，可例如通过加热表面或将热物件施加到膜上，对膜进行间接加热。在一些实施例中，膜使用红外光加热。膜可加热到约 50℃到约 150℃、约 50℃到约 120℃、约 60℃到约 130℃、约 70℃到约 120℃或约 60℃到约 90℃的温度。或者，可通过任何适合手段将膜润湿，例如在将膜馈入表面上之前或在表面上时，通过将润湿剂（包括水，膜组合物、用于膜组合物的塑化剂或上述的任何组合的溶液）喷洒到膜上进行直接润湿；或通过润湿表面或通过将湿物件施加到膜上进行间接润湿。

[0072] 膜已经加热和 / 或润湿之后，就可将其抽入到适当模具中，优选使用真空。可以通过利用任何适合手段实现用适合组合物填充模制膜。在一些实施例中，最优选方法将视产品形式和所需填充速度而定。在一些实施例中，模制膜通过在线填充技术填充。随后使用第二膜，通过任何适合方法封闭经填充的开口小包，形成袋。这可以在水平位置中并且使用连续恒定运动方式完成。封闭可通过以下完成：将第二膜，优选水溶性膜连续地馈入开口小包上方并且到开口小包上并且随后优选将第一膜和第二膜密封在一起，通常在模具之间的区域中并且因此介于小包之间。

[0073] 根据本发明的方法利用多个实施例中的任一个的密封溶液在两个膜表面之间形成密封。其它形式的密封（包括热密封）可用于溶液密封的补充。通常，仅形成密封（包括一些任选多余界限）的膜区域使用加热或密封溶液处理。加热或密封溶液可以通过任何

方法施加，通常施加于封闭膜材料上，并且通常仅施加于形成密封的区域上。溶液密封方法优选包括例如通过将密封溶液喷洒或印刷到模具（例如匹配模具表面）之间的区域上或封闭膜材料上将密封溶液选择性施加到这些区域，并且接着向这些区域施加压力，形成密封。可使用如上文所述的密封卷和带（任选地还提供热）。

[0074] 形成的水溶性小包或袋接着可通过切割装置切割。可使用任何适合方法完成切割。还可以连续方式进行切割是优选的，并且优选以恒定速度并且优选同时处于水平位置。切割装置可例如为锋利物件或热物件，因此在热物件的情况中，除了切削之外或作为切削的替代方案，热物件`烧穿`膜/密封区域。多隔室袋的不同隔室可使用并排型式在一起，其中所得结合袋可通过或不通过切割分开。或者，所述隔室可以单独地制造。应理解，通过使用适当馈入站，可能制造出并入有多种不同或独特组合物和/或不同或独特液体、凝胶或浆料组合物的多隔室小袋。

[0075] 图1示出了根据本发明使用如上文在任何密封溶液实施例中所述的密封溶液形成的密封水溶性小包100的横截面图。第一水溶性膜10包括第一表面12。如所示，第一水溶性膜10已成形（例如热成型）使得膜10的一部分界定体积（或隔室）40，在密封小包100之前可向所述体积（或隔室）中放置适合组合物50。在所示出的实施例中，第一表面12一般对应于在隔室40周围的第一水溶性膜10的上部或顶部（例如相对于隔室40的重力或填充方向）圆周表面。密封溶液可例如在第一水溶性膜10成形和/或向隔室40添加组合物50之前或之后通过任何适合手段（例如喷洒、印刷）施加于第一表面12。第二水溶性膜20随后与第一水溶性膜10接触以封闭隔室40（例如完全在隔室40的圆周的周围，但还预期由此仅部分封闭隔室的实施例）。如所示出，第二水溶性膜20的第二表面22（例如其底部或下部表面）接触第一表面12，其中密封溶液存在于两个表面12、22之间的界面区30处。两个表面12、22保持接触（例如通过压力）持续足以在两个膜10、20和表面12、22之间形成密封32的时间，因此产生密封水溶性小包100。选择密封时间以溶解两个膜10、20在界面区30中的表面部分，因此随后密封溶液的水组分远离界面区30的蒸发和/或扩散物质运输使膜10、20组分和密封溶液溶剂再固化成密封32。

[0076] 在图1中所示出的实施例中，第一表面12和第二表面22分别来自两个独立水溶性膜10、20（例如密封在一起的膜的独立片段，所述膜可由相同或不同组分形成）。在另一实施例中（未示出），第一表面12和第二表面22可为与相同水溶性膜10不同的区域（例如彼此折叠或密封的膜的同一片段的不同区域）。类似地，图1的实施例使用施加于第一表面12的密封溶液描述。在其它实施例中，在接触两个表面12、22和形成密封32之前，密封溶液可另外或替代地施加到第二表面22。在密封溶液施加于多个膜表面的情况中，密封溶液对于全部表面可相同或对于不同表面可不同（例如可视打算施加其的具体膜来选择密封溶液和其相应溶剂）。

[0077] 图2示出了水溶性小包100和密封32的整体膜区域10、20和界面区30中的代表性膜和密封溶液组分（C_1-C_4）的局部浓度的定性空间特征。所述特征沿具有标称厚度T的水溶性膜10、20的图1的线P说明，但更一般来说沿一般垂直于第一和第二表面12、22并且穿过界面区30的参考线施加。如下文所述，密封溶液溶剂（例如多元醇或其它）存在于界面区30中的局部浓度一般实质上高于多元醇存在于水溶性膜中和界面区30之外的整体浓度。举例来说，在界面区30中可观测到至少40、50、60、70、80或90重量%和/或高达60、

70、80、90 或 100 重量％的局部溶剂浓度（例如界面区 30 中的平均浓度或穿过界面区的浓度分布中的峰值）。与密封溶液溶剂互为补充，水溶性膜的一种或多种组分存在于界面区 30 中的局部浓度可实质上低于水溶性膜中和界面区之外的具体组分的整体浓度（举例来说，例如聚合物、塑化剂等整体膜组分（除密封溶液溶剂之外）可扩散到界面区 30 中，但由于用较浓密封溶液溶剂稀释而以相应较低浓度存在）。

[0078] 通过非限制性实例，图 2 中的代表性浓度特征可说明使用稀水包丙三醇密封溶液（例如 5 重量％到 10 重量％丙三醇）密封用丙三醇和丙二醇塑化的 PVOH 膜（例如在含有 60 重量％ PVOH、20 重量％丙三醇、15 重量％丙二醇作为添加组分以及 5 重量％水作为说明性平衡环境水分含量的膜中）产生的物品 100 和密封 32。在图 2 中，示出的组分为丙三醇 (C_1，作为密封溶液溶剂和膜塑化剂）、水 (C_2，作为环境水分）、PVOH(C_3，作为膜水溶性聚合物）以及丙二醇 (C_4，作为膜塑化剂）。尽管溶剂丙三醇相对稀，但密封加工期间所添加的水从密封溶液远离界面区 30 的蒸发和扩散物质运输在密封 32 中可产生溶剂丙三醇局部高度浓缩的区域。因为密封溶液用于溶解第一和第二水溶性膜 10、20 的边界区域，所以 PVOH 树脂和其丙二醇塑化剂组分输送到界面区 30 中，即使浓度由于界面区 30 中的密封溶液溶剂的稀释作用而低于整体膜 10、20 中。

[0079] 如上文所述，密封溶液尤其有效提供一种或多种益处，包括：减少水溶性膜 10、20 被密封溶液溶解的时间以及提高用密封溶液形成的所得密封 32 的强度，这都是相对于使用单独的水作为参考密封剂。所述益处可针对多种膜厚度实现，包括初始厚度在约 10 μm 到约 150 μm 或约 30 μm 到约 60 μm 范围内的那些（例如初始厚度至少 10、20、30、35 或 40 μm 和／或高达 40、50、60、70、80、100 或 150 μm，其中初始厚度指的是形成或密封方法期间膜的可能（局部）拉伸或薄化之前的标称膜厚度）。

[0080] 密封溶液尤其适用于对于水具有相对短烧穿时间（如下文所定义）的指定厚度的水溶性膜，只要所述短时间在使用单独的水作为密封剂可导致实质上膜破坏。在一些实施例中，选择使用单独的水作为测试溶剂时烧穿时间为约 45 秒或约 50 秒或更低的水溶性膜 10、20。然而，使用根据本发明的密封溶液，膜烧穿时间相对于水参考增加，并且一般为约 45 秒或约 50 秒或更久。更一般来说，在其它实施例中，仅水的烧穿时间可为至少约 10、20 或 30 秒和／或高达约 20、30、40、45、50 或 60 秒，并且密封溶液烧穿时间可为至少约 45、50、60、80 或 100 秒和／或高达约 60、80、100、150、200 或 500 秒，相对于相应的仅使用水的时间也提高。

[0081] 密封溶液产生的密封 32 的特征可为例如相对于用单独的水形成的密封对于指定厚度的水溶性膜具有增加的剥离强度或负荷（如下文所定义）。在各种实施例中，密封 32 展现比使用单独的水形成的相应密封大至少约 30％的剥离强度（（例如相对于仅水的密封提高至少约 30％、40％、50％或 60％和／或高达约 50％、60％、80％、100％、150％或 200％）。替代或另外地，密封的强度的特征可为最小相对剥离强度或剥离强度比率，定义为绝对剥离强度或负荷（例如针对指定厚度的膜以 N 为单位测量）比膜峰值负荷（例如针对相同厚度的膜还是以 N 为单位测量，作为下文所述的拉伸强度的量度）。举例来说，密封 32 可具有至少 12％、15％、20％或 30％和／或高达 40％、60％、80％或 100％的剥离强度比（以百分比表示）。

[0082] 水溶性小包可含有多种组合物。多隔室袋可在各独立隔室中含有相同或不同组合

物。本发明的这一特征可用于保持含有不相容成分（例如漂白剂和酶）的组合物物理上彼此分离或分隔。所述分隔可提供审美益处，延长使用寿命和 / 或降低袋内含物的物理不稳定性。

[0083] 适用组合物的非限制性实例包括人类和动物可摄取物品、个人护理组合物和清洁组合物。代表性人类和动物可摄取物品包括脱水或速溶饮料（咖啡、茶、果汁）、干制食品（例如基于淀粉的食品，例如意大利面、大米、燕麦片等）、宠物食品和营养或锻炼补充剂（例如蛋白质补充剂、维生素补充剂）。代表性个人组合物包括乳液（例如保湿和 / 或防晒霜）、保护性润肤剂和类似组合物。适合清洁组合物包括温和和强力液体清洁剂组合物、硬表面清洁组合物、常用于洗衣的清洁剂凝胶以及漂白剂和洗衣添加剂、洗发剂、沐浴乳和类似组合物。用于本发明的袋中的组合物可呈液体、凝胶、糊状物、固体或粉末形式。液体组合物可包含固体。固体可包括粉末或聚结物，例如微胶囊、珠粒、面条状物或一个或多个珠光球或其混合物。此类固体成分可通过洗涤或以预处理、延迟或依序释放组分形式提供技术效益；另外或替代地，其可提供美学效应。

[0084] 本发明的具体涵盖方面在本文中描述于以下编号段落中。

[0085] 1. 一种用于密封水溶性膜的方法，所述方法包含：

[0086] (a) 向水溶性膜的第一表面施加密封溶液，所述密封溶液包含 (i) 水，和 (ii) 具有 3 个或更多个羟基的多元醇，其中所述密封溶液在 20℃下测量的动态粘度（μ_s）小于 1.5cP；以及 (b) 使水溶性膜的第二表面与第一表面上的密封溶液接触足以在第一表面和第二表面之间形成密封的时间。

[0087] 2. 根据段落 1 所述的方法，其中所述多元醇以约 2 重量％到约 15 重量％范围内的量存在于密封溶液中。

[0088] 3. 根据前述段落中任一段落所述的方法，其中所述密封溶液基本上由水和一种或多种各自具有 3 个或更多个羟基的多元醇组成。

[0089] 4. 根据前述段落中任一段落所述的方法，其中所述多元醇含有 2 到 12 个碳原子和 3 到 12 个羟基。

[0090] 5. 根据前述段落中任一段落所述的方法，其中所述多元醇选自由以下各者组成的群组：丙三醇、赤藓糖醇、苏糖醇、阿糖醇、木糖醇、核糖醇、甘露糖醇、山梨糖醇、半乳糖醇、岩藻糖醇、艾杜糖醇、肌醇、庚七醇、异麦芽酮糖醇、麦芽糖醇、乳糖醇以及其组合。

[0091] 6. 一种用于密封水溶性膜的方法，所述方法包含：

[0092] (a) 向水溶性膜的第一表面施加密封溶液，所述水溶性膜的初始厚度小于约 50μm 并且包括基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物，所述密封溶液包含 (i) 水，和 (ii) 以约 2 重量％到约 15 重量％范围内的量存在于密封溶液中的多元醇，所述多元醇选自由以下组成的群组：丙三醇、赤藓糖醇、苏糖醇、阿糖醇、木糖醇、核糖醇、甘露糖醇、山梨糖醇、半乳糖醇、岩藻糖醇、艾杜糖醇、肌醇、庚七醇、异麦芽酮糖醇、麦芽糖醇、乳糖醇以及其组合，其中密封溶液在 20℃测量的动态粘度（μ_s）小于 1.5cP；以及 (b) 使水溶性膜的第二表面与第一表面上的密封溶液接触足以在第一表面和第二表面之间形成密封的时间，所述水溶性膜的初始厚度小于约 50μm 并且包括基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物。

[0093] 7. 根据段落 6 所述的方法，其中第一表面和第二表面的水溶性膜：(i) 具有约

86.5%到约89%范围内的水解度；以及(ii)进一步包含：(A)选自由以下组成的群组的糖醇塑化剂：异麦芽酮糖醇、麦芽糖醇、山梨糖醇、木糖醇、赤藓糖醇、福寿草醇、半乳糖醇、季戊四醇、甘露糖醇以及其组合，(B)选自由以下组成的群组的液体塑化剂：丙三醇、二丙三醇、乙二醇、二乙二醇、三乙二醇、四乙二醇、丙二醇、高达400MW的聚乙二醇、2-甲基-1,3-丙二醇以及其组合，和(C)选自由以下组成的群组的相容剂：纤维素醚、果胶的多糖、海藻酸钠的多糖、改性淀粉以及其组合。

[0094] 8.一种用于密封水溶性膜的方法，所述方法包含：

[0095] (a)向水溶性膜的第一表面施加密封溶液，所述密封溶液包含(i)水，和(ii)用于水溶性膜的至少一种聚合组分的溶剂，其中(A)如通过等式(I)所定义，溶剂和聚合组分的溶解度半径(Ra)为约5或更低：

[0096] $(Ra)^2=4(\delta_{D,S}-\delta_{D,P})^2+(\delta_{P,S}-\delta_{P,P})^2+(\delta_{H,S}-\delta_{H,P})^2$ (I)

[0097] 其中$\delta_{D,S}$为溶剂色散力，$\delta_{D,P}$为聚合组分色散力，$\delta_{P,S}$为溶剂极性力，$\delta_{P,P}$为聚合组分极性力，$\delta_{H,S}$为溶剂氢键力，并且$\delta_{H,P}$为聚合组分氢键力，其各自通过汉森溶解度参数评估的自洽法测定，以及(B)如在20℃下所测量，密封溶液的动态粘度(μ_s)小于1.5cP；以及(b)使水溶性膜的第二表面与第一表面上的密封溶液接触足以在第一表面和第二表面之间形成密封的时间。

[0098] 9.根据段落8所述的方法，其中所述溶解度半径在约1到约5范围内。

[0099] 10.根据段落8到9中任一段落所述的方法，其中(i)聚合组分包含聚乙烯醇；(ii)$\delta_{P,S}$为至少约10；以及(iii)$\delta_{H,S}$为至少约22。

[0100] 11.根据段落8到10中任一段落所述的方法，其中所述溶剂以约2重量%到约15重量%范围内的量存在于密封溶液中。

[0101] 12.根据段落8到11中任一段落所述的方法，其中所述密封溶液基本上由水和一种或多种各自具有相对于所述聚合组分约5或更低的溶解度半径的溶剂组成。

[0102] 13.根据前述段落中任一段落所述的方法，其中动态粘度在约1cP到约1.45cP范围内。

[0103] 14.根据前述段落中任一段落所述的方法，其中：(i)使用单独的水作为测试溶剂，水溶性膜具有约45秒或更短的烧穿时间；以及(ii)水溶性膜的烧穿时间(A)使用密封溶液作为测试溶剂时为约45秒或更长并且(B)大于使用单独的水作为测试溶剂时的所述烧穿时间。

[0104] 15.根据前述段落中任一段落所述的方法，其中所述密封相对于所述水溶性膜的峰值负荷呈现至少约12%的剥离强度。

[0105] 16.根据前述段落中任一段落所述的方法，其中所述密封呈现比单独的水形成的相应密封大至少约30%的剥离强度。

[0106] 17.根据前述段落中任一段落所述的方法，其中所述第一表面和所述第二表面各自独立地具有约10μm到约150μm范围内的初始厚度。

[0107] 18.根据前述段落中任一段落所述的方法，其中所述水溶性膜包含选自由以下组成的群组的水溶性聚合物：聚乙烯醇、聚乙烯亚胺、聚丙烯酸酯、水溶性丙烯酸酯共聚物、聚乙烯吡咯烷酮、支链淀粉、瓜尔胶、黄原胶、角叉菜胶、淀粉、乙氧基化淀粉、羟丙基化淀粉、聚氧化烯、聚丙烯酰胺、聚丙烯酸和其盐、纤维素、纤维素醚、纤维素酯、纤维素酰胺、聚乙酸

乙烯酯、聚羧酸和其盐、聚氨基酸、聚酰胺、明胶、甲基纤维素、羧甲基纤维素和其盐、糊精、乙基纤维素、羟基乙基纤维素、羟基丙基甲基纤维素、麦芽糊精、聚甲基丙烯酸酯、其共聚物、其掺合物以及其组合。

[0108] 19. 根据段落 18 所述的方法，其中所述水溶性聚合物在 20℃下具有约 3cP 到约 27cP 范围内的 4%溶液粘度。

[0109] 20. 根据前述段落中任一段落所述的方法，其中所述水溶性膜包含水溶性聚合物，其包含聚乙烯醇。

[0110] 21. 根据段落 20 所述的方法，其中所述水溶性聚合物包含基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物。

[0111] 22. 根据段落 20 到 21 中任一段落所述的方法，其中所述聚乙烯醇具有约 75%到约 99%范围内的水解度。

[0112] 23. 根据段落 20 到 21 中任一段落所述的方法，其中所述聚乙烯醇具有约 86.5%到约 89%范围内的水解度。

[0113] 24. 根据前述段落中任一段落所述的方法，其中所述第一表面和所述第二表面来自同一水溶性膜。

[0114] 25. 根据前述段落中任一段落所述的方法，其中所述第一表面和所述第二表面来自不同水溶性膜。

[0115] 26. 根据前述段落中任一段落所述的方法，其中第二表面与第一表面的接触包含向第一表面和第二表面施加压力以及向第一表面和第二表面施加热中的至少一个来形成密封。

[0116] 27. 根据前述段落中任一段落所述的方法，其中所述第二表面上面包含第二密封溶液，其在形成所述密封时与所述第一表面接触。

[0117] 28. 根据前述段落中任一段落所述的方法，其中：(i) 第一表面和第二表面中的至少一个的水溶性膜界定至少部分包围组合物的体积，和 (ii) 形成密封产生含有所述组合物的密封水溶性小包。

[0118] 29. 根据段落 28 所述的方法，其中所述组合物选自由以下各者组成的群组：人类和动物可摄取物品、个人护理组合物和清洁组合物。

[0119] 30. 一种物品，其包含根据前述段落中任一段落形成的密封水溶性膜。

[0120] 31. 一种物品，其包含：(a) 水溶性膜的第一表面和水溶性膜的第二表面，其在所述第一表面与所述第二表面之间的界面区处密封；以及 (b) 具有 3 个或更多个羟基的多元醇，其在所述界面区中的局部浓度实质上高于所述多元醇在所述水溶性膜中以及所述界面区之外的整体浓度。

[0121] 32. 一种物品，其包含：(a) 水溶性膜的第一表面和水溶性膜的第二表面，其在所述第一表面与所述第二表面之间的界面区处密封，其中第一表面和第二表面中的每一个的水溶性膜具有小于约 50μm 的初始厚度并且包含基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物；以及 (b) 多元醇，其在所述界面区中的局部浓度实质上高于所述多元醇在所述水溶性膜中以及所述界面区之外的整体浓度，所述多元醇选自由以下组成的群组：丙三醇、赤藓糖醇、苏糖醇、阿糖醇、木糖醇、核糖醇、甘露糖醇、山梨糖醇、半乳糖醇、岩藻糖醇、艾杜糖醇、肌醇、庚七醇、异麦芽酮糖醇、麦芽糖醇、乳糖醇以

及其组合。

[0122] 33. 一种物品，其包含：(a) 水溶性膜的第一表面和水溶性膜的第二表面，其在所述第一表面与所述第二表面之间的界面区处密封；以及 (b) 用于水溶性膜的至少一种聚合组分的溶剂，所述溶剂在所述界面区中的局部浓度实质上高于所述溶剂在所述水溶性膜中以及所述界面区之外的整体浓度，其中如等式 (I) 所定义，所述溶剂和所述聚合组分具有约 5 或更低的溶解度半径 (Ra)：

[0123] $(Ra)^2 = 4(\delta_{D,S} - \delta_{D,P})^2 + (\delta_{P,S} - \delta_{P,P})^2 + (\delta_{H,S} - \delta_{H,P})^2$ (I)

[0124] 其中 $\delta_{D,S}$为溶剂色散力，$\delta_{D,P}$为聚合组分色散力，$\delta_{P,S}$为溶剂极性力，$\delta_{P,P}$为聚合组分极性力，$\delta_{H,S}$为溶剂氢键力，并且 $\delta_{H,P}$为聚合组分氢键力，其各自通过汉森溶解度参数评估的自洽法测定。

[0125] 34. 根据段落 31 到 33 中任一段落所述的物品，其中所述水溶性膜的一种或多种组分在所述界面区中的局部浓度实质上低于所述一种或多种组分在所述水溶性膜中以及所述界面区之外的整体浓度。

[0126] 35. 一种用于密封水溶性膜的方法，所述方法包含：(a) 向水溶性膜的第一表面施加密封溶液，所述水溶性膜具有小于约 50μm 或约 40μm 的初始厚度并且包含基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物，所述密封溶液包含 (i) 水和 (ii) 具有 3 个或更多个羟基的多元醇；以及 (b) 使水溶性膜的第二表面与第一表面上的密封溶液接触足以在第一表面和第二表面之间形成密封的时间，所述水溶性膜具有小于约 50μm 或约 40μm 的初始厚度并且包含基本上由乙烯醇单体重复单元和乙酸乙烯酯单体重复单元组成的聚乙烯醇共聚物。

[0127] 实例

[0128] 烧穿时间测量

[0129] 通过以下“烧穿”测量程序测定指定测试溶剂溶解指定厚度的水溶性膜所需的时间。指定厚度的测试膜使用胶带附着到纸片段。使用滴管将约 50 微升的一滴测试溶剂（例如水或如本文所披露的密封溶液）施加于测试膜。测试溶剂适合地具有食品染色添加剂或其它视觉指示剂来帮助观测测试溶剂对测试膜的作用。当测试膜下的纸变得潮湿和/或根据所添加的针对测试溶剂的视觉指示剂变色时测量烧穿时间（即测试膜溶解（被测试溶剂“烧穿”）之后，放置液滴的位置周围的区域使食品染色剂或其它指示剂的颜色变化。

[0130] 膜拉伸和密封剥离强度测量

[0131] 这一方法用于测定撕裂或剥离水溶性膜（拉伸强度）或溶液密封的水溶性膜（密封剥离强度）所需的张力。所述程序包括测定张力和强度。使用英斯特朗拉伸测试设备 (INSTRON tensile testing apparatus) 或等效设备收集膜数据。使用具有网纹辊 140/10 的艾斯普夫打样设备 (ESIPROOF proofing apparatus) 或等效设备固持两个膜薄片与溶剂（例如水或本文所披露的密封溶液）。每次测量沿加工方向 (MD)（适当时）测试最少三个测试样本，每个测试样本用可靠的切割工具切割以确保尺寸稳定性和再现性。在 23℃ ±2.0℃和 35% ±5%相对湿度的标准实验室氛围中进行测试。

[0132] 对于剥离强度测定，通过沿加工方向 (MD)（适当时）以 12″(30.5cm) 尺寸切割 4″×12″(10.2cm×30.5cm) 膜薄片来制备测试样本。将膜的无光面（或适当时相对投射面）朝上，将两个薄片的四个拐角粘贴到表面。一个薄片覆盖到粘贴薄片中的一个的顶部，使

得无光面接触。在另一个粘贴薄片的顶部，在顶部放置其余薄片使得有光面与无光面接触。粘贴各顶部薄片的一个 4″(10.2cm) 端以将其固持到底部薄片。通过使用 140/10 网纹辊的艾斯普夫打样辊穿过各顶部薄片的未固定端。向刮刀施加 0.5mL 的量的测试密封溶液（例如水或水性溶剂溶液）。以恒定速度 (3″/ 秒）牵拉辊来涂布上部膜并且固持到下部薄片。将膜烧焊约 10 分钟到 15 分钟的时段，由此形成密封，但在测试样本的一端上留下两个未密封（自由）膜翼片进行随后的剥离测试。对于拉伸强度测定，制备厚度与剥离强度膜相同的单个（未密封）膜薄片的 1″ 宽 (2.54cm) 样品。接着将密封或未密封样品转移到英斯特朗拉伸测试机上进行测试，同时在 35％相对湿度环境中最小化暴露。根据制造商说明，准备好配备有 500N 测力计并且经校准的拉伸测试机。安装校正夹和表面。

[0133] 对于剥离测试，橡胶夹之间存在 0.50″(1.27cm) 间距，其中全部四个都是平面并且是正方形。沿加工方向 (MD) 切割三个（或更多个）1″- 宽 (2.54cm) 样品。将各样品的未密封翼片置于测试机的夹子中，小心确保样本与夹子对准并且与其平行，并且样本没有在测试机钳中牵拉得太紧。平衡负荷并且根据设备制造商的说明开始测试。测试结束时，将撕裂或分离层所需的张力（以 N 为单位）记录为剥离强度。类似地，对于拉伸强度，将三个（或更多个）1″ 宽 (2.54cm) 单个薄片样品安放到拉伸测试机中并且分析测定膜峰值强度（以 N 为单位）。

[0134] 实例 1-5

[0135] 用于高速转化水溶性膜的常见技术为使用转鼓型转化设备，其中通常使用水作为密封溶液略微湿润其所施加的覆盖的膜并且在使用辊稍微施加压力的情况下形成密封。密封溶液的重要特性包括耐烧穿性（即防止破坏和 / 或溶解水溶性膜）和形成良好密封的能力的组合，所述良好密封由通过密封峰值强度（或负荷）或密封峰值负荷比（膜峰值强度的比率）测量的密封强度表示。耐烧穿性在通常用于传递固体（例如粉末）产品的较小规格膜（例如 1.5mil 厚度膜）中变得更重要。合意地，膜密封溶液组合获得最小适合烧穿时间和最大密封强度。

[0136] 实例 1-5 使用单独的水作为对照密封剂和不同浓度的根据本发明的水包丙三醇溶液（一般 2.5 重量％到 50 重量％），根据密封溶液浓度评估五种不同基于 PVOH 的水溶性膜。对于各膜密封溶液组合，测试 1.5mil 厚度膜的烧穿时间和密封剥离强度。实例 1-5 的结果曲线和数据分别显示于图 3-7 和表 1-5 中。下文提供不同测试膜的具体结果的概述。具体来说，基于 PVOH 的膜展现使用增加的丙三醇浓度会改善（增加）烧穿时间。另外，PVOH 均聚物膜展现使用水包丙三醇密封溶液会实质改善密封剥离强度，而同时实现足以超过约 45-50 秒的最小所需临界值的烧穿时间提高。

[0137] 实例 1（包括 PVOH 共聚物 A 的 1.5mil 膜 A）：随着丙三醇浓度增加而提高的烧穿时间。0％到 35％丙三醇溶液范围内未观测到剥离强度统计差异。这一范围中观测到最大密封峰值负荷。有数据是 25％，这与 0 到 35％的范围有统计学上的不同。然而，这是单个点而不是趋势。因此，仅使用水的密封溶液可用来获得良好密封。单独的水也具有约 79 秒的可接受最小耐烧穿性。

[0138] 表 1. 膜 A 的烧穿时间和剥离强度

[0139]

密封溶液	烧穿，秒(95% CI)	剥离强度，N (95% CI)	膜峰值负荷，N	密封峰值负荷，N	峰值负荷比
100%水	78.85 (5.45)	14.63 (1.00)	33.86	14.63	0.43
2.5%丙三醇	77.10 (4.12)	13.51 (1.86)	33.86	13.51	0.40
5%丙三醇	94 (9.67)	12.96 (1.46)	33.86	12.96	0.38
10%丙三醇	115 (8.18)	14.79 (1.14)	33.86	14.79	0.44
15%丙三醇	212 (14.73)	13.30 (1.41)	33.86	13.30	0.39
20%丙三醇	295 (22.99)	16.15 (1.60)	33.86	16.15	0.48
25%丙三醇	399 (29.99)	12.91 (1.07)	33.86	12.91	0.38
30%丙三醇	652 (26.90)	13.30 (1.09)	33.86	13.30	0.39
35%丙三醇		13.46 (1.39)	33.86	13.46	0.40
40%丙三醇		12.45 (0.61)	33.86	12.45	0.37
45%丙三醇		12.95 (0.67)	33.86	12.95	0.38
50%丙三醇		12.65 (0.76)	33.86	12.65	0.37

[0140] 实例 2(包括 PVOH 共聚物 B 的 1.5mil 膜 B):随着丙三醇浓度增加而提高的烧穿时间。0%到 25%丙三醇溶液范围内未观测到剥离强度统计差异。这一范围中观测到最大密封峰值负荷。有数据是 10%，这与 0 到 35%的范围有统计学上的不同。然而，这是单个点而不是趋势。因此，仅使用水的密封溶液可用来获得良好密封。单独的水也具有约 80 秒的可接受最小耐烧穿性。

[0141] 表 2. 膜 B 的烧穿时间和剥离强度

[0142]

密封溶液	烧穿，秒（95% CI）	剥离强度，N（95% CI）	膜峰值负荷，N	密封峰值负荷，N	峰值负荷比
100%水	79.5（7.13）	10.16（1.43）	32.81	10.16	0.31
2.5%丙三醇	92.30（7.58）	11.47（2.01）	32.81	11.47	0.35
5%丙三醇	111（9.82）	11.19（1.97）	32.81	11.19	0.34
10%丙三醇	122（10.92）	14.31（1.85）	32.81	14.31	0.44
15%丙三醇	268.5（17.76）	11.55（1.85）	32.81	11.55	0.35
20%丙三醇		11.67（1.01）	32.81	11.67	0.36
25%丙三醇		9.67（1.48）	32.81	9.67	0.29
30%丙三醇		7.43（0.70）	32.81	7.43	0.23
35%丙三醇		9.77（0.67）	32.81	9.77	0.30
40%丙三醇		5.20（0.75）	32.81	5.20	0.16
45%丙三醇		3.14（0.75）	32.81	3.14	0.10
50%丙三醇		2.12（0.57）	32.81	2.12	0.06

[0143] 实例 3(包括 PVOH 共聚物 C 的 1.5mil 膜 C):随着丙三醇浓度增加而提高的烧穿时间。0%到 20%丙三醇溶液范围内未观测到剥离强度统计差异。这是观测到最大密封峰值负荷的范围。有数据是 15%，这与 0 到 35%的范围有统计学上的不同。然而，这是单个点而不是趋势。因此，仅使用水的密封溶液可用来获得良好密封。单独的水也具有约 95 秒的可接受最小耐烧穿性。

[0144] 表 3. 膜 C 的烧穿时间和剥离强度

[0145]

密封溶液	烧穿，秒（95% CI）	剥离强度，N（95% CI）	膜峰值负荷，N	密封峰值负荷，N	峰值负荷比
100%水	95.4（4.74）	10.83（1.79）	48.79	10.83	0.22
2.5%丙三醇	106.6（7.85）	10.55（2.34）	48.79	10.55	0.22

[0146]

5%丙三醇	153（8.79）	11.05（1.63）	48.79	11.05	0.23
10%丙三醇	253（14.21）	12.96（1.23）	48.79	12.96	0.27
15%丙三醇		13.61（1.38）	48.79	13.61	0.28
20%丙三醇		9.80（1.60）	48.79	9.80	0.20
25%丙三醇		3.29（0.42）	48.79	3.29	0.07
30%丙三醇		2.55（0.36）	48.79	2.55	0.05
35%丙三醇		0.99（0.11）	48.79	0.99	0.02
40%丙三醇		0.26（0.04）	48.79	0.26	0.01
45%丙三醇		0.86（0.30）	48.79	0.86	0.02
50%丙三醇		0.71（0.09）	48.79	0.71	0.01

[0147] 实例 4（包括 PVOH 共聚物 D 的 1.5mil 膜 D）：随着丙三醇浓度增加而提高的烧穿时间。与实例 1-3 的各种共聚物 PVOH 膜不同，0%丙三醇（或 100%水）不展现最大密封峰值负荷。在约 10%到 40%水包丙三醇范围内观测到最大密封强度。这一范围中观测到最大密封峰值负荷。重要的是，对于这一均聚物膜，100%水密封溶液不是形成溶液密封的选择方案。尽管使用 100%水有 88 秒的最小耐烧穿性是可接受的并且可使用单独的水作为密封剂形成密封，但使用 100%水时峰值密封强度并非其最大值。

[0148] 表 4. 膜 D 的烧穿时间和剥离强度

[0149]

密封溶液	烧穿，秒（95% CI）	剥离强度，N（95% CI）	膜峰值负荷，N	密封峰值负荷，N	峰值负荷比
100%水	87.7（6.30）	11.34（1.78）	42.26	11.34	0.27
2.5%丙三醇	117.60（9.12）	9.77（1.49）	42.26	9.77	0.23
5%丙三醇	127（12.53）	10.19（0.73）	42.26	10.19	0.24
10%丙三醇	138（12.36）	14.79（1.89）	42.26	14.79	0.35
15%丙三醇	305.4（20.05）	12.07（1.30）	42.26	12.07	0.29
20%丙三醇	531（23.48）	15.50（1.33）	42.26	15.50	0.37
25%丙三醇	1006（29.92）	14.32（1.90）	42.26	14.32	0.34
30%丙三醇		15.65（1.22）	42.26	15.65	0.37
35%丙三醇		13.81（1.15）	42.26	13.81	0.33
40%丙三醇		14.14（1.02）	42.26	14.14	0.33
45%丙三醇		11.16（0.93）	42.26	11.16	0.26
50%丙三醇		6.87（1.10）	42.26	6.87	0.16

[0150]

[0151] 实例5(包括PVOH均聚物E的1.5mil膜E):膜E为水溶性可食性膜,其包括(i)PVOH均聚物作为水溶性聚合物(标称23cP溶液粘度和88%水解度;100重量份/100份树脂(phr)),(ii)木糖醇作为糖醇塑化剂(8.52phr),(iii)山梨糖醇作为糖醇塑化剂(6.53phr),(iv)羧甲基纤维素醚作为糖醇增容剂(17.04phr),(v)丙三醇和丙二醇作为液体塑化剂(36.98phr组合)以及(vi)表面活性剂加工助剂(1.43phr)。烧穿时间随着丙三醇浓度增加而增加。与实例1-3的共聚物PVOH膜不同,0%丙三醇(或100%水)不展现最大密封峰值负荷。在5%到20%丙三醇溶液范围内观测到最大密封强度。这一范围中观测到最大密封峰值负荷。重要的是,对于这一均聚物膜,100%水密封溶液不是形成溶液密封的选择方案。另外,100%水约34秒的最小耐烧穿性是不可接受的。然而,在5%和更高的丙三醇含量时,获得54秒或更高的最小烧穿时间。

[0152] 表5.膜E的烧穿时间和剥离强度

[0153]

密封溶液	烧穿,秒(95% CI)	剥离强度,N(95% CI)	膜峰值负荷,N	密封峰值负荷,N	峰值负荷比
100%水	34.55(2.04)	2.44(0.81)	19.92	2.44	0.12
2.5%丙三醇	51.10(5.02)	2.10(0.87)	19.92	2.10	0.11
5%丙三醇	54(3.09)	4.16(0.92)	19.92	4.16	0.21
10%丙三醇	62(4.56)	3.77(0.95)	19.92	3.77	0.19
15%丙三醇	74.5(6.64)	4.95(0.32)	19.92	4.95	0.25
20%丙三醇	112(9.91)	4.93(0.86)	19.92	4.93	0.25
25%丙三醇	218(23.37)	2.95(0.38)	19.92	2.95	0.15
30%丙三醇	443(27.01)	0.61(0.16)	19.92	0.61	0.03
35%丙三醇	972(36.34)	0.65(0.11)	19.92	0.65	0.03
40%丙三醇		1.29(0.14)	19.92	1.29	0.06
45%丙三醇		0.75(0.24)	19.92	0.75	0.04
50%丙三醇		0.69(0.05)	19.92	0.69	0.03

[0154] 实例6-11

[0155] 类似于实例1-5,实例6-11使用单独的水作为对照密封剂和使用二醇和多元醇溶剂的不同浓度的密封溶液(一般2.5重量%到50重量%),根据密封溶液浓度评估基于PVOH的水溶性膜(包括PVOH均聚物F的膜F)。膜F为膜峰值负荷为约20.0N的水溶性可食性膜,其包括(i)PVOH均聚物作为水溶性聚合物(标称8cP溶液粘度和88%水解度;100重量份/100份树脂(phr)),(ii)木糖醇作为糖醇塑化剂(8.52phr),(iii)山梨糖醇作为糖醇塑化剂(6.53phr),(iv)羧甲基纤维素醚作为糖醇增容剂(17.04phr),(v)丙三醇和丙二醇作为液体塑化剂(36.98phr组合)以及(vi)表面活性剂加工助剂(1.43phr)。所用具体溶剂是丙三醇(实例6)、2-甲基-1,3-丙二醇(实例7)、丙二醇(实例8)、甘露糖醇(实例9)、山梨糖醇(实例10)以及木糖醇(实例11)。对于各膜密封溶液组合,测试1.5mil

厚度膜的烧穿时间和密封剥离强度。实例 6-11 的结果曲线和数据分别显示于图 8-13 和表 6-11 中。

[0156] 表 6. 膜 F- 丙三醇的烧穿时间和剥离强度

[0157]

密封溶液	烧穿，秒（95% CI）	剥离强度，N（95% CI）
100%水	43（1.52）	4.18（0.48）
2.5%丙三醇	47（2.48）	3.73（0.53）
5%丙三醇	51（2.41）	6.80（0.46）
10%丙三醇	61（1.98）	4.39（0.75）
15%丙三醇	67（2.70）	4.61（0.90）
20%丙三醇	113（5.91）	4.91（0.58）
25%丙三醇	171（10.27）	3.97（0.42）
30%丙三醇	250（15.29）	3.74（0.23）

[0158] 表 7. 膜 F-MP 二醇的烧穿时间和剥离强度

[0159]

密封溶液	烧穿，秒（95% CI）	剥离强度，N（95% CI）
100%水	43（1.52）	4.18（0.48）
2.5% MP 二醇	50（1.78）	5.14（0.96）
5% MP 二醇	52（1.79）	5.20（0.60）
10% MP 二醇	57（2.17）	5.22（0.60）
15% MP 二醇	84（3.27）	4.50（0.32）
20% MP 二醇	97（3.39）	3.24（1.69）
25% MP 二醇	156（7.23）	3.43（1.06）
30% MP 二醇	200（9.53）	3.07（1.12）
35% MP 二醇	320（23.35）	1.80（1.02）

[0160]

40% MP 二醇	432（17.51）	3.61（1.37）
45% MP 二醇	608（31.30）	3.93（1.19）
50% MP 二醇	654（28.18）	2.99（0.76）

[0161] 表 8. 膜 F- 丙二醇的烧穿时间和剥离强度

[0162]

密封溶液	烧穿，秒（95% CI）	剥离强度，N（95% CI）
100%水	43（1.52）	4.18（0.48）
2.5%丙二醇	51（1.75）	2.91（0.30）
5%丙二醇	53（1.60）	4.70（0.37）
10%丙二醇	61（3.01）	4.81（0.65）
15%丙二醇	97（3.87）	4.58（0.58）
20%丙二醇	111（3.43）	4.34（0.14）
25%丙二醇	175（7.27）	4.81（0.62）
30%丙二醇	211（9.25）	4.45（0.68）
35%丙二醇	449（25.41）	4.23（0.85）
40%丙二醇	434（16.62）	3.41（1.00）

[0163]　表 9. 膜 F- 甘露糖醇的烧穿时间和剥离强度

[0164]

密封溶液	烧穿，秒（95% CI）	剥离强度，N（95% CI）
100%水	43（1.52）	4.18（0.48）
2.5%甘露糖醇	42（2.01）	3.01（0.95）
5%甘露糖醇	55（1.51）	5.59（0.95）
10%甘露糖醇	67（3.76）	4.61（0.54）
15%甘露糖醇	91（5.10）	2.91（0.34）

[0165]　表 10. 膜 F- 山梨糖醇的烧穿时间和剥离强度

[0166]

密封溶液	烧穿，秒（95% CI）	剥离强度，N（95% CI）
100%水	43（1.52）	4.18（0.48）
2.5%山梨糖醇	51（2.84）	3.92（0.99）
5%山梨糖醇	50（2.70）	6.97（0.62）
10%山梨糖醇	72（3.08）	6.10（0.34）
15%山梨糖醇	87（3.87）	3.50（0.41）
20%山梨糖醇	107（4.87）	3.70（0.14）
25%山梨糖醇	225（18.21）	2.16（0.58）
30%山梨糖醇	539（52.46）	2.04（0.58）

[0167]

[0168]　表 11. 膜 F- 木糖醇的烧穿时间和剥离强度

[0169]

密封溶液	烧穿，秒（95% CI）	剥离强度，N（95% CI）
100%水	43（1.52）	4.18（0.48）
2.5%木糖醇	46（2.59）	4.58（0.36）
5%木糖醇	48（2.46）	5.84（0.59）
10%木糖醇	63（3.41）	5.63（0.39）
15%木糖醇	73（3.20）	4.76（0.37）
20%木糖醇	126（5.46）	4.94（0.27）
25%木糖醇	199（11.70）	4.25（0.58）

[0170] 值得注意的是，含有 3 个、5 个或 6 个羟基的多元醇溶剂都展现密封剥离强度实质改良，而同时实现足以超过至少约 45-50 秒的最小所要临界值的烧穿时间提高。相比之下，含有 2 个羟基的二醇溶剂尽管实现超过可接受最小值的烧穿时间，但并未展现与多元醇溶剂相同程度的相对于水的密封剥离强度提高。

[0171] 下表 12 提供针对实例 6-11 中测试的多种溶剂相对于作为水溶性膜中的相应聚合组分的 PVOH 均聚物的溶解度半径 (Ra)（参看上述等式 (2)）的 HSP 分析。表 12 中的值使用 Y-MB 方法和用于执行计算的可商购的 HSPIP 软件来计算。从表 12 可见，观测到多元醇溶剂与类似地具有较小的相对于 PVOH 的溶解度半径的二醇溶剂相比具有更好的溶液密封特性。

[0172] 表 12.HSP 分析 :PVOH- 溶剂溶解度半径

[0173]

	HSP 参数			
组分	δ_D	δ_P	δ_H	Ra
PVOH	19.3	10.4	26.5	-
丙三醇	18.3	11.3	28.5	3.0
甘露糖醇	17.6	12.3	28.6	4.4
山梨糖醇	17.6	12.3	28.6	4.4
木糖醇	18.0	11.9	29.2	4.0
2-甲基-1,3-丙二醇	17.3	9.3	21.4	6.6
丙二醇	17.4	8.8	21.7	6.3

[0174]

[0175] 给出前述描述仅为清楚理解，并且不应自其理解为不必要的限制，因为本发明范围内的修改可对于所属领域的技术人员显而易知。

[0176] 在本说明书全文以及随附权利要求书中，除非上下文另有要求，否则词语“包含 (comprise)”和变化形式（例如“包含 (comprises)”或“包含 (comprising)”）应理解为

暗示纳入所陈述整数或步骤或者整数或步骤的群组，但不排除任何其它整数或步骤或者整数或步骤的群组。

[0177] 在本说明书全文中，除非以其它方式描述，否则当将组合物描述为包括组分或物质时，预期所述组合物也可以基本上由所述组分或物质的任何组合组成或由其组成。同样，除非以其它方式描述，否则将方法描述为包括具体步骤，方法打算也可以基本上由所述步骤的任何组合组成或由其组成。在不存在非特定披露于本文中的任何要素或步骤的情况下，可适当地实践本文所说明性披露的本发明。

[0178] 本文中所披露的方法和其个别步骤的实践可手动地和／或借助于电子设备或由电子设备提供的自动化来执行。尽管已参考具体实施例描述工艺，但所属领域的普通技术人员将容易了解，可使用与所述方法相关的行为的其它执行方式。举例来说，除非以其它方式描述，否则在不背离所述方法的范围或精神的情况下，可以改变各种步骤的次序。另外，可将个别步骤中的一些组合、省略或进一步再分成其它步骤。

[0179] 本文中所引用的所有专利、公开案以及参考文献在此以引用的方式全部并入本文中。在本发明与所并入的专利、公开案以及参考文献之间发生冲突的情况下，应以本发明为准。

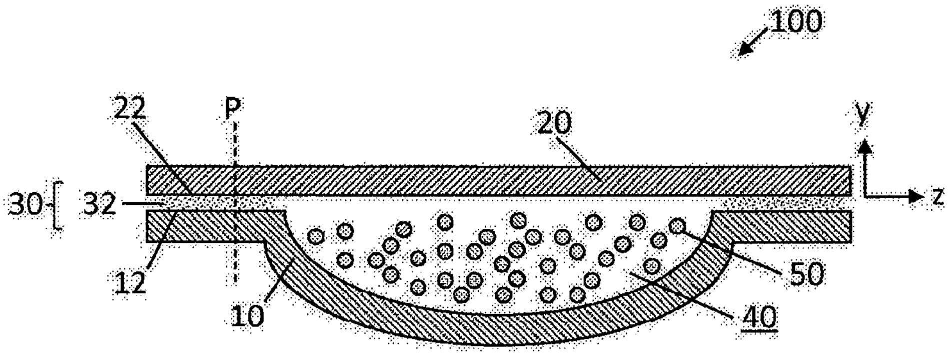

100
22
P
20
y
z
30
32
12
10
50
40

图 1

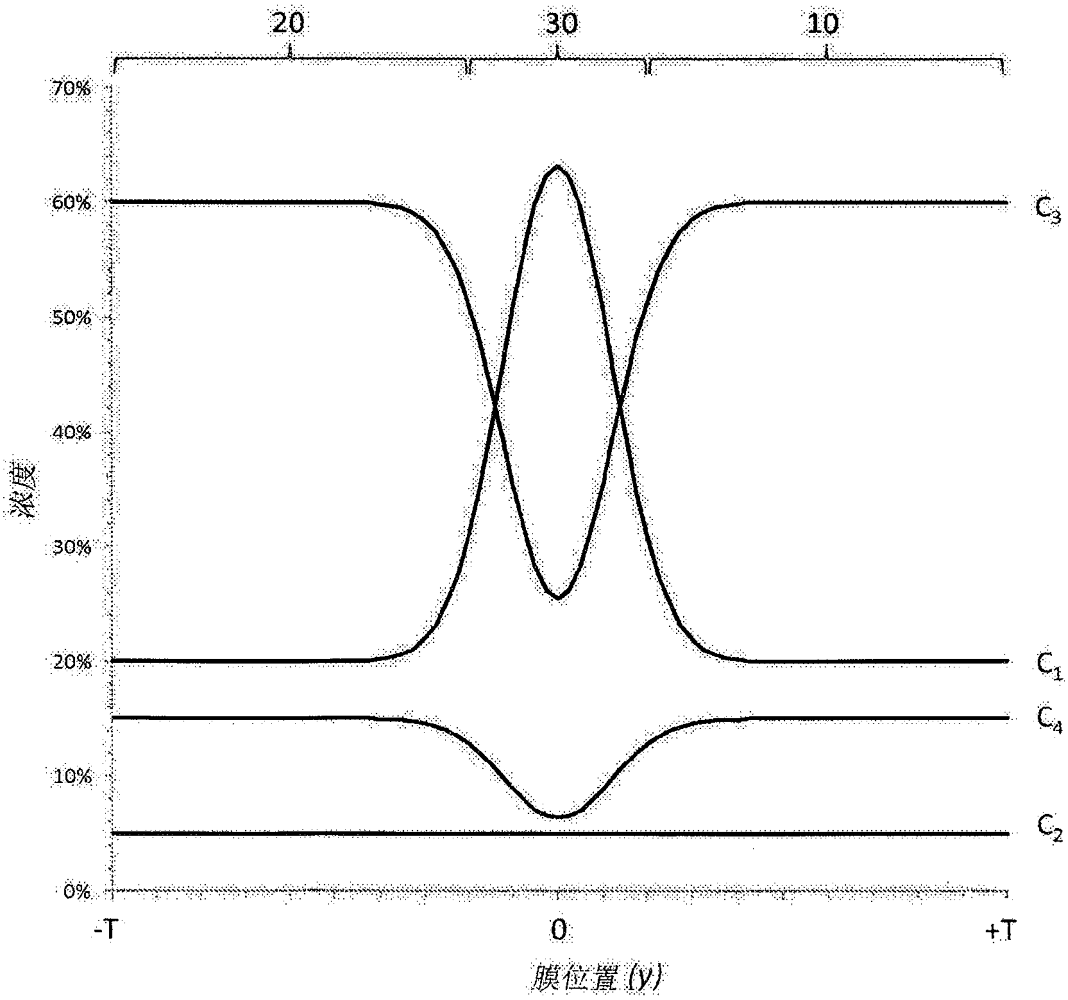

20
30
10
70%
60%
50%
40%
30%
20%
10%
0%
浓度
C3
C1
C4
C2
-T
0
+T
膜位置 (y)

图 2

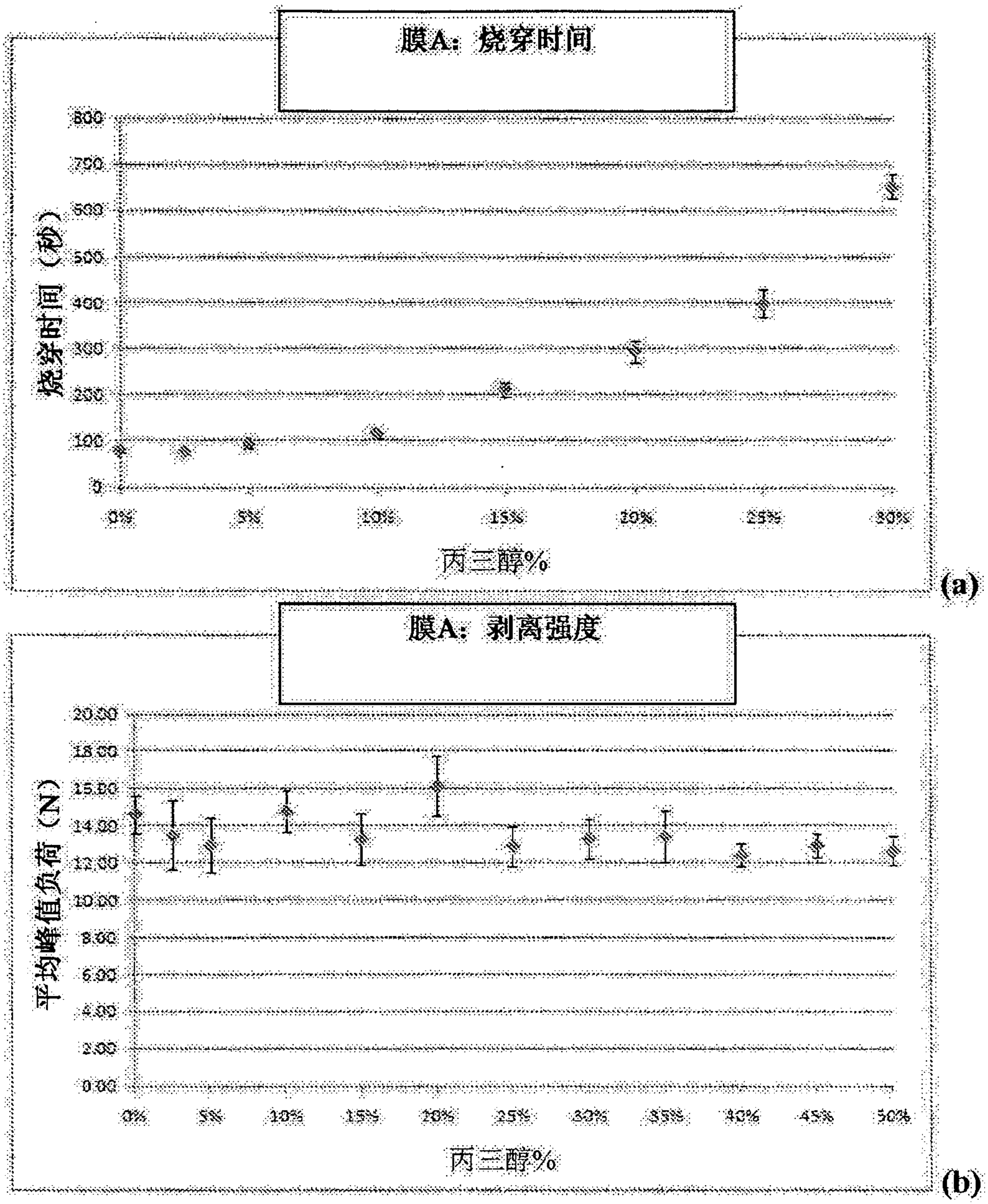

膜A：烧穿时间
烧穿时间（秒）
0
100
200
300
400
500
600
700
800
0%
5%
10%
15%
20%
25%
30%
丙三醇%
(a)
膜A：剥离强度
平均峰值负荷（N）
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
丙三醇%
(b)

图 3

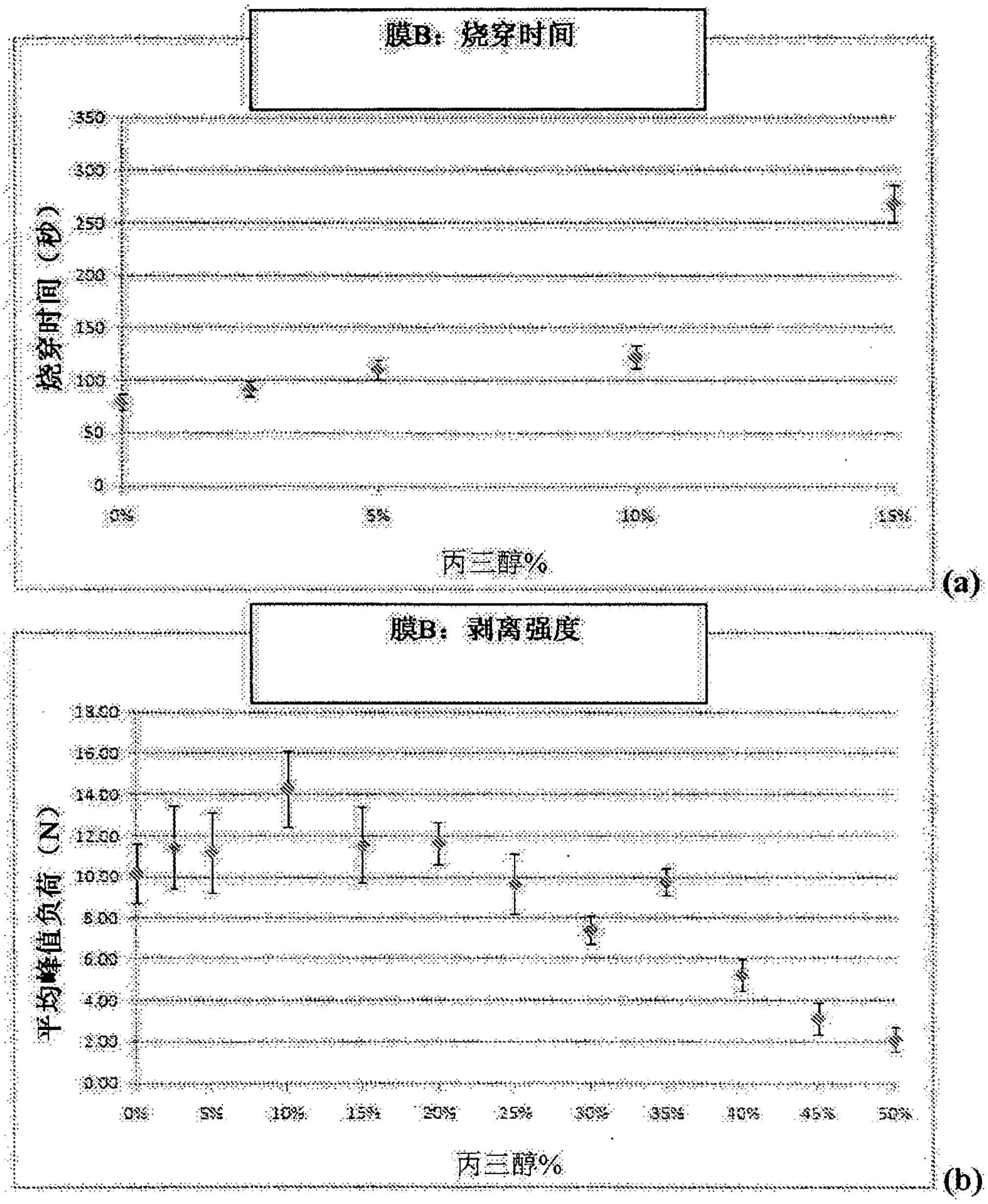

膜B：烧穿时间
烧穿时间（秒）
350
300
250
200
150
100
50
0
0%
5%
10%
15%
丙三醇%
(a)
膜B：剥离强度
平均峰值负荷（N）
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
丙三醇%
(b)

图 4

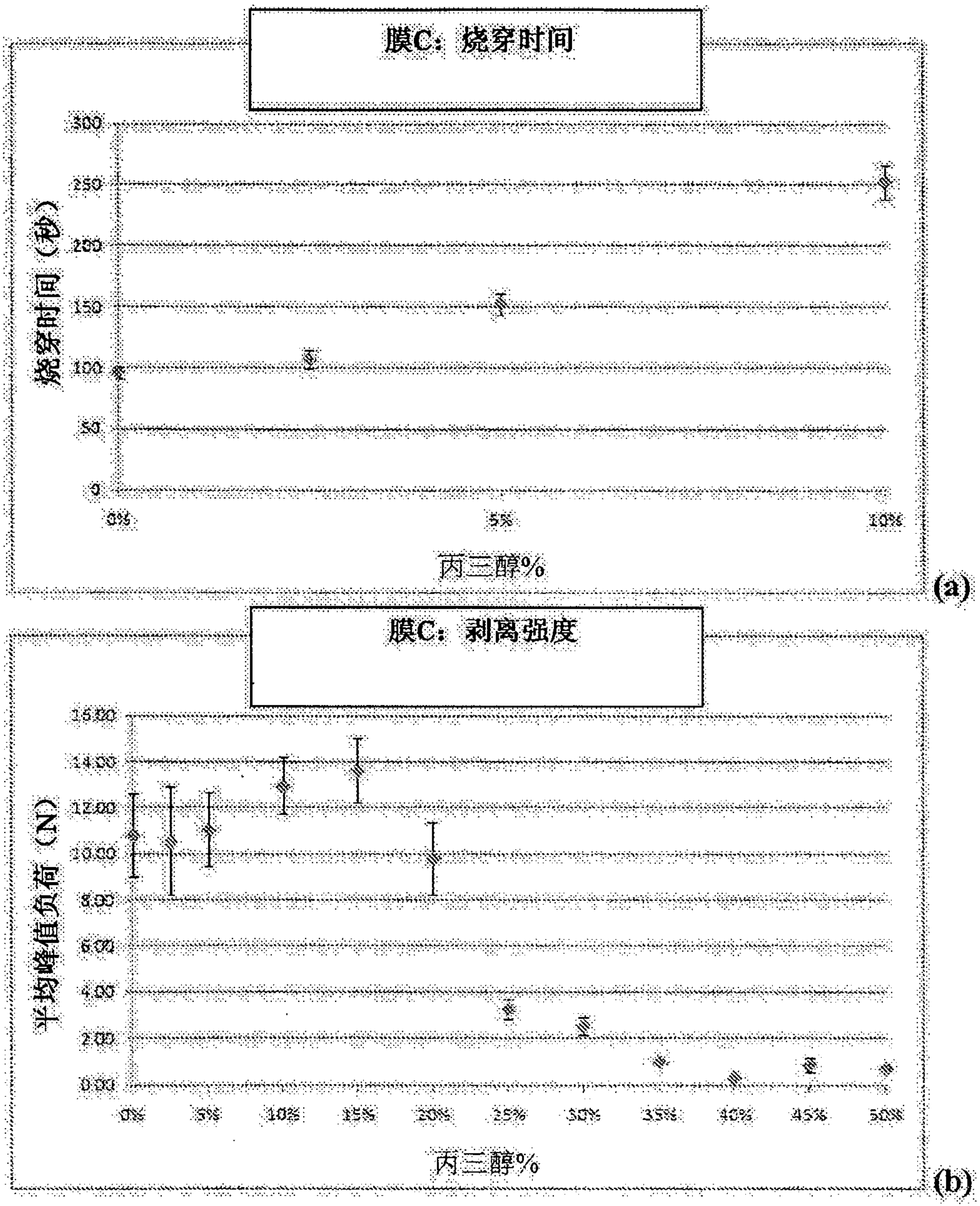

膜C：烧穿时间
烧穿时间（秒）
300
250
200
150
100
50
0
0%
5%
10%
丙三醇%
(a)
膜C：剥离强度
平均峰值负荷（N）
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
丙三醇%
(b)

图 5

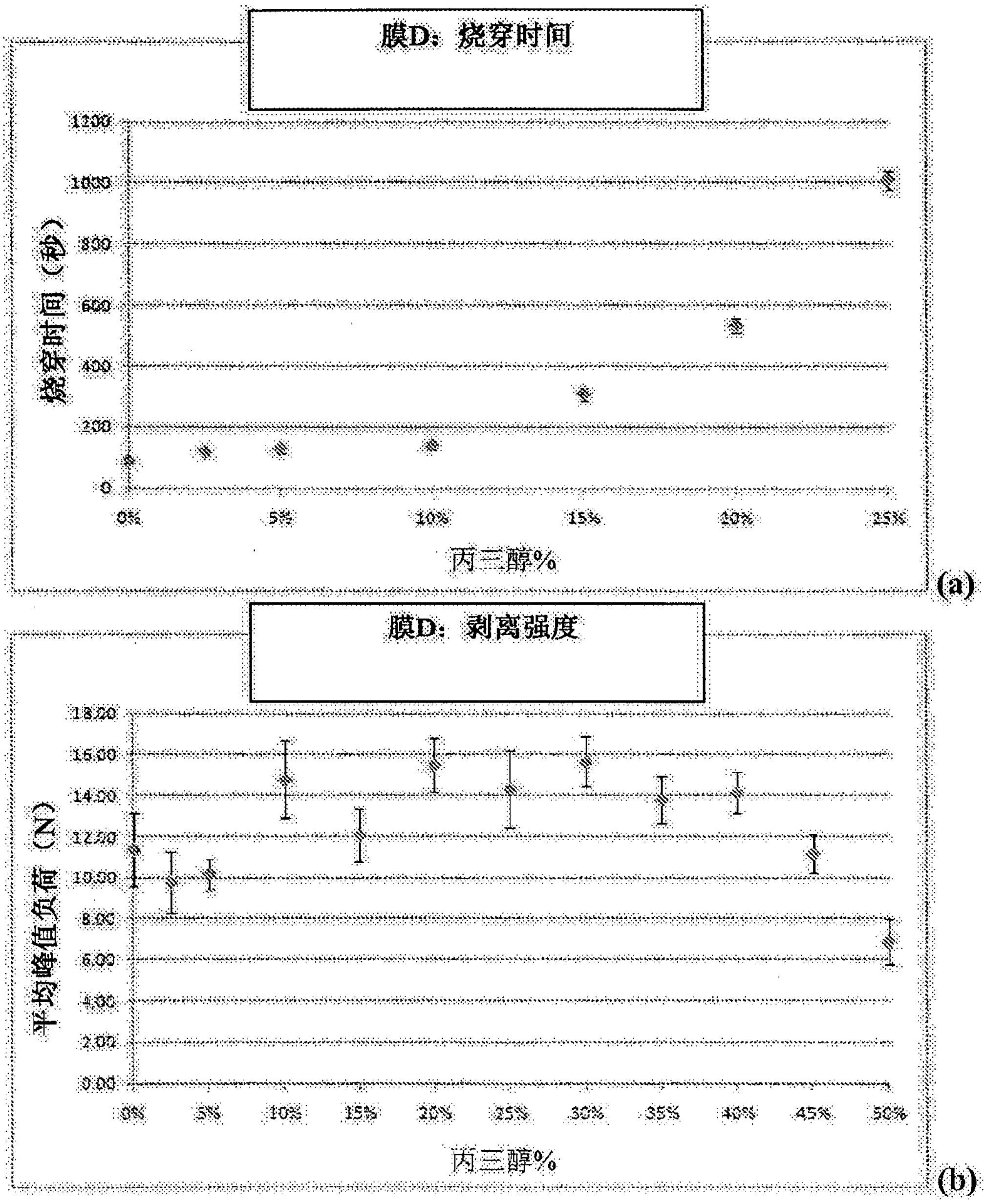

膜D：烧穿时间
1200
1000
800
600
400
200
0
烧穿时间（秒）
0%
5%
10%
15%
20%
25%
丙三醇%
(a)
膜D：剥离强度
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
平均峰值负荷（N）
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
丙三醇%
(b)

图 6

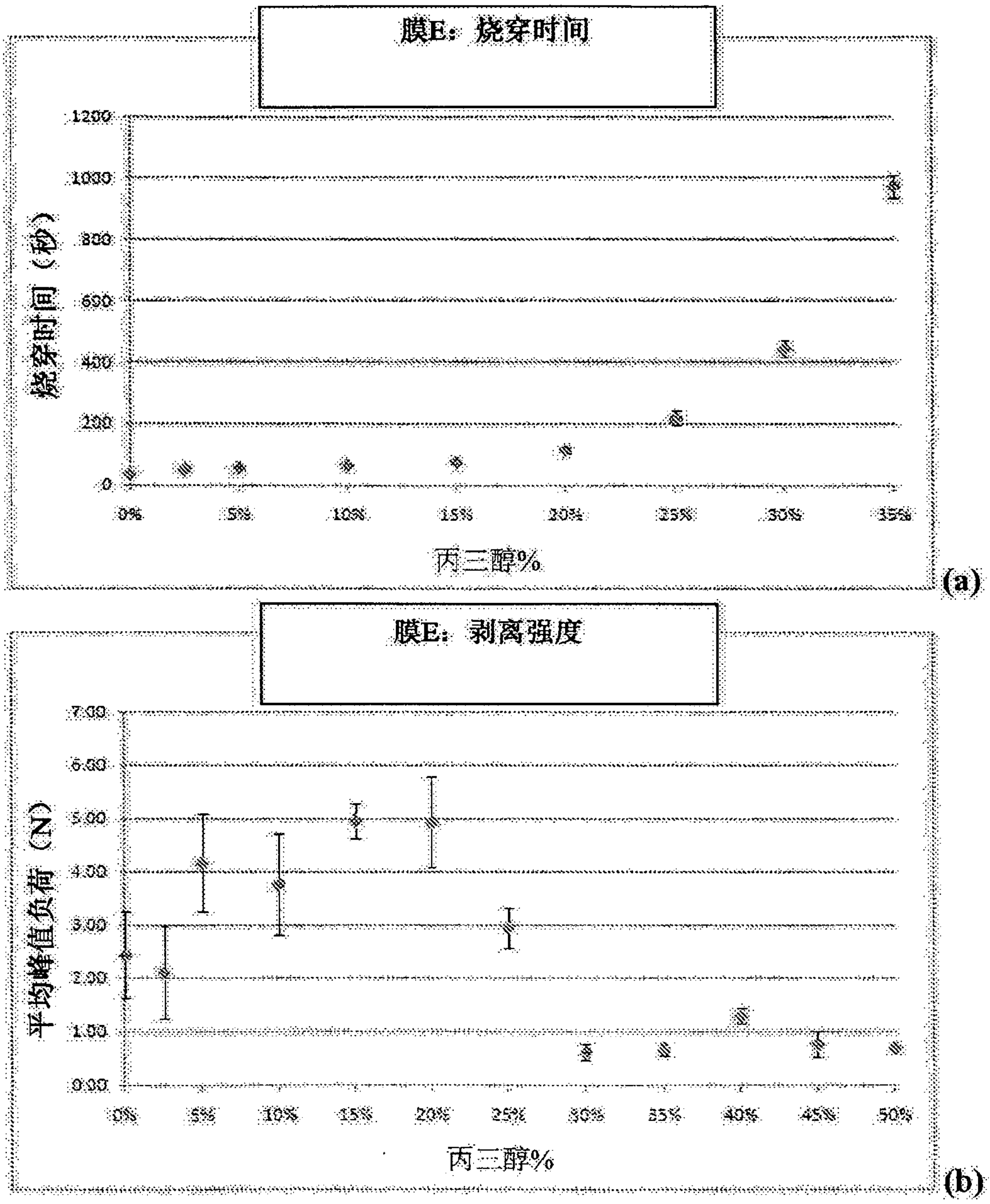

膜E：烧穿时间
烧穿时间（秒）
1200
1000
800
600
400
200
0
0%
5%
10%
15%
20%
25%
30%
35%
丙三醇%
(a)
膜E：剥离强度
平均峰值负荷（N）
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
丙三醇%
(b)

图 7

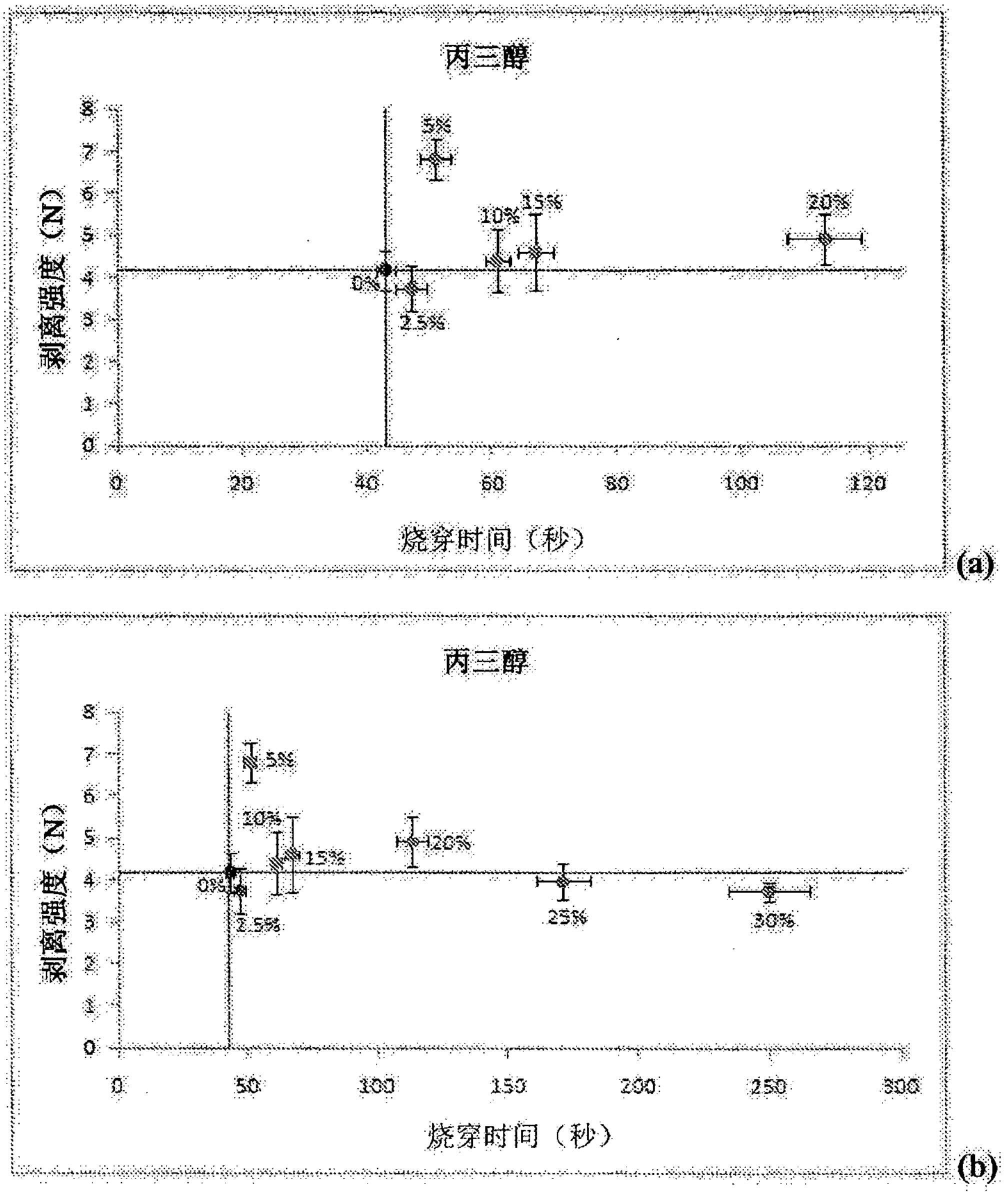
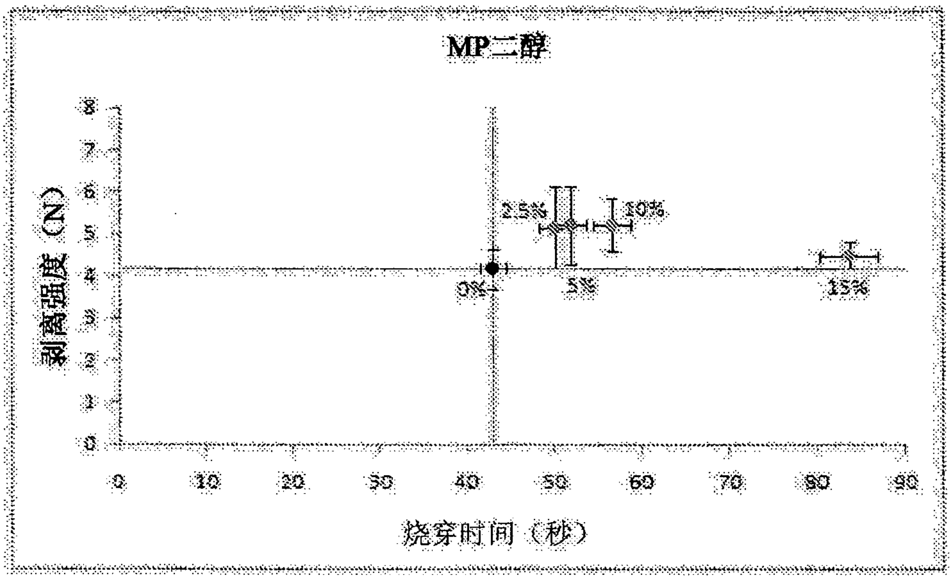
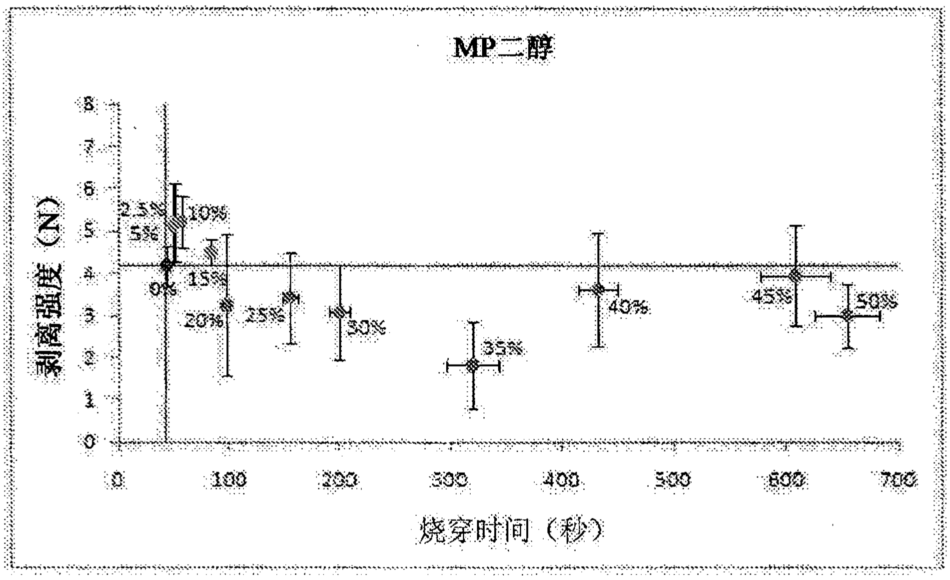

丙三醇
剥离强度（N）
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
烧穿时间（秒）
5%
10%
15%
20%
0%
2.5%
(a)
丙三醇
剥离强度（N）
8
7
6
5
4
3
2
1
0
0
50
100
150
200
250
300
烧穿时间（秒）
5%
10%
15%
20%
0%
2.5%
25%
30%
(b)

图 8


MP二醇
剥离强度（N）
烧穿时间（秒）
0
1
2
3
4
5
6
7
8
0
10
20
30
40
50
60
70
80
90
0%
2.5%
5%
10%
15%

(a)


MP二醇
剥离强度（N）
烧穿时间（秒）
0
1
2
3
4
5
6
7
8
0
100
200
300
400
500
600
700
0%
2.5%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%

(b)

图 9

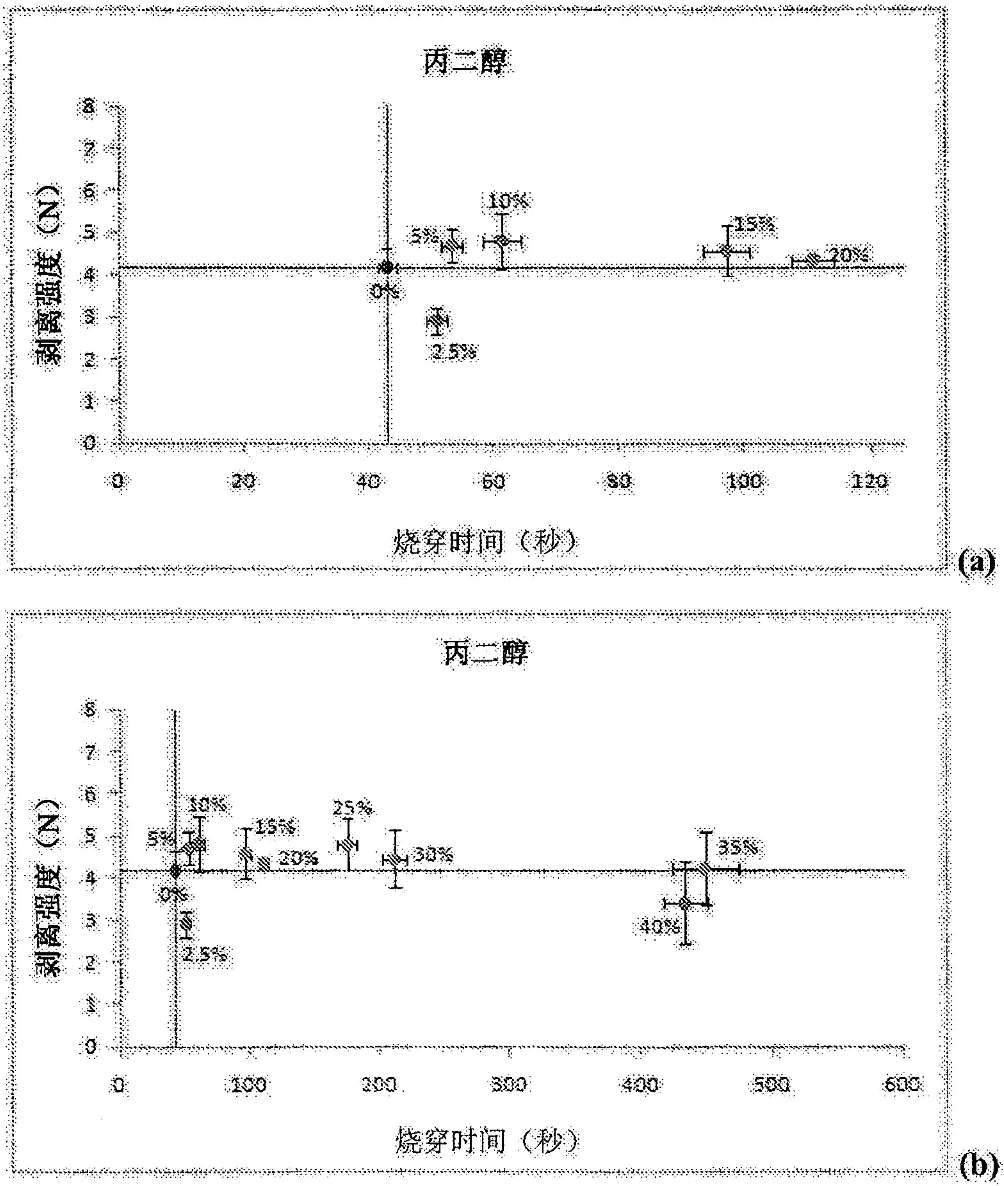

丙二醇
剥离强度（N）
0
1
2
3
4
5
6
7
8
0%
2.5%
5%
10%
15%
20%
0
20
40
60
80
100
120
烧穿时间（秒）
(a)
丙二醇
剥离强度（N）
0
1
2
3
4
5
6
7
8
0%
2.5%
5%
10%
15%
20%
25%
30%
35%
40%
0
100
200
300
400
500
600
烧穿时间（秒）
(b)

图 10

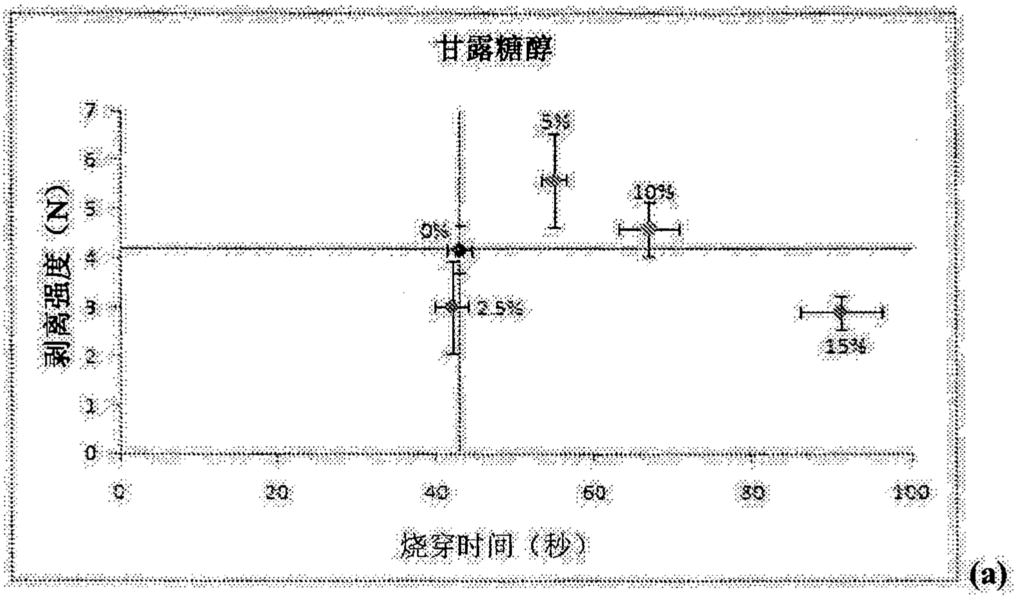


图 11

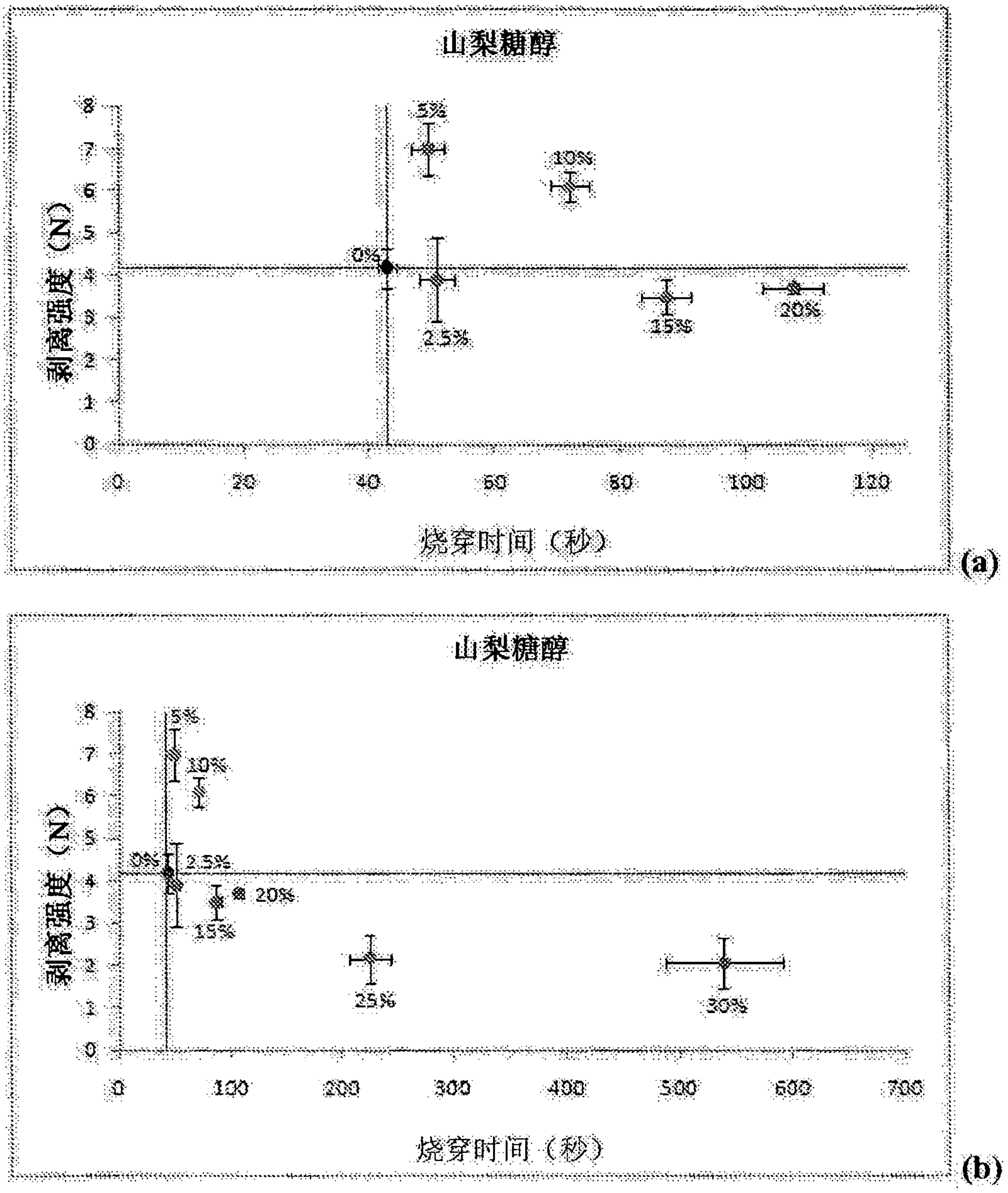

山梨糖醇
剥离强度（N）
烧穿时间（秒）
0
1
2
3
4
5
6
7
8
0
20
40
60
80
100
120
0%
2.5%
5%
10%
15%
20%
(a)
山梨糖醇
剥离强度（N）
烧穿时间（秒）
0
100
200
300
400
500
600
700
0%
2.5%
5%
10%
15%
20%
25%
30%
(b)

图 12

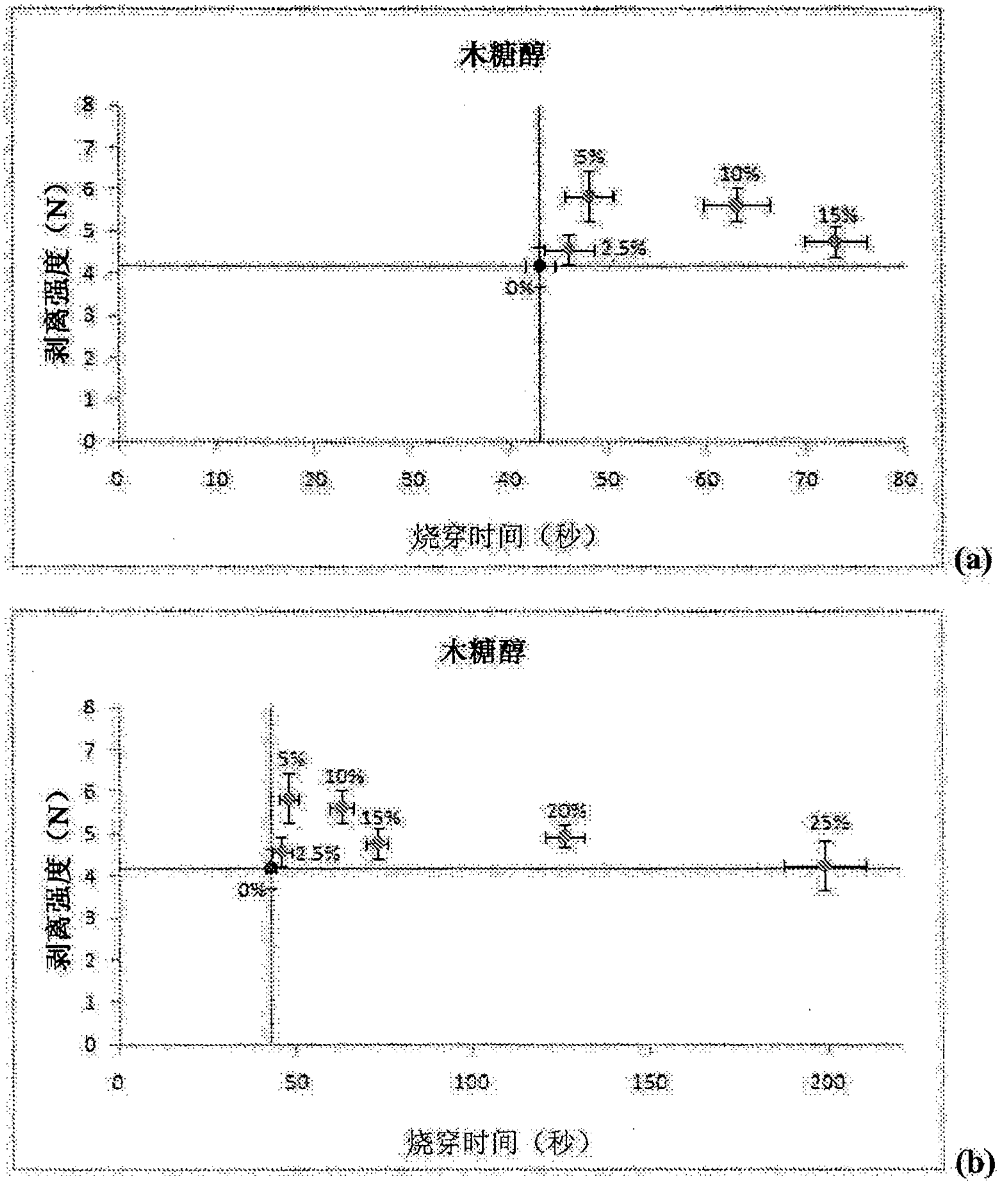

木糖醇
剥离强度（N）
0
1
2
3
4
5
6
7
8
0
10
20
30
40
50
60
70
80
烧穿时间（秒）
0%
2.5%
5%
10%
15%
(a)
木糖醇
剥离强度（N）
0
1
2
3
4
5
6
7
8
0
50
100
150
200
烧穿时间（秒）
0%
2.5%
5%
10%
15%
20%
25%
(b)

图 13

Abstract

Disclosed herein are sealing solutions for sealing water-soluble films, in particular aqueous mixtures including one or more polymeric solvents such as polyols. Aqueous sealing solutions including a relatively dilute solvent for one or more polymeric components of the water-soluble film (e.g., water-soluble polymeric components thereof, such as polyvinyl alcohol (PVOH)) can exhibit one or more benefits, including a reduction in dissolution of the film by the sealing solution and an increase in seal strength. Also disclosed are sealed articles formed with the sealing solutions, for example water-soluble packets containing various liquid or solid compositions.