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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

— *of inventorship (Rule 4.17(iv))*

[Continued on next page]

(54) Title: POLYSTYRENE CLARIFIED BLEND AND METHOD FOR MAKING SAME

(57) Abstract: A polystyrene copolymer blend product, achieving an optimal combination of haze/clarity, strength, toughness/snap, and organoleptic properties is provided. The polystyrene copolymer blend product includes a first layer forming about (2) to about (6) weight percent of the total weight percent of the product. The first layer includes from about (95) to about (100) weight percent of GPPS or HIPS, based on the weight of the layer. The polystyrene copolymer blend product includes a second (and optional third and fourth) layer(s) that form about. (98) to about (94) weight percent of the product. The second (and optional third and fourth) layer(s) include about (23) to about (43) weight percent of GPPS, from either about (35) to about (70) weight percent, such as from about (50) to about (65) weight percent of SBC, and from about (0) to about (17) weight percent of HIPS, based on the weight of the respective layer.

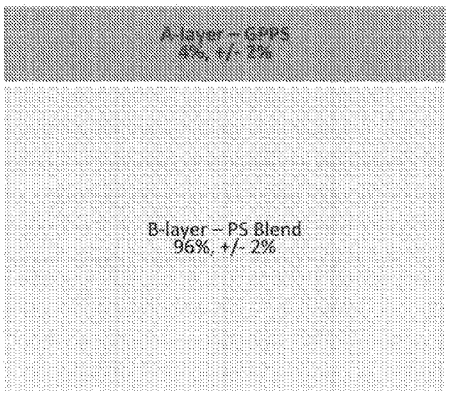

FIG. 1

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POLYSTYRENE CLARIFIED BLEND AND METHOD FOR MAKING SAME

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to pending United States Provisional Patent Application No. 62/303,848, filed March 4, 2016, which is hereby incorporated herein in its entirety.

FIELD OF THE INVENTION

The present disclosure relates generally to polystyrene blends and polystyrene products incorporating the same, and more specifically it relates to polystyrene blends and polystyrene products that achieve an optimal combination of haze/clarity, strength, toughness/snap, and organoleptic properties, where the product may be used in, for example, thermoformed food containers, to provide a visually clear package, or the like.

BACKGROUND OF THE INVENTION

Currently, general purpose polystyrene ("GPPS") is frequently used in household products for rigid packing, where transparency is required. However, general purpose polystyrene has low impact resistance and toughness. The thermoplastic blends that address this issue include polystyrene with mixture of other compounds such as nitrile, cyanide, carboxylic acid, and methacrylate.

However, these blends do not have the properties (e.g., impact resistance, transparency, toughness, and organoleptic properties) that are desired in products used in e.g., manufacture of appliance housings, household accessories, medical parts, food packaging, and the like. There exists an unfulfilled need for a

polystyrene blend that has an optimal combination of low haze/high clarity, adequate strength, improved toughness/good snap, and pleasing organoleptic properties.

SUMMARY OF ADVANTAGEOUS EMBODIMENTS OF THE DISCLOSURE

According to advantageous aspects of this disclosure, products (which may also be referred to herein as structures) incorporating polystyrene copolymer blends are provided that include a first layer, a second layer, an optional third layer and an optional fourth layer. As used herein, the term "product" may refer to any multi-layered product form, including a film, a laminate incorporating such film, a sheet, a pre-form and the like. Exemplary inventive multi-layered products include 2-, 3- and 4- layered products.

The first layer generally forms about 2 weight percent to about 6 weight percent of a the total weight percent of the product. The first layer generally includes about 95 weight percent to about 100 weight percent of GPPS or HIPS ("high impact polystyrene"), based on the weight of the layer. The second (along with the optional third and fourth) layer(s) generally forms or includes about 98 weight percent to about 94 weight percent of the total weight percent of the product. The second (and optional third and fourth) layer(s) generally independently includes from about 23 weight percent to about 43 weight percent of GPPS; from either about 50 weight percent to about 70 weight percent or from about 35 to 60 weight percent of SBC ("styrene butadiene copolymer"); and from about 0 weight percent to about 17 weight percent of HIPS.

The GPPS may include standard grades of GPPS.

The top and bottom layer may have a combined thickness between about 0.020 inches and about 0.060 inches.

In alternative embodiments, the top and bottom layer may have a combined thickness of less than about 0.020 inches.

In further alternative aspects, the top and bottom layer may have a combined thickness of greater than about 0.060 inches.

Inventive polystyrene copolymer blend products having a thickness of 0.020 inches may exhibit a haze value of around 0 to 70 in sheet haze, such as a sheet haze value ranging from 0 to 50, based upon standard sheet haze measurement methods known in the art, such as ASTM D 1746. Preferably, the polystyrene copolymer blend product exhibits a haze value under 10.0, such as under 6.0, and particularly under 2.0.

In an alternative embodiment, the polystyrene copolymer blend product having 0.020 inches of thickness may include around 0 to 30 in sheet haze. The polystyrene copolymer blend product may include a preferable haze value under 10.0, 6.0, and 2.0.

In an exemplary embodiment of this disclosure, the polystyrene copolymer blend product may include a second (and optionally, a third and fourth) layer each of which independently contains (i) about 25 weight percent to about 35 weight percent of GPPS, (ii) from either about 55 weight percent to about 65 weight percent of SBC or from about 35 to 60 weight percent SBC , and (iii) from about 5 weight percent to about 15 weight percent of HIPS, based on the weight of the layer .

In another exemplary embodiment of this disclosure, the polystyrene copolymer blend product may include a second and optionally, a third and fourth) layer(s) containing about 30 to 33 weight percent of GPPS, about 60 weight percent of SBC, and about 7 to 10 weight percent of HIPS, based on the weight of the layer .

In alternative embodiments, the second (and optionally, a third and fourth) layer may include a specific range of (i) about 30 weight percent to about 40 weight percent of GPPS, (ii) either about 55 weight percent to about 65 weight percent of SBC or from about 35 to 60 weight percent SBC, and (iii) from about 0 weight percent to 10 weight percent of HIPS, based on the weight of the layer.

The polystyrene copolymer blend product may be included within (e.g. used to form) a food package.

The polystyrene copolymer blend product may be included within (e.g. used to form) one or more of: an appliance housing, a household accessory, and a medical device.

In a further exemplary embodiment of this disclosure, the polystyrene copolymer blend product may include a second (and optional third and fourth) layer(s) containing (a) from about 60 weight percent to about 70 weight percent of SBC, (b) from about 23 weight percent to about 33 weight percent of GPPS, and (c) from about 2 weight percent to about 12 weight percent of HIPS, based on the weight of the layer.

In yet another example of this disclosure, the polystyrene copolymer blend product may include a second (and optional third and fourth) layer of preferably 55 to 65 weight percent of SBC, preferably about 28 to 35 percent of GPPS, and preferably about 7 to 14 weight percent of HIPS.

According to another aspect of this disclosure, a process of manufacturing a polystyrene copolymer blend product is provided. The process generally includes: (i) overlaying a first layer with a second (and optional third and fourth) layer(s) and (ii) applying a standard processing method for thermoplastics, wherein the overlaying includes: extruding a first layer, layer A, that forms about 2 weight percent to about 6 weight percent of ~~a~~ the total weight of the product; and extruding a second (and optional third and fourth) layer(s), layer B and optional C and optional D, that forms

about 98 weight percent to about 94 weight percent of the total weight of the product, wherein the first layer includes about 95 weight percent to about 100 weight percent of GPPS or HIPS based on the weight of the first layer, and wherein the second (and optionally, third and fourth) layer includes about 23 weight percent to about 43 weight percent of GPPS; from about 35 or 50 weight percent to about 70 weight percent, such as about 35 to 60 weight percent of SBC; and from about 0 weight percent to about 17 weight percent of HIPS, based on the weight of the respective layer.

The standard processing method for thermoplastics that may used to form the overlaid layers may include one or more of the known methods of: blown film; extrusion blow molding; extrusion profiles, film and sheet; and injection molding, including gas assisted. Additional standard processing methods for thermoplastics that may be applied to the overlaid layers to form end-products include any type of thermoforming, such as either thin-gauge thermoforming or thick-gauge thermoforming.

The second (and optional third and fourth) layer(s) may independently include from about 25 weight percent to about 35 weight percent of GPPS, from either about 55 weight percent to about 65 weight percent or from about 35 to 60 weight percent of SBC, and from about 5 weight percent to about 15 weight percent of HIPS, based on the weight of the layer.

A specific range of the copolymer blend for the second and optional third and fourth layer(s) may independently include about 30 weight percent to about 40 weight percent of GPPS, either from about 55 weight percent to about 65 weight percent or from about 35 to 60 weight percent of SBC, and from about 0 weight percent to 10 weight percent of HIPS, based on the weight of the layer.

The second (and optional third and fourth) layer(s) may independently include (a) from about 60 weight percent to about 70 weight percent of SBC, (b) from about 23 weight percent to about 33 weight percent of GPPS, and (c) from about 2 weight percent to about 12 weight percent of HIPS, based on the weight of the layer.

The second (and optional third and fourth) layer(s) may include preferably 65 weight percent of SBC, preferably about 28 percent of GPPS, and preferably about 7 weight percent of HIPS, based on the weight of the layer.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the disclosure, are incorporated in and constitute a part of this specification, illustrate embodiments of the disclosure and together with the detailed description serve to explain the principles of the disclosure. No attempt is made to show structural details of the disclosure in more detail than may be necessary for a fundamental understanding of the disclosure and the various ways in which it may be practiced. In the drawings:

Fig. 1 shows an example of a polystyrene copolymer structure, according to the principles of the disclosure.

Fig. 2 shows another example of a polystyrene copolymer structure, according to the principles of the disclosure.

Fig. 3 shows an example of a 3 layer polystyrene copolymer structure, according to the principles of the disclosure.

Fig. 4 shows an example of a 4 layer polystyrene copolymer structure, according to the principles of the disclosure.

Fig. 5 shows an exemplary schematic of a process for creating a polystyrene copolymer structure, according to the principles of the disclosure.

DETAILED DESCRIPTION OF ADVANTAGEOUS EMBODIMENTS OF THE INVENTION

The disclosure and the various features and advantageous details thereof are explained more fully with reference to the non-limiting embodiments and examples that are described and/or illustrated in the accompanying drawings and detailed in the following description. It should be noted that the features illustrated in the drawings are not necessarily drawn to scale, and features of one embodiment may be employed with other embodiments as the skilled artisan would recognize, even if not explicitly stated herein. Descriptions of well- known components and processing techniques may be omitted so as to not unnecessarily obscure the embodiments of the disclosure. The examples used herein are intended merely to facilitate an understanding of ways in which the disclosure may be practiced and to further enable those of skill in the art to practice the embodiments of the disclosure. Accordingly, the examples and embodiments herein should not be construed as limiting the scope of the disclosure. Moreover, it is noted that like reference numerals represent similar parts throughout the several views of the drawings.

FIG. 1 shows an example of a polystyrene copolymer structure according to the present disclosure. The structure includes at least one top layer, also referred to herein as the A-layer, and at least one bottom layer, also referred to herein as the B-layer. The top layer may also be referred to as a first layer and the bottom layer may also be referred to as a second layer (with optional additional bottom layer(s) being referred to as third and fourth layer(s), respectively). The top layer forms about 4 percent ± about 2 percent of the structure, based on weight, and is comprised of from about 95 to about 100 weight percent general purpose polystyrene (GPPS). The bottom layer forms about 96 percent ± about 2 percent of the structure, based on weight, and comprises a

polystyrene (PS) blend. The combined thickness of the top and bottom layers may be between about 0.020 inches and about 0.060 inches. Alternatively, the combined thickness may be greater than 0.060 inches, or less than 0.020 inches, as well.

FIG. 2 shows another example of a polystyrene copolymer structure according to the present disclosure. The structure includes at least one top layer, also referred to herein as the A-layer, and at least one bottom layer, also referred to herein as the B-layer. The top layer forms about 4 percent ± about 2 percent of the structure, based on weight, and is comprised of high impact polystyrene (HIPS). The bottom layer forms about 96 percent ± about 2 percent of the structure, based on weight, and comprises a polystyrene (PS) blend. The combined thickness of the top and bottom layers may be between about 0.020 inches and about 0.060 inches. Alternatively, the combined thickness may be greater than 0.060 inches, or less than 0.020 inches, as well.

FIG. 3 and FIG. 4 show examples of the two polystyrene copolymer blend structures according to the present disclosure. As shown, the first layer in Figs. 3 and 4 includes about 95 weight percent to about 100 weight percent of HIPS, based on the weight of the layer. The second, third and fourth layer each independently include about 23 weight percent to about 43 weight percent of GPPS, from either about 35 to 60 weight percent of SBC or about 50 to 65 weight percent of SBC, and from about 7 weight percent to about 17 weight percent of HIPS, based on the weight of the respective layer.

Suitable GPPS for incorporation into the inventive products, layer(s) and polystyrene copolymer blends include any general purpose polystyrene (GPPS) known in the extrusion, molding and/or thermoforming arts. Consequently, the GPPS may be any standard grade, such as, e.g., PS 1200/1201, PS 1290/1291, PS 1300/1301, PS 2600/2601, and PS 2610 GPPS, all from INEOS Styrolution Group GmbH; PS 3100; PSC 529, PSC 525 and PSC 500, all from Total Petrochemcials, Inc, and so on. General purpose polystyrene, well known in the art as a hard, transparent material with a high gloss, is also referred to in the art as standard polystyrene, normal polystyrene, clear polystyrene, or styrene homopolymer. As known in the art, GPPS has a density of about

1.04 g/cc. Suitable GPPS grades generally range in melt flow from about 1.6 g/10 min to about 4.5 g/10 min at a load of 5.00 kg and a temperature of 200 °C, per ASTM D 1238.

The inventive polystyrene copolymer blends further include styrene butadiene copolymer (SBC), which may include any standard grade suitable for extrusion and/or thermoforming and the like. Exemplary SBCs includeSTYROLUX® 684D SBC, STYROLUX® 3G55 SBC, STYROLUX® 3G46 SBC, STYROFLEX® 2G66 SBC, all from INEOS Styrolution Group GmbH, and so on. SBC is well known in the art as a thermoplastic resin that is transparent and impact-resistant. It is used to provide a high optical appearance. As known in the art, SBC has a density of about 1.0 to 1.02 g/cc. Suitable SBC grades generally range in melt flow from about 11 g/10 min to about 15 g/10 min at a load of 5.00 kg and a temperature of 200 °C per ASTM D 1238.

The inventive polystyrene copolymer blends may further include high impact polystyrene (HIPS). HIPS is well known in the art as a two phase system having a polystyrene matrix with polybutadiene disperse phase, and also referred to as toughened polystyrene or rubber-modified polystyrene. Suitable HIPS grades include any standard grade suitable in the extrusion, molding and/or thermoforming arts. Exemplary HIPS grades include PS 5300 , PS 5310, PS 5400/5401, PS 5410, PS 6200/6201, PS 6210/6211, PS 6220, PS 7120, and PS7800, all from INEOS Styrolution Group GmbH: 844E, 845E, 935E, 940E, 975E, 825E, 945E, and 960E, all from Total Petrochemcials, Inc.; and EB/EC6400, EB/EC6600, STYRON® 421, and STYRON® 484, all from Americas Styrenics LLC, and so on. HIPS is well known in the art as a thermoplastic resin that has elevated toughness and impact-resistance, but low transparency due to light scattering induced by the disperse phase. As known in the art, HIPS has a density of about 1.04 g/cc. Suitable HIPS grades generally range in melt flow from about 2.0 g/10 min to about 14.5 g/10 min at a load of 5.00 kg and a temperature of 200 °C per ASTM D 1238.

FIG. 5 discloses an example of a process 400 for manufacturing a polystyrene copolymer blend product in accordance with the present disclosure. At S410, the process includes extruding (or carrying out an extrusion process on) a first layer that comprises about 2 weight percent to about 6 weight percent of the total weight of the copolymer blend product, wherein the layer may include about 100 percent (+/- 5 percent) of a standard grade general purpose polystyrene (GPPS). Alternatively, the first layer may include about 100 percent (+/- 5 percent) of standard grade high impact polystyrene (HIPS). At S420, the process includes extruding (or carrying out the extrusion process on) a second (and optionally a third and fourth) layer that forms about 94 weight percent to about 98 weight percent of the total weight of the copolymer blend product, wherein the second (and optionally a third and fourth) layer may include a polystyrene blend.

At S420, the process of extruding (or carrying out the extrusion process on) the second (and optional third and fourth) layer(s) may include providing about 55 weight percent to about 70 weight percent (preferably between about 60 weight percent and about 65 percent) of styrene butadiene copolymer (SBC), about 25 weight percent to about 40 weight percent (preferably between 28 and 35 percent) of general purpose polystyrene (GPPS), and about 0 weight percent to about 15 weight percent (preferably between about 5 and 10 percent) of high impact polystyrene (HIPS), all based upon the weight of the respective layer. Alternatively, if the first layer includes about 100 weight percent of HIPS, the second (and optional third and fourth) layer may include providing about 60 weight percent to about 70 weight percent (preferably about 65 percent) of SBC, about 23 weight percent to about 33 weight percent (preferably about 28 percent) of GPPS, and about 2 weight percent to about 12 weight percent (preferably about 7 percent) of HIPS, all based upon the weight of the respective layer.

The process 400 may include any standard extrusion processing method for processing thermoplastics, including, blown film; extrusion blow moulding; extrusion profiles, film and sheet; injection molding, including gas assisted, and so on.

The process 400 may further include forming a further subsequent end- product or part from the first and second (and optional, third and fourth) layers, such as a yogurt cup or the like, where the product has a predetermined thickness. The predetermined thickness of the copolymer blend products and end-products therefrom may be between about 0.020 inches and about 0.060 inches. Alternatively, the predetermined thickness of the copolymer blend products and end-products therefrom may be less than about 0.020 inches. The predetermined thickness of the copolymer blend products and end-products thereform may likewise be greater than about 0.060 inches. The predetermined thickness of the copolymer blend products may vary based on one or more of a sheet thickness, a final part design, an end product requirement, and the like.

The polystyrene copolymer blends products of the present disclosure have low haze/ high transparency with high strength/ high stiffness compared to conventional polystyrene blends. The blends and blend products also do not have a noticeable odor, which is an important organoleptic characteristic that is often missing in other polystyrene blends. The copolymer blend products may be suitable in applications that require clear and tough parts, such as, e.g., manufacture of appliance housings, household accessories, medical parts, food containers, and so on.

EXAMPLE 1

A non-limiting example of a polystyrene copolymer blend product that is created according to the principles of the disclosure is shown in Table 1. This blend product includes (1) at least one top layer comprising about 2 weight percent to about 6 weight percent of the blend product, wherein the top layer includes about 100 weight percent (+/- about 5 percent) of standard grades of GPPS based on the weight of the top layer and (2) at least one bottom layer comprising about 94 weight percent to about 98 weight percent of the blend product, wherein the bottom layer may include (a) from either about 50 weight percent to about 70 weight percent of SBC or from about 35 weight

percent to 60 weight percent SBC, (b) from about 23 weight percent to about 43 weight percent of GPPS, and (c) from about 0 weight percent to about 17 weight percent of HIPS, based on the weight of the bottom layer .

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TABLE 1

FORMULATION	percent (wt.) top layer in copolymer product	percent (wt.) bottom layer in copolymer product	percent (wt.) GPPS in top layer	percent (wt.) GPPS in bottom layer	percent (wt.) SBC in bottom layer	percent (wt.) HIPS in bottom layer
Preferred Blend	4	96	100	30	60	10
Specific Range	2 - 6	94 - 98	95 - 100	25 - 35	50 – 65	5 - 17
Broad Range	2 - 6	94 - 98	95 - 100	23 - 43	50 - 70	0 - 17

As shown in Table 1 above, the preferred copolymer structure for the blend product includes about 4 weight percent for the top layer and about 96 weight percent for the bottom layer, based on the weight of the blend product. The broad range for the top
10 layer of the copolymer blend is about 2 weight percent to about 6 weight percent of the total weight of the blend product. The broad range for the bottom layer of the copolymer blend product is about 94 weight percent to about 98 weight percent of the total weight of the blend product.

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The preferred copolymer blend product may include about 100 weight percent of GPPS in the top layer. The broad range for the top layer of the copolymer blend product may

include about 95 weight percent to about 100 weight percent of GPPS, based on the weight of the top layer.

For the bottom layer, the preferred copolymer blend may include about 30 weight percent of GPPS, about 60 weight percent of SBC, and about 10 weight percent of HIPS, based on the weight of the bottom layer.

The broad range of the copolymer blend for the bottom layer may include from about 23 weight percent to about 43 weight percent of GPPS, from about 50 weight percent to about 70 weight percent of SBC, and from about 0 weight percent to about 17 weight percent of HIPS, based on the weight of the bottom layer.

The specific range of the copolymer blend for the bottom layer may include from about 25 weight percent to about 35 weight percent of GPPS, from about 55 weight percent to about 65 weight percent of SBC, and from about 5 weight percent to about 15 weight percent of HIPS, based on the weight of the bottom layer.

This copolymer blend results in improved haze/clarity properties with enhanced toughness and stiffness. The haze values from the Example 1 of the present disclosure are listed in Table 2 below. The minimum target may be 0 and the maximum target may vary as a function of thickness. The values are listed based on thickness of 0.020" and 0.051". Sheet haze was determined within each of the examples below in accordance with ASTM D 1746.

TABLE 2

Property	Value
Sheet haze, 0.020"	56.2
Minimum sheet haze, 0.020"	0.0
Maximum sheet haze, 0.020"	70.0
Sheet haze, 0.051"	74.2
Minimum sheet haze, 0.051"	0.0
Maximum sheet haze, 0.051"	80.0

EXAMPLE 2

Another non-limiting example of a polystyrene copolymer blend product that is created according to the principles of the disclosure is shown in Table 3. This blend product includes (1) a top layer forming about 2 weight percent to about 6 weight percent of the total weight of the copolymer blend product, wherein the top layer may include about 95 weight percent to about 100 weight percent (preferably about 100 percent) of standard grades of GPPS, based on the weight of the layer and (2) a bottom layer forming about 94 weight percent to about 98 weight percent of the total weight of the copolymer blend product, wherein the bottom layer includes (a) from about 55 weight percent to about 65 weight percent (preferably 60 percent) of SBC, (b) from about 30 weight percent to about 40 weight percent (preferably about 35 percent) of GPPS, and (c) from about 0 weight percent to about 10 weight percent (preferably about 5 percent) of HIPS, based on the weight of the layer.

TABLE 3

FORMULATION	percent (wt.) top layer in copolymer	percent (wt.) bottom layer in copolymer	percent (wt.) GPPS in top layer	percent (wt.) GPPS in bottom layer(s)	percent (wt.) SBC in bottom layer(s)	percent (wt.) HIPS in bottom layer(s)
Preferred Blend	4	96	100	35	60	5
Specific Range	2 - 6	94 - 98	100	30 - 40	55 - 65	0 - 10
Broad Range	2 - 6	94 - 98	95 - 100	23 - 43	50 - 70	0 - 17

As shown in Table 3 above, the preferred copolymer blend product includes about 4 weight percent of a the total weight percent of the blend product for the top layer and about 96 weight percent of the total weight percent of the blend product for the bottom layer. The broad range for the top layer of the copolymer blend product includes about 2 weight percent to about 6 weight percent of the total weight of the blend product. The broad range for the bottom layer of the copolymer blend product includes about 94 weight percent to about 98 weight percent of the total weight of the blend product.

The preferred copolymer blend may include about 100 weight percent of GPPS in the top layer. The broad range of the copolymer blend for the top layer may include from

about 95 weight percent to about 100 weight percent of GPPS, based on the weight of the layer. For the bottom layer, the preferred copolymer blend may include about 35 weight percent of GPPS, about 60 weight percent of SBC, and about 5 weight percent of HIPS based on the weight of the bottom layer. The broad range of the copolymer blend for the bottom layer may include from about 23 weight percent to about 43 weight percent of GPPS, from about 50 weight percent to about 70 weight percent of SBC, and from about 0 to 15 weight percent of HIPS, based on the weight of the bottom layer.

The specific range of the copolymer blend for the bottom layer may include about 30 to about 40 weight percent of GPPS, from about 55 weight percent to about 65 weight percent of SBC, and from about 0 weight percent to 10 weight percent of HIPS, based on the weight of the bottom layer.

This copolymer blend results in improved haze/clarity properties with enhanced toughness and stiffness. The haze values from the example 2 of the present disclosure are listed in Table 5 below, based on ASTM D 1746. The minimum target may be 0 and the maximum target may vary as a function of thickness. The values are listed based on thicknesses of 0.020" and 0.051".

TABLE 4

Property	Value
Sheet haze, 0.020"	27.9
Minimum sheet haze, 0.020"	0.0
Maximum sheet haze, 0.020"	40.0
Sheet haze, 0.051"	40.0
Minimum sheet haze, 0.051"	0.0
Maximum sheet haze, 0.051"	50.0

EXAMPLE 3

Another non-limiting example of a polystyrene copolymer blend product that is created according to the principles of the disclosure is shown in Table 5. This blend product includes (1) a top layer including about 2 weight percent to about 6 weight percent of the total weight of the copolymer blend product, wherein the top layer may include about 95 weight percent to about 100 weight percent (preferably about 100 percent) of standard grades of HIPS, based on the weight of the top layer and (2) a bottom layer comprising about 94 weight percent to about 98 weight percent of the total weight of the copolymer blend product, wherein the bottom layer includes (a) from about 60 weight percent to about 70 weight percent (preferably 65 percent) of SBC, (b) from about 23 weight percent to about 33 weight percent (preferably about 28 percent) of GPPS, and (c) from about 2 weight percent to about 12 weight percent (preferably about 7 percent) of HIPS, based on the weight of the bottom layer.

TABLE 5

FORMULATION	percent (wt.) top layer in copolymer	percent (wt.) bottom layer in copolymer	percent (wt.) HIPS in top layer	percent (wt.) GPPS in bottom layer(s)	percent (wt.) SBC in bottom layer(s)	percent (wt.) HIPS in bottom layer(s)
Preferred Blend	4	96	100	28	65	7
Specific Range	2 – 6	94 – 98	100	23 - 33	60 - 70	2 - 12
Broad Range	2 – 6	94 – 98	95 – 100	23 – 40	55 – 70	0 – 15

As shown in Table 5 above, the preferred copolymer structure for the copolymer blend product includes about 4 weight percent of the total weight of the product for the top layer and about 96 weight percent of the total weight of the product for the bottom layer. The broad range for the top layer of the copolymer blend product is about 2 weight percent to about 6 weight percent of the copolymer blend product. The broad range for the bottom layer of the copolymer blend product is about 94 weight percent to about 98 weight percent of the copolymer blend product.

The preferred copolymer blend product may include about 100 weight percent of HIPS in the top layer, based on the weight of the top layer. The broad range of the copolymer blend for the top layer of the copolymer blend product may include from about 95 weight percent to about 100 weight percent of HIPS, based on the weight of the opt layer. For the bottom layer, the preferred copolymer blend may include about 28 weight percent of GPPS, about 65 weight percent of SBC, and about 7 weight percent of HIPS. The broad range of the copolymer blend for the bottom layer may include from about 23 weight percent to about 43 weight percent of GPPS, from about 50 weight percent to about 70 weight percent of SBC, and from about 0 weight percent to 15 weight percent of HIPS, based on the weight of the bottom layer.

The specific range of the copolymer blend for the bottom layer may include about 23 weight percent to about 33 weight percent of GPPS, from about 60 weight percent to about 70 weight percent of SBC, and from about 2 weight percent to 12 weight percent of HIPS, based on the weight of the bottom layer.

This copolymer blend results in improved haze/clarity properties with enhanced toughness and stiffness. The haze values from the example 3 of the present disclosure are listed in Table 6 below, based upon ASTM D 1746. The minimum haze target may be 0 and the maximum haze target may vary as a function of thickness. The values are listed based on thickness of 0.020" and 0.051".

TABLE 6

Property	Value
Measured Sheet haze, 0.020"	16.4
Minimum Sheet haze, 0.020"	0.0
Maximum Sheet haze, 0.020"	30
Measured Sheet haze, 0.051"	*NIA*
Minimum Sheet haze, 0.051"	*NIA*
Maximum Sheet haze, 0.051"	*NIA*

The terms "including", "comprising" and variations thereof, as used in this disclosure, mean "including, but not limited to", unless expressly specified otherwise.

The terms "a", "an", and "the", as used in this disclosure, means "one or more", unless expressly specified otherwise.

The term "about", as used in this disclosure, means plus or minus ten percent range.

Although process steps, method steps, or the like, may be described in a sequential order, such processes and methods may be configured to work in alternate orders. In other words, any sequence or order of steps that may be described does not necessarily indicate a requirement that the steps be performed in that order. The steps of the processes or methods described herein may be performed in any order practical. Further, some steps may be performed

simultaneously.

When a single layer or article is described herein, it will be readily apparent that more than one layer or article may be used in place of a single layer or article. The functionality or the features of a layer or article may be alternatively embodied by one or more other layers or articles which are not explicitly described as having such functionality or features.

All ranges include each integer subsumed therein, to at least the hundredth place value.

Each element of the invention may be used interchangeably within any embodiment of the invention, unless noted to the contrary or its unsuitability is obvious from the context.

THAT WHICH IS CLAIMED IS:

1. A polystyrene copolymer blend product, comprising:

a first layer comprising about 2 weight percent to about 6 weight percent of a total weight of the product; and

a second, along with an optional third and optional fourth layer, comprising about 98 weight percent to about 94 weight percent of the total weight of the product,

wherein the first layer comprises about 95 weight percent to about 100 weight percent of GPPS or HIPS, based on the weight of the first layer, and

the second, optional third layer, and optional fourth layer each independently comprise about 23 weight percent to about 43 weight percent of GPPS, from about 50 weight percent to about 70 weight percent of SBC, and from about 0 to about 15 weight percent of HIPS, based on the weight of the respective layer.

2. The product of Claim 1, wherein the GPP exhibits a melt flow from about 1.6 g/10 min to about 4.5 g/10 min at a load of 5.00 kg and a temperature of 200 °C, per ASTM D 1238.

3. The product of Claim 1, wherein the product comprises a thickness between about 0.020 inches and about 0.060 inches.

4. The product of Claim 1, wherein the product comprises a thickness of less than about 0.020 inches.

5. The product of Claim 1, wherein the product comprises a thickness of greater than about 0.060 inches.

6. The product of Claim 1, wherein the product exhibits a sheet haze ranging from about 0 to 70 for product having a thickness of 0.020 inches, based on ASTM D 1746.

7. The product of Claim 6, wherein the product has a sheet haze ranging from about 0 to about 30 for product having a thickness of 0.020 inches, based on ASTM D 1746.

8. The product of Claim 1, wherein the second layer, the optional third layer and the optional fourth layer include from about 25 weight percent to about 35 weight percent of GPPS, from about 55 to about 65 weight percent of SBC, and from about 5 to about 15 weight percent of HIPS, based on the weight of the respective layer.

9. The product of Claim 1, wherein the second layer, the optional third layer and the optional fourth layer includes about 33 weight percent of GPPS, about 60 weight percent of SBC, and about 7 weight percent of HIPS, based on the weight of the respective layer.

10. The product of Claim 1, wherein the copolymer blend for the second layer, the optional third layer and the optional fourth layer comprises about 30 weight percent to about 40 weight percent of GPPS, from about 55 weight percent to about 65 weight percent of SBC, and from about 0 weight percent to 10 weight percent of HIPS, based on the weight of the respective layer.

11. A food package comprising a polystyrene copolymer blend product as claimed in Claim 1.

12. An appliance housing, a household accessory, or a medical device comprising a polystyrene copolymer blend as claimed in Claim 1.

13. The product of Claim 1, wherein the second layer, the optional third layer and the optional fourth layer comprise (a) from about 60 weight percent to about 70 weight percent of SBC, (b) from about 23 weight percent to about 33 weight percent of GPPS, and (c) from about 2 weight percent to about 12 weight percent of HIPS, based on the weight

of the respective layer.

14. The product of Claim 13, wherein the second layer, optional third layer and optional fourth layer comprise about 60 weight percent of SBC, about 33 percent of GPPS, and about 7 weight percent of HIPS.

15. A process of manufacturing a polystyrene copolymer blend product comprising:

overlaying a first layer with a second layer, optional third layer and optional fourth layer by applying a standard processing method for thermoplastics, wherein the overlaying comprises:

extruding a first layer that comprises about 2 weight percent to about 6 weight percent of a total weight of the product; and

extruding a second layer, optional third layer and optional fourth layer that comprise about 98 weight percent to about 94 weight percent of the total weight of the product;

wherein the first layer comprises about 95 weight percent to about 100 weight percent of GPPS or HIPS, based on the weight of the layer, and

the second layer, optional third layer and optional fourth layer comprise about 23 weight percent to about 40 weight percent of GPPS, from about 50 weight percent to about 70 weight percent of SBC, and from about 0 weight percent to about 17 weight percent of HIPS, based on the weight of the respective layer

16. The process of Claim 15, wherein the standard processing method for thermoplastics comprises one or more of: blown film extruding; extrusion blow molding; forming extrusion profiles, films and sheet; and injection molding.

17. The process of Claim 15, wherein the second layer, optional third layer and optional fourth layer include from about 25 weight percent to about 35 weight percent of GPPS, from about 55 weight percent to about 65 weight percent of SBC, and from about 5 weight percent to about 15 weight percent of HIPS,

based on the weight of the respective layer.

18. The process of Claim 15, wherein the copolymer blend for the second layer, optional third layer and optional fourth layer comprises about 30 weight percent to about 40 weight percent of GPPS, from about 55 weight percent to about 65 weight percent of SBC, and from about 0 weight percent to 10 weight percent of HIPS, based on the weight of the respective layer.

19. The process of Claim 15, wherein the second layer, optional third layer and optional fourth layer comprises (a) from about 60 weight percent to about 70 weight percent of SBC, (b) from about 23 weight percent to about 33 weight percent of GPPS, and (c) from about 2 weight percent to about 12 weight percent of HIPS, based on the weight of the respective layer.

20. The process of Claim 19, wherein the second layer, optional third layer and optional fourth layer comprises 60 weight percent of SBC, about 33 percent of GPPS, and about 7 weight percent of HIPS, based on the weight of the respective layer.

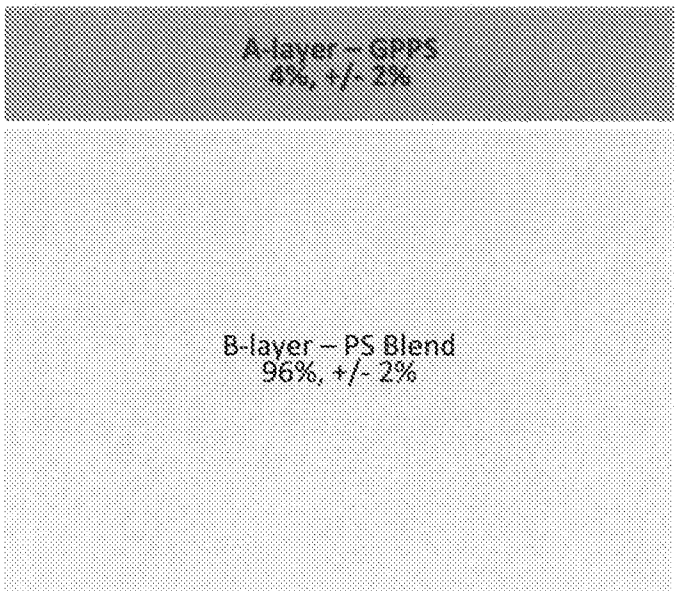

FIG. 1

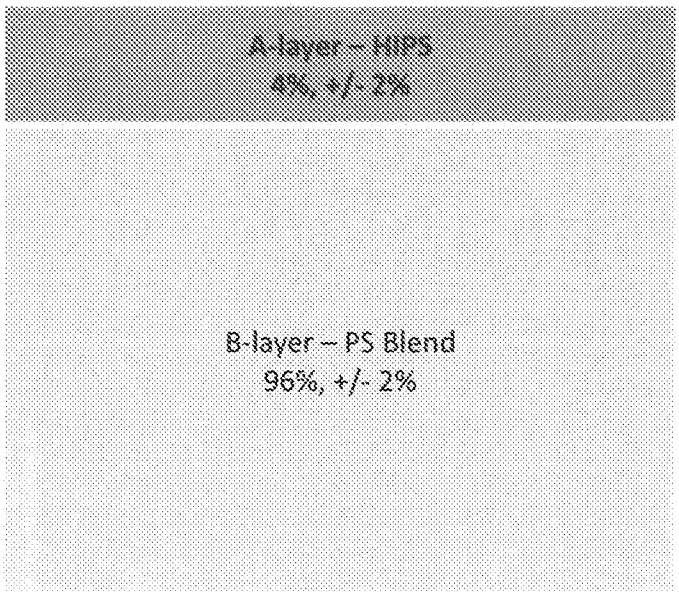

FIG. 2

Example 1 (3 layer option)		
A-layer	Nominal % +/- 5%	Material Type
	100%	GPPS
B-layer	50-65%	SBC
	23-43%	GPPS
	7-17%	HIPS
C-layer	50-65%	SBC
	23-43%	GPPS
	7-17%	HIPS

FIG. 3

Example 2 (4 layer option)		
A-layer	Nominal % +/- 5%	Material Type
	100%	GPPS
B-layer	50-65%	SBC
	43-23%	GPPS
	7-17%	HIPS
C-layer	50-65%	SBC
	43-23%	GPPS
	7-17%	HIPS
D-layer	50-65%	SBC
	43-23%	GPPS
	7-17%	HIPS

FIG. 4

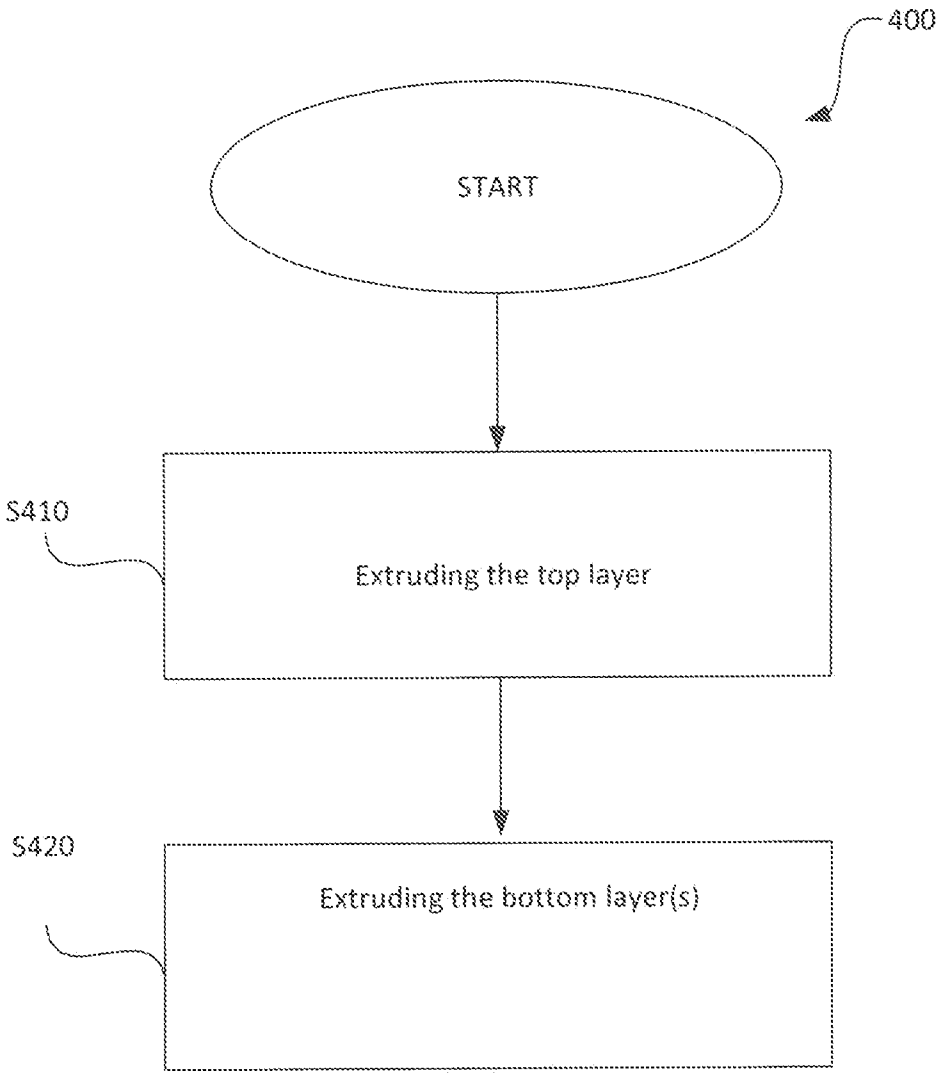
400
START
S410
Extruding the top layer
S420
Extruding the bottom layer(s)

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/020724

A. CLASSIFICATION OF SUBJECT MATTER

B32B 27/30(2006.01)i, B32B 27/08(2006.01)i, B32B 37/15(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B32B 27/30; B65B 53/02; B32B 5/16; B32B 27/08; B65D 71/00; C08F 212/08; C08L 25/08; B29C 47/06; B65D 75/36; B32B 37/15

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: polystyrene, blend, layer, GPPS, HIPS, SBC, weight percent, thickness, haze, food package

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015-0210049 A1 (KLOCKNER PENTAPLAST OF AMERICA, INC.) 30 July 2015 See claims 1, 3-20; and figures 3-6.	1-20
A	US 2010-0215877 A1 (MCGEE, R. L. et al.) 26 August 2010 See claim 1.	1-20
A	WO 2015-187173 A1 (PERFECSEAL, INC.) 10 December 2015 See claim 1 and figure 3.	1-20
A	US 5260110 A (NICHOLS, D. K.) 09 November 1993 See claim 1.	1-20
A	EP 0305764 A1 (BORG-WARNER CHEMICALS, INC.) 08 March 1989 See claim 1.	1-20

☐ 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	Date of mailing of the international search report
14 June 2017 (14.06.2017)	**14 June 2017 (14.06.2017)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/020724

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015-0210049 A1	30/07/2015	None	
US 2010-0215877 A1	26/08/2010	AR 068655 A1	25/11/2009
		CN 101815615 A	25/08/2010
		CN 101815615 B	10/07/2013
		EP 2195160 A1	16/06/2010
		TW 200925207 A	16/06/2009
		US 8431198 B2	30/04/2013
		WO 2009-045737 A1	09/04/2009
WO 2015-187173 A1	10/12/2015	EP 3152128 A1	12/04/2017
		US 2017-0081099 A1	23/03/2017
US 5260110 A	09/11/1993	CA 2012816 A1	09/12/1990
		DE 69010777 T2	09/03/1995
		EP 0401605 A2	12/12/1990
		EP 0401605 A3	26/06/1991
		EP 0401605 B1	20/07/1994
		JP 03-076643 A	02/04/1991
		JP 05-079501 B2	02/11/1993
EP 0305764 A1	08/03/1989	AU 2038188 A	09/02/1989
		AU 617339 B2	28/11/1991
		BR 8803853 A	21/02/1989
		DE 3887940 T2	01/06/1994
		EP 0305764 B1	23/02/1994
		ES 2063009 T3	01/01/1995
		HK 115594 A	27/10/1994
		HK 15795 A	10/02/1995
		JP 01-066215 A	13/03/1989
		KR 10-1989-0003817 A	18/04/1989
		US 4833223 A	23/05/1989
		US 5143955 A	01/09/1992