



(51) International Patent Classification:

C08J 5/18 (2006.01)

(21) International Application Number:

PCT/IL2024/050744

(22) International Filing Date:

28 July 2024 (28.07.2024)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

63/517,181 02 August 2023 (02.08.2023) US

(71) Applicant: SOLUTUM TECHNOLOGIES LTD [IL/IL];

8 Haharash Street, 6761304 Tel Aviv (IL).

(72) Inventors: DANZIGER, Oded; 25 Givati St., 5223254

Ramat Gan (IL). MOSHE DAVID, Yarden; 40 Hadagan

St., 1833340 Afula (IL). BEN ZVI BECHLER, Regev;

34/2 Aharon Eisenberg Street, 7628811 Rehovot (IL). DE-

RAWE, Moanes; P.O. 366, 2490800 Kfar Yassif (IL).

(74) Agent: BENSHAFRUT, Ronnie et al.; SELIGSOHN

GABRIELI BENSHEFRUT, Toyota Tower (B) / 67 Yigal

Alon St., 6744317 Tel-Aviv (IL).

(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, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, 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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every

kind of regional protection available): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, 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, ME, 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))

(54) Title: STRETCH FILMS

(57) Abstract: The technology concerns stretch films formed of PVOH based compositions.



STRETCH FILMS

TECHNOLOGICAL FIELD

The invention generally contemplates compositions for manufacturing stretch films and uses thereof.

BACKGROUND OF THE INVENTION

Polymeric stretch films frequently used as wrapping materials for a variety of products are typically very thin, yet exhibiting a high degree of stretchability, tear and puncture resistance. Current standard high performance stretch films are mainly based on virgin plastic materials, such as linear low-density polyethylene (LLDPE). While trying to reduce negative effects of such materials in the abundance of wrapping materials used in different industries, alternative renewable materials are more often used, improving recyclability of the products, and enabling to achieve thinner and lighter films requiring less material.

GENERAL DESCRIPTION

It is a purpose of the technology disclosed herein to provide a novel class of stretch wrapping films having unique compositions that do not only exhibit controlled film stretchability with improved mechanical properties but are also fully biodegradable or water degradable. The stretch films of the invention are single or multilayer films capable of deforming by stretching during use. The stretch films are generally adapted to retain their mechanical properties upon stretching. As will be further discussed below, the stretch films of the invention, irrespective of their structure and material compositions, may be pre-stretched during film production, or may be stretched only upon final use (wrapping). Stretching without tearing or ripping increases the film length by 50 to 400% relative to its length prior to stretching. The increase in length may be selected for specific uses to between 100 and 300% or to between 100 and 200% relative to the initial length.

A composition used for manufacturing a stretch film according to the invention typically comprises one or two preformed compounded materials designated herein Combination A and Combination B. Each of the Combinations is typically provided as a separate compounded form, or as a compounded form comprising both Combinations.

- 2 -

Stretch films may be formed from Combination A and/or Combination B as single layer films of either combination, or as multilayered films. As disclosed herein, stretch films of the invention may have a layered structure such as any of the following:

1. A single layer film of Combination A, or a multilayered film comprising a single layer of Combination A;
2. A single layer film of Combination B, or a multilayered film comprising a single layer of Combination B;
3. A single layer film of a mixture of Combination A and Combination B, or a multilayered film comprising a single layer formed of a mixture of Combination A and Combination B;
4. A bilayer film having a layer formed of Combination A and a layer of another polymer such as polypropylene (PP) or polyethylene (PE) or another polymer;
5. A bilayer film having a layer formed of Combination B and a layer of another polymer such as PP or PE or another polymer;
6. A multilayer film having at least one layer formed of Combination A and at least one layer of another polymer such as PP or PE or another;
7. A multilayer film having at least one layer formed of Combination B and at least one layer formed of another polymer such as PP or PE or another;
8. A multilayer film having at least one layer formed of Combination A, at least one layer formed of Combination B;
9. A multilayer film having at least one layer formed of Combination A, at least one layer formed of Combination B and at least one layer formed of another polymer such as PP or PE or another;
10. A multilayer film having at least one layer formed of Combination A and at least one layer formed of a mixture of Combination A and Combination B;
11. A multilayer film having at least one layer formed of Combination B and at least one layer formed of a mixture of Combination A and Combination B;
12. A multilayer film having at least one layer formed of Combination A, at least one layer formed of Combination B and at least one layer formed of a mixture of Combination A and Combination B; and
13. A multilayer film having at least one layer formed of Combination A, at least one layer formed of Combination B and at least one layer formed of a mixture

- 3 -

of Combination A and Combination B and at least one layer formed of another polymer such as PP or PE or another.

Based on Combination A and Combination B films of different layer compositions may be formed. As used herein, the term “*film*” refers to a single layered or a multilayered sheet of a material. Where a single layer film is concerned, the terms *layer* and *film* may have the same meaning. Where multilayered films are concerned, each individual sheet of a material that are stacked together to form the multilayered film is referred to as a *layer*.

Films of the invention may be simply designated based on their layer structure and composition; a layer formed of Combination A is designated “A”, a layer formed of Combination B is designated “B”, a layer formed of mixture of Combination A and Combination B is designated “A+B”, a layer formed of a different polymeric material is designated “X”, wherein each layer is separated from another by “/”. Using such a designation, films of the invention may be designated as follows: X/A, X/A/X, X/X/A, X/B, X/B/X, X/X/B, X/A/B, A/X/A, B/A/B/A, A/B/A/B, A+B/A/B, A/A+B/B, and any other combination of A, B, X and A+B. Using Combination A, Combination B and other compositions of the invention provide films that are not restricted in the number of layers, nor restricted in the order of layers in the film.

As further exemplified below, a layer formed of a mixture of compounded Combination A and compounded Combination B (A+B) may be a mixture wherein the weight ratio of Combination A to Combination B ranges between 100:1 to 1:100 A:B. In some embodiments, the ratio between the two Combinations may be between 5:1 and 1:5 or may be 1:1.

As used herein, Combination A and Combination B are each material compositions or compounded compositions defined as follows:

Combination A: comprising partially hydrolyzed polyvinyl alcohol (PVOH) having a degree of hydrolysis from 86 to 90%, at least one plasticizer and optionally at least one additive, wherein the total amount of the at least one plasticizer in the Combination A is 30wt% or less, or is between 5 and 30wt%, or between 7 and 30wt%, or between 5 and 10wt%;

and/or

Combination B: comprising at least two polyvinyl alcohol (PVOH) grades selected from the following PVOH grades:

- 4 -

(i) Grade (1): partially hydrolyzed grades having a degree of hydrolysis from 86 to 90% and a degree of polymerization (DP) of between 300 and 2000, or between 500 and 1400, e.g., 500, 800, or 1400,

(ii) Grade (2): medium hydrolyzed grades having a degree of hydrolysis between 91 and 97%, and

(iii) Grade (3): fully hydrolyzed grades having a degree of hydrolysis from 98% to >99% (or 100%) and a degree of polymerization of between 300 and 2000, or 500 and 1700, e.g., 1700; and at least one plasticizer (which is optionally present in an amount not exceeding 30wt%).

Typically, compositions and products of the invention do not include a crosslinking agent. While in some cases, a crosslinking agent may be used to modify certain characteristics of the products, a crosslinking agent is not generally required. Compositions of the invention may be further free of ethylene-polyvinyl alcohol copolymer (E-PVA).

Additionally, in some cases, the compounded compositions are free of water, or have a water content that is below 1wt% or below 0.5wt%. While the compositions formulated prior to compounding may include up to 5wt% water, the water content is reduced during compounding to the levels indicated.

In a first of its objects, the invention provides a composition for use in a method of forming a stretchable PVOH film, the composition being selected from Combination A and/or Combination B, wherein:

Combination A: comprising a partially hydrolyzed polyvinyl alcohol (PVOH) having a degree of hydrolysis from 86 to 90%, at least one plasticizer and optionally at least one additive, wherein the total amount of the at least one plasticizer in the Combination A is 30wt% or less, or between 5 and 30wt%, or between 7 and 30wt%, or between 5 and 10wt%;

and/or

Combination B: comprising at least two polyvinyl alcohol (PVOH) grades selected from the following PVOH grades:

(i) Grade (1): partially hydrolyzed grades having a degree of hydrolysis from 86 to 90% and a degree of polymerization (DP) of between 300 and 2000, or between 500 and 1400, e.g., 500, 800, or 1400,

- 5 -

(ii) Grade (2): medium hydrolyzed grades having a degree of hydrolysis between 91 and 97%, and

(iii) Grade (3): fully hydrolyzed grades having a degree of hydrolysis from 98% to >99% (or 100%) and a degree of polymerization of between 300 and 2000, or 500 and 1700, e.g., 1700; and at least one plasticizer.

The invention further provides a polymeric composition for forming a stretchable PVOH film, the composition being selected from:

-a composition (herein referred to as Combination A) comprising a partially hydrolyzed polyvinyl alcohol (PVOH) having a degree of hydrolysis from 86 to 90%, at least one plasticizer and optionally at least one additive, wherein the total amount of the at least one plasticizer in the formulation is 30wt% or less, or between 5 and 30wt%, or between 7 and 30wt%, or between 5 and 10wt%;

-a composition (herein referred to as Combination B) comprising at least two Polyvinyl alcohol (PVOH) grades selected from the following PVOH grades:

(i) Grade (1): partially hydrolyzed grades having a degree of hydrolysis from 86 to 90% and a degree of polymerization (DP) of between 300 and 2000, or between 500 and 1400, e.g., 500, 800, or 1400,

(ii) Grade (2): medium hydrolyzed grades having a degree of hydrolysis between 91 and 97%, and

(iii) Grade (3): fully hydrolyzed grades having a degree of hydrolysis from 98% to >99% (or 100%) and a degree of polymerization of between 300 and 2000, or 500 and 1700, e.g., 1700; and

at least one plasticizer;

-a composition comprising one or two or more polyvinyl alcohol (PVOH) grades selected from the following PVOH grades:

(i) Grade (1): partially hydrolyzed grades having a degree of hydrolysis from 86 to 90% and a degree of polymerization (DP) of between 300 and 2000, or between 500 and 1400, e.g., 500, 800, or 1400,

(ii) Grade (2): medium hydrolyzed grades having a degree of hydrolysis between 91 and 97%, and

(iii) Grade (3): fully hydrolyzed grades having a degree of hydrolysis from 98% to >99% (or 100%) and a degree of polymerization of between 300 and 2000, or 500 and 1700, e.g., 1700; and

- 6 -

at least one plasticizer in a maximum amount of 30wt%, or between 5 and 30wt%, or between 7 and 30wt%, or between 5 and 10wt%.

The invention further comprising a compounded polymeric material formed by compounding a composition selected from:

-a composition (herein referred to as Combination A) comprising partially hydrolyzed polyvinyl alcohol (PVOH) having a degree of hydrolysis from 86 to 90%, at least one plasticizer and optionally at least one additive, wherein the total amount of the at least one plasticizer in the formulation is 30wt% or less, or between 5 and 30wt%, or between 7 and 30wt%, or between 5 and 10wt%;

-a composition (herein referred to as Combination B) comprising at least two polyvinyl alcohol (PVOH) grades selected from the following PVOH grades:

(i) Grade (1): partially hydrolyzed grades having a degree of hydrolysis from 86 to 90% and a degree of polymerization (DP) of between 300 and 2000, or between 500 and 1400, e.g., 500, 800, or 1400,

(ii) Grade (2): medium hydrolyzed grades having a degree of hydrolysis between 91 and 97%, and

(iii) Grade (3): fully hydrolyzed grades having a degree of hydrolysis from 98% to >99% (or 100%) and a degree of polymerization of between 300 and 2000, or 500 and 1700, e.g., 1700; and

at least one plasticizer;

-a composition comprising one or two or more polyvinyl alcohol (PVOH) grades selected from the following PVOH grades:

(i) Grade (1): partially hydrolyzed grades having a degree of hydrolysis from 86 to 90% and a degree of polymerization (DP) of between 300 and 2000, or between 500 and 1400, e.g., 500, 800, or 1400,

(ii) Grade (2): medium hydrolyzed grades having a degree of hydrolysis between 91 and 97%, and

(iii) Grade (3): fully hydrolyzed grades having a degree of hydrolysis from 98% to >99% (or 100%) and a degree of polymerization of between 300 and 2000, or 500 and 1700, e.g., 1700; and

at least one plasticizer in a maximum amount of 30wt%, or between 5 and 30wt%, or between 7 and 30wt%, or between 5 and 10wt%.

The PVOH used in compositions and products of the invention may be made by saponification of polyvinyl acetate homopolymers or copolymers or which may be synthetically or semi-synthetically produced. The PVOH may be of any grade, degree of hydrolysis and molecular weight, unless otherwise specifically indicated. The PVOH used in compositions of the invention are typically un-crosslinked PVOH and the PVOH may be selected amongst such water-soluble materials comprising predominantly fully, partially or sub-partially hydrolyzed vinyl organic ester polymers, which are not internally associated or linked. In some embodiments, formulations and products of the invention exclude crosslinked PVOH.

The PVOH may be provided as a single grade of PVOH or a combination of grades. The PVOH may be typically selected amongst hydrolyzed PVOH having a degree of hydrolysis ranging between 86 and 99%. The PVOH may alternatively or additionally be selected amongst such having a degree of polymerization ranging between 500 and 3,000.

The PVOH may be a partially hydrolyzed PVOH with a degree of polymerization between 300 and 2,000. In some embodiments, the PVOH may be selected to have a degree of polymerization between 800 and 1400 or a molecular weight between 30 KDa and 70 KDa or a molecular weight between 35KDa and 62KDa.

In some embodiments, the PVOH may be selected amongst PVOH having a degree of hydrolysis between 98 and 99% and a degree of polymerization of between about 800 and 1,700; a degree of hydrolysis between 86 and 89% and a degree of polymerization of between about 1400 and 2,600; and a degree of hydrolysis between 86 and 89% and a degree of polymerization of between 500 and 800.

In some embodiments, the PVOH may be selected amongst one or more of the grades (1), (2) and (3):

Grade (1): partially hydrolyzed grades having a degree of hydrolysis from 86 to 90% and a degree of polymerization (DP) of between 300 and 2000, or between 500 and 1400, e.g., 500, 800, or 1400,

Grade (2): medium hydrolyzed grades having a degree of hydrolysis between 91 and 97%, and

Grade (3): fully hydrolyzed grades having a degree of hydrolysis from 98% to >99% (or 100%) and a degree of polymerization of between 300 and 2000, or 500 and 1700, e.g., 1700.

The amount of the PVOH used may be between 40 and 90 wt% (relative to the total weight of the composition). In some embodiments, the amount of the PVOH is between 40 and 90, 50 and 90, 70 and 90, 40 and 85, 40 and 80, 40 and 75, 40 and 70, 40 and 65, 40 and 60, 40 and 55, 40 and 50, 40 and 45, 45 and 90, 45 and 85, 45 and 80, 45 and 75, 45 and 70, 45 and 65, 45 and 60, 45 and 55, 50 and 90, 50 and 85, 50 and 80, 50 and 75, 50 and 65, 50 and 60, 60 and 90, 60 and 80, 70 and 90, or between 80 and 90 wt%.

The PVOH used in Combination A is typically of low hydrolysis, namely having a degree of hydrolysis between 86-90%. In some embodiments, the PVOH is of a grade having low hydrolysis and degree of polymerization that is 800, or which does not exceed 1400. In other words, the PVOH used in Combination A, is not one having a degree of polymerization of 1400 and higher.

The “*plasticizer*” present in compositions or products of the invention is one or more of such compounds used to increase fluidity or plasticity of the polymeric formulations. The at least one plasticizer is selected amongst such materials capable of reducing the glass transition temperature and/or melting point of the polymeric composition under melt extrusion. Without wishing to be bound by theory, the plasticizer used may also decrease the melt viscosity of the melted composition, tensile strength, hardness, density and increase parameters such as elongation at break, toughness and dielectric constant.

The at least one plasticizer used is generally compatible with PVOH, is stable under hot melt extrusion conditions and is sufficiently lubricating and stable in the final compounding product and stretchable film. The at least one plasticizer may be one or more plasticizer selected from sorbitol, maltitol, mannitol, glycerol, erythritol, propylene glycol, dipropylene glycol, triethylene glycol, tetraethylene glycol (TEG), triethanolamine (TEA), trimethylol propane, penta-erythritol, dipentaerythritol, dibutyl sebacate (DBS), polyglyceryl-4 laurate, ditrimethylol propane, urea, diglycerol, xylitol, acetyltributyl-citrate (ATBC), polyethylene glycol, triethylcitrate, vitamin E TPGS (d- α -tocopherol peg-1000 succinate), ethylene glycol, diethylene glycol, 1,2,4-butanetriol, epoxidized soy bean oil, ethoxylated glycerol epoxidized soy bean oil, and others.

In some embodiments, the at least one plasticizer is glycerol, sorbitol, a propylene glycol, a polyethylene glycol, and the like, and any combination thereof. In some embodiments, the at least one plasticizer is glycerol and/or sorbitol.

Typically, the amount of the plasticizer may depend on the nature of the plasticizer and the total amount of plasticizers needed. Where a single plasticizer is used in the composition, i.e., in either Combination A or Combination B, the amount of the plasticizer may be at least 10wt% and in some embodiments may not exceed 30 wt% or may not exceed 20wt%. Where two or more plasticizers are present, each may be present in an amount which together does not exceed 30 wt%. In other words, where two or more plasticizers are present, the amount of each may be between 5 and 15wt%, to a total amount of 30wt%. In some embodiments, the total amount may thus be between 10 and 30wt%.

In embodiments wherein a film of the invention is formed from both Combination A and Combination B, each comprising a plasticizer, the plasticizers may be same or different. Where the plasticizers are same, the total plasticizer amount may be between 7 and 20wt%. where the plasticizers are different, the amount of each may be between 5 and 15wt% to a total amount of 30wt%.

In cases where two or more plasticizers are used, each may be selected independently of the other or may be selected to be compatible with the other.

In some embodiments, the amount of the at least one plasticizer in either Combination A or Combination B is between 5, 7 or 10wt% and 30wt%. In some embodiments, the at least one plasticizer is a single plasticizer present at an amount of between 10 and 20wt%. In some embodiments, the at least one plasticizer is two or more plasticizers, each being present at an amount of between 10 and 20wt%, provided that the composition/combination is present at an amount not exceeding 30wt%.

In some embodiments, the at least one plasticizer is or comprises glycerol. In some embodiments, the at least one plasticizer is a combination of glycerol and sorbitol. In some embodiments, the amount of the sorbitol and the glycerol combined is below 30wt%, and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1. In some embodiments, the weight ratio sorbitol:glycerol, independent from their total amount or relative amount of each, is 1:1, 1:2, 1:3, 3:1, 2:1 or any ratio therebetween.

In some embodiments, the composition, e.g., for use in manufacturing of a stretch polymer or stretch film, comprises Combination A.

In some embodiments, Combination A comprises polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the composition is below 30wt% (or between 10

and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1, or is 1:1, 1:2, 1:3, 3:1, 2:1.

The at least one additive may be selected amongst inorganic additives, fillers or reinforcing agents and from low-molecular weight additives (having a molecular weight below 3000 Da), each selected for improving various properties of a product formed from the composition of the invention. Such additives may include processing aids, slip agents, light stabilizers, UV absorbers, flame retardants, antimicrobial agents, antiviral agents, blowing agents, nucleating agents, antioxidants, antiblocking agents, and others. In some embodiments, the at least one additive is not E-PVA, or a crosslinking agent.

In some embodiments, the additive is a hygroscopic agent, optionally selected from CaO, CaCl₂, LiCl, NaCl, CaI₂, MgCl₂, TiO₂, CaCO₃, alumina silicate fillers, SiO₂ and others. In some embodiments, the additive is CaO.

In some embodiments, the additive is an inorganic salt comprising a metallic or a non-metallic element. In some embodiments, the inorganic salt is an inorganic salt of a metal selected from alkali metals and alkaline metals. In some embodiments, the inorganic salt is a salt of a transition metal.

Non-limiting examples of inorganic salts include halide salts of a metal selected from Li, K, Ca, Na, Mg, Mn, Zn and others.

The inorganic salts may be halide salts (a halide atom being an anion of the metal cation). In some embodiments, the inorganic salt may be selected from LiCl, NaCl, CaCl₂, CaI₂ and MgCl₂. In some embodiments, the inorganic salt is CaCl₂.

In some embodiments, the composition comprises Combination A, namely, in some embodiments, polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the composition is optionally below 30wt%, and wherein a weight ratio sorbitol:glycerol is optionally between 1:3 to 3:1; and further comprises Combination B, namely a composition comprising at least two polyvinyl alcohol (PVOH) grades selected from:

(i) partially hydrolyzed grades having a degree of hydrolysis from 86 to 90% and a degree of polymerization (DP) of between 300 and 2000, or between 500 and 1400, e.g., 500, 800, or 1400,

(ii) medium hydrolyzed grades having a degree of hydrolysis between 91 and 97%, and

(iii) fully hydrolyzed grades having a degree of hydrolysis from 98% to >99% (or 100%) and a degree of polymerization of between 300 and 2000, or 500 and 1700, e.g., 1700;

and at least one plasticizer selected from sorbitol, glycerol, propylene glycol, polyethylene glycol, and combinations thereof.

In some embodiments, Combination B comprises at least two polyvinyl alcohol (PVOH) grades selected from partially hydrolyzed grades having a degree of hydrolysis from 86 to 90% and a degree of polymerization (DP) of between 300 and 2000, e.g., 500, 800, or 1400, and fully hydrolyzed grades having a degree of hydrolysis from 98% to >99% and a degree of polymerization of between 300 and 2000, e.g., 1700; and at least one plasticizer selected from sorbitol, glycerol, propylene glycol, polyethylene glycol, and combinations thereof.

In some embodiments, the at least two PVOH grades may be two or more different PVOH grades, each differing from the other in the degree of hydrolysis and/or degree of polymerization. The grades may differ in their degrees of hydrolysis, in their degree of polymerization and/or a combination of the two.

In some embodiments, the two or more grades may be selected from PVOH polymers having different degrees of polymerization.

In some embodiments, at least one PVOH grade is partially hydrolyzed having a degree of hydrolysis from 86 to 90% and at least one another PVOH grade is fully hydrolyzed having a degree of hydrolysis from 98 and above 99%.

In some embodiments, at least one PVOH grade having a degree of polymerization of between 300 and 2000, e.g., 500, 800, or 1400, and at least one another PVOH grade having a degree of polymerization of between 300 and 2000, e.g., 1700.

In some embodiments, at least one PVOH grade is selected from partially hydrolyzed grades having a degree of hydrolysis from 86 to 90% and a degree of polymerization (DP) of between 300 and 2000, e.g., 500, 800, or 1400, and at least one another PVOH grade is a fully hydrolyzed grade having a degree of hydrolysis from 98% to >99% and a degree of polymerization of e.g., 1700.

The compositions of the invention may be solid compositions or solution-state compositions, typically as flowable compositions or solutions.

In some embodiments, the composition is a compounded formulation.

The invention further provides a polymeric composition comprising:

- 12 -

- a. A compounded material formed of Combination A, as defined herein;
and/or
- b. A compounded material formed of Combination B, as defined herein.

As used herein, the ***compounded*** Combination or compounded material refers to the blending of the composition of Combination A and/or Combination B under conditions which result in a solid compound having a form such as a pellet or other particulate form (such as beads) which may be used in the manufacturing of a final polymeric product, e.g., polymeric films in single layer or multilayer forms. Through the compounding processes, the composition is converted into a form having properties that make the composition more effective, efficient and uniform and ready for further processing through processes including, e.g., molding or extrusion. The pellets may have any shape, but typically are small, columnar, or cylindrical bodies having flat surfaces such as cubes, rectangular parallelepipeds, etc. The pellets are formed from a homogeneous mixture of the composition of the invention processed as disclosed herein.

Thus, the invention further provides a compounded form of Combination A and/or Combination B, the compounded form may be a pellet or a solid material (e.g., beads).

In some embodiments, the pellet obtained by compounding a composition of the invention comprises crosslinked PVOH, wherein crosslinking comprises crosslinking between PVOH chains; between PVOH and the softening agent, e.g., glycerol; between PVOH, the softening agent and (other) polymers; between the softening agent and the other polymers or any other components present in the composition.

In some embodiments, compounding comprises thermally treating a composition of the invention (Combination A and/or Combination B) to cause one or more of:

- blending of the PVOH, plasticizer and optionally at least one additive;
- plasticization of PVOH forming hydrogen bonds between PVOH and the softening agent, e.g., glycerol;
- crosslinking between the PVOH and/or other ingredients as mentioned above;
and/or
- volatilization of water or other low-boiling point components.

The invention further provides a process of manufacturing a pellet from a composition of the invention, the process comprising compounding the composition under conditions selected to convert the composition into a solid particular material.

In some embodiments, the conditions include converting the composition into a molten state, further causing evaporation or partial evaporation of volatiles. The compounding may thus be carried out by extrusion, e.g., on an extruder such as a twin-screw extruder.

In some embodiments, the twin-screw extruder is a co-rotating or counter-rotating extruder.

In some embodiments, compounding comprises use of a kneader and/or a mixer.

In some embodiments, the compounding is achievable by heating the composition, followed by exposing the melt to a rapid decompression. In some embodiments, the compounding may be carried out on a twin-screw extruder equipped with a devolatilization system suited for causing unreacted monomers, solvent, water, dissolved gases, or other undesirable volatile materials to be removed from a polymer melt.

Pellets or solid particulate materials formed by compounding compositions of the invention may be used in manufacturing of a polymeric object, e.g., polymeric films or sheets, by further processing the pellet or solid particulate material by, e.g., molding or extrusion. Thus, in another aspect of the invention, there is provided use of a composition of the invention for manufacturing a polymeric product, such as a polymeric film or a polymeric sheet.

The invention further provides a process of manufacturing a PVOH film or a PVOH multilayer film, wherein the process comprises transforming, e.g., by molding or extruding, a compounded form of a PVOH composition (Combination A and/or Combination B) of the invention into the film.

In some embodiments, the process comprises extruding a compounded form of a composition of the invention.

In some embodiments, the compounded form of the composition is a pelletized form.

In some embodiments, the pelletized form is obtained by compounding as disclosed herein. In some embodiments, compounding is carried out by converting the composition into a molten state, further causing evaporation or partial evaporation of volatiles. The compounding may be carried out by extrusion, e.g., on an extruder such as a twin-screw extruder. In some embodiments, the twin-screw extruder is a co-rotating or counter-rotating extruder. In some embodiments, compounding comprises use of a

kneader and/or a mixer. In some embodiments, the compounding is achievable by heating the composition to obtain a melt, followed by exposing the melt to rapid decompression. In some embodiments, the compounding may be carried out on a twin-screw extruder equipped with a devolatilization system suited for causing unreacted monomers, solvent, water, dissolved gases, or other undesirable volatile materials to be removed from a polymer melt.

In some embodiments, the process of manufacturing a polymeric product such as a film or a sheet, comprises compounding a composition of the invention into a pellet form and transforming, e.g., by molding or extruding the pellet form, into the polymeric product.

In some embodiments, the process comprises:

- providing a composition according to the invention;
- compounding said composition into a pellet; and
- transforming the pellet into the polymeric product.

Depending on the size and shape of the polymeric product, a proper technique may be utilized. Where the product is a film or a sheet, the transformation may comprise blown film extrusion or cast film extrusion.

In some embodiments, the films or sheets are manufactured by blown film extrusion. In the process, the compounded material of the invention, often in form of pellets or beads, is loaded into a hopper and fed into a heated barrel with a screw. The pellets are gradually heated to melt the polymer, when the molten material is subsequently extruded through a die. Different dies may be used; one such die is an annular die or a ring-shaped die. The molten polymer enters the die head and air is injected via a hole in the die center to radially inflate the polymer into a thin tube that is many times its extruded diameter. The film thickness and width may be adjusted in order to meet a desired film profile. Following extrusion, the hot tube film is cooled and pulled by, e.g., nip rollers. As the film cools, it flattens and is transported for further processing.

The blown film extrusion process may be used to produce a wide variety of products, ranging from simple mono- or single-layer films to bilayers and higher complex multilayer structures for use in a variety of industries, e.g., in food packaging.

Multilayer films may similarly be manufactured by blown film coextrusion that combines two or more molten polymer materials.

In some embodiments, the films are manufactured by cast film extrusion process, whereby differently from the blown extrusion process, the molten polymer is fed through a flat die system to adopt its final flat film shape. For coextrusion, a die system may comprise a die and a feedblock and for a monolayer extrusion a flat die may be used.

The orientation of the polymer film may be determined or modified by a tenter frame, a double bubble or machine direction orientation.

Once formed, the films can be further modified by roll slitting, coating and/or printing. Films can also be subjected to corona treatment or plasma processing and can have release agents applied as desired.

In some embodiments, the extruded films are oriented while being stretched.

Each of the compositions of the invention may be used separately or in combination for manufacturing a stretch polymer sheet or film. Typically, each of the compositions herein designated Combinations A and B may be transformed into a compounded form by a method generally comprising a step of mixing the material combination under suitable conditions and a step of compounding the mixture. In a process of manufacturing a stretch film, one or both Combinations A and B or compounded forms thereof may be utilized. In some embodiments, a general process of manufacturing comprises obtaining either Combination, compounding the Combination(s) and extruding the compounded form into a polymeric sheet that may be stretched prior to during use, as further disclosed herein.

The stretch film may be a single layer film, or a standalone film formed of Combination A and/or Combination B or compounded forms thereof. In other cases, the stretch film may be a multilayer stretch film which comprises two or more films, at least one of which being formed of Combination A and/or Combination B or compounded forms thereof.

In some embodiments, the stretch film is a single layer film, or a standalone film formed of Combination A or Combination B or a compounded form of either Combination.

In some embodiments, the stretch film is a multilayer stretch film comprising at least one layer or film of a material Combination A and/or B, as disclosed herein, or compounded forms thereof, and one or more layers or films of a different material, e.g., polymeric material.

- 16 -

In some embodiments, the multilayer is arranged such that the at least one layer or film of a material Combination A and/or B, as disclosed herein, or compounded forms thereof is an exterior layer or arranged between two exterior layers. The exterior layers may be skin layers of a material or may be arranged as substrate layers for positioning of further layer(s).

Generally speaking, the at least one layer or film of a material Combination A and/or B, as disclosed herein, or compounded forms thereof may be a layer of material Combination A or a compounded form thereof, or a film of a material Combination B or a compounded form thereof. In some arrangements of the multilayer, the at least one layer may be two or more layers such that one of the two or more layers is a layer formed of Combination A or a compounded form thereof, and another of said two or more layers is a film of a material Combination B or compounded forms thereof.

Thus, the invention further provides a stretch film formed of a compounded material combination comprising polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1.

The invention further provides a stretch film arranged or provided as a multilayer comprising two or more material layers, at least one of said material layers comprising a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1.

The invention further provides a stretch film arranged or provided as a multilayer comprising two or more material layers, wherein:

- at least one of said material layers is formed of a compounded Combination A, as defined herein; and wherein

- at least another of said material layers is formed of a compounded Combination B, as defined herein.

A multilayer stretch film according to the invention may be a coextruded multilayer blown film comprising at least three layers: at least one layer of a polymeric or non-polymeric material and two or more layers, each being selected independently from Combination A and Combination B.

A multilayer stretch film according to the invention may be a coextruded multilayer blown film alternatively comprising at least three layers: at least one layer of a polymeric or non-polymeric material and two or more layers, each being selected independently from:

- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1;

- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%);

- a compounded combination of at least two PVOH grades, as defined and selected herein; and

- a compounded combination of Combination A and Combination B combined.

According to some embodiments, the multilayer stretch film comprises from 2 to 20 layers, wherein at least one of the layers is a layer formed of a compounded Combination according to the invention. The multilayer may be of the form A/B, A/B/A, B/A/B, A/A+B/B...etc. The multilayer may comprise one or more additional material layers of polymers of a variety of compositions. Such additional layers may be layers formed of a mixture of A and B, as defined hereinabove. Additional layers made of polymeric materials other than PVOH may also be included. Such layers may be formed (e.g., by co-extrusion) from compositions comprising or consisting PP, PE, PET, polyesters, and others.

Stretch films of the invention may be used in a variety of applications, including for example waste wrap films and pallet stretch wrap films. Also, a stretch film of the invention may be used as an agricultural stretch wrap film, or a bale wrap film.

In most general terms, a stretch film of any configuration according to the invention may be produced by conventional means, including for example cast extrusion or blow extrusion. A multilayer film may be similarly produced by conventional means, including for example co-extrusion. In some cases, a multilayer film may be produced by co-extrusion from two or more extruders, each extruder being designated to extrude an extrudable composition that is to form one of the layers. The layers may be composed of different compositions.

- 18 -

The invention further provides a process for producing a multilayer stretch film, the process comprising extruding a first compounded composition to form a first layer of the multilayer stretch film and extruding a second compounded composition on a face of said first layer of the multilayer stretch film, wherein each of the first and second compounded compositions is different and selected from

- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1;

- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%);

- a compounded combination formed of Combination B; and

- a compounded combination formed of Combination A and Combination B.

In some embodiments, the first compounded composition is formed of

- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1; or

- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%).

In some embodiments, the second compounded composition is formed of

- a compounded combination formed of Combination B; or

- a compounded combination of Combination A and Combination B.

In some embodiments, the process comprising providing a first compounded combination selected from:

- 19 -

- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1;

- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%);

- a compounded combination formed of Combination B; and

- a compounded combination formed of Combination A and Combination B.

In some embodiments, the process comprises providing a second compounded composition being different from the first compounded composition and selected from:

- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1;

- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%);

- a compounded combination formed of Combination B; and

- a compounded combination formed of Combination A and Combination B.

In some embodiments, the process comprising

- providing a first compounded composition selected from:

- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1;

- 20 -

- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%);
 - a compounded combination formed of Combination B; and
 - a compounded combination formed of Combination A and Combination B;
- providing a second compounded composition being different from the first compounded composition and selected from:
- a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1;
 - a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%);
 - a compounded combination formed of Combination B; and
 - a compounded combination formed of Combination A and Combination B;
- extruding the first compounded composition to form a first layer of the multilayer stretch film and extruding the second compounded composition on a face of said first layer of the multilayer stretch film.
- In some embodiments, the process comprising extruding a further composition to form a third layer of the film.
- In some embodiments, the process further comprises stretching the multilayer stretch film so that the film length increases by 50 to 500%.
- The process may further comprise slightly stretching the film to obtain a pre-stretched film. In some embodiments, the multilayer stretch film is stretched to increase the film length by 50 to 400%, 100 to 300%, 100 to 200%.

Films of the invention are stretchable to a length that is between 50 and 400% greater than a length of the film prior to stretching. The increase in length may be by 50, 100, 150, 200, 250, 300, 350 or 400 % relative to the initial length.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to better understand the subject matter that is disclosed herein and to exemplify how it may be carried out in practice, embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which:

Figs. 1A-C depict different film configurations according to embodiment of the invention.

Figs. 2A-D show tensile and elongation results measured for films of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS

Film Properties:

Stretch films of the invention generally have thicknesses of 8-50 microns. The films are strong and flexible, and compare well to conventional polyethylene stretch film. Modulus and stress at break are higher than PE at the same thickness. Typical values for 15-30 μm films prior to pre-stretch process are provided in **Table 1**:

Property	Value and units	Test method
Elongation at break	150-500 %	ASTM D882-12
Tensile strength	≥ 25 MPa	ASTM D882-12
Impact resistance	> 650 g	ASTM D1709 A
Elmendorf Tear	no tear with 1600g weight (30-micron film)	ASTM D1922
Water solubility, 30C	≤ 5 min	Internal shaker test (30 rpm)
Tackiness	High	Internal tackiness test

Table 1

Test methods:

Water solubility test: Water solubility is characterized via a shaker test, wherein the time required to dissolve a film of a given thickness at given temperature under agitation in an orbital shaker (e.g 30 rpm) is determined.

Test protocol (“shaker test”): A film (4*4 cm) is incubated in a vessel with 250 ml water at 30°C in an orbital shaker and the visual appearance es evaluated according to a predetermined table of values:

Very fast- few mins

Fast- <1 hr

Medium- <24 hrs

Slow- 2-4 days

Very slow- More than 5 days

After the test, the materials are sieved through a sieve and the mass fraction that does not pass through the sieve is reported.

Tackiness test: Films are exposed to 38C and 75% rh for 60 minutes, then two films are pressed together between rotating rolls of a laminating instrument (fixed pressure) at ambient temperature. The films are acclimated to ambient conditions for 30 minutes, then the tensile peel force required to open the laminated films is measured and reported as “tackiness level” as follows:

Very low- Can be peeled without peel force.

Low- <0. 1 (N/cm)

Medium- 0.1-0.25 (N/cm)

High- >0.25 (N/cm)

For an example of representative measurements from the tests above, the tests were used to characterize stretch film for wrapping pallets of beer: Film thickness 15-30 microns, with elongation >250-300% (MD and TD) and tensile strength: >40/30 (MD/TD) MPa. The film was tacky and gave good adhesion to the goods being wrapped. The material dissolved in 30°C water very quickly within a few minutes. Biodegradation (in water) is tested according to ISO 14851 and/or ISO 14852.

The test includes pre-mix, compounding, film production, film conditioning, pre-stretch (sometimes is omitted), Stretch evaluation

Pre-mix prep: Using a high-speed mixer of suitable capacity, add all of the components and mix at 85-100C until the pre-mix forms a freely flowing powder. Cool

to ambient or a slightly elevated temperature (~40°C) prior to subsequent feeding to the extruder.

Compounding: Typically, the compounding comprises mixing the composition in a high-speed mixer at 100 °C for 1 hour; feeding the mixture into a co-rotating twin-screw extruder equipped with a devolatilizing system and extruding same through round dies at 190-220 °C. The extrusion parameters such as screw design, rpm and feeding rate were optimized for optimal residence time and mixing inside the extruder. The emerging polymer strands were passed through an air-cooling system and a pelletizer. In some cases, the pellets may be processed into thin films using blown extrusion.

Film production: Can be by cast or blown film processes.

Conditioning: Humidity tents were provided for the film during production, designed to provide 6-9% humidity in the film (as measured by LOD of the resulting film, measured within ~24h).

Pre-stretch and Stretch Stages: The film use process may involve a pre-stretch step, but does not require it, or may involve pre-stretch and then wrapping without additional stretch during the wrap stage.

Pre-stretch stage: Extent of pre-stretch may typically be from ~90% to ~300% elongation relative to the original as-supplied film.

Stretch stage: Multiple wrapped layers. Total stretch process typically involves at least 3 total wrappings. (≥ 3 encompassments).

Stretch evaluation: Measure “stretchability” on stretch machine immediately after winding. The film was found not to break or tear in pre-stretch or stretch stages. After wrapping (for example a pallet of goods), meets criteria for holding (containment) force and for withstanding transport simulation tests and shipping conditions (for example ASTM D4169-16, ASTM D4728, and EUMOS 40509)

Storage: The stretch films produced are wrapped in PE so as not to have significant change in humidity content during storage and to protect the film until used for wrapping. Films may be applied to the goods by machine wrapping or by manually wrapping.

Experimental Details

All components were mixed and extruded through round dies at 190-220 °C using a co-rotating twin-screw extruder equipped with a devolatilizing system. The extrusion

parameters such as screw design, rpm and feeding rate were optimized for optimal residence time and mixing inside the extruder. The emerging polymer strands were passed through an air-cooling system and a pelletizer. The resulting pellets were further processed into thin films using blown extrusion.

To apply the film as a stretch package, the film is wrapped multiple times (at least 3 times) around an article that is to be stretch wrapped.

Example 1: Combination A (or as stand-alone with all materials mixed together, as opposed to in 2 sets of components):

76.5% partially hydrolyzed PVOH with DP 800, 15% sorbitol, and 8.5% glycerol was compounded using a twin-screw co-rotating extruder ($L/D = 48$) at 50 rpm and 190-210 °C with a round die 3 mm in diameter. The emerging polymer strand was passed through an air-cooling system and a pelletizing strand cutter. The resulting pellets were used to prepare a monolayer stretch film and, separately, a core layer in a multilayer film consisting of different layers of modified PVOH compositions. The film from Combination A dissolved in water very quickly, in accordance with the water solubility test (described above.)

Example 2:

Pre-Mix step: Pre-mix preparation of Combination A: A mixture of 90% of partially hydrolyzed (86-89% hydrolyzed) PVOH with DP of 800 and 10% of glycerol were placed into a high-speed mixer for 25-30 minutes until the temperature in the mixer reached 85 degrees C and the glycerol is absorbed in the PVA. If not used immediately, this premix should be stored in an aluminum bag. After the premix cools, 15% sorbitol is added and mix again without heating for several minutes.

Combination B: A mixture of 30% partially hydrolyzed (86-89% hydrolyzed) PVOH with DP of 500, 30% partially hydrolyzed (86-89% hydrolyzed) PVOH with DP of 1400, 10% partially hydrolyzed (86-89% hydrolyzed) PVOH with DP of 800, 20% fully hydrolyzed (98- >99% hydrolyzed) PVOH with DP of 1700, and 10% glycerol are run in a high-speed mixture for 25-30 minutes until the temperature in the mixer reached 85 degrees and the glycerol is absorbed in the PVOH. If not used immediately, this premix should be stored in an aluminum bag.

Compounding: The premix comprising Combination A is fed to a suitable twin-screw compounder and formed into pellets using the following compounder parameters (Table 2):

Materials	Hoper 1 feeder name			DSR w knives		
	Hoper 1 location			B1		
	Hopper 1 materials			PreMix 1 : Sorbitol		
	Hopper 1 material ratio [%]			85 :15		
	Hopper 1 output [rpm]			10		
	Hopper 1 output [Kg/hr %]			7.6	100%	
Working parameters	Screw design			Comp. 6.4		
	Screw speed [1/min]			450		
	Torque [%]			20		
	Side feeder Y/N [rpm]			Y	60	
	Pressure [bar]			4		
	SEI			0.099		
	Total output [Kg/hr]			7.6		
	Vent#1	Vent#2	Vac. [mbar]	C	O	O
	Die			2 holes, 5 mm		
	Conveyer frequency [Hz]			41.5 A		
Pelletizer speed [m/min]			11			
Temp	Tm [°C]			194		
	T1 [°C]			200	191	
	T2 [°C]			200	200	
	T3 [°C]			200	200	
	T4 [°C]			200	200	
	T5 [°C]			200	200	
	T6 [°C]			200	200	
	T7 [°C]			200	200	
	Sample size [kg]			50		

Table 2

If not used immediately, this premix should be stored in an aluminum bag. Independently the premix comprising Combination B is fed to a suitable twin-screw compounder and formed into pellets using the following compounder parameters (Table 3):

- 26 -

Materials	Hoper 1 feeder name			DSR		
	Hoper 1 location			B1		
	Hopper 1 materials			Premix 1		
	Hopper 1 material ratio [%]			100		
	Hopper 1 output [rpm]			10		
	Hopper 1 output [Kg/hr %]			6.5	100%	
Working parameters	Screw design			Comp. 6.4		
	Screw speed [l/min]			450		
	Torque [%]			61		
	Side feeder Y/N [rpm]			Y	60	
	Pressure [bar]			3		
	SEI			0.352		
	Total output [Kg/hr]			6.5		
	Vent#1	Vent#2	Vac. [mbar]	O	O	O
	Die			2 holes, 5 mm		
	Conveyer frequency [Hz]			40		
Pelletizer speed [m/min]			8.8			
Temp	Tm [°C]			194		
	T1 [°C]			200	199	
	T2 [°C]			200	200	
	T3 [°C]			200	205	
	T4 [°C]			200	207	
	T5 [°C]			200	206	
	T6 [°C]			200	204	
	T7 [°C]			200	200	
	Sample size [kg]			1.5		

Table 3

If not used immediately, this premix should be stored in an aluminum bag. Prior to feeding to a blown film extruder, a mixture of 50% of Combination A and 50% of Combination B is mixed for several minutes in a pellet blender.

The mixture was then fed to a blown film line, using the following blown film extruder parameters (**Table 4**):

- 27 -

	T5, °C	T4, °C	T3, °C	T2, °C	T1, °C	T-die1, °C (HEATING ZONE 6)	T-die2, °C (HEATING ZONE 7)	T- melt, °C
50% Comb A/ 50% Comb B	187.5	187	185.5	182	180	191.5	186	166.5

Table 4

Film with an average thickness of 35 microns was produced at a rate of 10 meters/minute in the presence of humidifying conditions providing 6 liters/hour of water vapor.

Example 3: Production of a monolayer 20 micron cast film

The following table refers to the properties of stretch films produced by the extrusion cast process. The pre-mix and compound production processes for these films can be seen in Example 1 and Example 2. Tensile strength and elongation at break (%) are provided in **Table 5**.

Film	Thickness	Tensile Strength (Mpa)	Elongation (%)
Combination A	35-40	MD:43 TD:44	MD:320 TD:345
50% Comb A/50% Comb B	35-40	MD:50 TD:46	MD:311 TD:352
50% Comb A/50% Comb B	20-25	MD:60 TD:55	MD:250 TD:310

Table 5

It can be seen that the first film, which contains only combination A, has higher elongation values compared to the film containing 50% of combination A and B. However, it has lower tensile strength values. The presence of both combination A and combination B slightly reduces the elongation values of the film but adds strength to it, making it more resistant to tearing and puncture resistance. Additionally, the thinner film (3) still provides good values in mechanical tests for tensile strength and elongation. Combinations A and B are materials presented in Examples 1 and 2.

Example 4: Multilayer cast film: symmetric and asymmetric configurations

Films were prepared with 20 to 40-micron total film thickness, where the film is comprised of 3-5 layers, as exemplified in **Figs. 1A-C**.

Combinations A and B are materials presented in Examples 1 and 2.

Symmetric and asymmetric sheets were produced using a cast film extruder. The purpose of this experiment was to determine whether the functionality of the sheets is improved in terms of blocking (easy opening of the film when used for wrapping). Film 1 – using different layers in the film prevented blocking when using 50% combination A and 50% combination B in the outer layers. This compound is less sensitive to water and humidity, making it easier to open. However, using combination A in the inner layer preserves the film's properties (especially elongation). The issue with this film is that it loses its ability to cling to itself during wrapping. Film 2 – Using 50% combination A and 50% combination B in only one outer layer results in a film without blocking, but with a cling layer that allows it to stick to itself. Film number 3 provides functional properties between film 1 and 2. Increasing the percentage of combination A makes the sheet more clingy to itself. Using 20% of combination B allows the sheet to be less clingy and have less blocking.

Example 5: 3-layer films with middle layer prepared as in Example 1 above (Combination A), and the surface layers prepared as a 50/50 blend of Combination A with Combination B. Films with various layer thicknesses were produced, where the inner middle layer had a uniform thickness of 10, 15, or 20 microns, and the surface layers had uniform thickness of 4.5, 7, or 10 microns. Typical overall film thickness was 30-40 microns.

Representative tensile strength (**Figs. 2A-B**) and % elongation results (**Figs. 2C-D**) for additional films, 20-25-micron thickness have been measured. As the figures suggest, despite the thinness of the films, they exhibited elongation values of 200-250% and exceptionally good tensile strengths. This dimension allows for the production of very thin films that are highly resistant to tearing and puncture resistance. A significant impact was observed on the manufacturing process and the properties of the film, considering the chill roll temperatures, the temperature profile across the process, and the distance between the chill roll and the die of the cast extruder. In the examples above, the selected parameters included: Chili roll temperature of 40 °C, a profile temperature

- 29 -

between 180 and 210 °C and a 30-mm distance between the die of the extruder and the chill roll.

In the figures, TD (Transverse Direction) in plastic films refers to the direction perpendicular to the machine direction (MD), focusing on the width of the film. MD (Machine Direction) indicates the direction along the length of the film during its manufacturing process, contrasting with the transverse direction (TD).

CLAIMS:

1. A polymeric composition comprising or consisting:

A compounded **Combination A** comprising partially hydrolyzed polyvinyl alcohol (PVOH), at least one plasticizer and optionally at least one additive, wherein the total amount of the at least one plasticizer in the Combination is between 5 and 30wt% ;
and/or

A compounded **Combination B** comprising at least two polyvinyl alcohol (PVOH) grades selected from

(i) partially hydrolyzed grades having a degree of hydrolysis from 86 to 90% and a degree of polymerization (DP) of between 300 and 2000, or between 500 and 1400, e.g., 500, 800, or 1400,

(ii) medium hydrolyzed grades having a degree of hydrolysis between 91 and 97%, and

(iii) fully hydrolyzed grades having a degree of hydrolysis from 98% to >99% (or 100%) and a degree of polymerization of between 300 and 2000, or 500 and 1700, e.g., 1700;

and at least one plasticizer.

2. The composition according to claim 1, wherein the at least one plasticizer is selected from sorbitol, maltitol, mannitol, glycerol, erythritol, propylene glycol dipropylene glycol, triethylene glycol, tetraethylene glycol (TEG), triethanolamine (TEA), trimethylol propane, penta-erythritol, dipentaerythritol, dibutyl sebacate (DBS), polyglyceryl-4 laurate, ditrimethylol propane, urea, diglycerol, xylitol, acetyltributyl-citrate (ATBC), polyethylene glycol, triethylcitrate, vitamin E TPGS (d- α -tocopherol peg-1000 succinate), ethylene glycol, diethylene glycol, 1,2,4-butanetriol, epoxidized soy bean oil, and ethoxylated glycerol.

3. The composition according to claim 1 or 2, wherein the at least one plasticizer is glycerol and/or sorbitol.

4. The composition according to claim 1 or 2, comprising a single plasticizer in either Combination A or Combination B, wherein the amount of the single plasticizer is at least 15wt% or between 15 and 20wt%.

5. The composition according to claim 1 or 2, comprising two or more plasticizers, each present in an amount not exceeding in combination 30 wt%.

6. The composition according to claim 1 or 2, comprising compounded Combination A and compounded Combination B, each compounded Combination comprising same or different plasticizer.
7. The composition according to any one of the preceding claims, wherein the at least one plasticizer is or comprises glycerol.
8. The composition according to any one of the preceding claims, wherein the at least one plasticizer is a combination of glycerol and sorbitol.
9. The composition according to claim 8, wherein the amount of the sorbitol and the glycerol combined is between 5 and 30wt%, and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1.
10. The composition according to claim 1, comprising or consisting compounded Combination A.
11. The composition according to claim 10, wherein compounded Combination A comprises polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is between 7 and 30wt% or between 10 and 30wt%, and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1.
12. The composition according to claim 10, wherein the PVOH used in compounded Combination A is partially hydrolyzed, having a degree of hydrolysis between 86-90%.
13. The composition according to claim 10, wherein the PVOH is partially hydrolyzed and with a degree of polymerization that is 800, or which does not exceed 2000.
14. The composition according to claim 1, comprising compounded Combination A, said combination A comprising polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is optionally below 30wt%, and wherein a weight ratio sorbitol:glycerol is optionally between 1:3 to 3:1; and further comprises compounded Combination B comprising (i) at least two polyvinyl alcohol (PVOH) grades selected from partially hydrolyzed grades having a degree of hydrolysis from 86 to 90% and a degree of polymerization (DP) of 500, 800, or 1400, and (ii) fully hydrolyzed grades having a degree of hydrolysis from 98% to >99% and a degree of polymerization of 1700; and at least one plasticizer selected from sorbitol, glycerol, propylene glycol, polyethylene glycol, and combinations thereof.

15. The composition according to claim 1, comprising or consisting compounded Combination B.

16. The composition according to claim 15, wherein compounded Combination B comprises at least two polyvinyl alcohol (PVOH) grades selected from partially hydrolyzed grades having a degree of hydrolysis from 86 to 89% and a degree of polymerization (DP) of 500, 800, or 1400, and fully hydrolyzed grades having a degree of hydrolysis from 98% to >99% and a degree of polymerization of 1700; and at least one plasticizer selected from sorbitol, glycerol, propylene glycol, polyethylene glycol, and combinations thereof.

17. The composition according to claim 16, wherein the at least two PVOH grades being two or more different PVOH grades, each differing in the degree of hydrolysis and/or degree of polymerization.

18. The composition according to claim 17, wherein the two or more grades are selected from PVOH polymers having different degrees of polymerization.

19. The composition according to claim 18, wherein at least one PVOH grade is partially hydrolyzed having a degree of hydrolysis from 86 to 89% and at least one other PVOH grade is fully hydrolyzed having a degree of hydrolysis from 98 and above 99%.

20. The composition according to claim 18, wherein at least one PVOH grade has a degree of polymerization of 500, 800, or 1400, and at least one another PVOH grade has a degree of polymerization of 1700.

21. The composition according to claim 18, wherein at least one PVOH grade is selected from partially hydrolyzed grades having a degree of hydrolysis from 86 to 89% and a degree of polymerization (DP) of 500, 800, or 1400, and at least one another PVOH grade is a fully hydrolyzed grade having a degree of hydrolysis from 98% to >99% and a degree of polymerization of 1700.

22. The composition according to any one of the preceding claims for manufacturing a stretch film.

23. The composition according to claim 22, wherein the stretch film is a single layer film or a multilayer film.

24. The composition according to claim 22 or 23, wherein the film comprises a layer formed of Combination A, Combination B or a mixture of Combination A and Combination B.

25. The composition according to any one of claims 22 to 24, wherein the film comprises at least one layer formed of Combination A, at least one layer formed of Combination B and/or at least one layer formed of a mixture of Combination A and Combination B, and optionally at least one layer formed of a polymer selected from polypropylene, polyethylene and polyesters.

26. The composition according to any one of the preceding claims, for manufacturing a stretch film stretchable to a length that is at least 50 to 500% longer than a length of the unstretched film.

27. A stretch film formed of a compounded Combination A and/or Combination B according to any one of claims 1 to 26.

28. The film according to claim 27, formed of a composition comprising compounded Combination A.

29. The film according to claim 27, formed of a composition comprising compounded Combination B.

30. The film according to claim 27, formed of a composition comprising one or more layers formed of compounded Combination A and/or B.

31. The film according to any one of claims 27 to 30, comprising at least one layer formed of compounded Combination A and at least one layer formed of compounded Combination B and optionally one or more layers formed of a mixture of compounded Combination A and Combination B.

32. The film according to any one of claims 24 to 31, being a multilayered film comprising two or more layers.

33. A stretch film arranged or provided as a multilayer comprising two or more layers, wherein:

- at least one of said layers is formed of a compounded Combination A, as defined in claim 1; and wherein

- at least another of said material layers is formed of a compounded Combination B, as defined in claim 1.

34. A stretch film arranged or provided as a multilayer film comprising two or more layers, wherein at least one of said layers is formed of a mixture of compounded Combinations A and B, as defined in claim 1.

35. The film according to any one of claims 27 and 34, being a coextruded multilayer blown film or cast film comprising at least three layers, wherein at least one layer of a

polymeric or non-polymeric material and two or more layers formed of a compounded Combination A, Combination B or a mixture thereof.

36. The film according to any one of claims 27 and 35, comprising 3, 4, 5, 6, 7, 8 or 9 layers, each of the layers being formed of a material composition selected from compounded Combination A, compounded Combination B and a mixture of compounded Combination A and Combination B.

37. A process for producing a multilayer stretch film, the process comprising extruding a first compounded composition to form a first layer of the multilayer stretch film and co-extruding a second compounded composition on a face of said first layer of the multilayer stretch film, wherein each of the first and second compounded compositions is different, each being selected from

- a compounded composition comprising polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1;

- a compounded composition comprising polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is between 5 and 30wt% (or between 10 and 30wt%);

- a compounded Combination B; and

- a compounded mixture of Combination A and Combination B.

38. The process according to claim 37, wherein the first compounded composition is formed of

- a compounded composition comprising polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1; or

- a compounded composition comprising polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is between 5 and 30wt% (or between 10 and 30wt%).

39. The process according to claim 37 or 38, wherein the second compounded composition is formed of

- 35 -

-a compounded Combination B, as defined in claim 1; or

-a compounded Combination A and Combination B, as defined in claim 1.

40. The process according to any one of claims 37 to 39, wherein the process comprising

-providing a first compounded composition selected from:

-a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1;

-a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is between 5 and 30wt%;

-a compounded combination formed of Combination B; and

-a compounded combination formed of Combination A and Combination B;

-providing a second compounded composition being different from the first compounded composition and selected from:

-a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%), and wherein a weight ratio sorbitol:glycerol is between 1:3 to 3:1;

-a compounded combination of polyvinyl alcohol (PVOH), sorbitol, glycerol and optionally at least one additive, wherein the total amount of the sorbitol and the glycerol combined in the formulation is below 30wt% (or between 10 and 30wt%);

-a compounded combination formed of Combination B; and

-a compounded combination formed of Combination A and Combination B;

-extruding the first compounded composition to form a first layer of the multilayer stretch film and co-extruding the second compounded composition on a face of said first layer of the multilayer stretch film.

41. The process according to claim 37, the process comprises co-extruding a further composition to form a third layer of the film.

- 36 -

42. The process according to claim 37, the process further comprises stretching the multilayer stretch film so that the film length increases by 50 to 500%.

1/3

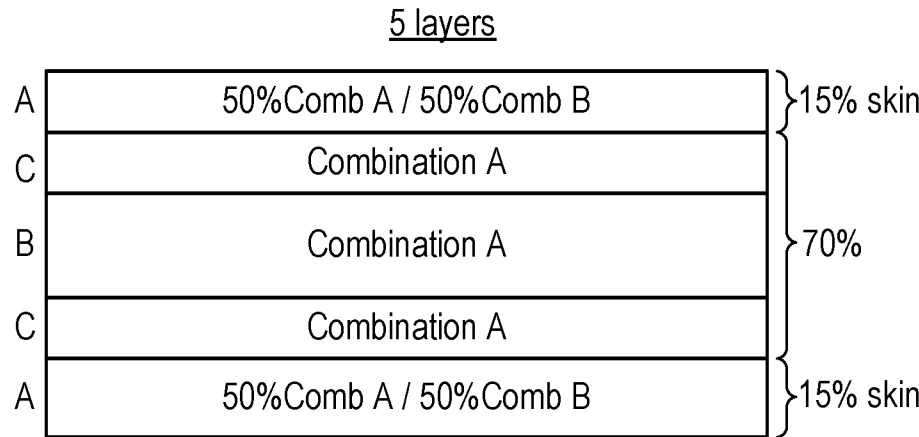


FIG. 1A

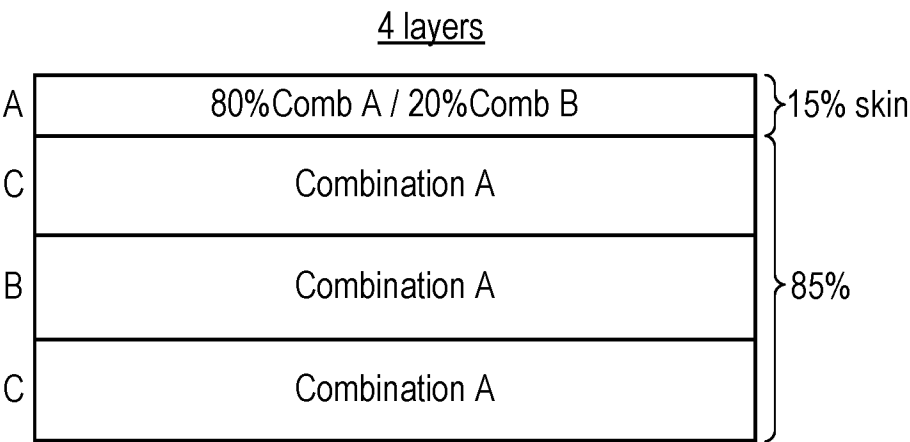


FIG. 1B

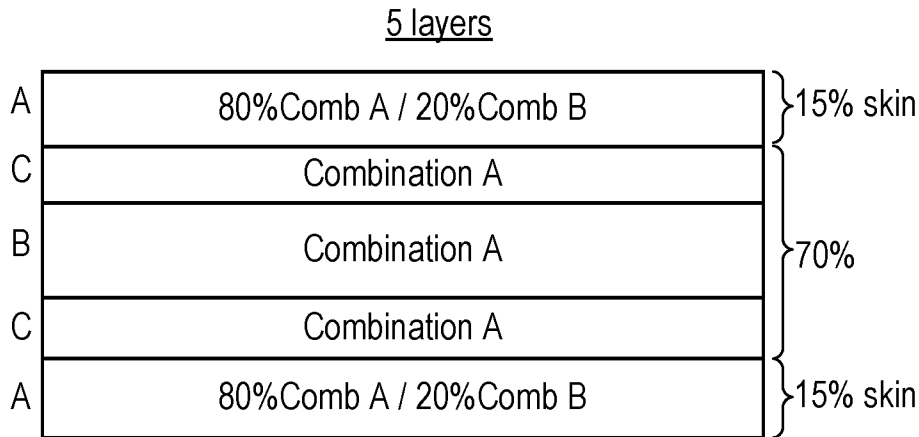


FIG. 1C

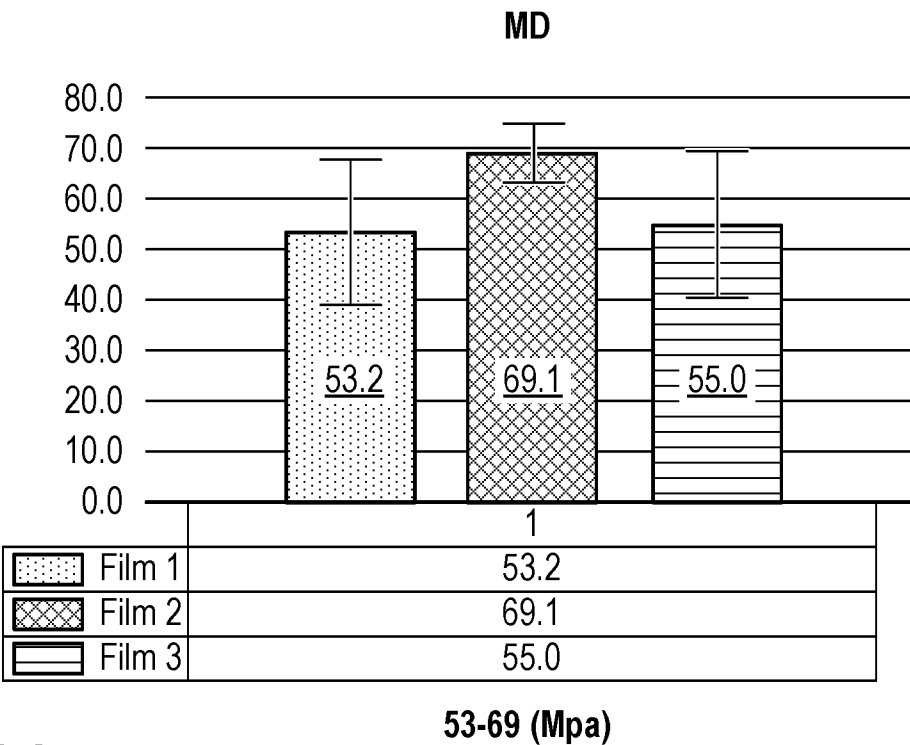


FIG. 2A

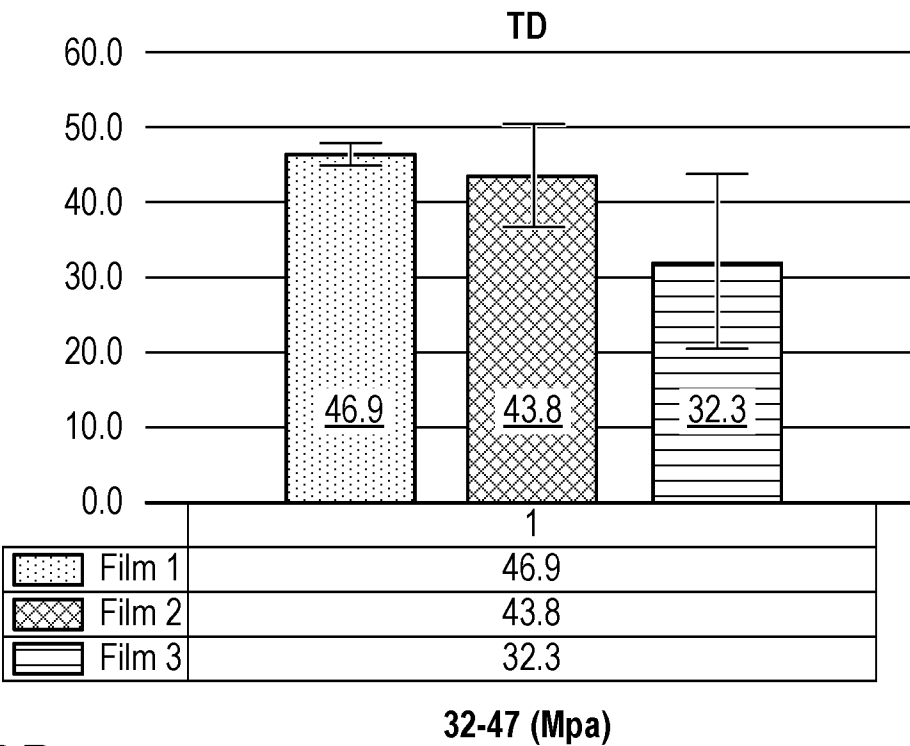


FIG. 2B

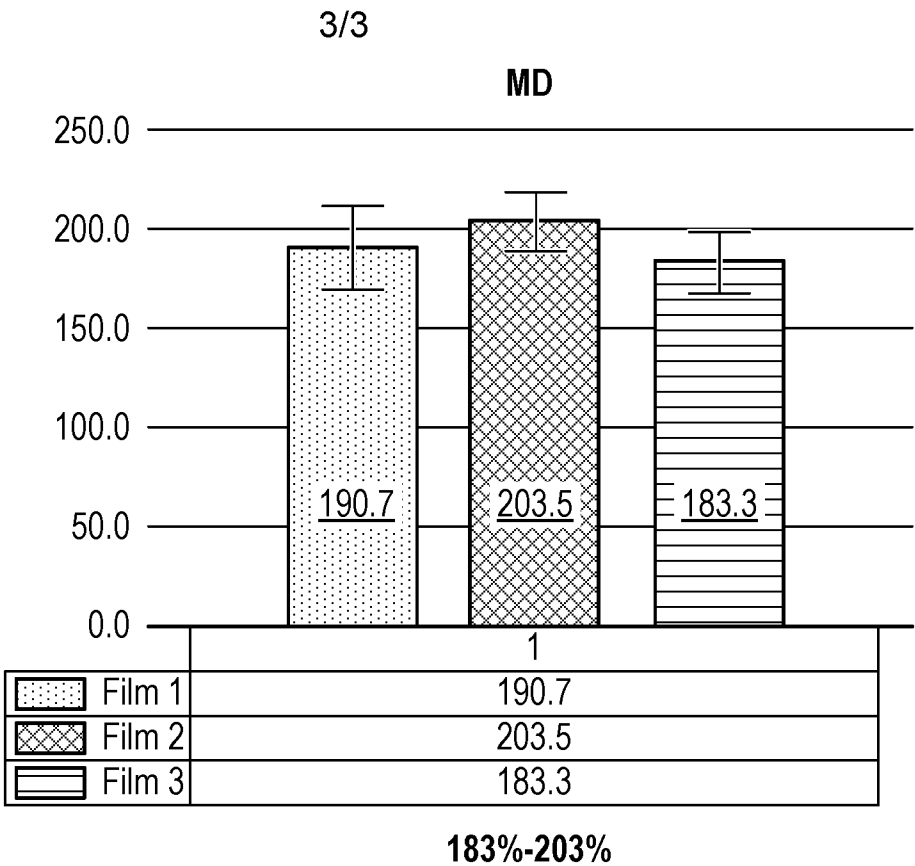


FIG. 2C

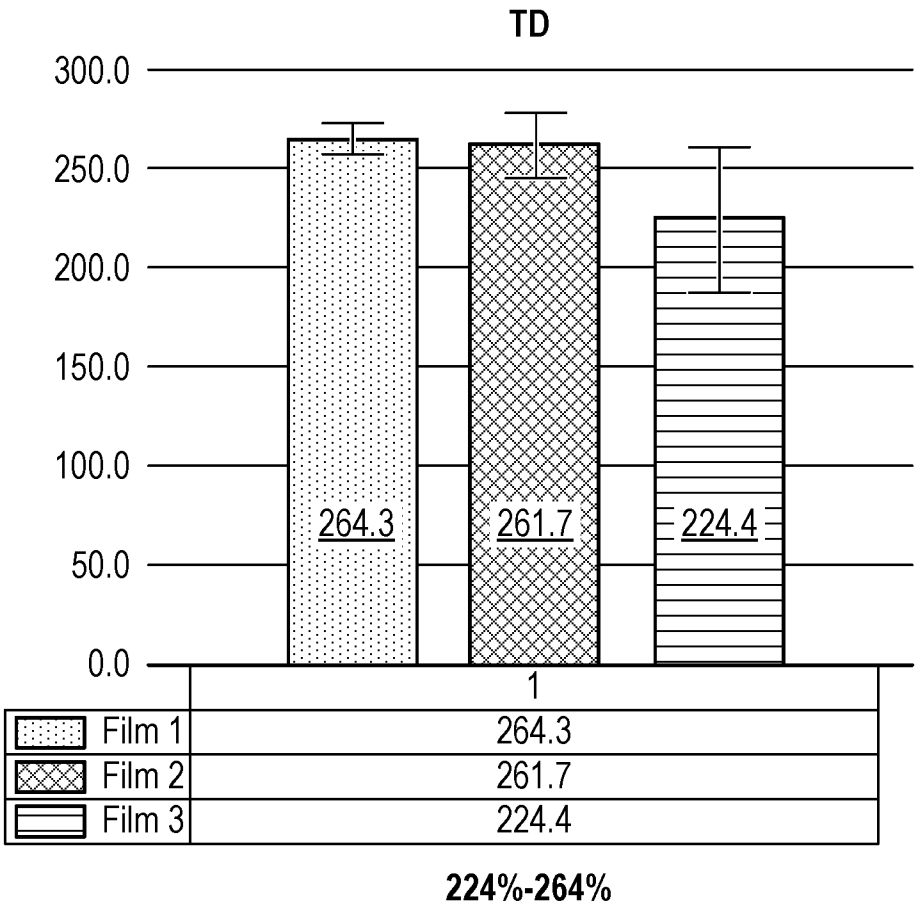


FIG. 2D

INTERNATIONAL SEARCH REPORT

International application No

PCT/IL2024/050744

A. CLASSIFICATION OF SUBJECT MATTER INV. C08J5/18 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 C08K		
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.
X	WO 2023/126922 A1 (SOLUTUM TECH LTD [IL]) 6 July 2023 (2023-07-06)	1-8,10, 12-42
Y	page 2, line 1 - page 4, line 15 claims 1-77 page 16, line 1 - page 17, line 3; table 2 page 21, line 22 - line 28 -----	9,11
Y	US 2007/276317 A1 (HENDERSON RULANDE [US] ET AL) 29 November 2007 (2007-11-29) table 4 -----	9,11
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
<p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"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</p> <p>"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</p> <p>"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</p> <p>"&" document member of the same patent family</p>		
Date of the actual completion of the international search 17 October 2024		Date of mailing of the international search report 31/10/2024
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 Meiser, Wibke

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IL2024/050744

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2023126922 A1	06-07-2023	EP 4419595 A1	28-08-2024
		IL 313364 A	01-08-2024
		WO 2023126922 A1	06-07-2023

US 2007276317 A1	29-11-2007	CA 2582948 A1	13-04-2006
		CN 101061167 A	24-10-2007
		EP 1799762 A1	27-06-2007
		ES 2639564 T3	27-10-2017
		JP 5669906 B2	18-02-2015
		JP 2008516016 A	15-05-2008
		JP 2014028963 A	13-02-2014
		KR 20070084032 A	24-08-2007
		NZ 554681 A	28-05-2010
		US 2007276317 A1	29-11-2007
		WO 2006037157 A1	13-04-2006
