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(54) Title: MULTILAYERED, TRANSPARENT ARTICLES CONTAINING POLYESTERS COMPRISING A CYCLOBUTANEDIOL AND A PROCESS FOR THEIR PREPARATION

(57) Abstract: Disclosed are transparent, multilayered articles having high transparency and low haze and a process for their preparation. The multilayer articles comprise at least one layer which contains at least one polyester comprising 2,2,4,4- tetramethyl-1 ,3-cyclobutanediol and a separate layer which contains copolyamide or homogeneous blend of polyamides. The polyester component and the polyamide component have refractive indices which differ by about 0.006 to about -0.0006. The small difference in the refractive indices enable the incorporation of regrind into one or more of the layers of the article while maintaining high clarity. These articles can exhibit improved excellent barrier properties and good melt processability while retaining excellent mechanical properties. Metal catalysts can be incorporated into one or more layers to impart oxygen-scavenging properties.

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MULTILAYERED, TRANSPARENT ARTICLES CONTAINING POLYESTERS COMPRISING A CYCLOBUTANEDIOL AND A PROCESS FOR THEIR PREPARATION

CROSS REFERENCES TO RELATED APPLICATONS

[0001] This application is a continuation-in-part of United States Patent Application Serial No. 11/363,418, filed February 27, 2006, which claims the benefit of United States Provisional Application Serial No.'s 60/657,746, filed March 2, 2005, and 60/657,747, filed March 2, 2005. This application further claims the benefit under 35 U.S.C. § 119(e) of United States Provisional Application Serial No. 60/691,567 filed on June 17, 2005, United States Provisional Application Serial No. 60/731,454 filed on October 28, 2005, United States Provisional Application Serial No. 60/731,389, filed on October 28, 2005, United States Provisional Application Serial No. 60/739,058, filed on November 22, 2005, and United States Provisional Application Serial No. 60/738,869, filed on November 22, 2005, United States Provisional Application Serial No. 60/750,692 filed on December 15, 2005, United States Provisional Application Serial No. 60/750,693, filed on December 15, 2005, United States Provisional Application Serial No. 60/750,682, filed on December 15, 2005, and United States Provisional Application Serial No. 60/750,547, filed on December 15, 2005, all of which are hereby incorporated by reference in their entireties.

FIELD OF THE INVENTION

[0002] This invention pertains to transparent, multilayered, shaped articles and a process for their preparation. More specifically, the invention pertains to transparent multilayered articles in which at least one layer contains at least one polyester comprising 2,2,4,4-tetramethyl-1,3-cyclobutanediol and a separate layer which contains copolyamide or homogeneous blend of polyamides. The layers have small differences in the absolute value of their refractive indices. This invention further pertains to a process for the preparation of transparent, multilayered shaped articles in which scrap polymer regrind can be recycled.

BACKGROUND OF THE INVENTION

[0003] Many products, in particular food products, are sensitive to the presence of oxygen and the loss or absorption of water. Packaged products with this sensitivity are susceptible to deterioration because of exposure to oxygen or absorption of moisture. Packaging materials which limit oxygen exposure to food articles, for example, help to maintain the quality of the food articles and to reduce spoilage. The use of such barrier packaging thus keeps the article in inventory longer and thereby reduces restocking costs and waste. Attempts to solve this problem have led to the widespread use of oxygen barriers and/or moisture barriers in packaging materials. Many polymeric materials are known to act as barriers to oxygen or moisture. For example, typical moisture barriers include polyethylene and polypropylene. Representative oxygen barriers include poly(ethylene vinyl alcohol) ("EVOH"), poly(vinyl alcohol) ("PVOH"), polyamides (nylons), and blends of these materials. Poly(vinylidene chloride), vinyl chloride copolymers, and vinylidene chloride-methyl acrylate copolymers also are useful as moisture and oxygen barriers.

[0004] These conventional barrier materials, however, are expensive and have unstable structural characteristics or other deficiencies that make fabrication of packaging materials solely out of barrier materials difficult or undesirable. For example, EVOH, while having superior oxygen barrier properties, is not effective as a moisture barrier. Other barrier materials are prohibitively expensive to be used solely as a packaging material. To avoid these problems, it has become a common practice to use multilayer structures in which the amount of expensive barrier material may be reduced to a thin layer and used in conjunction with an inexpensive polymer on one or both sides of the barrier layer as structural layers. The use of multilayer structures also helps to protect the barrier layer from deterioration by structural layers. Multilayer products, however, can be expensive to produce. Further, multilayer articles can present difficulties in recycling because the different polymer components are difficult to separate. In addition, blending the recovered scrap polymer or "regrind" with virgin polymer often will cause unsatisfactory haze or opaqueness because of the incompatibility of the virgin materials with the regrind.

[0005] The shortcomings of conventional barrier polymers also may be overcome by using a blend of the barrier polymer with another polymer. Unfortunately, as noted above, many blends of barrier polymers and other thermoplastic polymers are immiscible and are opaque or hazy. Such blends are not satisfactory for applications requiring clarity such as, for example, beverage containers.

[0006] Polyester polymers such as, for example, poly(ethylene terephthalate) ("PET"), are commonly used in packaging applications. PET has a number of properties that make it useful as a packaging material, including acceptable carbon dioxide barrier properties for soft drinks packaged in bottles containing multiple servings. However, improvements in the carbon dioxide barrier of PET are needed for soft drinks packaged in smaller bottles and in its oxygen barrier, which is not well-suited for packaging oxygen sensitive products such as, for example, beer, citrus products, tomato-based products, and aseptically packed meat. Poly(ethylene naphthalate) ("PEN") is 3-10 times more effective as a barrier than PET but is more expensive.

[0007] Multilayer structures can be used to improve the gas barrier characteristics of PET. For example, polymers that have excellent oxygen barrier (also referred to as "passive barrier") or scavenging properties (also referred to as "active barrier") may be combined with PET to produce a layered structure consisting of the individual polymers. These multilayer structures, however, are expensive to produce. Blends of barrier polymers with PET also have been used to improve the oxygen barrier of packages but, as noted above, often have poor transparency and are not suitable for many packaging applications. The poor transparency of blends also makes it difficult to recycle manufacturing scrap from polymer blends into virgin polymer.

[0008] Copolyester films and extrusion blow molded ("EBM") bottles are often desired for toughness, and are commonly used instead of PET for extrusion blow molding and film applications. These applications often require barrier that is comparable to that of oriented PET. Unfortunately, however, the barrier properties of copolyesters are inferior to oriented PET. Multilayer structures can be produced by coextruding a thin, barrier film into the center of a thicker bulk structure to improve the overall barrier. To be economical, however, EBM and film processes typically require that high levels (up to 80%) of regrind (i.e., flash and trim) are reprocessed. Unfortunately, typical barrier materials are not miscible with copolyesters and blends of these barrier polymers with polyesters often show a high level of haze and poor clarity. The haze level of the overall film structure, therefore, is increased to unacceptable levels when scrap polymer (i.e., regrind) is incorporated back into the primary layer.

[0009] A polymer blend that provides good passive and/or active barrier properties, is economical, and can be recycled efficiently is needed in the art. Such blends should be transparent, contain thermoplastic and barrier polymers that provide a high barrier for oxygen, water, and carbon dioxide, and can be used economically in article forming processes which incorporate a high level of regrind. In addition, there is need for barrier and thermoplastic polymer compositions that can be used to economically produce multilayered articles having high transparency and can tolerate a high level of regrind.

SUMMARY OF THE INVENTION

[0010] Polymer compositions having high transparency and high barrier properties can be prepared from a immiscible blend of one or more thermoplastic polymers and a copolyamide or a homogeneous, transamidized blend of at least 2 polyamides in which the difference in refractive index between the polyamide component and thermoplastic polymer component is about 0.006 to about -0.0006. Thus, the present invention provides a polymer composition, comprising an immiscible blend of:

(i) a first component comprising at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof; and

(ii) a second component comprising a homogeneous, transamidized blend of at least 2 polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) – RI(first component), of about 0.006 to about –0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less.

[0011] In another aspect of the invention, the first component comprises a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Thus, the invention also provides a polymer composition, comprising an immiscible blend of:

(i) a first component comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second component comprising a homogeneous, transamidized blend of at least 2 polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less.

[0012] The first component comprises at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends of these polymers, while the second component comprises a blend of at least 2 polyamides which have been transamidized to produce a homogeneous blend. We have discovered that refractive indices of the first and second components can be closely matched by selecting at least 2 polyamides having different levels of aliphatic and aromatic residues and transamidizing these polyamides to form a homogeneous blend. Thus, homogeneous blends of the thermoplastic polymers and the polymamides can be used to tailor refractive indices of the second component and the first component to within desired ranges such that the difference in refractive indices is about 0.006 to about -0.0006. For example, a homogeneous blend of a polyester and a polycarbonate comprising the residues of bisphenol A can be used as the first component and a transamidized, homogeneous blend of first polyamide comprising the residues of m-xylylenediamine and adipic acid, and a second aliphatic polyamide can be used as the barrier polymer. When the refractive indices are thus matched, the first and second components form clear, immiscible blends that are suitable for the preparation of high clarity, shaped articles that can be used in many packaging applications. Multilayered articles may also be prepared by a variety of processes known in the art. For example, the first and second components may be coextruded or coinjected from the melt into separate layers, or the layers may be formed individually and brought together in a subsequent process such as, for example, lamination.

[0013] The second component also can comprise a copolyamide having a ratio of aromatic and aliphatic dicarboxylic acid and diamine residues that can be varied to closely match the refractive indices of the first and second components. Thus, another aspect of the invention is a polymer composition, comprising an immiscible blend of:

(i) a first component comprising at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof; and

(ii) a second component comprising a copolyamide;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) – RI(first component), of about 0.006 to about –0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less. In another embodiment, the first component comprises a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. The invention, thus, provides a polymer composition, comprising an immiscible blend of:

(i) a first component comprising at least one polyester which comprises:

  (a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second component comprising a copolyamide;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less.

[0014] Another aspect of our invention is a polymer composition prepared by a process comprising melt blending:

(i) a first component comprising at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof; and

(ii) a second component comprising a homogeneous, transamidized blend of at least 2 polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the composition has a percent transmittance of at least 75%, and a haze of 10% or less. In yet another aspect of the invention, the first component comprises a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. The invention, therefore, also provides a polymer composition, prepared by a process comprising melt blending:

(i) a first component comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second component comprising a homogeneous, transamidized blend of at least 2 polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the composition has a percent transmittance of at least 75%, and a haze of 10% or less.

[0015] The compositions of our invention show excellent barrier properties. The oxygen barrier properties may be enhanced by incorporating transition metal catalysts such as, for example, cobalt, manganese, iron, ruthenium, copper, nickel, palladium, and platinum into the blends to produce oxygen scavenging compositions. The invention, thus, further provides an oxygen-scavenging composition comprising:

(A) an immiscible blend comprising

(i) first component comprising at least one thermoplastic polymer selected from polyester, polycarbonate, polyarylate, and homogeneous blends thereof;

(ii) a second component comprising a transamidized, homogeneous blend of at least two polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less; and

(B) at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements.

Typical metal catalysts include, but are not limited to, cobalt, manganese, and iron. The first component of the immiscible blend may comprise a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Thus, another embodiment of the invention is an oxygen-scavenging composition comprising:

(A) an immiscible blend comprising

(i) a first component comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second component comprising a homogeneous, transamidized blend of at least 2 polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less; and

(B) at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements.

[0016] The blends of the present invention are useful for producing clear, shaped articles having improved barrier properties, melt processability, and excellent mechanical properties, and which can be prepared using a high proportion of regrind to virgin polymer. These shaped articles may have a single layer or multiple layers and have numerous packaging applications. Accordingly, the invention further provides a process for forming a shaped article, comprising:

(A) melt blending

(i) a first component comprising at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof; and

(ii) a second component comprising a copolyamide or a homogeneous, transamidized blend of at least 2 polyamides;

wherein the first component (i) and second component (ii) form an immiscible blend, the second component and the first component have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less;

(B) forming a shaped article;

(C) recovering a scrap polymer composition comprising the blended first and second components (i) and (ii) ;

(D) grinding the scrap polymer composition to produce a polymer regrind;

(E) optionally, drying the scrap polymer composition;and

(F) combining the polymer regrind with the first and second components (i) and (ii) of step (A). In another example, the first component can comprise a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Thus, the instant invention also includes a process for forming a shaped article, comprising:

(A) melt blending

(i) a first component comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second component comprising a copolyamide or a homogeneous, transamidized blend of at least 2 polyamides;

wherein the first component (i) and second component (ii) form an immiscible blend, the second component and the first component have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less;

(B) forming a shaped article;

(C) recovering a scrap polymer composition comprising the blended first and second components (i) and (ii) ;

(D) grinding the scrap polymer composition to produce a polymer regrind;

(E) optionally, drying the scrap polymer composition;and

(F) combining the polymer regrind with the first and second components (i) and (ii) of step (A).

Examples of shaped articles which may be prepared by the process of the invention include, but are not limited to, sheets, films, tubes, bottles, or profiles. The shaped article may be produced by extrusion, calendering, thermoforming, blow-molding, extrusion blow-molding, injection molding, compression molding, casting, drafting, tentering, or blowing.

[0017] The shaped articles may have one or more layers comprising an immiscible blend of the first and second components or can have multiple layers in which the first and second components are in separate layers. The invention, therefore, also provides a multilayered, shaped article, comprising:

(i) a first layer comprising at least one thermoplastic polymer selected from polyester, polycarbonate, polyarylate, and homogeneous blends thereof; and

(ii) a second layer comprising a transamidized homogeneous blend of at least two polyamides;

wherein the second layer (ii) and the first layer (i) have a difference in refractive index, RI(second layer) - RI(first layer), of about 0.006 to about -0.0006, and the shaped article has a percent transmittance of at least 75%, and a haze of 10% or less. In another aspect, the first layer can comprise a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Thus, another embodiment of the invention is a multilayered, shaped article, comprising:

(i) a first layer comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second layer comprising a transamidized, homogeneous blend of at least two polyamides;

wherein the second layer (ii) and the first layer (i) have a difference in refractive index, RI(second layer) - RI(first layer), of about 0.006 to about -0.0006, and the shaped article has a percent transmittance of at least 75%, and a haze of 10% or less.

[0018] The invention further provides a process for forming a multilayered shaped article, comprising:

(i) heating a first component comprising at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof to a temperature of about Tg +100°C to about Tg + 300°C of the first component;

(ii) heating a second component comprising a copolyamide or a transamidized, homogeneous blend of at least two polyamides to a temperature of about Tg +100°C to about Tg + 300°C of the second component;

(iii) forming a shaped article having the first and second components in separate layers;

(iv) recovering scrap first and second components;

(v) grinding the scrap first and second components to produce a regrind;

(vi) optionally, drying the regrind; and

(vii) combining the regrind with the first component, second component, or a combination thereof, of steps (i) and (ii);

wherein the second component of step (ii) and the first component of step (i) of have a difference in refractive index, RI(second component) – RI(first component), of about 0.006 to about –0.0006, and the shaped article has a percent transmittance of at least 75%, and a haze of 10% or less. In another example, the first component can comprise a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Hence, another aspect of the invention is a process for forming a multilayered shaped article, comprising:

(i) heating a first component to a temperature of about Tg +100°C to about Tg + 300°C of the first component, the first component comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol;

(ii) heating a second component comprising a copolyamide or a transamidized, homogeneous blend of at least two polyamides to a temperature of about Tg +100°C to about Tg + 300°C of of the second component;

(iii) forming a shaped article having the first and second components in separate layers;

(iv) recovering scrap first and second components;

(v) grinding the scrap first and second components to produce a regrind;

(vi) optionally, drying the regrind; and

(vii) combining the regrind with the first component, second component, or a combination thereof, of steps (i) and (ii);

wherein the second component of step (ii) and the first component of step (i) of have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the shaped article has a percent transmittance of at least 75%, and a haze of 10% or less. The regrind may be incorporated into the first or second layer and may be from about 5 to about 60 weight percent of the article.

DETAILED DESCRIPTION

[0019] Polymer compositions having high clarity and good barrier properties can be prepared from an immiscible blend of one or more thermoplastic polymers and a transamidized, homogeneous blend of at least two polyamides, in which the difference in refractive index between the blend of polyamides and the thermoplastic polymers is about 0.006 to about -0.0006. The immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less. In a general embodiment, the present invention provides polymer composition, comprising an immiscible blend of:

(i) a first component comprising at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof; and

(ii) a second component comprising a homogeneous, transamidized blend of at least 2 polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less. The thermoplastic polymers and polyamides may be selected from a wide variety of polymers. For example, the first component can comprise a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. The refractive indices of the second component and the first component can be adjusted to give a difference of about 0.006 to about -0.0006 by the selection and ratio of the polyamides of the second component or, alternatively, by blending the thermoplastic polymers of the first component to form a homogeneous blend. Our novel compositons can be used to manufacture shaped articles having one or more layers such as, for example, sheets, films, tubes, bottles, and profiles. The shaped article may be produced by extrusion, calendering, thermoforming, blow-molding, extrusion blow-molding, injection molding, compression molding, casting, drafting, tentering, or blowing. Multilayer articles can be prepared in which the immiscible blend is present in one or more layers or the first and second components are in separate layers. Because of the small difference in the refractive indices of the first and second components, shaped articles prepared from the composition of the invention can incorporate substantial quantities of regrind and retain good transparency. The clarity and barrier properties of these shaped articles produced make them particularly useful for packaging applications.

[0020] Unless otherwise indicated, all numbers expressing quantities of ingredients, properties such as molecular weight, reaction conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by the present invention. At the very least, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques. Further, the ranges stated in this disclosure and the claims are intended to include the entire range specifically and not just the endpoint(s). For example, a range stated to be 0 to 10 is intended to disclose all whole numbers between 0 and 10 such as, for example 1, 2, 3, 4, etc., all fractional numbers between 0 and 10, for example 1.5, 2.3, 4.57, 6.1113, etc., and the endpoints 0 and 10. Also, a range associated with chemical substituent groups such as, for example, "C_1 to C_5 hydrocarbons", is intended to specifically include and disclose C_1 and C_5 hydrocarbons as well as C_2, C_3, and C_4 hydrocarbons.

[0021] Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the invention are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contains certain errors necessarily resulting from the standard deviation found in their respective testing measurements.

[0022] As used in the specification and the appended claims, the singular forms "a," "an" and "the" include their plural referents unless the context clearly dictates otherwise. For example, reference a "polymer," or a "shaped article," is intended to include the processing or making of a plurality of polymers, or articles. References to a composition containing or including "an" ingredient or "a" polymer is intended to include other ingredients or other polymers, respectively, in addition to the one named.

[0023] By "comprising" or "containing" or "including" we mean that at least the named compound, element, particle, or method step, etc., is present in the composition or article or method, but does not exclude the presence of other compounds, catalysts, materials, particles, method steps, etc, even if the other such compounds, material, particles, method steps, etc., have the same function as what is named, unless expressly excluded in the claims.

[0024] It is also to be understood that the mention of one or more method steps does not preclude the presence of additional method steps before or after the combined recited steps or intervening method steps between those steps expressly identified. Moreover, the lettering of process steps or ingredients is a convenient means for identifying discrete activities or ingredients and the recited lettering can be arranged in any sequence, unless otherwise indicated.

[0025] The term "polyester", as used herein, is intended to include homopolyesters, copolyesters, and terpolyesters. In general, polyesters are synthetic polymers prepared by the polycondensation of one or more difunctional and/or multifunctional carboxylic acids with one or more difunctional and/or multifunctional hydroxyl compounds. Typically, the difunctional carboxylic acid is a dicarboxylic acid or a hydroxycarboxylic acid, and the difunctional hydroxyl compound is a dihydric alcohol such as, for example, glycols and diols. Also, the polyesters of the invention can contain branching monomers which may contain 3 or more carboxylic acid groups, hydroxyl groups, or a combination of carboxylic acid and hydroxyl groups. Therefore, the terms "diacid" or "dicarboxylic acid", as used herein, are intended also to include multifuntional carboxylic acids which may be used as branching monomers such as, for example, trimellitic acid. Similarly, the terms "diol" or "glycol", as used herein, are intended also to include multifunctional hydroxyl compounds which may be used as branching monomers such as, for example, pentaerythritol. In the present invention, the difunctional or multifunctional carboxylic acid may be an aliphatic or cycloaliphatic dicarboxylic acid such as, for example, adipic acid, or an aromatic dicarboxylic acid such as, for example, terephthalic acid. The difunctional hydroxyl compound may be cycloaliphatic diol such as, for example, 1,4-cyclohexanedimethanol, a linear or branched aliphatic diol such as, for example, 1,4-butanediol, or an aromatic diol such as, for example, hydroquinone.

[0026] The polyesters used in the present invention typically are prepared from dicarboxylic acids and diols which react in substantially equal proportions and are incorporated into the polyester polymer as their corresponding residues. The polyesters derived from dicarboxylic acid and diol residues of the present invention, therefore, contain substantially equal molar proportions of acid residues (100 mole percent) and diol residues (100 mole percent) such that the total moles of repeating units is equal to 100 mole percent. The mole percentages provided in the present disclosure, therefore, may be based on the total moles of acid residues, the total moles of diol residues, or the total moles of repeating units. For example, a copolyester containing 30 mole percent terephthalic acid, based on the total acid residues, means that the copolyester contains 30 mole percent terephthalic residues out of a total of 100 mole percent acid residues. Thus, there are 30 moles of terephthalic residues among every 100 moles of acid residues. In another example, a copolyester containing 30 mole percent 1,4-cyclohexanedimethanol, based on the total diol residues, means that the copolyester contains 30 mole percent 1,4-cyclohexane-dimethanol residues out of a total of 100 mole percent diol residues. Thus, there are 30 moles of 1,4-cyclohexanedimethanol residues among every 100 moles of diol residues. As used herein, copolyesters of terephthalic acid, ethylene glycol, and 1,4-cyclohexandimethanol may be referred to as "PET" when the glycol component is primarily ethylene glycol, "PCT" when the glycol component is primarily 1,4-cyclohexanedimethanol, "PETG" when the ratio of ethylene glycol to 1,4-cyclohexanedimethanol is greater than 1 and "PCTG" when the ratio of ethylene glycol to 1,4-cyclohexanedimethanol ratio is less than 1.

[0027] The term "polyamide", as used herein, is intended to include synthetic polymers prepared by the polycondensation of one or more difunctional carboxylic acids with one or more difunctional amines or by the ring-opening polymerization of a lactam and may include homopolymers and copolymers. For example, the difunctional carboxylic acid can be a dicarboxylic acid such as adipic acid or isophthalic acid, and the difunctional amine can be a diamine such as, for example, hexamethylene diamine or m-xylylenediamine. The term "copolyamide", as used herein, is understood to mean a polyamide comprising at least 2, chemically distinct repeating units. For example, MXD6 nylon, is not a copolyamide because it contains only a single, chemically distinct repeating unit containing the residues of adipic acid and m-xylylenediamine. By contrast, poly(hexamethylene adipamide-co-isophthalamide), prepared by the condensation of hexamethylenediamine with adipic and isophthalic acid, has two chemically distinct repeating units, that is, a repeating unit containing the residues of hexamethylenediamine and adipic acid, and another repeating unit containing the residues of hexamethylene diamine and isophthalic acid.

[0028] The term "polycarbonate" is herein defined as the condensation product of a carbonate source and a diol source, having a carbonate component containing 100 mole percent carbonate units and a diol component containing 100 mole percent diol units, for a total of 200 mole percent monomeric units or 100 mole percent "repeating units". In one embodiment of the present invention, the polycarbonate portion of the first component is based upon the polycarbonate of 4,4'-isopropylidenediphenol, commonly known as bisphenol A polycarbonate. A wide variety of the linear or branched polycarbonates that may be utilized in the present invention may be derived from bisphenol A and can be prepared according to procedures well known in the art such as, for example, as disclosed in U.S. Patent No.'s 3,030,335 and 3,317,466. Examples of bisphenol A polycarbonates that may be used in the present invention and are available commerically include the materials marketed under the tradenames LEXAN®, available from the General Electric Company, and MAKROLON®, available from Bayer, Inc.

[0029] The term "polyarylate", as used herein, is understood to mean polyesters prepared by the polycondensation of one or more difunctional aromatic dicarboxylic acids with one or more dihydric phenols. For example, typical aromatic dicarboxylic acids are terephthalic and isophthalic acid, and typical aromatic diphenols are bisphenol A and hydroquinone.

[0030] The term "residue", as used herein in reference to the polymers of the invention, means any organic structure incorporated into a polymer through a polycondensation or ring opening reaction involving the corresponding monomer. The term "repeating unit", as used herein, means shortest sequence of monomer residues that can be found repeatedly in a polymer. For example, in polyesters, a repeating unit is an organic structure having dicarboxylic acid residue and a diol residue, or hydroxycarboxylic acid residues bonded through a carbonyloxy group. In a polyamide, a repeating unit is an organic structure having a dicarboxylic acid and a diamine residue, lactam, or aminoacid residues, bonded through a amide group.

[0031] It will also be understood by persons having ordinary skill in the art that the residues associated within the various polyesters, polyamide, polycarbonates, and polyarylates of the invention can be derived from the parent monomer compound itself or any derivative of the parent compound. For example, the dicarboxylic acid and amino acid residues referred to in the polymers of the invention may be derived from a dicarboxylic acid or aminoacid monomer or its associated acid halides, esters, salts, anhydrides, or mixtures thereof. Thus, as used herein, the term "dicarboxylic acid" or "aminoacid" is intended to include dicarboxylic acids and any derivative of a dicarboxylic acid, including its associated acid halides, esters, half-esters, salts, half-salts, anhydrides, mixed anhydrides, or mixtures thereof, useful in a polycondensation process with a diol to make a high molecular weight polyester, polyamide, polycarbonate, or polyarylate. The term "hydroxycarboxylic acid" is intended to include aliphatic and cycloaliphatic hydroxycarboxylic acids as well as monohydroxy-monocarboxylic acids and any derivative thereof, including their associated acid halides, esters, cyclic esters (including dimers such as lactic acid lactides), salts, anhydrides, mixed anhydrides, or mixtures thereof, useful in a polycondensation process or ring opening reaction to make a high molecular weight polyester. Similarly, "aminoacid" is intended to include aliphatic, aromatic, and cycloaliphatic aminoacids and any derivative thereof, including their associated acid halides, amides, cyclic amides (lactams), salts, anhydrides, mixed anhydrides, or mixtures thereof, useful in a polycondensation process or ring opening reaction to make a high molecular weight polyamide. In addition, the term "diamine" is intended to include diamines as well as their associated salts, amides, or any other derivative thereof that are useful for the preparation of polyamides.

[0032] Whenever the term "inherent viscosity" (I.V.) is used in this application, it will be understood to refer to viscosity determinations made at 25

°C using 0.5 grams of polymer per 100 ml of a solvent comprising 60 weight percent phenol and 40 weight % tetrachloroethane.

[0033] The term "refractive index" (abbreviated herein as "RI") as used herein, refers to refractive index measurements obtained according to standard methods well known in the art. The refractive indices reported herein were determined at a wavelength of 633 nm using a Metricon Prism Coupler™ model 2010 refractometer (available from Metricon Inc.) and are reported as the average of the refractive indices measured in 3 orthogonal directions (extrusion or stretch, transverse, and thickness directions). The phrase "difference in refractive index" as used herein in the context of the compositions, processes, and shaped articles of the invention always means the value obtained by subtracting the refractive index of the polyester, polycarbonate, or polyarylate-containing component (typically referred to herein as the "first component" or "first layer" in multilayered articles) from the refractive index of the polyamide- or copolyamide-containing component (typically referred to herein as the "second component" or "second layer" in multilayered articles). Thus, in accordance with the invention, the difference in refractive index ("ΔRI") should be calculated according to the following formula:

$$\Delta RI = RI\ (\textit{second component or layer}) - RI\ (\textit{first component or layer})$$

It will be evident to persons skilled in the art that the difference in refractive index may be a positive or negative number.

[0034] The term "%haze", as used herein, refers to haze values determined according to ASTM Method D1003 using a HunterLab UltraScan Sphere 8000 Colorimeter manufactured by Hunter Associates Laboratory, Inc., Reston, Va using Hunter's Universal Software (version 3.8) (%Haze = 100 * Diffuse Transmission / Total Transmission). The term "percent transmittance", as used herein, is synonymous with the term "percent transmission". The procedure for the determination of refractive index is provided in the Examples. For the compositions of the invention, haze and percent transmittance (i.e., % transmission) is determined by molding or casting the composition into a sheet or film having a thickness of 1/8 inch or less and measuring the haze and percent transmittance according to the procedures described in the examples. For shaped articles, including multilayer shaped articles, the haze and percent transmittance can be determined by cutting out a small (i.e., 1 X 1 cm) section of the article, having a thickness of 1/8 inch or less, and measuring the haze according the procedure described herein.

[0035] The term glass transition temperature ("Tg") as used herein, refers to the Tg values determined using differential scanning calorimetry ("DSC"), typically using a scan rate of 20°C/min. An example of a DSC instrument is TA Instruments 2920 Differential Scanning Calorimeter.

[0036] The compositions of the present invention comprise a first component comprising one or more thermoplastic polymers selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof. The term "thermoplastic polymer", as used herein, is intended to have its plain meaning as would be understood by persons having ordinary skill in the art, that is, a polymer that softens when exposed to heat and returns to its original condition when cooled to room temperature. The first component may comprise a single thermoplastic polymer or may comprise a blend of 2 or more polymers provided that the blend is a homogeneous blend. The term "homogeneous blend", as used herein, is synonymous with the term "miscible", and is intended to mean that the blend has a single, homogeneous phase as indicated by a single, composition-dependent Tg. For example, a first polymer that is miscible with second polymer may be used to "plasticize" the second polymer as illustrated, for example, in U.S. Patent No. 6,211,309. Homogeneous blends may be formed by simply blending two or polymers or, in the case of condensation polymers such as for example, polyesters or polyamides, by transesterifying or transamidating two or more polymers. By contrast, the term "immiscible", as used herein, denotes a blend that shows at least 2, randomly mixed, phases and exhibits more than one Tg. Some polymers may be immiscible and yet compatible with each other. A further general description of miscible and immiscible polymer blends and the various analytical techniques for their characterization may be found in *Polymer Blends* Volumes 1 and 2, Edited by D.R. Paul and C.B. Bucknall, 2000, John Wiley & Sons, Inc.

[0037] The first component may comprise one or more thermoplastic polymers selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof. For example, the first component may comprise a polyester comprising (a) diacid residues, comprising at least 80 mole percent, based on the total diacid residues, of the residues of at least one dicarboxylic acid selected from terephthalic acid, isophthalic acid, naphthalenedicarboxylic acid, and 1,4-cyclohexanedicarboxylic acid, and 0 to about 20 mole percent of the residues of at least one modifying dicarboxylic acid having 2 to 20 carbon atoms; and (b) diol residues comprising at least 80 mole percent, based on the total moles of diol residues, of the residues of at least one diol selected from ethylene glycol, 1,4-cyclohexanedimethanol; neopentyl glycol, diethylene glycol, 1,3-propanediol, 1,4-butanediol, and, 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and from 0 to about 20 mole percent of the residues of at least one modifying diol having from 3 to 16 carbons. Cyclic diols containing cis and trans isomers may be used as the pure *cis* or *trans* isomer or as a mixture of *cis* and *trans* isomers.

[0038] For example, the diacid residues can comprise the residues of one or more dicarboxylic acids selected from terephthalic acid, isophthalic acid, or combinations thereof, and the diol residues comprise the residues of one or more diols selected from 1,4-cyclohexanedimethanol, neopentyl glycol, ethylene glycol, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and combinations thereof. In one embodiment, for example, the diacid residues may comprise the residues of terephthalic acid and isophthalic acid. A higher concentration of terephthalic acid in the polyester than isophthalic acid is advantageous because the resulting polyester provides greater impact strength to the blend. For example, the diacid residues may comprise from about 60 to about 100 mole percent of the residues terephthalic acid and 0 to about 40 mole percent of the residues isophthalic acid and the diol residues may comprise about 100 mole percent of the residues of 1,4-cyclohexanedimethanol. Other examples of dicarboxylic acid content include about 80 to about 100 mole percent of the residues of terephthalic acid and 0 to 20 mole percent of the residues isophthalic acid, about 95 to about 100 mole percent of the residues of terephthalic acid, and about 100 mole percent of the residues of terephthalic acid.

[0039] Other representative polyesters that may be used as the thermoplastic polymers of component (i) include polyesters comprising: (a) diacid residues comprising about 80 to about 100 mole percent of the residues of terephthalic acid and diol residues comprising about 50 to about 90 mole percent of the residues of 1,4-cyclohexanedimethanol and about 10 to about 50 mole percent of the residues of neopentyl glycol; (b) diacid residues comprising 100 mole percent of the residues of terephthalic acid and diol residues comprising about 10 to about 40 mole percent of the residues of 1,4-cyclohexanedimethanol and 60 to about 90 mole percent of the residues of ethylene glycol; (c) diacid residues comprising about 100 mole percent terephthalic acid and diol residues comprising about 10 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol, 0 to about 90 mole percent of the residues of ethylene glycol, and about 1 to about 25 mole percent of the residues of diethylene glycol; and (d) diacid residues comprising 100 mole percent terephthalic acid and diol residues comprising about 50 to about 90 mole percent 1,4-cyclohexanedimethanol and about 10 to about 50 mole percent ethylene glycol.

[0040] In another embodiment, the first component can comprise at least one polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. For example, the polyester may comprise (a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and (b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol. Other representative examples of polyesters that may be used in the first component include, but are not limited to, polyesters comprising 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms and any one of the following diol residue compositions: (i) about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol; (ii) about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol; (iii) about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol; and (iv) about 20 to about 25 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 75 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

[0041] In yet another example, the dicarboxylic acid may be selected from terephthalic acid and isophthalic acid, and the diol is selected from 1,4-cyclohexanedimethanol and ethylene glycol. In one composition, for example, the dicarboxylic acid is terephthalic acid and the diol is 1,4-cyclohexanedimethanol. In yet another example, the diacid residues may comprise at least 95 mole percent of the residues of terephthalic acid and the diol residues may comprise about 10 to about 40 mole percent of the residues of 1,4-cyclohexanedimethanol, about 1 to about 25 mole percent of the residues of diethylene glycol, and about 35 to about 89 mole percent of the residues of ethylene glycol.

[0042] The polyester may further comprise 0 to about 30 mole percent of one or more residues of a modifying diacid containing 2 to 20 carbon atoms if desired. For example, from 0 to about 30 mole % of other aromatic dicarboxylic acids containing 8 to about 16 carbon atoms, cycloaliphatic dicarboxylic acids containing 8 to about 16 carbon atoms, aliphatic dicarboxylic acids containing about 2 to about 16 carbon atoms, or mixtures thereof may be used. Examples of modifying aromatic dicarboxylic acids include, but are not limited to, one or more of 4,4'-biphenyldicarboxylic acid, isophthalic acid, 1,4- naphthalene-dicarboxylic acid, 1,5- naphthalenedicarboxylic acid, 2,6- naphthalene-dicarboxylic acid, 2,7-naphthalenedicarboxylic acid, 4,4'-oxybenzoic acid, and trans-4,4'-stilbenedicarboxylic acid. Examples of modifying aliphatic dicarboxylic acids include, but are not limited to, one or more of oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, and sebacic acid. For example, the diacid component of the polyester may be modified with 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms.

[0043] In another embodiment, the polyester can comprise about 1 to about 99 mole percent, based on the total moles of diol residues, of the residues of 1,4-cyclohexanedimethanol, about 99 to about 1 mole percent of the residues ethylene glycol. Typical mole percentages for the residues of 1,4-cyclohexanedimethanol for the polyesters of the invention include from about 1 to about 10 mole percent, from about 1 to about 25 mole percent, from about 1 to about 40 mole percent, 50 mole percent and greater, and 100 mole percent.

In yet another embodiment, for example, the dicarboxylic acid is 1,4-cyclohexanedicarboxylic acid and the diol is 1,4-cyclohexanedimethanol. In a further example, the polyester may comprise the residues of 1,4-cyclohexane-dimethanol units and the neopentyl glycol. In yet another example, the polyester may comprise the residues of 1,4-cyclohexanedimethanol units and 2,2,4,4-tetramethyl-1,3-cyclobutanediol.

[0044] The diol component of the polyester also may be modified from 0 to about 20 mole percent of the residues of at least one modifying diol having from 3 to 16 carbons. Other ranges of modifying diol include, but are not limited to, from 0 to about 10 mole percent, and less than 5 mole percent. The modifying diol may be selected from one or more of 1,2-propanediol, 1,3-propanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, 1,4-cyclohexanedimethanol, p-xylene glycol, neopentyl glycol, polyethylene glycol, polytetramethylene glycol, and 2,2,4,4-tetramethyl-1,3-cyclobutanediol. Examples of polyalkylene glycols include poly(tetramethylene glycol) ("PTMG") and poly(ethylene glycol) ("PEG") having molecular weights up to about 2,000. The diol component, for example, can be modified with 0 to about 10 mole percent polyethylene glycol or polytetramethylene glycol to enhance elastomeric behavior. In another example, the diol residues may comprise about 10 to about 99 mole percent of residues of 1,4-cyclohexanedimethanol, 0 to about 90 mole percent of residues of ethylene glycol, and about 1 to about 25 mole percent of residues of diethylene glycol. The polyester also may contain up to about 5 mole percent, typically from about 0.01 to about 2.0 mole%, or more typically, about 0.01 to about 1 mole percent, based on the total acid or diol residues, of the residues of a polyfunctional branching agent derived from a compound having at least three carboxyl and/or hydroxy groups to form a branched polyester. Examples of such compounds include trimellitic acid, trimellitic anhydride, and pyromellitic dianhydride, glycerol, sorbitol, 1, 2, 6-hexanetriol, pentaerythritol, tartaric acid, citric acid, trimethylolethane, and trimesic acid, and the like. It will be understood by persons skilled in the art that the final composition can be arrived at by blending various resins or by direct reactor copolymerization. The latter is desirable to minimize compositional variability but economic necessities often make blending more cost effective.

[0045] Additional examples of polyesters are those containing about 100 mole percent terephthalic residues, based on the total diacid residues, and any one of the following diol residue compositions, based on the total diol residues: (i) about 1 to about 5 mole percent of the residues of 1,4-cyclohexane-dimethanol and about 99 to about 95 mole percent of the residues of ethylene glycol; (ii) about 29 to about 33 mole percent of the residues of 1,4-cyclo-hexanedimethanol and about 71 to about 67 mole percent of the residues of ethylene glycol; (iii) about 45 to about 55 mole percent of the residues of 1,4-cyclohexanedimethanol and about 55 to about 45 mole percent of the residues of ethylene glycol; (iv) about 60 to about 65 mole percent of the residues of 1,4-cyclohexanedimethanol and about 40 to about 35 mole percent of the residues of ethylene glycol; (v) about 79 to about 83 mole percent of the residues of 1,4-cyclohexanedimethanol and about 21 to about 17 mole percent of the residues of ethylene glycol; (vi) about 100 mole percent of the residues of 1,4-cyclohexanedimethanol; (vii) about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol; (viii) about 15 to about

40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexane-dimethanol; (ix) about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol; and (x) about 20 to about 25 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 75 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

[0046] It is believed that certain compositions comprising polyesters formed from terephthalic acid, an ester thereof, or mixtures thereof, 1,4-cyclohexanedimethanol and 2,2,4,4-tetramethyl-1,3-cyclobutanediol with certain monomer compositions, inherent viscosities and/or glass transition temperatures are superior to polyesters known in the art and to polycarbonate with respect to one or more of high impact strengths, hydrolytic stability, toughness, chemical resistance, good color and clarity, long crystallization half-times, low ductile to brittle transition temperatures, lower specific gravity, and thermoformability. These compositions are believed to be similar to polycarbonate in heat resistance and are still processable on the standard industry equipment.

[0047] In other aspects of the invention, for example, the Tg of the polyesters useful in the compositions, processes, and shaped articles of the invention can be at least one of the following ranges: 60 to 200°C; 60 to 190°C; 60 to 180°C; 60 to 170°C; 60 to 160°C; 60 to 155°C; 60 to 150°C; 60 to 145°C; 60 to 140°C; 60 to 138°C; 60 to 135°C; 60 to 130°C; 60 to 125°C; 60 to 120°C; 60 to 115°C; 60 to 110°C; 60 to 105°C; 60 to 100°C; 60 to 95°C; 60 to 90°C; 60 to 85°C; 60 to 80°C; 60 to 75°C; 65 to 200°C; 65 to 190°C; 65 to 180°C; 65 to

170°C; 65 to 160°C; 65 to 155°C; 65 to 150°C; 65 to 145°C; 65 to 140°C; 65 to 138°C; 65 to 135°C; 65 to 130°C; 65 to 125°C; 65 to 120°C; 65 to 115°C; 65 to 110°C; 65 to 105°C; 65 to 100°C; 65 to 95°C; 65 to 90°C; 65 to 85°C; 65 to 80°C; 65 to 75°C; 70 to 200°C; 70 to 190°C; 70 to 180°C; 70 to 170°C; 70 to 160°C; 70 to 155°C; 70 to 150°C; 70 to 145°C; 70 to 140°C; 70 to 138°C; 70 to 135°C; 70 to 130°C; 70 to 125°C; 70 to 120°C; 70 to 115°C; 70 to 110°C; 70 to 105°C; 70 to 100°C; 70 to 95°C; 70 to 90°C; 70 to 85°C; 70 to 80°C; 70 to 75°C; 75 to 200°C; 75 to 190°C; 75 to 180°C; 75 to 170°C; 75 to 160°C; 75 to 155°C; 75 to 150°C; 75 to 145°C; 75 to 140°C; 75 to 138°C; 75 to 135°C; 75 to 130°C; 75 to 125°C; 75 to 120°C; 75 to 115°C; 75 to 110°C; 75 to 105°C; 75 to 100°C; 75 to 95°C; 75 to 90°C; 75 to 85°C; 75 to 80°C; 80 to 200°C; 80 to 190°C; 80 to 180°C; 80 to 170°C; 80 to 160°C; 80 to 155°C; 80 to 150°C; 80 to 145°C; 80 to 140°C; 80 to 138°C; 80 to 135°C; 80 to 130°C; 80 to 125°C; 80 to 120°C; 80 to 115°C; 80 to 110°C; 80 to 105°C; 80 to 100°C; 80 to 95°C; 80 to 90°C; 80 to 85°C; 85 to 200°C; 85 to 190°C; 85 to 180°C; 85 to 170°C; 85 to 160°C; 85 to 155°C; 85 to 150°C; 85 to 145°C; 85 to 140°C; 85 to 138°C; 85 to 135°C; 85 to 130°C; 85 to 125°C; 85 to 120°C; 85 to 115°C; 85 to 110°C; 85 to 105°C; 85 to 100°C; 85 to 95°C; 85 to 90°C; 90 to 200°C; 90 to 190°C; 90 to 180°C; 90 to 170°C; 90 to 160°C; 90 to 155°C; 90 to 150°C; 90 to 145°C; 90 to 140°C; 90 to 138°C; 90 to 135°C; 90 to 130°C; 90 to 125°C; 90 to 120°C; 90 to 115°C; 90 to 110°C; 90 to 105°C; 90 to 100°C; 90 to 95°C; 95 to 200°C; 95 to 190°C; 95 to 180°C; 95 to 170°C; 95 to 160°C; 95 to 155°C; 95 to 150°C; 95 to 145°C; 95 to 140°C; 95 to 138°C; 95 to 135°C; 95 to 130°C; 95 to 125°C; 95 to 120°C; 95 to 115°C; 95 to 110°C; 95 to 105°C; 95 to 100°C; 100 to 200°C; 100 to 190°C; 100 to 180°C; 100 to 170°C; 100 to 160°C; 100 to 155°C; 100 to 150°C; 100 to 145°C; 100 to

140°C; 100 to 138°C; 100 to 135°C; 100 to 130°C; 100 to 125°C; 100 to 120°C; 100 to 115°C; 100 to 110°C; 105 to 200°C; 105 to 190°C; 105 to 180°C; 105 to 170°C; 105 to 160°C; 105 to 155°C; 105 to 150°C; 105 to 145°C; 105 to 140°C; 105 to 138°C; 105 to 135°C; 105 to 130°C; 105 to 125°C; 105 to 120°C; 105 to 115°C; 105 to 110°C; 110 to 200°C; 110 to 190°C; 110 to 180°C; 110 to 170°C; 110 to 160°C; 110 to 155°C; 110 to 150°C; 110 to 145°C; 110 to 140°C; 110 to 138°C; 110 to 135°C; 110 to 130°C; 110 to 125°C; 110 to 120°C; 110 to 115°C; 115 to 200°C; 115 to 190°C; 115 to 180°C; 115 to 170°C; 115 to 160°C; 115 to 155°C; 115 to 150°C; 115 to 145°C; 115 to 140°C; 115 to 138°C; 115 to 135°C; 110 to 130°C; 115 to 125°C; 115 to 120°C; 120 to 200°C; 120 to 190°C; 120 to 180°C; 120 to 170°C; 120 to 160°C; 120 to 155°C; 120 to 150°C; 120 to 145°C; 120 to 140°C; 120 to 138°C; 120 to 135°C; 120 to 130°C; 125 to 200°C; 125 to 190°C; 125 to 180°C; 125 to 170°C; 125 to 165°C; 125 to 160°C; 125 to 155°C; 125 to 150°C; 125 to 145°C; 125 to 140°C; 125 to 138°C; 125 to 135°C; 127 to 200°C; 127 to 190°C; 127 to 180°C; 127 to 170°C; 127 to 160°C; 127 to 150°C; 127 to 145°C; 127 to 140°C; 127 to 138°C; 127 to 135°C; 130 to 200°C; 130 to 190°C; 130 to 180°C; 130 to 170°C; 130 to 160°C; 130 to 155°C; 130 to 150°C; 130 to 145°C; 130 to 140°C; 130 to 138°C; 130 to 135°C; 135 to 200°C; 135 to 190°C; 135 to 180°C; 135 to 170°C; 135 to 160°C; 135 to 155°C; 135 to 150°C; 135 to 145°C; 135 to 140°C; 140 to 200°C; 140 to 190°C; 140 to 180°C; 140 to 170°C; 140 to 160°C; 140 to 155°C; 140 to 150°C; 140 to 145°C; 148 to 200°C; 148 to 190°C; 148 to 180°C; 148 to 170°C; 148 to 160°C; 148 to 155°C; 148 to 150°C; greater than 148 to 200°C; greater than 148 to 190°C; greater than 148 to 180°C; greater than 148 to 170°C; greater than 148 to 160°C; greater than

148 to 155°C; 150 to 200°C; 150 to 190°C; 150 to 180°C; 150 to 170°C; 150 to 160; 155 to 190°C; 155 to 180°C; 155 to 170°C; and 155 to 165°C.

[0048] In other aspects of the invention, the glycol component for the polyesters of the invention include but are not limited to at least one of the following combinations of ranges: 1 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 99 mole % 1,4-cyclohexanedimethanol, 1 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to

99 mole % 1,4-cyclohexanedimethanol; 1 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 20 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 80 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 15 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 85 to 99 mole % 1,4-cyclohexanedimethanol; 1 to 10 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 90 to 99 mole % 1,4-cyclohexanedimethanol; and 1 to 5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 95 to 99 mole % 1,4-cyclohexanedimethanol.

[0049] In other aspects of the invention, the glycol component for the polyesters of the invention include but are not limited to at least one of the following combinations of ranges: 0.01 to less than 5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 95 to 99.99 mole % 1,4-cyclohexanedimethanol; 0.01 to 4.5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 95.5 to 99.99 mole % 1,4-cyclohexanedimethanol; 0.01 to 4 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 96 to 99.99 mole % 1,4-cyclohexanedimethanol; 0.01 to 3.5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 96.5 to 99.99 mole % 1,4-cyclohexanedimethanol; 0.01 to 3 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 97 to 99.99 mole % 1,4-cyclohexanedimethanol; 0.01 to 2.5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 97.5 to 99.99 mole % 1,4-cyclohexanedimethanol; 0.01 to 2 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 98 to 99.99 mole % 1,4-cyclohexanedimethanol; 0.01 to 1.5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 98.5 to 99.99 mole % 1,4-cyclohexanedimethanol; 0.01 to 1 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 99 to 99.99 mole % 1,4-cyclohexanedimethanol; and 0.01 to 0.5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 99.5 to 99.99 mole % 1,4-cyclohexanedimethanol.

[0050] In other aspects of the invention, the glycol component can include but is not limited to at least one of the following combinations of ranges: 5 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 95 mole % 1,4-cyclohexanedimethanol, 5 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 95 mole % 1,4-cyclohexanedimethanol; and 5 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 95 mole % 1,4-cyclohexanedimethanol.

[0051] In other aspects of the invention, the glycol component can include but is not limited to at least one of the following combinations of ranges: 5 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 95 mole % 1,4-cyclohexanedimethanol; 5 to less than 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 65 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 20 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 80 to 95 mole % 1,4-cyclohexanedimethanol ; 5 to 15 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 85 to 95 mole % 1,4-cyclohexanedimethanol; 5 to 10 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 90 to 95 mole % 1,4-cyclohexanedimethanol; greater than 5 to less than 10 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and less than 90 to greater than 95 mole % 1,4-cyclohexanedimethanol; 5.5 mole % to 9.5 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 94.5 mole % to 90.5 mole % 1,4-cyclohexanedimethanol; and 6 to 9 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 94 to 91 mole % 1,4-cyclohexanedimethanol.

[0052] In other aspects of the invention, the glycol component for the polyesters of invention can include but is not limited to at least one of the following combinations of ranges: 10 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 90 mole % 1,4-cyclohexanedimethanol; 10 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 90 mole % 1,4-cyclohexanedimethanol; 10 to less than 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 65 to 90 % 1,4-cyclohexanedimethanol; 10 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 90 mole % 1,4-cyclohexanedimethanol; 10 to 20 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 80 to 90 mole % 1,4-cyclohexanedimethanol; and 10 to 15 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 85 to 90 mole % 1,4-cyclohexanedimethanol.

[0053] In other aspects of the invention, the glycol component can include but is not limited to at least one of the following combinations of ranges: 14 to

99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 80mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 86 mole % 1,4-cyclohexanedimethanol; 14 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 86 mole % 1,4-cyclohexanedimethanol; 14 to 24 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 76 to 86 mole % 1,4-

cyclohexanedimethanol; and 14 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 86 mole % 1,4-cyclohexanedimethanol.

[0054] In other aspects of the invention, the glycol component of the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges: 15 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 85 mole % 1,4-cyclohexanedimethanol; 15 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 35 mole % 2,2,4,4-

tetramethyl-1,3-cyclobutanediol and 65 to 85 mole % 1,4-cyclohexane-dimethanol; 15 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 85 mole % 1,4-cyclohexanedimethanol; 15 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 85 mole % 1,4-cyclohexanedimethanol; and 15 to 24 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 76 to 85 mole % 1,4-cyclohexanedimethanol.

[0055] In other aspects of the invention, the glycol component for the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges: 20 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 80 mole % 1,4-cyclohexanedimethanol; 20 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 80 mole % 1,4-cyclohexanedimethanol; 20 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 80 mole % 1,4-cyclohexanedimethanol; 20 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 80 mole % 1,4-cyclohexane-dimethanol; 20 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 80 mole % 1,4-cyclohexanedimethanol; 20 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 80 mole % 1,4-cyclohexanedimethanol; 20 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 80 mole % 1,4-cyclohexanedimethanol; 20 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 80 mole % 1,4-cyclohexanedimethanol; 20 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 80 mole % 1,4-cyclohexane-dimethanol; 20 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 80 mole % 1,4-cyclohexanedimethanol; 20 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 80 mole % 1,4-cyclohexanedimethanol; 20 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to

80 mole % 1,4-cyclohexanedimethanol; 20 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 80 mole % 1,4-cyclohexanedimethanol; 20 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 80 mole % 1,4-cyclohexanedimethanol; 20 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 80 mole % 1,4-cyclohexanedimethanol; 20 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 80 mole % 1,4-cyclohexanedimethanol; and 20 to 25 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 75 to 80 mole % 1,4-cyclohexanedimethanol.

[0056] In other aspects of the invention, the glycol component for the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges: 25 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 50 mole % 2,2,4,4-tetramethyl-

1,3-cyclobutanediol and 50 to 75 mole % 1,4-cyclohexanedimethanol; 25 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 75 mole % 1,4-cyclohexanedimethanol; 25 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 75 mole % 1,4-cyclohexanedimethanol; and 25 to 30 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 70 to 75 mole % 1,4-cyclohexanedimethanol.

[0057] In other aspects of the invention, the glycol component for the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges: 30 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 70 mole % 1,4-cyclohexanedimethanol; 30 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 70 mole % 1,4-cyclohexanedimethanol; 30 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 70 mole % 1,4-cyclohexanedimethanol; 30 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 70 mole % 1,4-cyclohexanedimethanol; 30 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 70 mole % 1,4-cyclohexanedimethanol; 30 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 70 mole % 1,4-cyclohexanedimethanol; 30 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 70 mole % 1,4-cyclohexanedimethanol; 30 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 70 mole % 1,4-cyclohexanedimethanol; 30 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 70 mole % 1,4-cyclohexanedimethanol; 30 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to

70 mole % 1,4-cyclohexanedimethanol; 30 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 70 mole % 1,4-cyclohexanedimethanol; 30 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 70 mole % 1,4-cyclohexanedimethanol; 30 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 70 mole % 1,4-cyclohexanedimethanol; 30 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 70 mole % 1,4-cyclohexanedimethanol; 30 to 35 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 65 to 70 mole % 1,4-cyclohexanedimethanol.

[0058] In other aspects of the invention, the glycol component for the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges: 35 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 65 mole % 1,4-cyclohexanedimethanol; 35 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 65 mole % 1,4-cyclohexanedimethanol; 35 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 65 mole % 1,4-cyclohexanedimethanol; 35 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 65 mole % 1,4-cyclohexanedimethanol; 35 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 65 mole % 1,4-cyclohexanedimethanol; 35 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 65 mole % 1,4-cyclohexanedimethanol; 35 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 65 mole % 1,4-cyclohexanedimethanol; 35 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 65 mole % 1,4-cyclohexanedimethanol; 35 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 65 mole % 1,4-cyclohexanedimethanol; 35 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 65 mole % 1,4-cyclohexanedimethanol; 35 to 50 mole % 2,2,4,4-tetramethyl-

1,3-cyclobutanediol and 50 to 65 mole % 1,4-cyclohexanedimethanol; 35 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 65 mole % 1,4-cyclohexanedimethanol; 35 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 65 mole % 1,4-cyclohexanedimethanol; 35 to 40 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 60 to 65 mole % 1,4-cyclohexanedimethanol.

[0059] In other aspects of the invention, the glycol component for the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges: 40 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 60 mole % 1,4-cyclohexanedimethanol; 40 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 60 mole % 1,4-cyclohexanedimethanol; 40 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 60 mole % 1,4-cyclohexanedimethanol; 40 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 60 mole % 1,4-cyclohexanedimethanol; 40 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 60 mole % 1,4-cyclohexanedimethanol; 40 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 60 mole % 1,4-cyclohexanedimethanol; 40 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 60 mole % 1,4-cyclohexanedimethanol; 40 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 60 mole % 1,4-cyclohexanedimethanol; 40 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 60 mole % 1,4-cyclohexanedimethanol; 40 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 60 mole % 1,4-cyclohexanedimethanol; 40 to less than 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 50 to 60 mole % 1,4-cyclohexanedimethanol; 40 to 50 mole % 2,2,4,4-tetramethyl-

1,3-cyclobutanediol and 50 to 60 mole % 1,4-cyclohexanedimethanol; and 40 to 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 55 to 60 mole % 1,4-cyclohexanedimethanol.

[0060] In other aspects of the invention, the glycol component for the polyesters of the invention can include but are not limited to at least one of the following combinations of ranges: 45 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 55 mole % 1,4-cyclohexanedimethanol; 45 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 55 mole % 1,4-cyclohexanedimethanol; 45 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 55 mole % 1,4-cyclohexanedimethanol; 45 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 55 mole % 1,4-cyclohexanedimethanol; 45 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 55 mole % 1,4-cyclohexanedimethanol; 45 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 55 mole % 1,4-cyclohexanedimethanol; 45 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 55 mole % 1,4-cyclohexanedimethanol; 45 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 55 mole % 1,4-cyclohexanedimethanol; 45 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 55 mole % 1,4-cyclohexanedimethanol; greater than 45 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to less than 55 mole % 1,4-cyclohexanedimethanol; 45 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to 55 mole % 1,4-cyclohexanedimethanol; and 45 to 50 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 50 to 60 mole % 1,4-cyclohexanedimethanol.

[0061] In other aspects of the invention, the glycol component for the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges: greater than 50 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to less than 50 mole % 1,4-cyclohexanedimethanol; greater than 50 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to less than 50 mole % 1,4-cyclohexanedimethanol; greater than 50 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to less than 50 mole % 1,4-cyclohexanedimethanol; greater than 50 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to less than 50 mole % 1,4-cyclohexanedimethanol; greater than 50 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to less than 50 mole % 1,4-cyclohexanedimethanol; greater than 50 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to less than 50 mole % 1,4-cyclohexanedimethanol; greater than 50 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to less than 50 mole % 1,4-cyclohexanedimethanol; greater than 50 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to less than 50 mole % 1,4-cyclohexanedimethanol; greater than 50 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to less than 50 mole % 1,4-cyclohexanedimethanol.

[0062] In other aspects of the invention, the glycol component for the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges: 55 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 45 mole % 1,4-cyclohexanedimethanol; 55 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 45 mole % 1,4-cyclohexanedimethanol; 55 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 45 mole % 1,4-cyclohexanedimethanol; 55 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 45 mole % 1,4-cyclohexanedimethanol; 55 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to

45 mole % 1,4-cyclohexanedimethanol; 55 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 45 mole % 1,4-cyclohexanedimethanol; 55 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 45 mole % 1,4-cyclohexanedimethanol; 55 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 45 mole % 1,4-cyclohexanedimethanol; and 55 to 60 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 40 to 45 mole % 1,4-cyclohexanedimethanol.

[0063] In other aspects of the invention, the glycol component for the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges: 60 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 40 mole % 1,4-cyclohexanedimethanol; 60 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 40 mole % 1,4-cyclohexanedimethanol; 60 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 40 mole % 1,4-cyclohexanedimethanol; 60 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 40 mole % 1,4-cyclohexanedimethanol; 60 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 40 mole % 1,4-cyclohexanedimethanol; 60 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 40 mole % 1,4-cyclohexanedimethanol; and 60 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 30 to 40 mole % 1,4-cyclohexanedimethanol.

[0064] In other aspects of the invention, the glycol component for the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges: 65 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 35 mole % 1,4-cyclohexanedimethanol; 65 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 35 mole % 1,4-cyclohexanedimethanol; 65 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 35 mole % 1,4-cyclohexanedimethanol; 65 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 35 mole % 1,4-cyclohexane-dimethanol; 65 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 35 mole % 1,4-cyclohexanedimethanol; 65 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 35 mole % 1,4-cyclohexanedimethanol; and 65 to 70 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 40 mole % 1,4-cyclohexanedimethanol.

[0065] In other aspects of the invention, the glycol component for the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges: 70 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 30 mole % 1,4-cyclohexanedimethanol; 70 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 30 mole % 1,4-cyclo-hexanedimethanol; 70 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 30 mole % 1,4-cyclohexanedimethanol; 70 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 30 mole % 1,4-cyclohexane-dimethanol; 70 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 30 mole % 1,4-cyclohexanedimethanol; 70 to 75 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 25 to 30 mole % 1,4-cyclohexanedimethanol.

[0066] In other aspects of the invention, the glycol component for the polyesters of the invention includes but is not limited to at least one of the following combinations of ranges: 75 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 25 mole % 1,4-cyclohexanedimethanol; 75 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 25 mole % 1,4-cyclo-hexanedimethanol; 75 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 25 mole % 1,4-cyclohexanedimethanol; and 75 to 85 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 15 to 25 mole % 1,4-cyclohexane-dimethanol.

[0067] In other aspects of the invention, the glycol component for the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges: 80 to 99 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1 to 20 mole % 1,4-cyclohexanedimethanol; 80 to 95 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 5 to 20 mole % 1,4-cyclo-hexanedimethanol; 80 to 90 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 10 to 20 mole % 1,4-cyclohexanedimethanol.

[0068] In other aspects of the invention, the glycol component for the polyesters of the invention can include but is not limited to at least one of the following combinations of ranges 37 to 80 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 20 to 63 mole % 1,4-cyclohexanedimethanol; 40 to less than 45 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and greater than 55 to 60 mole % 1,4-cyclohexanedimethanol; greater than 45 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 45 to less than 55 mole % 1,4-cyclo-hexanedimethanol; and 46 to 55 mole % 2,2,4,4-tetramethyl-1,3-cyclo-butanediol and 45 to 54 mole % 1,4-cyclohexanedimethanol; and 46 to 65 mole % 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 35 to 54 mole % 1,4-cyclohexanedimethanol.

[0069] In other aspects of the invention where the mole percent of 2,2,4,4-tetramethyl-1,3-cyclobutanediol is present at 0.01 to less than 5 mole % based on the mole percentages for the diol component equaling 100 mole % and where the presence of CHDM is optional, the glycol component for the polyesters useful the invention include but are not limited to at least of the following combinations of ranges: 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 95 mole %of ethylene glycol residues, and 0 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 94.99 mole %of ethylene glycol residues, and 0.01 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 90 mole %of ethylene glycol residues, and 5 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 85 mole %of ethylene glycol residues, and 10 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 80 mole %of ethylene glycol residues, and 15 to 99.98 mole % of 1, 4-cyclohexane-dimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclo-butanediol residues, greater than 0.01 to 75 mole % of ethylene glycol residues, and 20 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 70 mole % of ethylene glycol residues, and 25 to 99.98 mole % of 1, 4-cyclohexanedimethanol; greater than 0.01 to 65 mole % of ethylene glycol residues, and 30 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 60 mole % of ethylene glycol residues, and 35 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 55 mole % of ethylene glycol residues, and 40 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 50 mole % of ethylene glycol residues, and 45 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 45 mole % of ethylene glycol residues, and 50 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 40 mole % of ethylene glycol residues, and 55 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 35 mole % of ethylene glycol residues, and 60 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 30 mole % of ethylene glycol residues, and 65 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 25 mole % of ethylene glycol residues, and 70 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 20 mole % of ethylene glycol residues, and 75 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 15 mole % of ethylene glycol residues, and 80 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 10 mole % of ethylene glycol residues, and 85 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, greater than 0.01 to 5 mole % of ethylene glycol residues, and 90 to 99.98 mole % of 1, 4-cyclohexanedimethanol; 0.01 to less than 5 mole % of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues, and greater than 0.01 to 5 mole % of ethylene glycol residues, and 90 to 99.98 mole % of 1, 4-cyclohexanedimethanol.

[0070] The glycol component may also contain one of the following ranges of 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues: 0.01 to 4.5 mole %; 0.01 to 4 mole %; 0.01 to 3.5 mole %; 0.01 to 3 mole %; 0.01 to 2.5 mole %; 0.01 to 2.0 mole %; 0.01 to 2.5 mole %; 0.01 to 2 mole %; 0.01 to 1.5 mole %; 0.01 to 1.0 mole %; and 0.01 to 0.5 mole %. The remainder of the glycol component can be any amount of 1,4-cyclohexanedimethanol and/or ethylene glycol so long as the total amount of the glycol component equals 100 mole %.

[0071] In addition to the diols set forth above, the polyesters useful in the polyester compositions of the invention may be made from 1,3-propanediol, 1,4-butanediol, or mixtures thereof. It is contemplated that compositions of the invention made from 1,3-propanediol, 1,4-butanediol, or mixtures thereof can possess at least one of the Tg ranges described herein, at least one of the inherent viscosity ranges described herein, and/or at least one of the glycol or diacid ranges described herein. In addition or in the alternative, the polyesters made from 1,3-propanediol or 1,4-butanediol or mixtures thereof may also be made from 1,4-cyclohexanedmethanol in at least one of the following amounts: from 0.1 to 99 mole %; 0.1 to 90 mole %; from 0.1 to 80 mole %; from 0.1 to 70 mole %; from 0.1 to 60 mole %; from 0.1 to 50 mole %; from 0.1 to 40 mole %; from 0.1 to 35 mole %; from 0.1 to 30 mole %; from 0.1 to 25 mole %; from 0.1 to 20 mole %; from 0.1 to 15 mole %; from 0.1 to 10 mole %; from 0.1 to 5 mole %; from 1 to 99 mole %; from 1 to 90 mole %; from 1 to 80 mole %; from 1 to 70 mole %; from 1 to 60 mole %; from 1 to 50 mole %; from 1 to 40 mole %; from 1 to 35 mole %; from 1 to 30 mole %; from 1 to 25 mole %; from 1 to 20 mole %; from 1 to 15 mole %; from 1 to 10 mole %; from 1 to 5 mole %; from 5 to 80 mole %; 5 to 70 mole %; from 5 to 60 mole %; from 5 to 50 mole %; from 5 to 40 mole %; from 5 to 35 mole %; from 5 to 30 mole %; from 5 to 25 mole %; from 5 to 20 mole %; and from 5 to 15 mole %; from 5 to 10 mole %; from 10 to 99 mole %; from 10 to 90 mole %; from 10 to 80 mole %; from 10 to 70 mole %; from 10 to 60 mole %; from 10 to 50 mole %; from 10 to 40 mole %; from 10 to 35 mole %; from 10 to 30 mole %; from 10 to 25 mole %; from 10 to 20 mole %; from 10 to 15 mole %; from 20 to 99 mole %; 20 to 95 mole %; from 20 to 80 mole %; from 20 to 70 mole %; from 20 to 60 mole %; from 20 to 50 mole %; from 20 to 40 mole %; from 20 to 35 mole %; from 20 to 30 mole %; and from 20 to 25 mole %.

[0072] The polyesters generally will have inherent viscosity (I.V.) values in the range of about 0.1 dL/g to about 1.4 dL/g. Additional examples of I.V. ranges include about 0.65 dL/g to about 1.0 dL/g and about 0.7 dL/g to about 0.85 dL/g. As described previously, inherent viscosity is measured at 25 oC using 0.5 grams of polymer per 100 ml of a solvent comprising 60 weight percent phenol and 40 weight % tetrachloroethane. For embodiments of the invention, the polyesters useful in the invention may exhibit at least one of the following inherent viscosities as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.5 g/100 ml at 25°C: 0.10 to 1.2 dL/g; 0.10 to 1.1 dL/g; 0.10 to 1 dL/g; 0.10 to less than 1 dL/g; 0.10 to 0.98 dL/g; 0.10 to 0.95 dL/g; 0.10 to 0.90 dL/g; 0.10 to 0.85 dL/g; 0.10 to 0.80 dL/g; 0.10 to 0.75 dL/g; 0.10 to less than 0.75 dL/g; 0.10 to 0.72 dL/g; 0.10 to 0.70

dL/g; 0.10 to less than 0.70 dL/g; 0.10 to 0.68 dL/g; 0.10 to less than 0.68 dL/g; 0.10 to 0.65 dL/g; 0.10 to 0.6 dL/g; 0.10 to 0.55 dL/g; 0.10 to 0.5 dL/g; 0.10 to 0.4 dL/g; 0.10 to 0.35 dL/g; 0.20 to 1.2 dL/g; 0.20 to 1.1 dL/g; 0.20 to 1 dL/g; 0.20 to less than 1 dL/g; 0.20 to 0.98 dL/g; 0.20 to 0.95 dL/g; 0.20 to 0.90 dL/g; 0.20 to 0.85 dL/g; 0.20 to 0.80 dL/g; 0.20 to 0.75 dL/g; 0.20 to less than 0.75 dL/g; 0.20 to 0.72 dL/g; 0.20 to 0.70 dL/g; 0.20 to less than 0.70 dL/g; 0.20 to 0.68 dL/g; 0.20 to less than 0.68 dL/g; 0.20 to 0.65 dL/g; 0.20 to 0.6 dL/g; 0.20 to 0.55 dL/g; 0.20 to 0.5 dL/g; 0.20 to 0.4 dL/g; 0.20 to 0.35 dL/g; 0.35 to 1.2 dL/g; 0.35 to 1.1 dL/g; 0.35 to 1 dL/g; 0.35 to less than 1 dL/g; 0.35 to 0.98 dL/g; 0.35 to 0.95 dL/g; 0.35 to 0.90 dL/g; 0.35 to 0.85 dL/g; 0.35 to 0.80 dL/g; 0.35 to 0.75 dL/g; 0.35 to less than 0.75 dL/g; 0.35 to 0.72 dL/g; 0.35 to 0.70 dL/g; 0.35 to less than 0.70 dL/g; 0.35 to 0.68 dL/g; 0.35 to less than 0.68 dL/g; 0.35 to 0.65 dL/g; 0.40 to 1.2 dL/g; 0.40 to 1.1 dL/g; 0.40 to 1 dL/g; 0.40 to less than 1 dL/g; 0.40 to 0.98 dL/g; 0.40 to 0.95 dL/g; 0.40 to 0.90 dL/g; 0.40 to 0.85 dL/g; 0.40 to 0.80 dL/g; 0.40 to 0.75 dL/g; 0.40 to less than 0.75 dL/g; 0.40 to 0.72 dL/g; 0.40 to 0.70 dL/g; 0.40 to less than 0.70 dL/g; 0.40 to 0.68 dL/g; 0.40 to less than 0.68 dL/g; 0.40 to 0.65 dL/g; greater than 0.42 to 1.2 dL/g; greater than 0.42 to 1.1 dL/g; greater than 0.42 to 1 dL/g; greater than 0.42 to less than 1 dL/g; greater than 0.42 to 0.98 dL/g; greater than 0.42 to 0.95 dL/g; greater than 0.42 to 0.90 dL/g; greater than 0.42 to 0.85 dL/g; greater than 0.42 to 0.80 dL/g; greater than 0.42 to 0.75 dL/g; greater than 0.42 to less than 0.75 dL/g; greater than 0.42 to 0.72 dL/g; greater than 0.42 to 0.70 dL/g; greater than 0.42 to less than 0.70 dL/g; greater than 0.42 to 0.68 dL/g; greater than 0.42 to less than 0.68 dL/g; and greater than 0.42 to 0.65 dL/g.

[0073] For embodiments of the invention, the polyesters useful in the invention may exhibit at least one of the following inherent viscosities as determined in 60/40 (wt/wt) phenol/ tetrachloroethane at a concentration of 0.5 g/100 ml at 25°C: 0.45 to 1.2 dL/g; 0.45 to 1.1 dL/g; 0.45 to 1 dL/g; 0.45 to 0.98 dL/g; 0.45 to 0.95 dL/g; 0.45 to 0.90 dL/g; 0.45 to 0.85 dL/g; 0.45 to 0.80 dL/g; 0.45 to 0.75 dL/g; 0.45 to less than 0.75 dL/g; 0.45 to 0.72 dL/g; 0.45 to 0.70 dL/g; 0.45 to less than 0.70 dL/g; 0.45 to 0.68 dL/g; 0.45 to less than 0.68 dL/g; 0.45 to 0.65 dL/g; 0.50 to 1.2 dL/g; 0.50 to 1.1 dL/g; 0.50 to 1 dL/g; 0.50 to less than 1 dL/g; 0.50 to 0.98 dL/g; 0.50 to 0.95 dL/g; 0.50 to 0.90 dL/g; 0.50 to 0.85 dL/g; 0.50 to 0.80 dL/g; 0.50 to 0.75 dL/g; 0.50 to less than 0.75 dL/g; 0.50 to 0.72 dL/g; 0.50 to 0.70 dL/g; 0.50 to less than 0.70 dL/g; 0.50 to 0.68 dL/g; 0.50 to less than 0.68 dL/g; 0.50 to 0.65 dL/g; 0.55 to 1.2 dL/g; 0.55 to 1.1 dL/g; 0.55 to 1 dL/g; 0.55 to less than 1 dL/g; 0.55 to 0.98 dL/g; 0.55 to 0.95 dL/g; 0.55 to 0.90 dL/g; 0.55 to 0.85 dL/g; 0.55 to 0.80 dL/g; 0.55 to 0.75 dL/g; 0.55 to less than 0.75 dL/g; 0.55 to 0.72 dL/g; 0.55 to 0.70 dL/g; 0.55 to less than 0.70 dL/g; 0.55 to 0.68 dL/g; 0.55 to less than 0.68 dL/g; 0.55 to 0.65 dL/g; 0.58 to 1.2 dL/g; 0.58 to 1.1 dL/g; 0.58 to 1 dL/g; 0.58 to less than 1 dL/g; 0.58 to 0.98 dL/g; 0.58 to 0.95 dL/g; 0.58 to 0.90 dL/g; 0.58 to 0.85 dL/g; 0.58 to 0.80 dL/g; 0.58 to 0.75 dL/g; 0.58 to less than 0.75 dL/g; 0.58 to 0.72 dL/g; 0.58 to 0.70 dL/g; 0.58 to less than 0.70 dL/g; 0.58 to 0.68 dL/g; 0.58 to less than 0.68 dL/g; 0.58 to 0.65 dL/g; 0.60 to 1.2 dL/g; 0.60 to 1.1 dL/g; 0.60 to 1 dL/g; 0.60 to less than 1 dL/g; 0.60 to 0.98 dL/g; 0.60 to 0.95 dL/g; 0.60 to 0.90 dL/g; 0.60 to 0.85 dL/g; 0.60 to 0.80 dL/g; 0.60 to 0.75 dL/g; 0.60 to less than 0.75 dL/g; 0.60 to 0.72 dL/g; 0.60 to 0.70 dL/g; 0.60 to less than 0.70 dL/g; 0.60 to 0.68 dL/g; 0.60 to less than 0.68 dL/g; 0.60 to 0.65 dL/g; 0.65 to 1.2 dL/g; 0.65 to 1.1 dL/g; 0.65 to 1 dL/g; 0.65 to less than 1 dL/g; 0.65 to 0.98 dL/g; 0.65 to 0.95 dL/g; 0.65 to 0.90 dL/g; 0.65 to 0.85 dL/g; 0.65 to 0.80 dL/g; 0.65 to 0.75 dL/g; 0.65 to less than 0.75 dL/g; 0.65 to 0.72 dL/g; 0.65 to 0.70 dL/g; 0.65 to less than 0.70 dL/g; 0.68 to 1.2 dL/g; 0.68 to 1.1 dL/g; 0.68 to 1 dL/g; 0.68 to less than 1 dL/g; 0.68 to 0.98 dL/g; 0.68 to 0.95 dL/g; 0.68 to 0.90 dL/g; 0.68 to 0.85 dL/g; 0.68 to 0.80 dL/g; 0.68 to 0.75 dL/g; 0.68 to less than 0.75 dL/g; 0.68 to 0.72 dL/g; greater than 0.76 dL/g to 1.2 dL/g; greater than 0.76 dL/g to 1.1 dL/g; greater than 0.76 dL/g to 1 dL/g; greater than 0.76 dL/g to less than 1 dL/g; greater than 0.76 dL/g to 0.98dL/g; greater than 0.76 dL/g to 0.95 dL/g; greater than 0.76 dL/g to 0.90 dL/g; greater than 0.80 dL/g to 1.2 dL/g; greater than 0.80 dL/g to 1.1 dL/g; greater than 0.80 dL/g to 1 dL/g; greater than 0.80 dL/g to less than 1 dL/g; greater than 0.80 dL/g to 1.2 dL/g; greater than 0.80 dL/g to 0.98dL/g; greater than 0.80 dL/g to 0.95 dL/g; greater than 0.80 dL/g to 0.90 dL/g.

[0074] For the polyesters of the invention containing 2,2,4,4-tetramethyl-1,3-cyclobutanediol, the molar ratio of cis/trans 2,2,4,4-tetramethyl-1,3-cyclobutanediol can vary from the pure form of each or mixtures thereof. In certain embodiments, the molar percentages for cis and/or trans 2,2,4,4,-tetramethyl-1,3-cyclobutanediol are greater than 50 mole % cis and less than 50 mole % trans; or greater than 55 mole % cis and less than 45 mole % trans; or 30 to 70 mole % cis and 70 to 30 % trans; or 40 to 60 mole % cis and 60 to 40 mole % trans; or 50 to 70 mole % trans and 50 to 30 % cis; or 50 to 70 mole % cis and 50 to 30 % trans; or 60 to 70 mole % cis and 30 to 40 mole % trans; or greater than 70 mole % cis and less than 30 mole % trans; wherein the total sum of the mole percentages for cis- and trans- 2,2,4,4-tetramethyl-1,3-cyclobutanediol is equal to 100 mole %. The molar ratio of cis/trans 1,4-cyclohexandimethanol can vary within the range of 50/50 to 0/100, for example, between 40/60 to 20/80.

[0075] It is contemplated that compositions of the invention can possess at least one of the inherent viscosity ranges described herein and at least one of the monomer ranges for the compositions described herein unless otherwise stated. It is also contemplated that compositions of the invention can possess at least one of the Tg ranges described herein and at least one of the monomer ranges for the compositions described herein unless otherwise stated. It is also contemplated that compositions of the invention can possess at least one of the inherent viscosity ranges described herein, at least one of the Tg ranges described herein, and at least one of the monomer ranges for the compositions described herein unless otherwise stated.

[0076] In certain embodiments, terephthalic acid or an ester thereof, such as, for example, dimethyl terephthalate or a mixture of terephthalic acid residues and an ester thereof can make up a portion or all of the dicarboxylic acid component used to form the polyesters useful in the invention. In certain embodiments, terephthalic acid residues can make up a portion or all of the dicarboxylic acid component used to form the present polyester at a concentration of at least 70 mole %, such as at least 80 mole %, at least 90 mole % at least 95 mole %, at least 99 mole %, or even 100 mole %. In certain embodiments, higher amounts of terephthalic acid can be used in order to produce a higher impact strength polyester. For purposes of this disclosure, the terms "terephthalic acid" and "dimethyl terephthalate" are used interchangeably herein. In one embodiment, dimethyl terephthalate is part or all of the dicarboxylic acid component used to make the polyesters useful in the present invention. In all embodiments, ranges of from 70 to 100 mole %; or 80 to 100 mole %; or 90 to 100 mole %; or 99 to 100 mole %; or 100 mole % terephthalic acid and/or dimethyl terephthalate and/or mixtures thereof may be used.

[0077] In addition to terephthalic acid, the dicarboxylic acid component of the polyester useful in the invention can comprise up to 30 mole %, up to 20 mole %, up to 10 mole %, up to 5 mole%, or up to 1 mole % modifying aromatic dicarboxylic acids. Yet another embodiment contains 0 mole % modifying aromatic dicarboxylic acids. Thus, if present, it is contemplated that the amount of one or more modifying aromatic dicarboxylic acids can range from any of these preceding endpoint values including, for example, from 0.01 to 30 mole %, 0.01 to 20 mole %, from 0.01 to 10 mole %, from 0.01 to 5 mole % and from 0.01 to 1 mole. In one embodiment, modifying aromatic dicarboxylic acids that may be used in the present invention include but are not limited to those having up to 20 carbon atoms, and which can be linear, para-oriented, or symmetrical. Examples of modifying aromatic dicarboxylic acids which may be used in this invention include, but are not limited to, isophthalic acid, 4,4'-biphenyldicarboxylic acid, 1,4-, 1,5-, 2,6-, 2,7-naphthalenedicarboxylic acid, and trans-4,4'-stilbenedicarboxylic acid, and esters thereof. In one embodiment, the modifying aromatic dicarboxylic acid is isophthalic acid.

[0078] The carboxylic acid component of the polyesters useful in the invention can be further modified with up to 10 mole %, such as up to 5 mole % or up to 1 mole % of one or more aliphatic dicarboxylic acids containing 2-16 carbon atoms, such as, for example, malonic, succinic, glutaric, adipic, pimelic, suberic, azelaic and dodecanedioic dicarboxylic acids. Certain embodiments can also comprise 0.01 or more mole %, such as 0.1 or more mole %, 1 or more mole %, 5 or more mole %, or 10 or more mole % of one or more modifying aliphatic dicarboxylic acids. Yet another embodiment contains 0 mole % modifying aliphatic dicarboxylic acids. Thus, if present, it is contemplated that the amount of one or more modifying aliphatic dicarboxylic acids can range from any of these preceding endpoint values including, for example, from 0.01 to 10 mole % and from 0.1 to 10 mole %. The total mole % of the dicarboxylic acid component is 100 mole %.

[0079] Esters of terephthalic acid and the other modifying dicarboxylic acids or their corresponding esters and/or salts may be used instead of the dicarboxylic acids. Suitable examples of dicarboxylic acid esters include, but are not limited to, the dimethyl, diethyl, dipropyl, diisopropyl, dibutyl, and diphenyl esters. In one embodiment, the esters are chosen from at least one of the following: methyl, ethyl, propyl, isopropyl, and phenyl esters.

[0080] The 1,4-cyclohexanedimethanol may be cis, trans, or a mixture thereof, such as a cis/trans ratio of 60:40 to 40:60. In another embodiment, the trans-1,4-cyclohexanedimethanol can be present in an amount of 60 to 80 mole %.

[0081] The glycol component of the polyester portion of the polyester composition useful in the invention can contain 25 mole % or less of one or more modifying glycols which are not 2,2,4,4-tetramethyl-1,3-cyclobutanediol or 1,4-cyclohexanedimethanol; in one embodiment, the polyester useful in the invention may contain less than 15 mole % or of one or more modifying glycols.

In another embodiment, the polyesters useful in the invention can contain 10 mole % or less of one or more modifying glycols. In another embodiment, the polyesters useful in the invention can contain 5 mole % or less of one or more modifying glycols. In another embodiment, the polyesters useful in the invention can contain 3 mole % or less of one or more modifying glycols. In another embodiment, the polyesters useful in the invention can contain 0 mole % modifying glycols. Certain embodiments can also contain 0.01 or more mole %, such as 0.1 or more mole %, 1 or more mole %, 5 or more mole %, or 10 or more mole % of one or more modifying glycols. Thus, if present, it is contemplated that the amount of one or more modifying glycols can range from any of these preceding endpoint values including, for example, from 0.01 to 15 mole % and from 0.1 to 10 mole %.

[0082] Modifying glycols useful in the invention refer to diols other than 2,2,4,4-tetramethyl-1,3-cyclobutanediol and 1,4-cyclohexanedimethanol and can contain 2 to 16 carbon atoms. Examples of suitable modifying glycols include, but are not limited to, ethylene glycol, 1,2-propanediol, 1,3-propanediol, neopentyl glycol, 1,4-butanediol, 1,5-pentanediol, polyethylene glycol, diethylene glycol, polytetramethylene glycol, 1,6-hexanediol, p-xylene glycol, or mixtures thereof. One embodiment for the modifying glycol is ethylene glycol. Other modifying glycols include, but are not limited to, 1,3-propanediol and 1,4-butanediol. In another embodiment, ethylene glycol is excluded as a modifying diol. In another embodiment, 1,3-propanediol and 1,4-butanediol are excluded as modifying diols. In another embodiment, 2, 2-dimethyl-1,3-propanediol is excluded as a modifying diol.

[0083] The polyesters and/or the polycarbonates useful in the polyester compositions of the invention can comprise from 0 to about 10 mole percent of one or more residues of a branching monomer, also referred to herein as a branching agent, having 3 or more carboxyl substituents, hydroxyl substituents, or a combination thereof. Additional examples of mole percent ranges of branching agent that may be present in the polyester or polycarbonates of the invention are from about 0.05 to about 5 mole percent, from about 0.01 to about 1 mole percent, about 0.01 to about 0.7, about 0.01 to about 0.5, and from about 0.1 to about 0.7 mole percent, based on the total moles of diols or diacid residues of the polyester and/or polycarbonate, respectively, In certain embodiments, the branching monomer or agent can be added during the polymerization of the polyester. The polyesters of the invention can thus be linear or branched. The polycarbonate can also be linear or branched. In certain embodiments, the branching monomer or agent may be added prior to and/or during and/or after the polymerization of the polycarbonate.

[0084] Examples of branching monomers include, but are not limited to, multifunctional acids or multifunctional alcohols such as trimellitic acid, trimellitic anhydride, pyromellitic dianhydride, trimethylolpropane, glycerol, pentaerythritol, citric acid, tartaric acid, 3-hydroxyglutaric acid, glycerol, sorbitol, 1, 2, 6-hexanetriol, trimethylolethane, and/or trimesic acid and the like. In one embodiment, the branching monomer residues can comprise 0.01 to 1 mole percent of one or more residues chosen from at least one of the following: trimellitic anhydride, pyromellitic dianhydride, glycerol, sorbitol, 1, 2, 6-hexanetriol, pentaerythritol, trimethylolethane, and/or trimesic acid. The branching monomer may be added to the polyester reaction mixture or blended with the polyester in the form of a concentrate as described, for example, in U.S. Patent No.'s 5,654,347 and 5,696,176.

[0085] Because of the long crystallization half-times (e.g., greater than 5 minutes) at 170°C exhibited by certain polyesters useful in the present invention, it can be possible to produce containers injection blow molded articles, injection stretch blow molded articles, extrusion blow molded articles and extrusion stretch blow molded. The polyesters of the invention can be are "amorphous" or semicrystalline. In one aspect, certain polyesters useful in the invention can have a relatively low crystallinity. Certain polyesters useful in the invention can thus have a substantially amorphous morphology, meaning that the polyesters comprising substantially unordered regions of polymer.

[0086] In one embodiment, an "amorphous" polyester can have a crystallization half-time of greater than 5 minutes at 170°C or greater than 10 minutes at 170°C or greater than 100 minutes at 170°C. In one embodiment, of the invention, the crystallization half-times are greater than 1,000 minutes at 170°C. In another embodiment of the invention, the crystallization half-times of the polyester useful in the invention are greater than 10,000 minutes at 170°C. The crystallization half time of the polyester, as used herein, may be measured using methods well-known to persons of skill in the art. For example, the crystallization half time of the polyester, $t_{1/2}$, can be determined by measuring the light transmission of a sample via a laser and photo detector as a function of time on a temperature controlled hot stage. This measurement can be done by exposing the polymers to a temperature, T_{max}, and then cooling it to the desired temperature. The sample can then be held at the desired temperature by a hot stage while transmission measurements were made as a function of time.

Initially, the sample can be visually clear with high light transmission, and becomes opaque as the sample crystallizes. The crystallization half-time is the time at which the light transmission is halfway between the initial transmission and the final transmission. T_{max} is defined as the temperature required to melt the crystalline domains of the sample (if crystalline domains are present). The sample can be heated to T_{max} to condition the sample prior to crystallization half time measurement. The absolute Tmax temperature is different for each composition. For example PCT can be heated to some temperature greater than 290°C to melt the crystalline domains.

[0087] The polymers of the invention may be crystalline, semicrystalline, or amorphous polymers. The term "semicrystalline", as used herein, means that the polymer contains two phases: an ordered crystalline phase and an unordered amorphous phase. Polymers with a semicrystalline morphology exhibit both a crystalline melting temperature (Tm) and a glass transition temperature (Tg) and may be distinguished from "amorphous" polymers, which exhibit only a glass transition temperature.

[0088] The polyesters of the instant invention are readily prepared from the appropriate dicarboxylic acids, esters, anhydrides, or salts, and the appropriate diol or diol mixtures using typical polycondensation reaction conditions. As noted previously, the dicarboxylic acid component of the polyesters of the present invention can be derived from dicarboxylic acids, their corresponding esters, or mixtures thereof. Examples of esters of the dicarboxylic acids useful in the present invention include the dimethyl, dipropyl, diisopropyl, dibutyl, and diphenyl esters, and the like. In one embodiment, for example, terephthalic acid may be used as the starting material. In another example, dimethyl terephthalate may be used as the starting material. In yet another embodiment, mixtures of terephthalic acid and dimethyl terephthalate may be used as the starting material and/or as an intermediate material.

[0089] The polyesters of the present invention are prepared by procedures known to persons skilled in the art. They may be made by continuous, semi-continuous, and batch modes of operation and may utilize a variety of reactor types. Examples of suitable reactor types include, but are not limited to, stirred tank, continuous stirred tank, slurry, tubular, wiped-film, falling film, or extrusion reactors. The reaction of the diol and dicarboxylic acid may be carried out using conventional polyester polymerization conditions or by melt phase processes, but those with sufficient crystallinity may be made by melt phase followed by solid phase polycondensation techniques. For example, when preparing the polyester by means of an ester interchange reaction, i.e., from the ester form of the dicarboxylic acid components, the reaction process may comprise two steps. In the first step, the diol component and the dicarboxylic acid component, such as, for example, dimethyl terephthalate, are reacted at elevated temperatures, typically, about 150°C to about 250°C for about 0.5 to about 8 hours at pressures ranging from about 0.0 kPa gauge to about 414 kPa gauge (60 pounds per square inch, "psig"). Preferably, the temperature for the ester interchange reaction ranges from about 180°C to about 230°C for about 1 to about 4 hours while the preferred pressure ranges from about 103 kPa gauge (15 psig) to about 276 kPa gauge (40 psig). Thereafter, the reaction product is heated under higher temperatures and under reduced pressure to form the polyester with the elimination of diol, which is readily volatilized under these conditions and removed from the system. This second step, or polycondensation step, is continued under higher vacuum and a temperature which generally ranges from about 230°C to about 350°C, preferably about 250°C to about 310°C and, most preferably, about 260°C to about 290°C for about 0.1 to about 6 hours, or preferably, for about 0.2 to about 2 hours, until a polymer having the desired degree of polymerization, as determined by inherent viscosity, is obtained. The polycondensation step may be conducted under reduced pressure which ranges from about 53 kPa (400 torr) to about 0.013 kPa (0.1 torr). Stirring or appropriate mixing techniques well known in the art can be used in both stages to ensure adequate heat transfer and surface renewal of the reaction mixture. The reaction rates of both stages are increased by appropriate catalysts such as, for example, alkoxy titanium compounds, alkali metal hydroxides and alcoholates, salts of organic carboxylic acids, alkyl tin compounds, metal oxides, and the like. A three-stage manufacturing procedure, similar to that described in U.S. Patent No. 5,290,631, may also be used, particularly when a mixed monomer feed of acids and esters is employed.

[0090] To ensure that the reaction of the diol component and dicarboxylic acid component by an ester interchange reaction is driven to completion, it is sometimes desirable to employ about 1.05 to about 2.5 moles of diol component to one mole dicarboxylic acid component. Persons of skill in the art will understand, however, that the ratio of diol component to dicarboxylic acid component is generally determined by the design of the reactor in which the reaction process occurs.

[0091] In the preparation of polyester by direct esterification, i.e., from the acid form of the dicarboxylic acid component, polyesters are produced by reacting the dicarboxylic acid or a mixture of dicarboxylic acids with the diol component or a mixture of diol components. The reaction is conducted at a pressure of from about 7 kPa gauge (1 psig) to about 1379 kPa gauge (200 psig), preferably less than 689 kPa (100 psig) to produce a low molecular weight polyester product having an average degree of polymerization of from about 1.4 to about 10. The temperatures employed during the direct esterification reaction typically range from about 180°C to about 280°C, more preferably ranging from about 220°C to about 270°C. This low molecular weight polymer may then be polymerized by a polycondensation reaction.

[0092] The thermoplastic polymers of the invention may also comprise a polyarylate. Polyarylates are obtained by polymerization of a dihydric phenol and a dicarboxylic acid. Examples of polyarylates that can be used in the compositions, processes, and shaped articles of the instant invention are described in U.S. Patent No.'s 4,598,130; 5,034,502; and 4,374,239. Examples of dihydric phenols that can be used to prepare the polyarylates are bisphenols such as bis(4-hydroxyphenyl)methane; 2,2-bis(4-hydroxyphenyl) propane ("bisphenol-A"); 2,2-bis(4-hydroxy-3-methylphenyl)propane; 4,4-bis(4-hydroxyphenyl)heptane; 2,2-bis(4-hydroxy-3,5-dichlorophenyl)propane; 2,2-bis(4-hydroxy-3,5-dibromophenyl)propane; dihydric phenol ethers such as, for example, bis(4-hydroxyphenyl)ether; bis(3,5-dichloro-4-hydroxyphenyl)ether;; dihydroxydiphenyls such as, for example, p,p'-dihydroxydiphenyl, 3,3'-dichloro-4, 4'-dihydroxydiphenyl; dihydroxyaryl sulfones such as, for example, bis(4- hydroxyphenyl)sulfone; bis(3,5-dimethyl-4-hydroxyphenyl)sulfone; dihydroxy benzenes such as, for example, resorcinol; hydroquinone; halo- and alkyl-substituted dihydroxy benzenes such as, for example, 1,4-dihydroxy-2,5-dichlorobenzene; 1,4- dihydroxy-3-methylbenzene; and dihydroxy diphenyl sulfoxides such as, for example, bis(4-hydroxyphenyl)sulfoxide; and bis(3,5-dibromo-4-hydroxyphenyl) sulfoxide. A variety of additional dihydric phenols are also available such as are disclosed, for example, in U.S. Patent No.'s 2,999,835; 3,028,365 and 3,153,008. Also suitable are copolymers prepared from the above dihydric phenols copolymerized with halogen-containing dihydric phenols such as 2,2-bis(3,5-dichloro-4-hydroxyphenyl)propane and 2,2-bis(3,5-dibromo- 4-hydroxyphenyl)propane. It is also possible to employ two or more different dihydric phenols or a copolymer of a dihydric phenol with a glycol, with hydroxy or acid terminated polyester, or with a dibasic acid as well as blends of any of the above materials. Suitable dicarboxylic acids include, but are not limited to, aromatic dicarboxylic acids such as phthalic, isophthalic, terephthalic, o-phthalic, o-, m-, and p-phenylenediacetic acids, and polynuclear aromatic acids such as, for example, diphenic acid and 1,4-naphthalic acid.

[0093] Additional examples of polyarylates that can be used in the present invention include those polymers resulting from the polymerization of bisphenol A (2,2-bis-(4-hydroxyphenyl)propane) and a 50:50 mixture iso/terephthalic acids. Some of the polymers are commercially available under the trademark "U-Polymer U-100" (available from Unitika America Corporation). Other examples are polyarylates based on tetramethyl bisphenol-A; 4,4'-dihydroxy-benzophenone; and 5-tertiary-butyl isophthalic acid dichloride.

[0094] The polyarylates of the present invention can be prepared by any polyester forming reactions well known in the art such as, for example, interfacial polymerization by mixing a solution of an aromatic dicarboxylic acid dihalide in an organic solvent with an alkaline aqueous solution of a bisphenol under stirring to react these materials; solution polymerization by reacting an aromatic dicarboxylic acid dihalide with a bisphenol in the presence of a deacidifying agent such as pyridine in an organic solvent; molten polymerization by reacting an aromatic dicarboxylic acid diphenyl ester with a bisphenol; molten polymerization by reacting an aromatic dicarboxylic acid, diphenyl carbonate and a bisphenol; molten polymerization by reacting an aromatic dicarboxylic acid with a bisphenol diacetate; and polymerization by reacting an aromatic dicarboxylic acid with a bisphenol diacetate. Examples of methods for preparation of polyarylates are disclosed in U.S. Patent No.'s 5,034,502, 4,321,355, and 4,374,239. The polyarylates of the invention typically have inherent viscosities of about 0.5 to about 1.1 dL/gm.

[0095] In addition, the polyester, polycarbonates, and polyarylates may further comprise one or more of the following: antioxidants, melt strength enhancers, branching agents (e.g., glycerol, trimellitic acid and anhydride), chain extenders, flame retardants, fillers, acid scavengers, dyes, colorants, pigments, antiblocking agents, flow enhancers, impact modifiers, antistatic agents, processing aids, mold release additives, plasticizers, slips, stabilizers, waxes, UV absorbers, optical brighteners, lubricants, pinning additives, foaming agents, antistats, nucleators, and the like. Colorants, sometimes referred to as toners, may be added to impart a desired neutral hue and/or brightness to the polyester. Preferably, the polyester compositions may comprise 0 to about 30 weight percent of one or more processing aids to alter the surface properties of the composition and/or to enhance flow. Representative examples of processing aids include calcium carbonate, talc, clay, mica, zeolites, wollastonite, kaolin, diatomaceous earth, TiO_2, NH4Cl, silica, calcium oxide, sodium sulfate, and calcium phosphate. Various pigments or dyes, might be used, for example, to make a colored articles. An antistat or other coating may also be applied to the surface of the article.

[0096] The second component (ii) of the compositions of the invention comprises a transamidized, homogeneous blend of at least two polyamides. Typically, the homogeneous blend will comprise from 2 to about 10 different polyamides. In another example, the homogeneous blend can comprise from 2 to 4 polyamides. In accordance with the present invention, polyamides that display a melting point below about 300°C can be used as at least one polyamide. In another example, polyamides with the melting point less than about 275°C and glass transition temperature greater than about 25°C may be used. Typically, the polyamides have an I.V. between about 0.3 dL/g and about 2.0 dL/g and, preferably at least 0.5 dL/g.

[0097] For the composition of the invention, it is advantageous that transamidation occur between the polyamides to produce of homogeneous blend. The term "transamidized", as used herein, is intended to be synonymous with the terms "transamidate" and "transamidation", and refers to the process of exchanging amido groups between two different polyamides. Thus, a "transamidized blend" of polyamides, as used herein, is a blend in which the polyamide components have exchanged an amount of amido groups sufficient to cause the blend to become a homogeneous blend. Transamidation between two or more polyamides can be accomplished by contacting the polyamides at elevated temperatures, typically from about 270°C to about 350°C. Other examples of transamidation temperatures are about 280°C to about 350°C and about 290°C to about 340°C. Transamidation between the polyamides is indicated by the presence of a single glass transition temperature ("Tg") for the blend as determined by differential scanning calorimetry ("DSC") using standard techniques well known to persons skilled in the art such as, for example, described in ASTM Method D3418. The polyamides may be heated together directly at these temperature or in the presence of the thermoplastic polymers of the first component (i). For example, the contacting and, hence, transamidation of the polyamides can take place by melt blending of the first and second components, during extrusion, or other high temperature processing of the polymer composition and its components. In another example, the polyamides may be heated together in a separate vessel and then melt blended with the first component.

[0098] The first and second polyamides of the second component may be selected from a wide range of polyamides. To better match the refractive index of the first component, it is desirable, but not essential, that at least one of the polyamides comprise aromatic residues. In one example, the polyamides can comprise partially aromatic polyamides and aliphatic polyamides having a number average molecular weight of 7,000 or less. Combinations of such polyamides are included also within the scope of the invention. Partially aromatic polyamides comprise amide linkages between at least one aromatic ring and at least one nonaromatic species. Although wholly aromatic polyamides generally are liquid crystalline, the blends of such resins having melting points less than 300°C can be used for this invention. When homogeneous blends of polyamides are used, the rapid transamidization (amide-amide interchange) of aliphatic nylon with aromatic or partially aromatic polyamide permits the tailoring of refractive index of the polyamide blend by adjusting the ratios of aliphatic polyamide to aromatic, or partially aromatic, polyamide. This technique enables a matching of the refractive index of the homogeneous polyamide blend to the thermoplastic polymer such as, for example, one or more polyesters, of the first component. A reference for transamidization can be found in the work by Y. Takeda, et.al., *Polymer*, 1992 vol. 33, pg. 3394.

[0099] In accordance with the invention, the second component can be a transamidized, homogeneous blend of 2 or more polyamides such as, for example, a first polyamide and a second polyamide which are selected to give a refractive index in the second component such that second and first components have a difference in refractive index (RI(second component) – RI(first component)) of about 0.006 to about -0.0006. To match the refractive index of the first component, it is advantageous that the first and second polyamide have different amounts of aromatic and aliphatic residues. For example, the second component (ii) can comprise a homogeneous blend of a first polyamide, comprising aromatic residues, and of a second polyamide comprising aliphatic residues. The term "aliphatic", as used herein with respect to the diamine and dicarboxylic acid monomers of the polyamides of the present invention, means that carboxyl or amino groups of the monomer are not connected through an aromatic nucleus. For example, adipic acid contains no aromatic nucleus in its backbone, i.e., the chain of carbon atoms connecting the carboxylic acid groups; thus, it is "aliphatic". By contrast, the term "aromatic" means the dicarboxylic acid or diamine contains an aromatic nucleus in the backbone such as, for example, terephthalic acid or 1,4-metaxylylenediamine. Representative examples of aromatic polyamides are those polyamids comprising at least 70 mole % of residues comprising diamines such as m-xylylenediamine or a xylylenediamine mixture comprising m-xylylenediamine and up to 30% of p-xylylenediamine and an aliphatic dicarboxylic acid having 6 to 10 carbon atoms. The term "aliphatic", therefore, is intended to include both aliphatic and cycloaliphatic structures such as, for example, diamine, diacids, lactams, aminoalcohols,and aminocarboxylic acids, that contain as a backbone a straight or branched chain or cyclic arrangement of the constituent carbon atoms which may be saturated or paraffinic in nature, unsaturated (i.e., containing non-aromatic carbon-carbon double bonds), or acetylenic (i.e., containing carbon-carbon triple bonds). Thus, in the context of the description and the claims of the present invention, aliphatic is intended to include linear and branched, chain structures (referred to herein as "aliphatic") and cyclic structures (referred to herein as "alicyclic" or "cycloaliphatic"). The term "aliphatic", however, is not intended to exclude any aromatic substituents that may be attached to the backbone of an aliphatic or cycloaliphatic diol or diacid or hydroxycarboxylic acid.

[0100] The weight percentage ratio of the first and second polyamides present in the transamidized, homogeneous blend typically may range from about 1:50 to about 50:1 based on the total weight of the second component. Other examples of weight percentage ratios are 1:20 to about 20:1 and about 1:10 to about 10:1.

[0101] Examples of polyamides that may be used in the homogeneous blends of the present invention include polyamides comprising one or more of residues selected from isophthalic acid, terephthalic acid, cyclohexane-dicarboxylic acid, meta-xylylenediamine (also referred to herein as "m-xylylenediamine"), para-xylylenediamine (also referred to herein as "p-xylylenediamine"), 1,3- cyclohexane(bis)methylamine, 1,4-cyclohexane(bis)-

methylamine, aliphatic diacids with 6 to 12 carbon atoms, aliphatic amino acids or lactams with 6 to 12 carbon atoms, aliphatic diamines with 4 to 12 carbon atoms. Other generally known polyamide forming diacids and diamines can be used. The polyamides also may contain small amounts of trifunctional or tetrafunctional comonomers such as trimellitic anhydride, pyromellitic dianhydride, or other polyamide forming polyacids and polyamines known in the art.

[0102] Examples of partially aromatic polyamides include, but are not limited to: poly(m-xylylene adipamide) (referred to herein as "MXD6" nylon), poly(hexamethylene isophthalamide), poly(hexamethylene adipamide-co-isophthalamide), poly(hexamethylene adipamide-co-terephthalamide), and poly(hexamethylene isophthalamide-co-terephthalamide). In one embodiment, the partially aromatic polyamide is poly(m-xylylene adipamide). In one embodiment, the partially aromatic polyamides may have a number average molecular weight of 7000 or less. Representative examples of aliphatic polyamides include poly(2-pyrrolidinone) (nylon 4, 6; CAS No. 44,299-2); polycapramide (nylon 6; CAS No. 18,111-0), poly(2-piperidone) (nylon 5, CAS No. 24938-57-6); poly(7-aminoheptanoic acid) (nylon 7; CAS No. 25035-01-2); poly(nonanamide) (nylon 9; CAS No. 25748-72-5); poly(11-aminoundecanoic acid) (nylon 11; CAS No. 25035-04-5); poly(12-aminolauric acid) (nylon 12, CAS No. 24937-16-4); poly(ethyleneadipamide) (nylon 2,6); polytetramethylene-adipamide (nylon 4,6; CAS No. 50327-22-5); polyhexamethylene-adipamide (nylon 6,6; CAS No. 42,917-1), (nylon 6,9; CAS No. 18,806-9) poly-(hexamethylene-sebacamide) (nylon 6,10; CAS No. 9008-66-6), poly(hexamethylene-undecanamide) (nylon 6, 11) poly (hexamethylene-dodecamide) (nylon 6,12; CAS No. 24936-74-1), poly(octamethylene-adipamide) (nylon 8,6); adipic acid-decamethylenediamine copolymer (nylon 10,6; CAS No. 26123-27-3); polydecamethylene- dodecamide (nylon 10, 12); poly(dodecamethylene-adipamide) (nylon 12,6); and poly(dodecamethylene-sebacamide) (nylon 12,8).

[0103] For example, the second component (ii) can comprise a homogeneous blend comprising a first polyamide comprising the residues of m-xylylenediamine and adipic acid, and a second polyamide comprising the residues of at least one aliphatic or cycloaliphatic monomer selected from adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, undecanedioc acid, dodecanedioc acid, caprolactam, butyrolactam, 11-aminoundecanedioc acid, and hexamethylene diamine. The first polyamide, for example, can comprise MXD6 nylon, which is commerically available from Mitsubishi Corporation. In another example, the second polyamide can comprise at least one polyamide selected from from nylon 4; nylon 6; nylon 9; nylon 11; nylon 12; nylon 6,6; nylon 5,10; nylon 6,12; nylon 6,11; nylon 10,12; and combinations thereof. In yet another example, the second polyamide can comprise nylon 6, nylon 6,6, or blends thereof.

[0104] The second component also may comprise a single copolyamide in which the composition of monomer residues is chosen to give a refractive index that closely matches the refractive index of the first component. Thus, in another embodiment, the invention provides a polymer composition, comprising an immiscible blend of:

(i) a first component comprising at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof; and

(ii) a second component comprising a copolyamide;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) – RI(first component), of about 0.006 to about –0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less. In another embodiment, the first component can comprise a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol.. Thus, another embodiment of the invention is a polymer composition, comprising an immiscible blend of:

(i) a first component comprising at least one polyester which comprises:

  (a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

  (b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second component comprising a copolyamide;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less. For example, the copolyamide can comprise the residues of m-xylylenediamine, p-xylylenediamine, or a combination thereof; and the residues of at least one monomer selected from terephthalic acid, isophthalic acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, undecanedioc acid, dodecanedioc acid, caprolactam, butyrolactam, 11-amino-undecanedioc acid, and 1,6-hexamethylenediamine. In another example, the copolyamide can comprise about 15 to about 100 mole percent of the residues of m-xylylenediamine, based on a total diamine residue content of 100 mole%, and about 15 to about 85 mole percent of the residues adipic acid and about 85 to about 15 mole percent of the residues of one or more aliphatic or cycloaliphatic dicarboxylic acids selected from pimelic acid, suberic acid, azelaic acid, sebacic acid, undecandioic acid, dodecandioic acid, and 1,4-cyclohexanedicarboxylic acid, based on a total diacid residue content of 100 mole%. It is understood that the various embodiments of homogeneous blends of polyamides and copolyamides referred to herein can be combined with any of the embodiments of the polyesters discussed hereinabove.

[0105] Other examples of copolyamides that can be used as in composition of the invention, either alone or as part of a homogeneous blend with another polyamide, include, but are not limited to, copolyamides comprising from about 15 to about 100 mole percent of the residues of m-xylylenediamine, based on a total diamine residue content of 100 mole%, and the residues of adipic acid. Typical amounts of adipic acid residues which may be present in these copolyamides, based on the total moles of diacid residues, are about 5 to about 85 mole percent, about 20 to about 80 mole percent, and about 25 to about 75 mole percent. The remainder of the dicarboxylic acid residues can comprise residues from one or more aliphatic dicarboxylic acids having from 7-12 carbon atoms, such as pimelic acid, suberic acid, azelaic acid, sebacic acid, undecanedioic acid, dodecanedioic acid, or 1,4-cyclohexane-dicarboxylic acid. In another example, the polyamide acid also may comprise residues from isophthalic acid and terephthalic acid.

[0106] The copolyamides of the invention also may comprise other diamines or lactam residues in addition to m-xylylenediamine residues. For example, the copolyamide can comprise at least 15 mole percent, or at least about 20 mole percent of the residues of m-xylylenediamine with the remainder of the diamines residues comprising the residues of one or more aliphatic or aromatic diamines. For example, the copolyamide may comprise about 80 mole percent or about 85 mole %, of the residues of 1,6-hexamethylene diamine, based on the total moles of diamine residues. Varying amounts of p-xylylene-diamine, 1,3-cyclohexanebis(methylamine), or 1,4-cyclohexanebis(methyl-amine), also may be used. Similarly, the copolyamide may comprise the residues of a lactam, such as caprolactam, or lactams based on gamma-amino-butyric acid or 11-amino-undecanoic acid, in an amount from about 10 mole percent to about 90 mole percent, or from about 10 mole percent to about 70 mole percent based on the total moles of repeating units. In another embodiment, the copolyamides of the invention can comprise from about 15 mole percent to about 85 mole percent, about 20 to about 80 mole percent, or about 25 to about 75 mole percent of the residues from m-xylylenediamine, based on the total moles of diamine residues with the remainder of the diamine residues content comprising residues from one or more diamines, such as aliphatic diamines, and especially 1,6-hexamethylene diamine. In this embodiment, the diamine residues may further comprise minor amounts of the residues of other diamines, for example p-xylylenediamine, or a cyclic aliphatic diamine such as, for example, one or more of: 1,3-cyclohexanebis(methylamine) or 1,4-cyclohexanebis(methylamine). Further, the polyamide may optionally include, in place of a portion of the adipic acid, residues from one or more aliphatic or aromatic dicarboxylic acids having from 7-12 carbon atoms, such as pimelic acid, suberic acid, azelaic acid, sebacic acid, undecandioic acid, dodecandioic acid, 1,4-cyclohexanedicarboxylic acid, or isophthalic acid, which may be present in an amount from about 15 mole percent to about 85 mole percent, optionally with minor amounts of terephthalic acid. The polyamide also may comprise the residues of a lactam, such as caprolactam, or lactams based on gamma-amino-butyric acid or 11-amino-undecanoic acid, in an amount from about 10 mole percent to about 90 mole percent, or about 10 mole% to 70 mole percent, based on the total moles repeating units.

[0107] In yet another embodiment, the copolyamides according to the invention may comprise from about 15 mole percent up to about 90 mole percent of residues from adipic acid, with the remaining diacid residues comprising the about 10 to about 85 mole percent of the residues of isophthalic acid, based on the total moles of dicarboxylic acid residues. Additional examples of adipic acid and isophthalic acid residue content include about 20 to 80 mole percent, and about 25 to about 75 mole percent. In this embodiment, the polyamide may optionally comprise minor amounts of residues from one or more aliphatic dicarboxylic acids having from 7-12 carbon atoms, such as pimelic acid, suberic acid, azelaic acid, sebacic acid, undecandioic acid, dodecandioic acid, or 1,4-cyclohexanedicarboxylic acid, optionally with minor amounts of terephthalic acid. Optionally, the polyamides may comprise m-xylylenediamine residues. Examples of m-xylylenediame residue concentrations include about 15 to about 90 mole percent, about 20 to about 85 mole percent, or about 25 to about 80 mole percent. The remaining residues can comprise from one or more aliphatic diamines, such as, for example, 1,6-hexamethylene diamine, one or more aromatic diamines such as, for example, p-xylylene-diamine. Similarly, the copolyamide also may comprise the residues of a lactam such as, for example, caprolactam, or lactams based on gamma-amino-butyric acid or 11-amino-undecanoic acid, in an amount from about 10 mole percent to about 90 mole percent or about 10 mole percent to about 70 mole percent, based on the total moles of repeating units.

[0108] In yet another example, the copolyamides of the invention may comprise the residues of one or more lactams such as, for example, caprolactam, or lactams based on gamma-amino-butyric acid or 11-amino-undecanoic acid, in an amount from about 10 mole percent to about 90 mole percent, or from about 10 mole percent to about 70 mole percent, or from about 15 mole percent to about 60 mole percent, based on the total moles of repeating units. The residues of one or more aliphatic dicarboxylic acids having from 7-12 carbon atoms, such as pimelic acid, suberic acid, azelaic acid, sebacic acid, undecandioic acid, dodecandioic acid, or 1,4-cyclohexanedicarboxylic acid, also may be present in amounts from about 20 mole percent to about 80 mole percent, based on the total moles of repeating units. For example, the copolyamide may comprise residues from isophthalic acid or terephthalic acid. In this embodiment, the copolyamides can comprise from about 15 mole percent to about 85 mole percent of the residues from m-xylylenediamine, based on the total moles of diamine residues. Other examples of m-xylylenediamine content are about 20 to about 80 mole percent and about 25 to about 75 mole percent. The remainder of the diamine residues may comprise the residues of one or more diamines aliphatic diamines such as, for example, 1,6-hexamethylene diamine. In this embodiment, the diamine residues may further comprise minor amounts of the residues of other diamines, for example p-xylylenediamine, or a cyclic aliphatic diamine such as, for example, one or more of: 1,3-cyclohexanebis(methylamine) or 1,4-cyclohexanebis(methylamine). Optionally, minor amounts of one or more of: p-xylylenediamine, 1,3-cyclohexanebis(methylamine), or 1,4-cyclohexanebis(methylamine), may be used.

[0109] Another embodiment of the invention is polymer composition, consisting essentially of an immiscible blend of:

(i) a first component consisting essentially of at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof; and

(ii) a second component consisting essentially of a homogeneous, transamidized blend of at least 2 polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less. In another aspect of the invention, the first component consists essentially of a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Thus, the invention also provides a polymer composition, consisting essentially of an immiscible blend of:

(i) a first component consisting essentially of at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues consisting essentially of about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second component consisting essentially of a homogeneous, transamidized blend of at least 2 polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less. The phrase "consisting essentially of", as used herein is intended to encompass compositions which are immiscible blends, that is, having at least 2, composition-dependent Tg's as measured by

DSC, and which have first component containing a polyester, polycarbonate, polyarylate, or homogeneous blends thereof and a second component containing a homogeneous, transamidized blend of at least 2 polyamides. In this embodiment, the composition is understood to exclude any elements that would substantially alter the essential properties of the composition to which the phrase refers. For example, compositions may include other components that do not alter the refractive index of the components, %haze of the immiscible blend, the %transmittance, or the miscibility of the immiscible blend. For example, the addition of a compatibilizer, which may alter the miscibility and refractive index of the composition, would be excluded from this embodiment. Similarly, a second component containing a copolyamide prepared by copolymerization of the component monomers would be excluded because such a copolyamide would be considered to have different properties than a homogeneous, transamidized blend of at least 2 polyamides, even if the mole percentage of the monomer residues are equivalent.

[0110] The polyamides used in the present invention typically are prepared from dicarboxylic acids and diamines, which react in substantially equal proportions, or by the ring-opening polymerization of lactams, and are incorporated into the polyamide polymer as their corresponding residues. The polyamides derived from dicarboxylic acid and diamine residues of the present invention, therefore, contain substantially equal molar proportions of acid residues (100 mole percent) and diamine residues (100 mole percent) such that the total moles of repeating units is equal to 100 mole percent. The mole percentages provided in the present disclosure, therefore, may be based on the total moles of acid residues, the total moles of diamine residues, or the total moles of repeating units. For example, a polyamide or copolyamide containing 30 mole percent terephthalic acid, based on the total acid residues, means that the copolyamide contains 30 mole percent terephthalic residues out of a total of 100 mole percent acid residues. Thus, there are 30 moles of terephthalic residues among every 100 moles of acid residues. In another example, a copolyamide containing 30 mole percent m-xylylenediamine, based on the total diamine residues, means that the copolyester contains 30 mole percent m-xylylenediamine residues out of a total of 100 mole percent diamine residues. Thus, there are 30 moles of m-xylylenediamine residues among every 100 moles of diamine residues.

[0111] Any method known in the art can be used to produce the polyamides. The polyamides are generally prepared by melt phase polymerization from a diacid-diamine complex which may be prepared either *in situ* or in a separate step. In either method, the diacid and diamine are used as starting materials. Alternatively, an ester form of the diacid may be used, preferably the dimethyl ester. If the ester is used, the reaction must be carried out at a relatively low temperature, generally 80 to 120°C, until the ester is converted to an amide. The mixture is then heated to the polymerization temperature. In the case of polycaprolactam, either caprolactam or 6-aminocaproic acid can be used as a starting material and the polymerization may be catalyzed by the addition of adipic acid/hexamethylene diamine salt which results in a nylon 6/66 copolymer. When the diacid-diamine complex is used, the mixture is heated to melting and stirred until equilibration.

[0112] The molecular weight is controlled by the diacid-diamine ratio. An excess of diamine produces a higher concentration of terminal amino groups.

For oxygen-scavenging compositions, it is advantageous to adjust the diacid-diamine ratio to produce the concentration of terminal amine groups to 20 mmole/kg or less. If the diacid-diamine complex is prepared in a separate step, excess diamine is added prior to the polymerization. The polymerization can be carried out either at atmospheric pressure or at elevated pressures.

[0113] To exhibit satisfactory clarity and low haze, the second component and first component of the immiscible blend typically have refractive indices which differ by about 0.006 to about -0.0006, that is, the RI(second component) - RI(first component) is about 0.006 to about -0.0006. Other examples of differences in the absolute value of the refractive indices are about 0.005 to about -0.0006, about 0.004 to about -0.0006, about 0.003 to about -0.0006, about 0.005 to about -0.0005, and about 0.004 to about -0.0005. Persons of skill in the art will understand, however, that the difference in refractive indices which may be acceptable depends on the blend composition, particle diameter, refractive index, wavelength, and particle structure as described by Biangardi et al., *Die Angew. Makromole. Chemie,* 183, 221 (1990).

[0114] The immiscible blend of the instant invention has excellent clarity and has a % transmittance of at least 75%, as determined by ASTM Method D1003, and a haze of 10% or less. According to this method, the %haze value is calculated from the %transmittance value. Other examples of % transmittance are at least 77%, at least 80%, and at least 85%. Additional examples of haze values which may be exhibited by the blends of the invention are 9% or less, 7% or less, 5% or less, and 3% or less. For the compositions of the invention, haze is determined by molding or casting the composition into a sheet or film having a thickness of 1/8 inch or less and measuring the haze according to the procedure described in the examples. For shaped articles, including multilayer shaped articles, the haze can be determined by cutting out a small (i.e., 1 X 1 cm) section of the article, having a thickness of 1/8 inch or less, and measuring the haze according the procedure given in the examples.

[0115] The first component also may comprise homogeneous blend of one or more polymers. For example, the first component may comprise a homogeneous blend of a first polyester with one or more polymers chosen from a polycarbonate, a second polyester, and a polyarylate. The polyester may be any polyester as described herein. For example, the first component may comprise a homogeneous blend of a polyester and a polycarbonate comprising the residues of bisphenol A.

[0116] The polycarbonate may comprise about 90 to 100 mole percent, based on the total moles of diol residues, of the residues bisphenol A, and from 0 to about 10 mole percent of the residues of one or more modifying aliphatic diols or dihydric phenols having from 2 to 16 carbons. Representative examples include bis(4-hydroxyphenyl)methane; 2,2-bis(4-hydroxyphenyl) propane ("bisphenol-A"); 2,2-bis(4-hydroxy-3-methylphenyl)propane; 4,4-bis(4-hydroxyphenyl)heptane; 2,2-bis(4-hydroxy-3,5-dichlorophenyl)propane; 2,2-bis(4-hydroxy-3,5-dibromophenyl)propane; dihydric phenol ethers such as, for example, bis(4-hydroxyphenyl)ether; bis(3,5-dichloro-4-hydroxyphenyl)ether;; dihydroxydiphenyls such as, for example, p,p'-dihydroxydiphenyl, 3,3'-dichloro-4, 4'-dihydroxydiphenyl; dihydroxyaryl sulfones such as, for example, bis(4- hydroxyphenyl)sulfone; bis(3,5-dimethyl-4-hydroxyphenyl)sulfone; dihydroxy benzenes such as, for example, resorcinol; hydroquinone; halo- and alkyl-substituted dihydroxy benzenes such as, for example, 1,4-dihydroxy-2,5-

dichlorobenzene; 1,4- dihydroxy-3-methylbenzene; and dihydroxy diphenyl sulfoxides such as, for example, bis(4-hydroxyphenyl)sulfoxide; and bis(3,5-dibromo-4-hydroxyphenyl) sulfoxide. A variety of additional dihydric phenols are also available such as are disclosed, for example, in U.S. Patent No.'s 2,999,835; 3,028,365 and 3,153,008. Also suitable are copolymers prepared from the above dihydric phenols copolymerized with halogen-containing dihydric phenols such as 2,2-bis(3,5-dichloro-4-hydroxyphenyl)propane and 2,2-bis(3,5-dibromo- 4-hydroxyphenyl)propane. It is also possible to employ two or more different dihydric phenols or a copolymer of a dihydric phenol with a glycol, with hydroxy or acid terminated polyester, or with a dibasic acid as well as blends of any of the above materials. Suitable dicarboxylic acids include, but are not limited to, aromatic dicarboxylic acids such as phthalic, isophthalic, terephthalic, o-phthalic, o-, m-, and p-phenylenediacetic acids, and polynuclear aromatic acids such as, for example, diphenic acid and 1,4-naphthalic acid.

[0117] Representative examples of aliphatic diols include ethylene glycol, propanediols, butanediols, pentanediols, hexandiols, heptanediols, octanediols, neopentyl glycol, aryl-alkyl glycols such as styrene glycol, xylylene glycols, dihydroxy alkyl ethers of dihydric phenols such as the dihydroxy ethyl ether of bisphenol-A, and the like. Other examples of aliphatic diols are higher molecular weight aliphatic dihydroxy compounds such as, for example, polyethylene glycols, polystyrene glycols, polypropylene glycols, polybutylene glycols, polythioglycols, poly-arylalkyl ether glycols and copolymer polyether glycols. Additional representative examples of dihydric phenols and aliphatic diols are described in U.S. Patent No.'s 3,030,335 and 3,317,466. The polycarbonate may further comprise the residues of one or more branching agents such as, for example, tetraphenolic compounds, tri-(4-hydroxyphenyl) ethane, pentaerythritol triacrylate and other compounds as disclosed in U.S. Patent No.'s 6,160,082; 6,022,941; 5,262,511; 4,474,999; and 4,286,083. Other suitable branching agents are mentioned herein below. In a further example, the polycarbonate comprises at least 95 mole percent, based on the total moles of diol residues, of the residues of bisphenol A.

[0118] The inherent viscosity of the polycarbonate portion of the blends according to the present invention is preferably at least about 0.3 dL/g, more preferably at least 0.5 dL/g. The melt flow of the polycarbonate portion of the blends according to the present invention is preferably between 1 and 20, and more preferably between 2 and 18, as measured according to ASTM Method D1238 at a temperature of 300°C and using a weight of 1.2 kg.

[0119] Processes for the preparation of polycarbonates are well known in the art. The linear or branched polycarbonates that can be used in the invention and disclosed herein are not limited to or bound by the polycarbonate type or its production method. Generally, a dihydric phenol, such as bisphenol A, is reacted with phosgene with the use of optional mono-functional compounds as chain terminators and tri-functional or higher functional compounds as branching or crosslinking agents. Monofunctional, difunctional, and trifunctional reactive acyl halides also can used in the preparation of polycarbonates as terminating compounds (mono-functional), comonomers (di-functional), or branching agents (tri-functional or higher).

[0120] For example, the polycarbonate portion of the present blend can be prepared in the melt, in solution, or by interfacial polymerization techniques well known in the art. Suitable methods include the steps of reacting a carbonate source with a diol at a temperature of about 0°C to 315°C at a pressure of about 0.1 to 760 mm Hg for a time sufficient to form a polycarbonate. Commercially available polycarbonates that can be used in the present invention, are normally made by reacting an aromatic diol with a carbonate source such as, for example, phosgene, dibutyl carbonate, or diphenyl carbonate, to incorporate 100 mole percent of carbonate units, along with 100 mole percent diol units into the polycarbonate. Other representative examples of methods of producing polycarbonates are described in U.S. Patent No.'s 5,498,688; 5,494,992; and 5,489,665.

[0121] Blends of the of polyesters and polycarbonates can be made by methods which include the steps of blending the polycarbonate and polyester portions at a temperature of about 25 °C to 350°C for a time sufficient to form a clear blend composition. Suitable conventional blending techniques include the melt method and the solution-prepared method. Other suitable blending techniques include dry blending and/or extrusion.

[0122] The compositions of the present invention, including the immiscible and homogeneous blends contained therein, may be prepared by any method known in the art and are useful as thermoplastic molding compositions and for formation of films and single and multilayered articles. In addition to physically blending the various components of the blend, homogeneous polyesters blends may be prepared by transesterification of the polyester components. Similarly, homogeneous blends of polyamides may be prepared by transamidation of the polyamide components.

[0123] The melt blending method includes blending the polymers at a temperature sufficient to melt the first component and second component portions, and thereafter cooling the blend to a temperature sufficient to produce a clear blend. The term "melt" as used herein includes, but is not limited to, merely softening the polymers. Examples of melt mixing methods generally known in the polymers art are described in *Mixing and Compounding of Polymers* (I. Manas-Zloczower & Z. Tadmor eds., Carl Hanser Verlag publisher, N.Y. 1994).

[0124] The solution-prepared method includes dissolving the appropriate weight/weight ratio of the first component and second component in a suitable organic solvent such as methylene chloride or a 70/30 mixture of methylene chloride and hexafluoroisopropanol, mixing the solution, and separating the blend composition from solution by precipitation of the blend or by evaporation of the solvent. Solution-prepared blending methods are generally known in the polymers art.

[0125] The melt blending method is the preferred method for producing the blend compositions of the present invention. The melt blending method is more economical and safer than the solution method, which requires the use of volatile solvents. The melt blending method also is more effective in providing clear blends. Any of the clear blends of the present invention that can be prepared by solution blending also can be prepared by the melt method. Some of the blends of the present invention, however, can be prepared by the melt method, but not by the solution-prepared method. Any blending process which provides clear blends of the present invention is suitable. One of ordinary skill in the art will be able to determine appropriate blending methods for producing the clear blends of the present invention.

[0126] These first and second components of the composition may be compounded in the melt, for example, by using a single screw or twin screw extruder. They may also be prepared by blending in solution. Additional components such as stabilizers, flame retardants, colorants, lubricants, release agents, impact modifiers, and the like may also be incorporated into the formulation. For example, the compositions can be produced via a melt extrusion compounding of the first component and the second component with any other composition components such as, for example, metal catalysts, dyes, toners, fillers, and the like. The composition may be formed by dry blending solid particles or pellets of each of thermoplastic polymers and the polyamide components and then melt blending the mixture in a suitable mixing means such as an extruder, a roll mixer, or the like. When it is desired to produce a the second component comprising a transamidized, homogeneous blend of polyamides *in situ* (i.e., in the presence of the first component), it is advantageous to conduct the processing at a temperature that will cause transamidation between the polyamides to occur. Typically, these temperatures range from about 270°C to about 350°C. Other examples of transamidation temperatures are about 280°C to about 350°C and about 290°C to about 340°C. Blending is conducted for a period of time that will yield a well dispersed, immiscible blend. Such may easily be determined by those skilled in the art. If desired, the composition may be cooled and cut into pellets for further processing, it may be extruded into films, sheets, profiles, and other shaped elements, injection or compression molded to form various shaped articles, or it may be formed into films and optionally uniaxially or biaxially stretched by means well known in the art.

[0127] The amounts of the first and second components in the immiscible blend may vary widely. For example, the immiscible blend of our novel composition may comprise about 5 to about 99 weight percent of the first component and about 95 to about 1 weight percent of the second component, based on the total weight of the composition. Other non-limiting, representative examples of weight percentages of the first and second components include about 50 to about 99 weight percent of the first component and about 50 to about 1 weight percent of the second component, about 60 to about 99 weight percent of the first component and about 40 to about 1 weight percent of the second component, and about 70 to about 99 weight percent of the first component and about 30 to about 1 weight percent of the second component.

[0128] Our invention also provides a composition prepared by a process comprising melt blending:

(i) a first component comprising at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof; and

(ii) a second component comprising a homogeneous, transamidized blend of at least 2 polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the composition has a percent transmittance of at least 75%, and a haze of 10% or less. In yet another aspect of the invention, the first component comprises a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. The invention, therefore, also provides a polymer composition, prepared by a process comprising melt blending:

(i) a first component comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second component comprising a homogeneous, transamidized blend of at least 2 polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the composition has a percent transmittance of at least 75%, and a haze of 10% or less. The composition includes the various embodiments of the polyesters, polycarbonates, polyarylates, homogeneous blends, and polyamides as described above and any combination thereof. For example, the second component of the composition can comprise a homogeneous, transamidized blend of at least 2 polyamides in which transamidation may be accomplished by contacting the polyamides at elevated temperatures, typically from about 270°C to about 350°C. Other examples of transamidation temperatures are about 280°C to about 350°C and about 290°C to about 340°C.

[0129] The homogeneous blend of component (ii) can comprise a first polyamide, comprising aromatic residues, and a second polyamide comprising aliphatic residues, as described previously. For example, typical polyamides that can be used as the second polyamide include, but are not limited to, nylon 4; nylon 6; nylon 9; nylon 11; nylon 12; nylon 6,6; nylon 5,10; nylon 6,12; nylon 6,11; nylon 10,12; and combinations thereof. In addition to the polyesters described previously, the first component can comprise a homogeneous blend of a polyester and a polycarbonate comprising the residues of bisphenol A.

[0130] Another aspect of the instant invention is a method for the preparation of a transparent polymer blend, comprising:

(A) selecting a first component comprising at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof;

(B) determining the refractive index of the first component;

(C) providing a second component comprising

(i) a copolyamide having a mole ratio of aliphatic and aromatic residues, wherein the mole ratio of aliphatic and aromatic residues is selected to produce a second component refractive index that satisfies the following formula:

$$0.006 \geqq RI(\text{second component}) - RI(\text{first component}) \geqq -0.0006$$

or;

(ii) a homogeneous, transamidized blend of a first and second polyamide, at least one of the polyamides having aromatic residues, wherein the weight percentage of the first and second polyamide is selected to produce a second component refractive index that satisfies the following formula:

$0.006 \geqq RI(\text{second component}) - RI(\text{first component}) \geqq -0.0006$

wherein RI is refractive index; and

(D) melt blending the first and second components to produce an immiscible blend having a percent transmittance of at least 75%, and a haze of 10% or less.

In yet another aspect of the invention, the first component comprises a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Thus, our invention also provides a method for the preparation of a transparent polymer blend, comprising:

(A) selecting a first component comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(B) determining the refractive index (RI) of the first component;

(C) providing a second component comprising

(i) a copolyamide having a mole ratio of aliphatic and aromatic residues, wherein the mole ratio of aliphatic and aromatic residues is selected to produce a second component refractive index that satisfies the following formula:

0.006 ≧ RI (second component) - RI (first component) ≧ -0.0006

or;

(ii) a homogeneous, transamidized blend of a first and second polyamide, at least one of the polyamides having aromatic residues, wherein the weight percentage of the first and second polyamide is selected to produce a second component refractive index that satisfies the following formula:

0.006 ≧ RI (second component) - RI (first component) ≧ -0.0006

wherein RI represents the refractive index of the first and second components; and

(D) melt blending the first and second components to produce an immiscible blend having a percent transmittance of at least 75%, and a haze of 10% or less.

Our methods include the various embodiments of the polyesters, polycarbonates, polyarylates, homogeneous blends, copolyamides, and polyamides as described previously and any combination thereof.

[0131] Our method comprises selecting the first component which may be a polyester, polycarbonate, polyarylate or homogeneous blend thereof. The refractive index of the first component may be determined using methods well known to persons skilled in the art. The second component, which may comprise as single copolyamide or a transamidized, homogeneous blend of at least two polyamides, is tailored to closely match the refractive index of the first component by selecting the appropriate mixture of aromatic and aliphatic monomers in the case of a copolyamide, or by selecting a mixture of polyamides containing the desired mixture of aromatic and aliphatic residues if a homogeneous blend of polyamides is used. The choice of the proper ratio of monomers or of polyamides can be determined, for example, by trial and error, or, in another example, by plotting the refractive index of various polyamides or copolyamides containing varying amounts of aromatic residues and aliphatic residues, and selecting the molar ratio of aromatic:aliphatic residues or the weight percentage ratio of polyamides that will give the targeted refractive index. The first and second components may be melt blended. When the second component comprises a transamidized, homogeneous blend of at least 2 polyamides, it is desirable to carry out the melt blending step at a temperature effective for the transmidation process. Typical transamidation temperature ranges are as described previously.

[0132] The thermoplastic polymers also may be selected to match the refractive index of the second component. Thus, another aspect of the invention is a method for the preparation of a transparent polymer blend, comprising:

(A) selecting a second component comprising

(i) a copolyamide having a mole ratio of aliphatic and aromatic residues; or

(ii) a homogeneous, transamidized blend of a first and second polyamide, at least one of the polyamides having aromatic residues;

(B) determining the refractive index of the second component;

(C) providing a first component comprising at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof wherein the polyester, polycarbonate, polyarylate, or homogeneous blend thereof is selected to produce a first component refractive index that satisfies the following formula:

$$0.006 \geqq RI(\textit{second component}) - RI(\textit{first component}) \geqq -0.0006$$

wherein RI is refractive index; and

(D) melt blending the first and second components to produce an immiscible blend having a percent transmittance of at least 75%, and a haze of 10% or less. As described above, the first component comprises a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Thus, the invention also includes a method for the preparation of a transparent polymer blend, comprising:

(A) selecting a second component comprising

  (i) a copolyamide having a mole ratio of aliphatic and aromatic residues; or

  (ii) a homogeneous, transamidized blend of a first and second polyamide, at least one of the polyamides having aromatic residues;

(B) determining the refractive index of the second component;

(C) selecting a first component comprising at least one polyester which comprises:

  (a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

wherein the polyester is selected to produce a first component refractive index that satisfies the following formula:

$$0.006 \geqq RI\ (second\ component) - RI\ (first\ component) \geqq -0.0006$$

wherein RI is refractive index; and

(D) melt blending the first and second components to produce an immiscible blend having a percent transmittance of at least 75%, and a haze of 10% or less.

It is further understood that the above methods also include any combination of the various embodiments of the polyesters, polycarbonates, polyarylates, homogeneous blends, copolyamides, polyamides described previously.

[0133] In one example, the blending of thermoplastic polymers to obtain a second component and first component that have a difference in refractive index of about 0.006 to about -0.0006 may be illustrated with particular reference to polycarbonate/polyester blends. For example, the complete miscibility of a polycarbonate of bisphenol A and PCTG permits the tailoring of refractive index (RI) of the polycarbonate/PCTG blend, by adjusting the polycarbonate/PCTG ratio. By adjusting the polycarbonate ratio. the refractive index of the first component of the present invention may be matched to within about 0.006 to about -0.0006 of that of the second component comprising a copolyamide or a homogeneous, transamidized blend of polyamides. For example, a polymer may be determined to be a suitable modifying polymer of the homogeneous polyester/polycarbonate blends described hereinabove if a clear blend is formed by: 1) blending the modifying polymer with a pre-existing blend containing the polycarbonate and polyester portions, or 2) blending the modifying polymer with the polycarbonate portion prior to the introduction of the polyester portion, or 3) blending the modifying polymer with the polyester portion prior to the introduction of the polycarbonate portion, or 4) mixing the modifying polymer, polycarbonate portion and polyester portion all together prior to blending.

[0134] The clear blends of the present invention can still be modified by the incorporation of modifying polymers to produce performance blends, which may not necessarily be clear. For example, polyamides such as nylon 6,6 from DuPont, poly(ether-imides) such as ULTEM poly(ether-imide) from General Electric, polyphenylene oxides such as poly(2,6-dimethylphenylene oxide) or poly(phenylene oxide)/polystyrene blends such as the NORYL resins from General Electric, polyesters, polyphenylene sulfides, polyphenylene sulfide/sulfones, poly(ester-carbonates) such as LEXAN 3250 poly(ester-carbonate) (General Electric), polycarbonates other than LEXAN polycarbonate from General Electric, polyarylates such as ARDEL D100 polyarylate (Amoco), polysulfones, polysulfone ethers, poly(ether-ketones) or aromatic dihydroxy compounds can be used as blend modifiers to modify properties or to reduce flammability. Some of the aromatic dihydroxy compounds used to prepare these polymers are disclosed in U.S. Patent No. 3,030,335 and U.S. Patent No. 3,317,466.

[0135] The copolyamide or homogeneous blend of polyamides of the composition of the invention can function as a barrier polymer and, as such, improve the barrier properties of the overall composition. The term "barrier polymer", as used herein, means a polymer having one or more of the following properties: (1) a water permeability of 2 gm-mils/100 sq in/24 hr or less, as measured by ASTM Method No. F1249 at 38°C; (2) an oxygen permeability of 5 cc(STP)-mils/100 sq in/24 hrs-atm or less, as measured by ASTM Method No. D3985 at 23°C, or (3) a carbon dioxide permeability of 25 cc(STP)-mils/100 sq in/24 hrs atm or less, as measured by ASTM Method No. D1434 at 23°C.

[0136] The barrier properties may be enhanced by incorporating a metal catalyst to produce an oxygen-scavenging composition which catalyzes the reaction of oxygen with one or more polyamides in the composition. Our invention, therefore, further provides an oxygen-scavenging composition comprising:

(A) an immiscible blend comprising

(i) first component comprising at least one thermoplastic polymer selected from polyester, polycarbonate, polyarylate, and homogeneous blends thereof;

(ii) a second component comprising a transamidized, homogeneous blend of at least two polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less; and

(B) at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements.

The first component of the immiscible blend may comprise a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Thus, another embodiment of the invention is an oxygen-scavenging composition comprising:

(A) an immiscible blend comprising

(i) a first component comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second component comprising a homogeneous, transamidized blend of at least 2 polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less; and

(B) at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements.

[0137] In addition to a homogeneous blend of one or polyamides, the oxygen-scavenging compositions of the invention also may include a single copolyamide as described hereinabove for the other embodiments of the invention. Thus, the invention also provides an oxygen-scavenging composition comprising:

(A) an immiscible blend comprising

(i) first component comprising at least one thermoplastic polymer selected from polyester, polycarbonate, polyarylate, and homogeneous blends thereof;

(ii) a second component comprising a copolyamide;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less; and

(B) at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements.

As described above, the first component of the immiscible blend may comprise a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-

1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Thus, another embodiment of the invention is an oxygen-scavenging composition comprising:

(A) an immiscible blend comprising

(i) a first component comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second component comprising a copolyamide;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less; and

(B) at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements.

It should be further understood the oxygen scavenging compositions include any combination of the various embodiments of the first and second components, polyesters, polycarbonates, polyarylates, homogeneous blends, copolyamides, and polyamides described hereinabove.

[0138] Similarly, another embodiment of the instant invention is an oxygen-scavenging composition consisting essentially of:

(A) an immiscible blend consisting essentially of

(i) first component consisting essentially of at least one thermoplastic polymer selected from polyester, polycarbonate, polyarylate, and homogeneous blends thereof;

(ii) a second component consisting essentially of a copolyamide or a transamidized, homogeneous blend of at least two polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less; and

(B) at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements;

wherein the first component and the second component have refractive indices which differ in absolute value by 0.008 or less and the shaped article has a % transmittance of at least 75%, and a haze of 10% or less. In yet another example, the invention provides an oxygen-scavenging composition consisting essentially of :

(A) an immiscible blend comprising

(i) a first component consisting essentially of at least one polyester which comprises:

(a) diacid residues consisting essentially of about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues consisting essentially of about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second component consisting essentially of a homogeneous, transamidized blend of at least 2 polyamides;

wherein the second component (ii) and the first component (i) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less; and

(B) at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements.

In these embodiments, the composition is understood to exclude any elements that would substantially alter the essential properties of the composition to which the phrase refers, such as, for example, the refractive index of the components, %haze of the immiscible blend, the %transmittance, the miscibility of the first and second components, or the oxygen-scavenging propertions of the composition. For example, the addition an oxygen-scavenging component other than a copolyamide or a transmidized blend of polyamides such as, for example, a diene, polyether, or any easily oxidizable organic compound other than the components as listed in the claims would be excluded.

[0139] The oxygen-scavenging compositions of the invention can include one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements as set forth in the 1984 revision of the Periodic Table by the Internation Union of Pure and Applied Chemistry . Typical oxidation catalysts include transition metal catalysts which can readily interconvert between at least two oxidation states. Examples of metals which can be used include copper, nickel, cobalt, iron, manganese, and combinations thereof. Any amount of catalyst which is effective in catalyzing oxygen scavenging may be used but, typically, the metal will be used in amounts from about 5 ppm to about 1,000 ppm. Other ranges of metal concentration include, about 50 ppm to about 750 ppm, about 5 to about 600 ppm, about 10 to about 500 ppm, about 50 ppm to about 500 ppm, and about 50 to about 300 ppm based on the total weight of the oxygen-scavenging composition. The metal typically may be used as the elemental metal itself, as a metal complex containing organic ligands, as an oxide, or as a metal salt. Examples of counterions for metal salts include, but are not limited to, chloride, acetate, acetylacetonate, stearate, palmitate, 2-ethylhexanoate, neodecanoate, octanoate, or naphthenate, and mixtures thereof. The metal salt may also be an ionomer, in which case a polymeric counterion is employed. Such ionomers are well known in the art.

[0140] In one example, the metal catalyst is cobalt or a compound containing cobalt such as, for example, a cobalt salt. The cobalt may be in the +2 or +3 oxidation state. Other examples of metal catalysts are rhodium in the +2 oxidation state and copper in the +2 oxidation state. The metals may be added in salt form, conveniently as carboxylate salts such as, for example, cobalt octanoate, cobalt acetate, or cobalt neodecanoate. The reported amounts are based on the weight of the polymer blends and measured on the metal, not its compound weight as added to the composition. In the case of cobalt as the metal, typical amounts are at least 50 ppm, or at least 60 ppm, or at least 75 ppm, or at least 100 ppm, or at least 125 ppm. The catalyst can be added neat or in a carrier (such as a liquid or wax) to an extruder or other device for making an article, or it can be added in a concentrate with a polyamide polymer, in a concentrate with a polyester polymer, or in a concentrate with the immiscible blend. The carrier may either be reactive or non-reactive with the first and second component and either volatile or non-volatile carrier liquids may be employed. The metal catalyst may be added at a variety of points and by way of a variety of blending protocols during the preparation of the oxygen scavenging composition. A particularly useful approach is to bring the polyamide and transition metal together late in the preparation of the final blend composition, even as late as in the final melt step before forming the article, so that the oxygen scavenging activity of the polyamide is not prematurely initiated. In some instances, such as when cobalt is provided as a transition metal, it may be preferred to add the cobalt during blending of first and second components, instead of, for example, during the preparation of the thermoplastic polymers.

[0141] In one embodiment, for example, the first component of the oxygen-scavenging composition can comprise a polyester having any combination of monomer residues as described previously. For example, the polyester can comprise (a) diacid residues comprising at least 80 mole percent, based on the total diacid residues, of the residues of at least one dicarboxylic acid selected from terephthalic acid, isophthalic acid, naphthalenedicarboxylic acid, and 1,4-cyclohexanedicarboxylic acid, and 0 to about 20 mole percent of the residues of at least one modifying dicarboxylic acid having 2 to 20 carbon atoms; and (b) diol residues comprising at least 80 mole percent, based on the total moles of diol residues, of the residues of at least one diol selected from ethylene glycol, 1,4-cyclohexanedimethanol; neopentyl glycol, diethylene glycol, 1,3-propanediol, 1,4-butanediol, and, 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and from 0 to about 20 mole percent of the residues of at least one modifying diol having from 3 to 16 carbons. In another example, the diacid residues can comprise about 60 to 100 mole percent of the residues of terephthalic acid and 0 to about 40 mole percent of the residues of isophthalic acid and the diol residues can comprise about 100 mole percent of the residues of 1,4-cyclohexanedimethanol. In another example, the diacid residues can comprise about 100 mole percent, based on the total moles of diacid residues, of the residues of terephthalic acid. Other specific examples of polyesters that may be used as the first component include polyesters comprising: (i) about 80 to about 100 mole percent of the residues of terephthalic acid and about 50 to about 90 mole percent of the residues 1,4-cyclohexanedimethanol and about 10 to about

50 mole percent neopentyl glycol; (ii) about 100 mole percent of the residues of terephthalic acid and about 10 to about 40 mole percent of the residues of 1,4-cyclohexanedimethanol and 60 to about 90 mole percent of the residues of ethylene glycol; and (iii) about 100 mole percent of the residues of terephthalic acid and about 10 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol, 0 to about 90 mole percent of the residues of ethylene glycol, and about 1 to about 25 mole percent of the residues of diethylene glycol. Additional examples of polyesters are those comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; and any one of the following diol residue compositions, based on the total diol residues: (i) about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol; (ii) about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexane-dimethanol; (iii) about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol; and (iv) about 20 to about 25 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 75 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol. The polyester may also further comprise about 0.1 to about 1 mole%, based on the total diacid residues, of the residues of at least one branching agent selected from trimellitic acid, trimellitic anhydride, and pyromellitic dianhydride, glycerol, sorbitol, 1, 2, 6-hexanetriol, pentaerythritol, tartaric acid, citric acid, trimethylolethane, and trimesic acid as described hereinabove.

[0142] Additional examples of polyesters are those containing about 100 mole percent terephthalic residues, based on the total diacid residues, and any one of the following diol residue compositions, based on the total diol residues: (i) about 1 to about 5 mole percent of the residues of 1,4-cyclohexanedimethanol and about 99 to about 95 mole percent of the residues of ethylene glycol; (ii) about 29 to about 33 mole percent of the residues of 1,4-cyclohexanedimethanol and about 71 to about 67 mole percent of the residues of ethylene glycol; (iii) about 45 to about 55 mole percent of the residues of 1,4-cyclohexanedimethanol and about 55 to about 45 mole percent of the residues of ethylene glycol; (iv) about 60 to about 65 mole percent of the residues of 1,4-cyclohexanedimethanol and about 40 to about 35 mole percent of the residues of ethylene glycol; (v) about 79 to about 83 mole percent of the residues of 1,4-cyclohexanedimethanol and about 21 to about 17 mole percent of the residues of ethylene glycol; (vi) about 100 mole percent of the residues of 1,4-cyclohexanedimethanol; (vii) about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol; (viii) about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol; (ix) about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol; and (x) about 20 to about 25 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 75 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

[0143] The first component may also comprise a homogeneous blend of at least one polyester and at least one polycarbonate. The polycarbonates that can be used in these homogeneous blends have been described previously.

[0144] The transamidized, homogeneous blend or the copolyamide can comprise any polyamide as described previously such as for example, various nylons. It is advantageous, however, that the copolyamide or homogeneous blend of polyamides of the oxygen-scavenging composition comprise the residues of m-xylylenediamine, p-xylylenediamine, or a combination thereof. For example, the second component may comprise a homogeneous blend of a first polyamide comprising the residues of m-xylylenediamine and adipic acid, and a second polyamide comprising nylon 6, nylon 6,6, or blends thereof. As a further example, this homogeneous blend may be combined in an immiscible blend with a first component comprising a homogeneous blend of the polyester and a polycarbonate comprising the residues of bisphenol A. It is desirable also for optimum oxygen scavenging properties that the copolyamide or homogeneous blend of polyamides contain 20 mmoles/kg or less of free amino groups. The concentration of free amino groups can be determined using techniques well known to persons having ordinary skill in the art such as, for example, by titration.

[0145] In another example, the oxygen scavenging composition comprises a copolyamide of m-xylylenediamine adipate. The use of a modified m-xylylenediamine adipate, in which some of the adipic acid residues, or some of the m-xylylenediamine residues, or some of both, are replaced with other residues, can give an oxygen-scavenging composition with improved oxygen-scavenging properties when compared with compositions containing only the m-xylylenediamine adipate homopolymer. Other polyamide barrier polymers, as described herein, may also be used as part of the oxygen scavenging composition.

[0146] The compositions of the present invention described hereinabove may be used to fabricate shaped articles such as, for example, sheets, films, tubes, preforms, bottles, or profiles. Such articles may be formed by any means well known to persons skilled in the art such as, for example, by extrusion, calendering, thermoforming, blow-molding, extrusion blow-molding, injection molding, compression molding, casting, drafting, tentering, or blowing.

[0147] For example, the compositions of the present invention may be fabricated into shaped articles such as, for example, films, by any technique known in the art. Formation of films can be achieved by melt extrusion, as described, for example, in U.S. Patent No. 4,880,592, or by compression molding as described, for example, in U.S. Patent No. 4,427,614, or by any other suitable method. For example, films may be produced by the well known cast film, blown film and extrusion coating techniques, the latter including extrusion onto a substrate. Such a substrate may also include a tie-layer. Films produced by melt casting or blowing can be thermally bonded or sealed to a substrate using an adhesive. The compositions may be fabricated into monolayer or multi-layer films by any technique known in the art. For example, monolayer, or multi-layer films may be produced by the well known cast film, blown film and extrusion coating techniques, the latter including extrusion onto a substrate. Representative substrates include films, sheets, and woven and nonwoven fabrics. Monolayer, or multilayer films produced by melt casting or blowing can be thermally bonded or sealed to a substrate using an adhesive.

[0148] For example, the composition may be formed into a film using a conventional blown film apparatus. The film forming apparatus may be one which is referred to in the art as a "blown film" apparatus and includes a circular die head for bubble blown film through which the composition is forced and formed into a film "bubble". The "bubble" is ultimately collapsed and formed into a film.

[0149] The compositions also may be used to form shaped articles through extrusion blow molding and injection stretch-blow molding. An injection molding process softens the copolyamide or homogeneous polyamide blend in a heated cylinder, injecting it while molten under high pressure into a closed mold, cooling the mold to induce solidification, and ejecting the molded preform from the mold. Molding compositions are well suited for the production of preforms and subsequent reheat stretch-blow molding of these preforms into the final bottle shapes having the desired properties. The injection molded preform is heated to suitable orientation temperature in the 100°C to 150°C range and then stretch-blow molded. The latter process consists of first stretching the hot preform in the axial direction by mechanical means such as by pushing with a core rod insert followed by blowing high pressure air (up to 500 psi) to stretch in the hoop direction. In this manner, a biaxially oriented blown bottle is made. Typical blow-up ratios range from 5/1 to 15/1.

[0150] The excellent transparency and low haze of the compositions of the invention enable the preparation of transparent, shaped articles with the incorporation of substantial amounts of scrap polymer or “regrind”. The term “regrind”, as used herein, is understood to have its commonly accepted meaning in art, that is, scrap polymer that recovered from an article forming process and ground into smaller particles. Often, regrind is sold as scrap for incorporation into shaped articles in which the transparency of the article is immaterial to its application. For certain shaped articles such as, for example, bottles and films used in packaging applications, low haze and high transparency are desirable features. The manufacture of these articles, in particular, multilayered articles, inherently produces large quantities of scrap polymer which frequently cannot be returned to the article-forming process because of the formation of unacceptable levels of haze. Because of the close match in the refractive indices of the first and second components, low haze, transparent, shaped articles may be produced from the compositions of the invention with the inclusion of regrind.

[0151] Another aspect of our invention, therefore, is a process for forming a shaped article, comprising:

(A) melt blending

(i) a first component comprising at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof; and

(ii) a second component comprising a copolyamide or a homogeneous, transamidized blend of at least 2 polyamides;

wherein the first component (i) and second component (ii) form an immiscible blend, the second component and the first component have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less;

(B) forming a shaped article;

(C) recovering a scrap polymer composition comprising the blended first and second components (i) and (ii) ;

(D) grinding the scrap polymer composition to produce a polymer regrind;

(E) optionally, drying the scrap polymer composition;and

(F) combining the polymer regrind with the first and second components (i) and (ii) of step (A).

In another example, the first component can comprise a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Thus, the instant invention also includes a process for forming a shaped article, comprising:

(A) melt blending

(i) a first component comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second component comprising a copolyamide or a homogeneous, transamidized blend of at least 2 polyamides;

wherein the first component (i) and second component (ii) form an immiscible blend, the second component and the first component have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the immiscible blend has a percent transmittance of at least 75%, and a haze of 10% or less;

(B) forming a shaped article;

(C) recovering a scrap polymer composition comprising the blended first and second components (i) and (ii) ;

(D) grinding the scrap polymer composition to produce a polymer regrind;

(E) optionally, drying the scrap polymer composition;and

(F) combining the polymer regrind with the first and second components (i) and (ii) of step (A).

Our process, thus, permits the incorporation of scrap polymer regrind into the shaped article with retention of low haze and high transparency. It should be further understood the above process includes the various embodiments of the first and second components, polyesters, polycarbonates, polyarylates, homogeneous blends, copolyamides, polyamides, oxygen-scavenging compositions, and any combination thereof described hereinabove.

[0152] For example, as described previously, the immiscible blend formed from the first and second components may further comprise at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements. Examples of metals include, but are not limited to, copper, nickel, cobalt, iron, manganese, and combinations thereof. Typically, the metal is present in amounts of about 5 to about 600 parts per million by weight of the metal, based on the total weight of the shaped article. The preferred metal is cobalt.

[0153] The shaped article of our inventive process may be formed by any methods known in the art and described hereinabove. For example, the shaped article may be formed by extrusion, calendering, thermoforming, blow-molding, extrusion blow-molding, injection molding, compression molding, casting, drafting, tentering, or blowing.

[0154] Although the process of the invention may be used to prepare any shaped article, representative articles that may be produced are sheets, films, preforms, tubes, and bottles. These articles may have a single layer or contain from 2 to about 7 layers. The regrind may be incorporated into one or more of these layers which typically may comprise from about 50 to 100 weight percent regrind based on the weight of the one or more layers. Other examples of regrind levels that can be present in the shaped article are 5 to about 95 weight percent, about 10 to about 60 weight percent, about 15 to about 50 weight, and about 20 to about 30 weight percent, based on the total weight of the one or more layers.

[0155] The shaped article may comprise multiple layers in which one or more of the layers comprise the first and second component as an immiscible blend or in which the first component and the second component are present in separate layers. Thus, another aspect of the instant invention, is a multilayered, shaped article, comprising:

(i) a first layer comprising at least one thermoplastic polymer selected from polyester, polycarbonate, polyarylate, and homogeneous blends thereof; and

(ii) a second layer comprising a transamidized homogeneous blend of at least two polyamides;

wherein the second layer (ii) and the first layer (i) have a difference in refractive index, RI(second layer) – RI(first layer), of about 0.006 to about –0.0006, and the shaped article has a percent transmittance of at least 75%, and a haze of 10% or less.

In another aspect, the first layer can comprise a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Thus, another embodiment of the invention is

A multilayered, shaped article, comprising:

(i) a first layer comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second layer comprising a transamidized, homogeneous blend of at least two polyamides;

wherein the second layer (ii) and the first layer (i) have a difference in refractive index, RI(second layer) - RI(first layer), of about 0.006 to about -0.0006, and the shaped article has a percent transmittance of at least 75%, and a haze of 10% or less. The shaped article may include the various embodiments of the first and second components, polyesters, polycarbonates, polyarylates, homogeneous blends, copolyamides, polyamides, oxygen-scavenging compositions, shaped articles, and any combination thereof described hereinabove.

[0156] The multilayered shaped article may be produced by extrusion, calendering, thermoforming, blow-molding, extrusion blow-molding, injection molding, compression molding, casting, drafting, tentering, or blowing. Because of the close match between the refractive indices of the first and second layers, the multilayered article may further comprise a regrind comprising a mixture of the first and second layers, which may be incorporated into first layer, second layer, or a combination of the first and second layer. Typically, the regrind is about 5 weight percent to about 60 weight percent of the multilayered article, based on the total weight of the article. Other examples of weight percentages of regrind in the shaped article are about 10 weight percent to about 40 weight percent and about 20 weight percent to about 30 weight percent of the total weight of the article.

[0157] The multilayered article can have from 2 to about 7 layers depending on its intended application. For example, as described above, the shaped article may be a sheet, film, tube, bottle, or preform. Complex layered structures are possible also. For example, the shaped article can have a layered structure represented by ABA, ABABA, ABCBA, or ACBCA in which layer A comprises the first layer (i), layer B comprises the second layer (ii), and layer C comprises a regrind comprising a mixture of scrap first and second layers (i) and (ii), polyester or polycarbonate obtained from post consumer recycle, or a combination thereof. Depending on the composition of the regrind, it can be advantageous that layer B and layer C have a difference in refractive index, RI(layer B) - R(layer C), of about 0.006 to about -0.0006 to maintain the transparency of the article and the ability to incorporate regrind.

[0158] In another embodiment, layer A can comprise the second layer (ii), layer B comprises the first layer (i) and layer C comprises a a mixture of scrap first and second layers (i) and (ii), polyester or polycarbonate obtained from post consumer recycle, or a combination thereof.

[0159] In addition, the second layer (ii) of our novel multilayered article can further comprise at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements. Examples of metals include copper, nickel, cobalt, iron, manganese, and combinations thereof. Typically, the metal is present in amounts of about 10 to about 500 parts per million by weight of the metal, based on the total weight of the shaped article. Other examples of metal concentrations are about 5 ppm to about 600 ppm, and 10 ppm to about 750 ppm, based on the total weight of the shaped article. The preferred metal is cobalt.

[0160] In yet another embodiment, the multilayered, shaped article of the invention can further comprise at least one additional layer comprising about 50 to about 100 weight percent of regrind, based on the total weight of the layer. The additional layer containing the regrind can further comprise at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements. Examples of metals include copper, nickel, cobalt, iron, manganese, and combinations thereof. Typically, the metal is present in amounts of about 10 to about 500 parts per million by weight of the metal, based on the total weight of the shaped article. Other examples of metal concentrations are about 5 ppm to about 600 ppm, and 10 ppm to about 750 ppm, based on the total weight of the shaped article. The preferred metal is cobalt.

[0161] As noted above, the multilayered, shaped article may comprise the various embodiments of the shaped articles, thermoplastic polymers, polyamides, immiscible blends, homogeneous blends, and oxygen scavenging compositions as described earlier. For example, the at least one thermoplastic polymer may comprise a linear or branched polyester comprising at least 80 mole percent, based on the total diacid residues, of the residues of at least one dicarboxylic acid selected from terephthalic acid, isophthalic acid, naphthalenedicarboxylic acid, and 1,4-cyclohexanedicarboxylic acid, and 0 to about 20 mole percent of the residues of at least one modifying dicarboxylic acid having 2 to 20 carbon atoms; and (b) diol residues comprising at least 80 mole percent, based on the total moles of diol residues, of the residues of at least one diol selected from ethylene glycol, 1,4-cyclohexanedimethanol; neopentyl glycol, diethylene glycol, 1,3-propanediol, 1,4-butanediol, and, 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and from 0 to about 20 mole percent of the residues of at least one modifying diol having from 3 to 16 carbons; and the one or more barrier polymers comprise a homogeneous blend of a first polyamide comprising the residues of m-xylylenediamine and adipic acid, and a second polyamide comprising nylon 6, nylon 6,6, or blends thereof. Additional examples of polyesters are those comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid;

0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and any one of the following diol residue compositions, based on the total diol residues: (i) about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol; (ii) about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexane-dimethanol; (iii) about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol; and (iv) about 20 to about 25 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 75 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol. The polyester may also further comprise about 0.1 to 1 mole%, based on the total diacid residues, of the residues of at least one branching agent selected from trimellitic acid, trimellitic anhydride, and pyromellitic dianhydride, glycerol, sorbitol, 1, 2, 6-hexanetriol, pentaerythritol, tartaric acid, citric acid, trimethylolethane, and trimesic acid as described hereinabove.

[0162] For example, the thermoplastic polymer may comprise a branched polyester. In a further example, the thermoplastic polymer further comprise a homogeneous blend of the polyester and a polycarbonate comprising the residues of bisphenol A.

[0163] The multilayered, shaped articles of the present invention may be prepared by any method known to persons of ordinary skill in the art. For example, the shaped articles can be formed by any conventional technique for forming films, including lamination, extrusion lamination, coinjection, stretch-blow molding and coextrusion blowmolding, and may be illustrated with particular reference to a typical method for making multilayer film by coextrusion. For example, the first and second components, as well as any optional layers, are fed into infeed hoppers of the extruders of like number, each extruder handling the material for one or more of the layers. Typically, for compositions of the present invention, the first and second components each will be heated to a temperature of about Tg + 100°C to about Tg + 300°C before and during extrusion, wherein Tg is the glass transition temperature of the first or second component as measured by differential scanning calorimetry. The melted streams from the individual extruders are fed into a single manifold co-extrusion die. While in the die, the layers are juxtaposed and combined, then emerge from the die as a single multiple layer film of polymeric material. After exiting the die, the film is cast onto a first controlled temperature casting roll, passes around the first roll, and then onto a second controlled temperature roll, which is normally cooler than the first roll. The controlled temperature rolls largely control the rate of cooling of the film after it exits the die. In another method, the film forming apparatus may be one which is referred to in the art as a blown film apparatus and includes a multi-manifold circular die head for bubble blown film through which the film composition is forced and formed into a film bubble which may ultimately be collapsed and formed into a film. Processes of coextrusion to form film and sheet laminates are generally known. Alternatively the individual layers may first be formed into sheets and then laminated together under heat and pressure with or without intermediate adhesive layers.

[0164] The transparency and low haze of the compositions of the invention also enable the preparation of multilayered, transparent, shaped articles with the incorporation of substantial amounts of scrap polymer or "regrind". Our invention, therefore, also provides a process for forming a multilayered, shaped article, comprising:

(i) heating a first component comprising at least one thermoplastic polymer selected from polyesters, polycarbonates, polyarylates, and homogeneous blends thereof to a temperature of about Tg +100°C to about Tg + 300°C of the first component;

(ii) heating a second component comprising a copolyamide or a transamidized, homogeneous blend of at least two polyamides to a temperature of about Tg +100°C to about Tg + 300°C of the second component;

(iii) forming a shaped article having the first and second components in separate layers;

(iv) recovering scrap first and second components;

(v) grinding the scrap first and second components to produce a regrind;

(vi) optionally, drying the regrind; and

(vii) combining the regrind with the first component, second component, or a combination thereof, of steps (i) and (ii);

wherein the second component of step (ii) and the first component of step (i) of have a difference in refractive index, RI(second component) – RI(first component), of about 0.006 to about -0.0006, and the shaped article has a percent transmittance of at least 75%, and a haze of 10% or less. In another example, the first component can comprise a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Hence, another aspect of the invention is a process for forming a multilayered shaped article, comprising:

(i) heating a first component to a temperature of about Tg +100°C to about Tg + 300°C of the first component, the first component comprising at least one polyester which comprises:

    (a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

    (b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol;

(ii) heating a second component comprising a copolyamide or a transamidized, homogeneous blend of at least two polyamides to a temperature of about Tg +100°C to about Tg + 300°C of the second component;

(iii) forming a shaped article having the first and second components in separate layers;

(iv) recovering scrap first and second components;

(v) grinding the scrap first and second components to produce a regrind;

(vi) optionally, drying the regrind; and

(vii) combining the regrind with the first component, second component, or a combination thereof, of steps (i) and (ii);

wherein the second component of step (ii) and the first component of step (i) of have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the shaped article has a percent transmittance of at least 75%, and a haze of 10% or less. The above processes may include the various embodiments of the first and second components, polyesters, polycarbonates, polyarylates, homogeneous blends, copolyamides, polyamides, oxygen-scavenging compositions, shaped articles, article-forming processes, and any combination thereof described hereinabove.

[0165] Our process enables the incorporation of substantial amounts of regrind into shaped article while maintaining low haze and high transparency. The regrind will typically comprise a mixture of the first and second components of steps (i) and (ii) that are produced as scrap during the article-forming process, but any polymer material can be used as long as its refractive index differs from the that second component by about 0.006 to about -0.0006. The regrind material of the process can be combined with the first component of step (i), the second component of step (ii) or a combination of the first and second components. The regrind may be incorporated into the first or second layer and can be from about 5 weight percent to about 60 weight percent of the shaped article, based on the total weight of the shaped article. Other representative examples of regrind content for the shaped artice of the process of the invention are about 10 weight percent to about 40 weight percent of the shaped article and about 20 weight percent to about 30 weight percent of the shaped article.

[0166] The multilayered article of our process can have from 2 to about 7 layers depending on its intended application. For example, as described above, the multilayered, shaped article may be a sheet, film, tube, bottle, or preform. Complex layered structures are possible also. For example, the shaped article can have a layered structure represented by ABA, ABABA, ABCBA, or ACBCA in which layer A comprises the first component of step (i), layer B comprises the second component of step (ii), and layer C comprises a regrind comprising a mixture of scrap first and second components from steps (i) and (ii), polyester or polycarbonate obtained from post consumer recycle, or a combination thereof. Depending on the composition of the regrind, it can be advantageous that layer B and layer C have a difference in refractive index, RI(layer B) - R(layer C), of about 0.006 to about -0.0006 to maintain the transparency of the article and the ability to incorporate regrind.

[0167] In another embodiment, layer A can comprise the second component of step (ii), layer B comprises the first component of step (i) and layer C comprises a a mixture of scrap first and second components of steps (i) and (ii), polyester or polycarbonate obtained from post consumer recycle, or a combination thereof.

[0168] In addition, the second component of step (ii) of our novel multilayered article can further comprise at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements. Examples of metals which can be used include copper, nickel, cobalt, iron, manganese, and combinations thereof. Typically, the metal is present in amounts of about 10 to about 500 parts per million by weight of the metal, based on the total weight of the shaped article. Other examples of metal concentrations are about 5 ppm to about 600 ppm, and 10 ppm to about 750 ppm, based on the total weight of the shaped article. The preferred metal is cobalt. When metals are present, is advantageous to adjust the diacid-diamine ratio to produce the concentration of terminal amine groups to 20 mmole/kg or less.

[0169] In yet another embodiment, step (iii) of the process of the invention can further comprise forming at least one additional layer comprising about 50 to about 100 weight percent of regrind, based on the total weight of the layer. The additional layer containing the regrind can further comprise at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements. Examples of metals include copper, nickel, cobalt, iron, manganese, and combinations thereof. Typically, the metal is present in amounts of about 10 to about 500 parts per million by weight of the metal, based on the total weight of the shaped article. Other examples of metal concentrations are about 5 ppm to about 600 ppm, and 10 ppm to about 750 ppm, based on the total weight of the shaped article. The preferred metal is cobalt.

[0170] As noted above, the multilayered, shaped article may comprise the various embodiments of the shaped articles, thermoplastic polymers, polyamides, immiscible blends, homogeneous blends, and oxygen scavenging compositions as described earlier. For example, the at least one thermoplastic polymer may comprise a polyester comprising at least 80 mole percent, based on the total diacid residues, of the residues of at least one dicarboxylic acid selected from terephthalic acid, isophthalic acid, naphthalenedicarboxylic acid, and 1,4-cyclohexanedicarboxylic acid, and 0 to about 20 mole percent of the residues of at least one modifying dicarboxylic acid having 2 to 20 carbon atoms; and (b) diol residues comprising at least 80 mole percent, based on the total moles of diol residues, of the residues of at least one diol selected from ethylene glycol, 1,4-cyclohexanedimethanol; neopentyl glycol, diethylene glycol, 1,3-propanediol, 1,4-butanediol, and, 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and from 0 to about 20 mole percent of the residues of at least one modifying diol having from 3 to 16 carbons; and the one or more barrier polymers comprise a homogeneous blend of a first polyamide comprising the residues of m-xylylenediamine and adipic acid, and a second polyamide comprising nylon 6, nylon 6,6, or blends thereof. Additional examples of polyesters are those comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and any one of the following diol residue compositions, based on the total diol residues: (i) about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol; (ii) about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol; (iii) about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol; and (iv) about 20 to about 25 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 75 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol. The polyester may also further comprise about 0.1 to 1 mole%, based on the total diacid residues, of the residues of at least one branching agent selected from trimellitic acid, trimellitic anhydride, and pyromellitic dianhydride, glycerol, sorbitol, 1, 2, 6-hexanetriol, pentaerythritol, tartaric acid, citric acid, trimethylolethane, and trimesic acid as described hereinabove.

[0171] For example, the thermoplastic polymer may comprise a branched polyester. In a further example, the thermoplastic polymer further comprise a homogeneous blend of the polyester and a polycarbonate comprising the residues of bisphenol A.

[0172] Another embodiment of our invention further is a process for forming a multilayered shaped article, comprising:

(A) heating a first component comprising (i) at least one polyester comprising: (a) diacid residues comprising at least about 95 mole percent, based on the total diacid residues, of the residues of terephthalic acid; and (b) diol residues comprising at least 95 mole percent, based on the total moles of diol residues, of the residues of at least one diol selected from ethylene glycol and 1,4-cyclohexanedimethanol; (ii) at least one polycarbonate comprising the residues of bisphenol A; or (iii) a homogeneous blend thereof to a temperature of about Tg +100°C to about Tg + 300°C of the first component;

(B) heating a second component comprising a transamidized, homogeneous blend of a polyamide comprising diamine and diacid residues, the polyamide comprising about 100 mole percent, based on the total diamine residues, of the residues of m-xylylenediame and about 100 mole percent, based on the total diacid residues, of the residues of adipic acid, and at least one polyamide selected from nylon 6 and nylon 6,6 to a temperature of about 290°C;

(C) forming a shaped article having the first and second polymer compositions in separate layers;

(D) recovering scrap first and second components;

(E) grinding the scrap first and second components to produce a regrind;

(F) optionally, drying the regrind; and

(G) combining the regrind with the first component, second component, or a combination thereof, of steps (A) and (B);

wherein the second component of step (B) and the first component of step (B) have a difference in refractive index, RI(second component) - RI(first component), of about 0.006 to about -0.0006, and the shaped article has a percent transmittance of at least 75%, and a haze of 10% or less. In another example, the first component can comprise a polyester comprising the residues of terephthalic acid, 2,2,4,4-tetramethyl-1,3-cyclobutanediol, and 1,4-cyclohexanedimethanol. Accordingly, another embodiment of the invention is a process for forming a multilayered shaped article, comprising:

(A) heating a first component to a temperature of about Tg +100°C to about Tg + 300°C of the first component, the first component comprising at least one polyester which comprises:

(a) diacid residues comprising about 95 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; and

(b) diol residues comprising about 15 to about 40 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 60 to about 85 mole percent of the residues of 1,4-cyclohexane-dimethanol;

wherein the polyester has an inherent viscosity of about 0.55 to about 0.75 dL/g;

(B) heating a second component to a temperature of about 290°C to about 310°C, the second component comprising a transamidized, homogeneous blend of (a) a polyamide having diamine and diacid residues and comprising about 100 mole percent, based on the total diamine residues, of the residues of m-xylylenediame and about 100 mole percent, based on the total diacid residues, of the residues of adipic acid; and (b) at least one polyamide selected from nylon 6 and nylon 6,6;

(C) forming a shaped article having the first and second polymer compositions in separate layers;

(D) recovering scrap first and second components;

(E) grinding the scrap first and second components to produce a regrind;

(F) optionally, drying the regrind; and

(G) combining the regrind with the first component, second component, or a combination thereof, of steps (A) and (B);

wherein the second component of step (B) and the first component of step (B) have a difference in refractive index, RI(second component) –

RI(first component), of about 0.006 to about -0.0006, and the shaped article has a percent transmittance of at least 75%, and a haze of 10% or less.

The above processs may include the various embodiments of the first and second components, polyesters, polycarbonates, polyarylates, homogeneous blends, copolyamides, polyamides, oxygen-scavenging compositions, shaped articles, article-forming processes, and any combination thereof described hereinabove.

[0173] As described previously, the regrind may comprise a mixture of the first and second components (i) and (ii) and can be combined with the first component (i), second component (ii), or a combination thereof. The regrind can be from about 5 weight percent to about 60 weight percent of the shaped article, based on the total weight of the shaped article. Other representative examples of regrind content for the shaped artice of the process of the invention are about 10 weight percent to about 40 weight percent of the shaped article and about 20 weight percent to about 30 weight percent of the shaped article. The polyester of the process can comprises diacid residues comprising at least about 95 mole percent of the residues of terephthalic acid and can have a range of diol compositions. For example, the polyester can comprise diol residues comprising about 1 to about 5 mole percent of the residues of 1,4-cyclohexanedimethanol and about 99 to about 95 mole percent of the residues of ethylene glycol. Other examples of diol compositions for the polyester of our process include, but are not limited to: (i) diol residues comprising about 29 to about 33 mole percent of the residues of 1,4-cyclohexanedimethanol and about 71 to about 67 mole percent of the residues of ethylene glycol; (b) diol residues comprising about 45 to about 55 mole percent of the residues of 1,4-cyclohexanedimethanol and about 55 to about 45 mole percent of the residues of ethylene glycol; (iii) residues comprising about 60 to about 65 mole percent of the residues of 1,4-cyclohexanedimethanol and about 40 to about 35 mole percent of the residues of ethylene glycol; (iv) diol residues comprising about 79 to about 83 mole percent of the residues of 1,4-cyclohexanedimethanol and about 21 to about 17 mole percent of the residues of ethylene glycol; and (v) diol residues comprising about 100 mole percent of the residues of 1,4-cyclohexanedimethanol. Additional examples of polyesters are those comprising diacid residues comprising about 95 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid, and any one of the following diol residue compositions, based on the total diol residues: (i) about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol; (ii) about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol; (iii) about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol; and (iv) about 20 to about 25 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 75 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol. The polyester may further comprise about 0.01 to 1 mole%, based on the total diacid residues, of the residues at least one branching agent selected from trimellitic acid, trimellitic anhydride, and pyromellitic dianhydride, glycerol, sorbitol, 1, 2, 6-

hexanetriol, pentaerythritol, tartaric acid, citric acid, trimethylolethane, and trimesic acid.

[0174] In a further example, the thermoplastic polymer may further comprise a homogeneous blend of the polyester and a polycarbonate comprising the residues of bisphenol A. Each of the polyester and polycarbonate may be linear or branched.

[0175] In addition, the second component of step (ii) of our novel process can further comprise at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements. Examples of metals which can be used include copper, nickel, cobalt, iron, manganese, and combinations thereof. Typically, the metal is present in amounts of about 10 to about 500 parts per million by weight of the metal, based on the total weight of the shaped article. Other examples of metal concentrations are about 5 ppm to about 600 ppm, and 10 ppm to about 750 ppm, based on the total weight of the shaped article. The preferred metal is cobalt. When metals are present, is advantageous to adjust the diacid-diamine ratio to produce the concentration of terminal amine groups to 20 mmole/kg or less.

[0176] In yet another embodiment, step (C) of the process of the invention can further comprise forming at least one additional layer comprising about 50 to about 100 weight percent regrind, based on the total weight of the layer. The additional layer containing the regrind can further comprise at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements. Examples of metals include copper, nickel, cobalt, iron, manganese, and combinations thereof. Typically, the metal is present in amounts of about 10 to about 500 parts per million by weight of the metal, based on the total weight of the shaped article. Other examples of metal concentrations are about 5 ppm to about 600 ppm, and 10 ppm to about 750 ppm, based on the total weight of the shaped article. The preferred metal is cobalt.

[0177] The shaped articles of the invention may be further oriented by stretching which may improve the barrier properties of the article. As described earliner, it may be desirable to incorporate other conventional additives or modifying polymers with the polymeric compositions of the present invention. For example, there may be added antioxidants, heat and light stabilizers, dyes, antistatic agents, lubricants, preservatives, processing aids, slip agents, antiblocking agents, pigments, flame retardants, blowing agents, and the like. More than one additive may be used. The additive may be present in any desired amount, but typically are not present at more than about 20 weight percent, preferably not more than 10 weight percent, of the total weight of the shaped article.

[0178] The polymer compositions, oxygen-scavenging compositions, and shaped articles prepared therefrom also may comprise up to about 30 weight percent, preferably less than about 20 weight percent, of certain platelet particles derived from at least one layered silicate material to improve their barrier properties. The platelet particles can be modified with at least one ammonium compound. The amount of platelet particles may be determined by measuring the residual ash of the polymer-platelet particle compositions when treated in accordance with ASTM D5630-94. The gas barrier improvement typically increases with increasing concentration of platelet particles in the composite. While amounts of platelet particles as low as about 0.01 percent provide improved barrier (especially when well dispersed and ordered), compositions having at least about 0.5 weight percent of the platelet particles are preferred because they display desirable improvements in gas permeability.

[0179] Generally layered silicate materials are a dense agglomeration of platelet particles which are closely stacked together like cards. The platelet particles of the present invention typically have a thickness of less than about 2 nm and a diameter in the range of about 10 to about 5000 nm. For the purposes of this invention, measurements refer only to the platelet particle and not to the ammonium compounds or any additional dispersing aids and treatment compounds which might be used. Suitable platelet particles are derived from layered silicate materials that are typically free flowing powders having a cation exchange capacity between about 0.3 and about 3 meq/g and preferably between about 0.8 and about 1.5 meq/g. Examples of suitable layered silicate materials include mica-type layered phyllosilicates, including clays, smectite clays, sodium montmorillonite, sodium hectorite, bentonites, nontronite, beidelite, volonsloite, saponite, sauconite, magadite, kenyaite, synthetic sodium hectorites, and the like. Clays of this nature are available from various companies including Southern Clay Products and Nanocor, Inc. The most preferred platelet particles are derived from sodium bentonite or sodium montmorillonite. Such clays are readily available in the U.S., known as Wyoming type montmorillonite, and other parts of the world, including the Kunipia clays available from Kunimine Industries, Inc.

[0180] The layered silicate materials are typically treated to improve dispersion into the polymer composition. Many useful clay treatments are known in the art, and these treatments may also be used before, after, or during incorporation of the layered silicate materials into the composites of this invention without deviating from the scope of this invention. Examples of useful treatments include, but are not limited to treatments with silane compounds, expanding agents, polymers and oligomers, dispersing aids, organic cation salts, and their combinations.

[0181] Examples of useful treatment with silane compounds include those treatments disclosed in International Publication No. WO 93/11190. Examples of useful silane compounds includes (3-glycidoxypropyl)trimethoxysilane, 2-methoxy (polyethyleneoxy)propyl heptamethyl trisiloxane, octadecyl dimethyl (3-trimethoxysilylpropyl) ammonium chloride and the like.

[0182] Examples of useful treatment with expanding agents include oligomeric polymers well known in the art. Representative polymers and oligomers for treating clays include those disclosed in U.S. Patent No.'s 5,552,469 and 5,578,672. Many dispersing aids are known, covering a wide range of materials including water, alcohols, ketones, aldehydes, chlorinated solvents, hydrocarbon solvents, aromatic solvents, and the like or combinations thereof.

EXAMPLES

[0183] *General:* The invention is further illustrated by the following examples. The glass transition temperatures (Tg's) of the polyesters, polyamides, and blends were determined by ASTM Method D3418 using a TA Instruments 2920 differential scanning calorimeter (DSC) at a scan rate of 20°C/min. Heat Deflection Temperature was determined by ASTM Method D648, and Notched Izod Impact Strength was performed according to ASTM Method D256. Flexural properties were determined according to ASTM Method D790. The tensile properties of the blends were determined according to ASTM Method D638 at 23°C. The inherent viscosity of the polyesters was determined in 60/40 (wt/wt) phenol/tetrachloroethane at a concentration of 0.5 g/100 mL at 25 °C. The diol content of the polyester portion of these blends was determined by proton nuclear magnetic resonance spectroscopy (^1H NMR). The miscibility of the blends was determined by differential scanning calorimetry of pressed films and molded objects.

[0184] Haze values were determined by ASTM Method D1003 (%Haze = 100 * Diffuse Transmission / Total Transmission) using a HunterLab UltraScan Sphere 8000 Colorimeter manufactured by Hunter Associates Laboratory, Inc., Reston, VA., using Hunter's Universal Software (version 3.8). Calibration and operation of the instrument was carried out according to the HunterLab User Manual. Diffuse transmission (% transmission) was obtained by placing a light trap on the other side of the integrating sphere from the sample port, thus eliminating the straight-thru light path. Only light scattered by greater than 2.5 degrees was measured. Total transmission includes measurement of light passing straight-through the sample and also off-axis light scattered to the sensor by the sample. The sample was placed at the exit port of the sphere so that off-axis light from the full sphere interior is available for scattering. Clarity was determined visually and with haze measurements. For blends and the various compositions of the invention, haze and percent transmittance was determined by forming the composition into a sheet, film, or plaque having a thickness of 1/8 inch or less and measuring the haze and percent transmittance according to the above procedure. For shaped articles, including multilayer shaped articles, the haze and percent transmittance was determined by cutting out a small (i.e., 1 X 1 cm) section of the article, having a thickness of 1/8 inch or less, and measuring the haze and percent transmittance according the procedure described above.

[0185] Refractive index was measured at 633 nm with a Metricon Prism Coupler™ model 2010 refractometer (available from Metricon Inc.) and is reported as the average of the refractive indices measured in 3 orthogonal directions (extrusion or stretch, transverse, and thickness directions). Oriented films were produced on a TM Long film stretcher (named for the producer) which uniaxially or biaxially stretches samples of pressed, blown, or extruded film. The operation of the film stretcher was based upon the movement of two drawbars at right angles to each other upon hydraulically driven rods. There was a fixed draw bar opposed to each moving draw bar. These pairs of opposed moving and fixed draw bars, to which the four edges of the film specimen are attached, form the two axes at right angles to each other along which the specimen is stretched in any stretch ratio up to four or seven times original size, depending on the machine being used. Samples were placed in grips on the machine and heated prior to stretching if desired. The outputs from the device are stress versus elongation data (if desired) at the temperature of the experiment and the stretched film.

[0186] Oxygen permeabilities of films were determined using Ox-Tran Oxygen Permeation instruments manufactured by MOCON, Inc. Minneapolis, MN. Oxygen permeabilities were calculated from the known area of the films in the test, thickness of the film, partial pressure differential of oxygen across the film, and the measured steady state transmission rate. In the case of samples which exhibit active oxygen scavenging, the measured flux is not truly at steady state, since the transmission rate can slowly change as the efficiency of the oxygen scavenging reaction changes with time. However, in these instances, the oxygen transmission can often be considered to be at pseudo-steady state during the duration of permeation measurement. In the active oxygen scavenger samples included in the examples which follow, little to no change in scavenger efficiency was evident during the course of the measurements and permeabilities were calculated from the measured pseudo-steady state transmission rates.

[0187] *Comparative Examples 1-12*: The copolyesters listed in Table 1, with the exception of polyester G, were prepared from terephthalic acid, ethylene glycol, and 1,4-cyclohexanedimethanol (CHDM). The amount of CHDM in the polyesters is shown in Table 1. Example F contains 100% CHDM (0% ethylene glycol) but 26 mole% of the acid portion is isophthalic acid instead of terephthalic acid. Polyester G was prepared as follows: 21.24 lb (49.71 gram-mol) dimethyl terephthalate, 12.61 lb (39.77 gram-mol) 1,4-cyclohexanedimethanol, and 6.30 lb (19.88 gram-mol) 2,2,4,4-tetramethyl-1,3-cyclobutanediol were reacted together in the presence of 200 ppm of the catalyst butyltin tris(2-ethylhexanoate). The cis/trans ratio of the 2,2,4,4-tetramethyl-1,3-cyclobutanediol was approximately 50/50. The cis/trans ratio of the 1,4-cyclohexanedimethanol was approximately 30/70. The reaction was carried out under a nitrogen gas purge in an 18-gallon stainless steel pressure vessel fitted with a condensing column, a vacuum system, and a HELICONE-type agitator. With the agitator running at 25 RPM, the reaction mixture temperature was increased to 250°C and the pressure was increased to 20 psig. The reaction mixture was held for 2 hours at 250°C and 20 psig pressure. The pressure was then decreased to 0 psig at a rate of 3 psig/minute. The temperature of the reaction mixture was then increased to 270°C and the pressure was decreased to 90 mm of Hg. After a 1 hour hold time at 270°C and 90 mm of Hg, the agitator speed was decreased to 15 RPM, the reaction mixture temperature was increased to 290°C, and the pressure was decreased to <1 mm of Hg. The reaction mixture was held at 290°C and at a pressure of <1 mm of Hg for 12 minutes. The pressure of the pressure vessel was then increased to 1 atmosphere using nitrogen gas. The molten polymer was then extruded from the pressure vessel. The cooled, extruded polymer was ground to pass a 6-mm screen. The polymer had an inherent viscosity of 0.590 dL/g and a Tg of 106°C. NMR analysis showed that the polymer was composed of 77.1 mol% 1,4-cyclohexane-dimethanol residues and 22.9 mol% 2,2,4,4-tetramethyl-1,3-cyclobutanediol residues. The polymer had color values of: L*= 83.27, a*= -1.34, and b*= 5.08.

Table 1

Polyester	CHDM (mole%) in polyester	Tg	Refractive Index of polyester
A	1.5	81	1.5708
B	31	83	1.5644
C	50	84	1.5593
D	62	86	1.5573
E	81	91	1.5547
F	100	88	1.5519
G	77	106	1.5470

[0188] The copolyesters and MXD6 6121 polyamide (containing 100 mole% m-xylylene and 100 mole% adipic acid, available from Mitsubishi Corporation) were dried overnight at 70°C. Each of these copolyesters were bag blended with a MXD6 at 1, 3, and 5 wt% and fed to a Sterling 1.5 inch single screw extruder at 90 rpm under the following temperature settings (degrees C) to form a blend:

Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
240	250	260	260	260

[0189] The blends were dried overnight at 70°C and then injection molded into 1/8 inch thick 4" square plaques at 270°C on a Toyo 90 injection molding machine. The refractive index of the MXD6 was measured to be 1.5824. The resulting haze values and the result of the subtraction of the refractive index of the polyester from the refractive index of the nylon are shown in Table 2:

Table 2

Example	Polyester Type	Polyester (wt%)	MXD6 (wt%)	% Haze	Total Transmission (%)	RI(nylon) – RI(polyester)
C-1	A	99	1	5.2	82.8	0.0116
C-2	A	97	3	14.3	81.6	0.0116
C-3	A	95	5	29.8	82.0	0.0116
C-4	B	99	1	5.1	79.5	0.0180
C-5	B	97	3	22.4	70.7	0.0180
C-6	B	95	5	42.9	62.4	0.0180
C-7	C	99	1	8.5	80.7	0.0231
C-8	C	97	3	31.0	70.4	0.0231
C-9	C	95	5	50.7	62.6	0.0231
C-10	D	99	1	11.5	77.6	0.0251
C-11	D	97	3	59.0	63.3	0.0231
C-12	D	95	5	81.6	53.5	0.0231

[0190] *Examples 13-24, 27-29, 31-32, 34-36, 38 and Comparative Examples 25-26, 30, 33, 36-37, and 39*: Nylon 6 (availabe as Zytel® 7335F from DuPont) and MXD6 (grade 6121) were dried at 120°C for 48 hours and bag blended in various ratios. Polyamide bag blends were then fed to a Sterling 1.5

inch single screw extruder at 90 rpm under the following conditions (°C) to form a homogeneous, transamidized blends as indicated by the presence of a single, composition dependent Tg value for each blend. The Tg values are shown in Table 3.

Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
250	270	300	300	300

[0191] Portions of the transamidized nylon blends or MXD6 were dried overnight at 120°C and then either injection molded into 1/8 inch thick samples at 240°C on a Toyo 90 injection molding machine or extruded into 15 mil thick film at 240°C. The films were prepared by the following extrusion process: The extruder used was a conventional 2.54 cm diameter Killian extruder, 24:1 L:D (length:diameter) ratio, fitted with a feed screw with 3:1 compression ratio and twisted maddock mixing section. The conventional feedblock was used to convey the melt to a conventional 15.24 cm coathanger die. A 2-roll cast film downstack configuration was used for quenching the melt. These films were then stretched on the TM-Long 4x in each direction at 95 °C. The properties of these films before stretching are shown in Table 3 and after stretching are shown in Table 3A. It should be noted that oxygen permeabilities in Tables 3A were measured at 30°C and 50% relative humidity with 100% O_2 as the test gas.

Table 3 - Film Properties Before Stretching

Example	MXD6 (wt%)	Nylon 6 (wt%)	Tg (°C)	Oxygen Permeability (cc*mil/ 100in²*day*atm)	Thickness (mil)	Refractive Index
13	100	0	88	0.533	15.003	1.5824
14	95	5	87	0.440	15.000	1.5772

Example	MXD6 (wt%)	Nylon 6 (wt%)	Tg (°C)	Oxygen Permeability (cc*mil/ 100in^2*day*atm)	Thickness (mil)	Refractive Index
15	90	10	83	0.100	14.465	1.5739
16	87	13	83	0.063	14.498	1.5724
17	85	15	81	0.413	14.065	1.5717
18	75	25	77	1.266	15.260	1.5655
19	73	27	76	1.060	14.065	1.5641
20	70	30	75	1.317	14.535	1.5617
21	65	35	72	1.334	14.755	1.5599
22	62	38	72	0.740	16.385	1.5575
23	60	40	70	0.709	14.630	1.5536
24	0	100	44			1.5318

Table 3A - Film Properties After Stretching

Example	MXD6 (wt%)	Nylon 6 (wt%)	Oxygen Permeability (cc*mil/(100in^2*day*atm)	Thickness (mil)
13	100	0	0.230	0.900
14	95	5	0.238	0.930
15	90	10	0.263	0.850
16	87	13	0.340	0.860
17	85	15	0.325	0.820
18	75	25	0.499	0.900
19	73	27	1.402	0.885
20	70	30	0.622	0.880
21	65	35	0.215	0.970
22	62	38	0.847	1.095
23	60	40	0.982	0.995
24	0	100		

[0192] To generate examples and comparative examples shown in Table 4, portions of the transamidized blends or MXD6 were dried overnight between 70 and 120°C and then compounded with the polyesters of Table 1. The polyesters were dried overnight between 70 and 120°C. Each of these polyesters of Table 1 were bag blended with 10 wt% of selected transamidized blends of Table 3 or MXD6 and fed to a Sterling 1.5 inch single screw extruder at 90 rpm under the following temperature settings (°C) to form an immiscible blend:

Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
240	260	280	280	280

The blends were dried overnight at 70°C and then injection molded into 1/8 inch thick 4" square plaques at 270°C on a Toyo 90 injection molding machine. The resulting haze values and the result of the subtraction of the refractive index of the polyester from the refractive index of the nylon are shown in Table 4.

[0193] To generate example 38 and comparative example C-39, the transamidized blend from example 20 of Table 3 was dried overnight at 70°C and then bag blended with either polyester A or C of Table 1. The polyesters were also dried overnight between 70 and 120°C. The bag blends were then injection molded into 1/8 inch thick 4" square plaques at 270°C on a Toyo 90 injection molding machine. The resulting haze values and the results of the subtraction of the refractive index of the polyester from the refractive index of MXD6 or the nylon blends are shown in Table 4.

Table 4 - Polyester blends with homogeneous MXD6/Nylon 6 blends

Example	Polyester Type	Blend Example of Table 3	CHDM (mole%) in polyester	Blend MXD6 (wt%)	Blend Nylon 6 (wt%)	Haze %	Total %Trans.	RI(nylon) - RI(polyester)
C-25	A	13	1.5	100	0	28.1	71.1	0.0116
C-26	A	14	1.5	95	5	13.5	76.0	0.0064
27	A	15	1.5	90	10	6.3	77.8	0.0031
28	A	16	1.5	87	13	6.9	78.1	0.0016
29	A	17	1.5	85	15	7.7	77.9	0.0009

Example	Polyester Type	Blend Example of Table 3	CHDM (mole%) in polyester	Blend MXD6 (wt%)	Blend Nylon 6 (wt%)	Haze %	Total %Trans.	RI(nylon) - RI(polyester)
C-30	B	17	31	85	15	21.3	81.8	0.0073
31	B	18	31	75	25	5.0	86.5	0.0011
32	B	19	31	73	27	8.5	85.4	-0.0003
C-33	B	20	31	70	30	16.2	84.1	-0.0027
34	C	20	50	70	30	4.1	86.8	0.0024
36	C	21	50	65	35	8.3	84.5	0.0006
C-36	C	22	50	62	38	13.6	82.8	-0.0018
C-37	C	23	50	60	40	19.3	80.2	-0.0057
38	C	20	50	70	30	3.7	86.3	0.0024
C-39	A	20	3.5	70	30	33.0	69.9	-0.0091

[0194] *Example 40:* In this prophetic example, a synthetic route to a polyamide with the appropriate refractive index is employed instead of blending two polyamides as in the above Examples 13-24. Any method known in the art can be used to produce these directly synthetic polyamides. The polyamides are generally prepared by melt phase polymerization from a diacid-diamine complex which may be prepared either *in situ* or in a separate step. In either method, the diacid and diamine are used as starting materials. Alternatively, an ester form of the diacid may be used, preferably the dimethyl ester. If the ester is used, the reaction must be carried out at a relatively low temperature, generally 80 to 120°C, until the ester is converted to an amide. The mixture is then heated to the polymerization temperature. For this prophetic example, the polyamide synthesized is poly(m-xylylene pimelamide) which is synthesized from the diamine m-xylylenediamine and the diacid pimelic acid. This polyamide is then blended with 90 wt% of the copolyester A in Table 1, in accordance with methods disclosed in Examples 25-39. The difference in refractive index between these the copolyester A and poly(m-xylylene pimelamide) is predicted to be 0.0034 and is predicted to be transparent. The resulting blend is predicted to have a haze value of less 10% and a transmittance of greater than 75%.

[0195] *Examples 42, 47-49, and 56 and Comparative Examples 41, 43-46, and 50-55. Monolayer Films of blends and Oxygen-Scavenging Compositions:* Several MXD6/N6 transamidized blends were prepared in the manner discussed above for examples 13-24 and are given in Table 5. The refractive index values listed in Table 5 were measured on 15mil films of these transamidized blends in the manner discussed above for examples 13-24. Three wt% or 5 wt% of either these transamidized MXD6/N6 preblends or MXD6 were bag blended with several of the copolyesters from Table 1 as per Table 6. These pellet blends were then dried overnight at 60 °C - 70°C and then fed to a Killian 1.0 inch single screw extruder at 95 rpm at the temperatures indicated in Table 6 to form nominally 30 mil thick films from the immiscible blend. All films containing pure MXD6 had haze values greater than 10%. The films where the refractive index of nylon blend was matched to the refractive index of corresponding polyester within a range of 0.006 to -0.0006 were clear (haze ≦ 10%).

Table 5 - Homogeneous MXD6 - Nylon 6 Blends

Nylon	Composition	Refractive Index	Tg (°C)
W -	Transamidized MXD6/23wt% Nylon 6 preblend	1.5650	78
X -	Transamidized MXD6/30wt% Nylon 6 preblend	1.5617	75
Y -	Transamidized MXD6/41wt% Nylon 6 preblend	1.5528	70
Z -	Transamidized MXD6/50wt% Nylon 6 preblend	1.5472	66
MXD6	MXD6	1.5824	88

[0196] To produce oxygen-scavenging compositions, a concentrate containing cobalt neodecanoate was added to two of the films. This concentrate was prepared as follows. Separate feeds of polyester type C and cobalt neodecanoate, in the form of a pastille and supplied as Cobalt Ten-Cem™ 22.5% (available from OMG Corp.) were fed into a 57mm twin-screw extruder and melt blended at barrel set points of approximately 235°C. Molten polymer exited the extruder in the form of approximate 0.08" diameter strands which were water quenched and cut into approximate 0.125" length pellets. The ratio (by weight) of polyester to polyamide to concentrate was 93:5 to 5 to 1.5 and the concentration of cobalt metal in the concentrate was such that this ratio resulted in about 140 to 150 ppm cobalt in the final blended film. The samples which contained cobalt exhibited excellent oxygen scavenging capacity. These samples, which were mounted on the Ox-Tran permeation instrument 1 week after extrusion, had average apparent permeabilities under these conditions of less than 0.15 cc(STP)*mil/100 in^2/day/atm for over 6 months.

Table 6 - 30 mil Monolayer Film Results

Example	Polyester	Nylon	Melt Temp	% Haze	Total Trans. (%)	RI(nylon) - RI(polyester)	Oxygen Permeability*
C-41	B	3% MXD6	250°C	22.72	88.1	0.0180	
42	B	3% W	250°C	1.13	90.5	0.0006	
C-43	C		250°C	0.47	90.8	n/a	25.06
C-44	C	3% MXD6	250°C	35.90	87.8	0.0231	
C-45	C	5% MXD6	280°C	53.57	87.7	0.0231	13.62
C-46	C	5% MXD6 + Co	280°C	34.12	86.2	0.0231	0.20
47	C	3% X	250°C	1.00	90.7	0.0024	
48	C	5% X	280°C	0.98	90.6	0.0024	20.70
49	C	5% X +	280°C	1.10	90.4	0.0024	0.09

Example	Polyester	Nylon	Melt Temp	% Haze	Total Trans. (%)	RI(nylon) - RI(polyester)	Oxygen Permeability*
		Co					
C-50	E	3% MXD6	290°C	27.12	85.6	0.0277	
C-51	E	3% Y	290°C	2.99	90.8	-0.0019	
C-52	F	3% MXD6	250°C	64.06	87.9	0.0305	
C-53	F	3% Z	250°C	2.28	92.3	-0.0047	
C-54	G		280°C	0.74	90.9	n/a	
C-55	G	3% MXD6	280°C	82.57	81.0	0.0354	
56	G	3% Z	280°C	2.09	90.8	0.0002	

* apparent permeabilities (average of 2 films per composition and 3 permeability measures per film) fifteen days after mounting on the instrument measured at 23°C and about 60 to 80% relative humidity using air as the upstream test gas.

[0197] *Examples 59 and 62 and Comparative Examples 57-58 and 60-61 - Regrind of Multilayer Films*: Multilayer films were prepared by coextruding two 15 mil layers of polyester C around a 4 mil thick layer of either MXD6 or transamidized MXD6/30wt% N6 blend "X". This is referred to as an "ABA" structure where the "A" layers are the outer layers and the "B" layer is the interior layer. A Killian 1" extruder was used to extrude the outer layers from polyester C at a temperature of 265 °C. A 0.75" Killian extruder was used to extrude the inner layers at a temperature of 285°C for the MXD6, and 275°C for the transamidized MXD6/30wt% Nylon 6 blend "X" In order to simulate the reuse of these multilayer films as regrind in a monolayer structure, these multilayer films were then ground up and dry blended with additional polyester C pellets at a 50/50 ratio. This dry blend was then dried at 70°C and extruded on a Killian 1" extruder at a temperature of 240 °C into 20 mil films. Haze values are shown in Table 7. The coextruded films all have haze values less then 2%. However, when these films are reground and blended with neat polyester "C", the film containing the C/MXD6 regrind blend the values increase above 10%. The film containing the "C/X" regrind remains clear.

[0198] In a similar manner, multilayer films were prepared by co-extruding two 15 mil layers of polyester G around a 5 mil thick layer of either MXD6 or transamidized MXD6/50wt% N6 blend "Z". This is referred to as an "ABA" structure where the "A" layers are the outer layers and the "B" layer is the interior layer. A Killian 1" extruder was used to extrude the outer layers from polyester G at a temperature of 285 °C. A 0.75" Killian extruder was used to extrude the inner layers of either MXD6 or the transamidized MXD6/50wt% Nylon 6 blend "Z" at a temperature of 285°C. In order to simulate the reuse of these multilayer films as regrind in a monolayer structure, these multilayer films were then ground up and dry blended with additional polyester G pellets at a 50/50 ratio. This dry blend was then dried at 100 °C and extruded on a Killian 1" extruder at a temperature of 280 °C into 20 mil films. Haze values are shown in Table 7. The coextruded films all have haze values less then 2.5%. However, when these films are reground and blended with neat polyester "G", the film containing the G/MXD6 regrind blend the values increase above 10%. The film containing the "G/Z" regrind remains clear.

Table 7

		30 mil ABA Coextruded Films (4 mil B layer)		20 mil Monolayer films produced from a mixture of 50% "C" or "G" pellets with 50% ground coextruded film		
Example	Materials	Haze (%)	Total Transmittance (%)	Haze (%)	Total Transmittance (%)	RI(nylon) - RI(polyester)
C-57	C	0.12	91.5	0.09	91.5	n/a
C-58	C/MXD6/C	1.49	91.1	16.44	87.3	0.0231
59	C/X/C	0.62	91.2	0.37	91.5	0.0022
C-60	G	0.74	90.9	0.24	91.1	n/a

C-61	G/MXD6/G	2.15	91.1	87.34	82.5	0.0354
62	G/Z/G	0.74	90.9	1.88	90.6	0.0002

[0199] Example 64 *and Comparative Examples 63 - Adhesion of multilayer films*: ABA films were prepared by co-extruding two 15 mil layers of polyester C around a 4 mil thick layer of either MXD6 or transamidized MXD6/30wt% N6 blend "X". The Nylon 6 used in the transamidized blend in this example was Zytel 7301. A Killian 1" extruder was used to extrude the outer polyester C layers at a temperature of 265°C. A 0.75" Killian extruder was used to extrude the inner layers at the temperatures indicated in Table 8. The transamidized MXD6/30wt% N6 blend "X" shows superior adhesion over MXD6 to polyester C. Furthermore, improved adhesion of the transamidized MXD6/30wt% N6 blend to polyester C was obtained when the inner layer melt temperature was increased from 280°C to 285°C. MXD6 adhesion did not show any temperature dependency.

Table 8

Example	Materials	"B" layer melt temperature	Average Peel Strength g/mm
C-63	C/MXD6/C	270°C	1.74
		280°C	1.7
		285°C	1.88
64	C/X/C	270°C	4.33
		280°C	4.42
		285°C	7.14

CLAIMS

What is claimed:

1. A multilayered, shaped article, comprising:

(i) a first layer comprising at least one polyester which comprises:

(a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and

(b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second layer comprising a transamidized, homogeneous blend of at least two polyamides;

wherein said second layer (ii) and said first layer (i) have a difference in refractive index, RI(second layer) - RI(first layer), of about 0.006 to about -0.0006, and said shaped article has a percent transmittance of at least 75%, and a haze of 10% or less.

2. The shaped article of claim 1 which further comprises a regrind comprising a mixture of said first and second layers.

3. The shaped article of claim 2 wherein said first layer or said second layer comprises said regrind.

4. The shaped article of claim 2 wherein said regrind is about 5 weight percent to about 60 weight percent of said article, based on the total weight of said article.

5. The shaped article of claim 4 wherein said regrind is about 10 weight percent to about 40 weight percent of said article, based on the total weight of said article.

6. The shaped article of claim 5 wherein said regrind is about 20 weight percent to about 30 weight percent of said article, based on the total weight of said article.

7. The shaped article of claim 1 wherein said homogeneous blend of layer (ii) is formed by contacting said at least two polyamides at a temperature effective to cause transamidation.

8. The shaped article of claim 7 wherein said temperature is from about 290°C to about 340°C.

9. The shaped article of claim 1 which is formed by extrusion.

10. The shaped article of claim 7 wherein said contacting is in an extruder.

11. The shaped article of claim 1 which has from 2 to 7 layers.

12. The shaped article of claim 1 which is produced by extrusion, calendering, thermoforming, blow-molding, extrusion blow-molding, injection molding, compression molding, casting, drafting, tentering, or blowing.

13. The shaped article of claim 12 which is a sheet, film, tube, bottle, or preform.

14. The shaped article of claim 11 which has a layered structure represented by ABA, ABABA, ABCBA, or ACBCA wherein layer A comprises said first layer (i), layer B comprises said second layer (ii), and layer C comprises a regrind comprising a mixture of scrap first and second layers (i) and (ii), polyester or polycarbonate obtained from post consumer recycle, or a combination thereof.

15. The shaped article of claim 1 wherein said second layer (ii) and said first layer (i) have have a difference in refractive index, RI(second layer) – RI(first layer), of about 0.005 to about –0.0006.

16. The shaped article of claim 1 wherein said modifying aromatic dicarboxylic acid is selected from 4,4'-biphenyldicarboxylic acid,

isophthalic acid, 1,4- naphthalenedicarboxylic acid, 1,5- naphthalene-dicarboxylic acid, 2,6- naphthalenedicarboxylic acid, 2,7-naphthalenedicarboxylic acid, 4,4'-oxybenzoic acid, and trans-4,4'-stilbenedicarboxylic acid; and said modifying aliphatic dicarboxylic acid is selected from malonic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, and dodecanedioc acid.

17. The shaped article of claim 1 wherein said diol residues further comprise about 25 mole percent or less, based on the total diol residues, of the residues of at least one modifying diol selected from ethylene glycol, 1,2-propanediol, 1,3-propanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, p-xylene glycol, neopentyl glycol, polyethylene glycol, diethylene glycol, and polytetramethylene glycol.

18. The shaped article of claim 1 wherein said polyester further comprises about 0.01 to 1 mole percent, based on the total diacid or diol residues, of the residues of at least one branching agent selected from trimellitic acid, trimellitic anhydride, and pyromellitic dianhydride, glycerol, sorbitol, 1, 2, 6-hexanetriol, pentaerythritol, tartaric acid, citric acid, trimethylol-ethane, and trimesic acid.

19. The shaped article of claim 1 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

20. The shaped article of claim 19 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

21. The shaped article of claim 20 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

22. The shaped article of claim 1 wherein said diacid residues comprise about 100 mole percent terephthalic acid.

23. The shaped article of claim 22 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

24. The shaped article of claim 23 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

25. The shaped article of claim 24 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

26. The shaped article of claim 1 wherein said first component further comprises a homogeneous blend of said polyester and a polycarbonate comprising the residues of bisphenol A.

27. The shaped article of claim 26 wherein said polyester and said polycarbonate are branched.

28. A multilayered, shaped article, comprising:
    (i) a first layer comprising at least one polyester which comprises:
        (a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
        (b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol; and about 1 to about 99

mole percent of the residues of 1,4-cyclohexanedimethanol; and

(ii) a second layer comprising a copolyamide;

wherein said second layer (ii) and said first layer (i) have a difference in refractive index, RI(second layer) - RI(first layer), of about 0.006 to about -0.0006, and said shaped article has a percent transmittance of at least 75%, and a haze of 10% or less.

29. The shaped article of claim 28 wherein said copolyamide comprises the residues of m-xylylenediamine, p- xylylenediamine, or a combination thereof; and the residues of at least one monomer selected from terephthalic acid, isophthalic acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, undecanedioc acid, dodecanedioc acid, caprolactam, butyrolactam, 11-amino-undecanedioc acid, and 1,6-hexamethylenediamine.

30. The shaped article of claim 29 wherein said copolyamide comprises about 15 to about 100 mole percent of the residues of m-xylylenediamine, based on a total diamine residue content of 100 mole%; and about 15 to about 85 mole percent of the residues adipic acid and about 85 to about 15 mole percent of the residues of one or more aliphatic or cycloaliphatic dicarboxylic acids selected from pimelic acid, suberic acid, azelaic acid, sebacic acid, undecandioic acid, dodecandioic acid, and 1,4-cyclohexane-dicarboxylic acid, based on a total diacid residue content of 100 mole%.

31. The shaped article of claim 30 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

32. The shaped article of claim 31 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

33. The shaped article of claim 32 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

34. The shaped article of claim 30 wherein said diacid residues comprise about 100 mole percent terephthalic acid.

35. The shaped article of claim 34 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

36. The shaped article of claim 35 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-

cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

37. The shaped article of claim 36 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

38. The shaped article of claim 1 wherein said homogeneous blend of layer (ii) comprises a first polyamide, comprising aromatic residues, and a second polyamide comprising aliphatic residues.

39. The shaped article of claim 38 wherein said homogeneous blend of layer (ii) comprises a first polyamide comprising the residues of m-xylylenediamine and adipic acid, and said second polyamide comprises the residues of at least one aliphatic or cycloaliphatic monomer selected from adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, undecanedioc acid, dodecanedioc acid, caprolactam, butyrolactam, 11-aminoundecanedioc acid, and hexamethylene diamine.

40. The shaped article of claim 38 wherein said second polyamide comprises at least one polyamide selected from from nylon 4; nylon 6; nylon 9; nylon 11; nylon 12; nylon 6,6; nylon 5,10; nylon 6,12; nylon 6,11; nylon 10,12; and combinations thereof.

41. The shaped article of claim 40 wherein said second polyamide comprises nylon 6, nylon 6,6, or blends thereof.

42. The shaped article of claim 40 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

43. The shaped article of claim 42 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

44. The shaped article of claim 43 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

45. The shaped article of claim 40 wherein said diacid residues comprise about 100 mole percent terephthalic acid.

46. The shaped article of claim 45 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

47. The shaped article of claim 46 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

48. The shaped article of claim 47 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

49. The shaped article of claim 40 wherein said first component further comprises a homogeneous blend of said polyester and a polycarbonate comprising the residues of bisphenol A.

50. The shaped article of claim 49 wherein said polyester and said polycarbonate are branched.

51. The shaped article of claim 50 wherein said polyester further comprises about 0.01 to 1 mole percent, based on the total diacid or diol residues, of the residues of at least one branching agent selected from trimellitic acid, trimellitic anhydride, and pyromellitic dianhydride, glycerol, sorbitol, 1, 2, 6-hexanetriol, pentaerythritol, tartaric acid, citric acid, trimethylolethane, and trimesic acid.

52. The shaped article of claim 49 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

53. The shaped article of claim 52 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

54. The shaped article of claim 53 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

55. The shaped article of claim 49 wherein said diacid residues comprise about 100 mole percent terephthalic acid.

56. The shaped article of claim 55 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

57. The shaped article of claim 56 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-

cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

58. The shaped article of claim 57 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

59. The shaped article of claim 29 or 39 wherein said second layer (ii) further comprises at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements.

60. The shaped article of claim 59 wherein said metal is selected from copper, nickel, cobalt, iron, manganese, and combinations thereof.

61. The shaped article of claim 60 which contains from about 5 to about 600 parts per million by weight of said metal, based on the total weight of said shaped article.

62. The shaped article of claim 61 wherein said metal is cobalt.

63. The shaped article of claim 62 wherein said homogeneous blend of layer (ii) comprises 20 mmole/Kg or less of terminal amine groups.

64. The shaped article of claim 2 further comprising at least one additional layer comprising about 50 to about 100 weight percent of said regrind, based on the total weight of said at least one layer.

65. The shaped article of claim 64 wherein said at least one additional layer comprises about 5 to about 600 parts per million by weight of at least one metal selected from from copper, nickel, cobalt, iron, manganese, and combinations thereof.

66. The shaped article of claim 65 wherein said metal is cobalt.

67. A process for forming a multilayered shaped article, comprising:
   (i) heating a first component to a temperature of about Tg +100°C to about Tg + 300°C of said first component, said first component comprising at least one polyester which comprises:
      (a) diacid residues comprising about 70 to about 100 mole percent, based on the total diacid residues, of the residues of terephthalic acid; 0 to about 30 mole percent of the residues of at least one modifying aromatic dicarboxylic acid having up to 20 carbon atoms; and 0 to about 10 mole percent of the residues of at least one modifying aliphatic dicarboxylic acid having up to 16 carbon atoms; and
      (b) diol residues comprising about 1 to about 99 mole percent, based on the total diol residues, of the residues of 2,2,4,4-

tetramethyl-1,3-cyclobutanediol; and about 1 to about 99 mole percent of the residues of 1,4-cyclohexanedimethanol;

(ii) heating a second component comprising a copolyamide or a transamidized, homogeneous blend of at least two polyamides to a temperature of about Tg +100ºC to about Tg + 300ºC of of said second component;

(iii) forming a shaped article having said first and second components in separate layers;

(iv) recovering scrap first and second components;

(v) grinding said scrap first and second components to produce a regrind;

(vi) optionally, drying said regrind; and

(vii) combining said regrind with said first component, second component, or a combination thereof, of steps (i) and (ii);

wherein said second component of step (ii) and said first component of step (i) of have a difference in refractive index, RI(second component) – RI(first component), of about 0.006 to about -0.0006, and said shaped article has a percent transmittance of at least 75%, and a haze of 10% or less.

68. The process of claim 67 wherein said regrind comprises a mixture of said first and second components of steps (i) and (ii).

69. The process of claim 68 wherein said regrind is combined with said first component of step (i).

70. The process of claim 68 wherein said regrind is about 5 weight percent to about 60 weight percent of said shaped article, based on the total weight of said shaped article.

71. The process of claim 70 wherein said regrind is about 10 weight percent to about 40 weight percent of said shaped article.

72. The process of claim 71 wherein said regrind is about 20 weight percent to about 30 weight percent of said shaped article

73. The process of claim 67 wherein said homogeneous blend of component (ii) is formed by contacting said at least two polyamides at a temperature effective to cause transamidation.

74. The process of claim 73 wherein said temperature is from about 290°C to about 340°C.

75. The process of claim 67 wherein said forming is by extrusion, calendering, thermoforming, blow-molding, extrusion blow-molding, injection molding, compression molding, casting, drafting, tentering, or blowing.

76. The process of claim 75 which is a sheet, film, tube, bottle, or preform.

77. The process of claim 75 wherein said forming is in an extruder.

78. The process of claim 75 wherein said shaped article has 2 to 7 layers.

79. The process of claim 78 wherein said shaped article has a layered structure represented by ABA, ABABA, or ABCBA wherein layer A comprises said first component (i), layer B comprises said second component (ii), and layer C comprises a regrind comprising a mixture of scrap first and second components (i) and (ii), polyester or polycarbonate obtained from post consumer recycle, or a combination thereof.

80. The process of claim 67 wherein said second component of step (ii) and said first component of step (i) have have a difference in refractive index, RI(second component) - RI(first component), of about 0.005 to about -0.0006.

81. The process of claim 67 wherein said modifying aromatic dicarboxylic acid is selected from 4,4'-biphenyldicarboxylic acid, isophthalic acid, 1,4-naphthalenedicarboxylic acid, 1,5- naphthalenedicarboxylic acid, 2,6-naphthalenedicarboxylic acid, 2,7-naphthalenedicarboxylic acid, 4,4'-oxybenzoic acid, and trans-4,4'-stilbenedicarboxylic acid; and said modifying aliphatic dicarboxylic acid is selected from malonic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, and dodecanedioc acid.

82. The process of claim 67 wherein said diol residues further comprise about 25 mole percent or less, based on the total diol residues, of the residues of at least one modifying diol selected from ethylene glycol, 1,2-propanediol, 1,3-propanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, p-xylene glycol, neopentyl glycol, polyethylene glycol, diethylene glycol, and polytetramethylene glycol.

83. The process of claim 67 wherein said polyester further comprises about 0.01 to 1 mole percent, based on the total diacid or diol residues, of the residues of at least one branching agent selected from trimellitic acid, trimellitic anhydride, and pyromellitic dianhydride, glycerol, sorbitol, 1, 2, 6-hexanetriol, pentaerythritol, tartaric acid, citric acid, trimethylolethane, and trimesic acid.

84. The process of claim 67 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

85. The process of claim 84 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

86. The process of claim 85 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

87. The process of claim 67 wherein said diacid residues comprise about 100 mole percent terephthalic acid.

88. The process of claim 87 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

89. The process of claim 88 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

90. The process of claim 89 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

91. The process of claim 67 wherein said first component further comprises a homogeneous blend of said polyester and a polycarbonate comprising the residues of bisphenol A.

92. The process of claim 91 wherein said polyester and said polycarbonate are branched.

93. The process of claim 67 wherein said second component of step (ii) comprises a copolyamide comprising the residues of m-xylylenediamine, p- xylylenediamine, or a combination thereof; and the residues of at least one monomer selected from terephthalic acid, isophthalic acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, undecanedioc acid, dodecanedioc acid, caprolactam, butyrolactam, 11-amino-undecanedioc acid, and 1,6-hexamethylenediamine.

94. The process of claim 93 wherein said copolyamide comprises the residues of m-xylylenediamine, p-xylylenediamine, or a combination thereof; and the residues of at least one monomer selected from terephthalic acid, isophthalic acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, undecanedioc acid, dodecanedioc acid, caprolactam, butyrolactam, 11-amino-undecanedioc acid, and 1,6-hexamethylene-diamine.

95. The process of claim 94 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclo-

butanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

96. The process of claim 95 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

97. The process of claim 96 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

98. The process of claim 94 wherein said diacid residues comprise about 100 mole percent terephthalic acid.

99. The process of claim 98 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

100. The process of claim 99 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

101. The process of claim 100 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

102. The process of claim 67 wherein said second component of step (ii) comprises a homogeneous blend comprising a first polyamide, comprising aromatic residues, and a second polyamide comprising aliphatic residues.

103. The process of claim 102 wherein said homogeneous blend comprises a first polyamide comprising the residues of m-xylylenediamine and adipic acid, and said second polyamide comprises the residues of at least one aliphatic or cycloaliphatic monomer selected from adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, undecanedioc acid, dodecanedioc acid, caprolactam, butyrolactam, 11-aminoundecanedioc acid, and hexamethylene diamine.

104. The process of claim 103 wherein said second polyamide comprises at least one polyamide selected from from nylon 4; nylon 6; nylon 9; nylon 11; nylon 12; nylon 6,6; nylon 5,10; nylon 6,12; nylon 6,11; nylon 10,12; and combinations thereof.

105. The process of claim 104 wherein said second polyamide comprises nylon 6, nylon 6,6, or blends thereof.

106. The process of claim 104 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

107. The process of claim 106 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

108. The process of claim 107 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

109. The process of claim 104 wherein said diacid residues comprise about 100 mole percent terephthalic acid.

110. The process of claim 109 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

111. The process of claim 110 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

112. The process of claim 111 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

113. The process of claim 104 wherein said first component further comprises a homogeneous blend of said polyester and a polycarbonate comprising the residues of bisphenol A.

114. The process of claim 113 wherein said polyester and said polycarbonate are branched.

115. The process of claim 114 wherein said polyester further comprises about 0.01 to 1 mole percent, based on the total diacid or diol residues, of the residues of at least one branching agent selected from trimellitic acid, trimellitic anhydride, and pyromellitic dianhydride, glycerol, sorbitol, 1, 2, 6-hexanetriol, pentaerythritol, tartaric acid, citric acid, trimethylolethane, and trimesic acid.

116. The process of claim 113 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

117. The process of claim 116 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

118. The process of claim 117 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

119. The process of claim 113 wherein said diacid residues comprise about 100 mole percent terephthalic acid.

120. The process of claim 119 wherein said diol residues comprise about 5 to about 60 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 40 to about 95 mole percent of the residues of 1,4-cyclohexanedimethanol.

121. The process of claim 120 wherein said diol residues comprise about 15 to about 40 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclo-

butanediol and about 60 to about 85 mole percent of the residues of 1,4-cyclohexanedimethanol.

122. The process of claim 121 wherein said diol residues comprise about 20 to about 30 mole percent of the residues of 2,2,4,4-tetramethyl-1,3-cyclobutanediol and about 70 to about 80 mole percent of the residues of 1,4-cyclohexanedimethanol.

123. The process of claim 103 wherein said second component further comprises at least one metal selected from Groups 3-12, Rows 4-6 of the Periodic Table of the Elements.

124. The process of claim 123 wherein said metal is selected from copper, nickel, cobalt, iron, manganese, and combinations thereof.

125. The process of claim 124 which contains from about 5 to about 600 parts per million by weight of said metal, based on the total weight of said shaped article.

126. The process of claim 125 wherein said metal is cobalt.

127. The process of claim 125 wherein said homogeneous blend comprises 20 mmole/Kg or less of terminal amine groups.

128. The process of claim 67 wherein step (iii) further comprises forming at least one additional layer comprising about 50 to about 100 weight percent of said regrind, based on the total weight of said layer.

129. The process of claim 128 wherein said at least one additional layer comprises about 10 to about 500 parts per million by weight of at least one metal selected from from copper, nickel, cobalt, iron, manganese, and combinations thereof, based on the total weight of said shaped article.

130. The process of claim 129 wherein said metal is cobalt.

131. The shaped article of any one of claims 1, 20, or 48 wherein said polyester has an inherent viscosity of 0.5 to 0.75 dL/g.

132. The shaped article of claim 131 wherein said inherent viscosity is 0.6 to 0.72 dL/g.

133. The process of any one of claims 67, 85, or 90 wherein said polyester has an inherent viscosity of 0.5 to 0.75 dL/g.

134. The process of claim 133 wherein said inherent viscosity is 0.6 to 0.72 dL/g.

135. The shaped article of any one of claims 1, 20, or 48 wherein said polyester has a glass transition temperature of about 110°C to about 150°C.

136. The shaped article of claim 135 wherein said glass transition temperature is about 120°C to about 135°C.

137. The process of any one of claims 67, 85, or 90 wherein said polyester has a glass transition temperature of about 110°C to about 150°C.

138. The process of claim 137 wherein said glass transition temperature is about 120°C to about 135°C.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2006/012660

A. CLASSIFICATION OF SUBJECT MATTER
INV. B29B17/00 B32B27/08 B32B27/34 B32B27/36 C08L77/02
C08L77/06 C08L67/02

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 B29B B65D C08L

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 practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6 699 549 B1 (UEYAMA TAKAHISA ET AL) 2 March 2004 (2004-03-02)	1-66, 131,132, 135,136
A	column 3, line 30 - column 465; claims 1-27	67-130, 133,134, 137,138
Y	US 5 989 663 A (MORRIS ET AL) 23 November 1999 (1999-11-23) column 4, line 18 - column 5, line 67; claims 1-22	1-66, 131,132, 135,136
Y	WO 03/066329 A (EASTMAN CHEMICAL COMPANY) 14 August 2003 (2003-08-14) page 5, line 10 - page 6, line 23; claims 1,9	1-66, 131,132, 135,136

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 July 2006	31/07/2006

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	EP 1 475 308 A (MITSUBISHI GAS CHEMICAL COMPANY, INC) 10 November 2004 (2004-11-10) page 3, paragraph 12-20; claims 1-26; examples 1-7	1-66, 131,132, 135,136 67-130, 133,134, 137,138
A	EP 1 262 524 A (MITSUBISHI GAS CHEMICAL COMPANY, INC) 4 December 2002 (2002-12-04) page 2, paragraph 1 page 7, paragraph 43 - page 8, paragraph 57 page 9, paragraph 62-64; claims 1-18; tables 1-11	1-138

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2006/012660

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 6699549	B1	02-03-2004	AT	299435	T	15-07-2005
			AU	749877	B2	04-07-2002
			AU	3534999	A	16-11-1999
			BR	9909881	A	26-12-2000
			CN	1300250	A	20-06-2001
			DE	69926125	D1	18-08-2005
			DE	69926125	T2	11-05-2006
			DK	1084035	T3	24-10-2005
			EP	1084035	A1	21-03-2001
			ES	2245507	T3	01-01-2006
			WO	9955528	A1	04-11-1999
			JP	11300914	A	02-11-1999
US 5989663	A	23-11-1999	US	6096854	A	01-08-2000
WO 03066329	A	14-08-2003	AU	2003216159	A1	02-09-2003
			EP	1472086	A1	03-11-2004
			JP	2005516800	T	09-06-2005
EP 1475308	A	10-11-2004	AU	2004201837	A1	25-11-2004
			CA	2466451	A1	06-11-2004
			CN	1550326	A	01-12-2004
			US	2004224112	A1	11-11-2004
EP 1262524	A	04-12-2002	AU	784042	B2	19-01-2006
			AU	4064002	A	05-12-2002
			CN	1396208	A	12-02-2003
			DE	60205677	D1	29-09-2005
			DE	60205677	T2	09-03-2006
			US	2003068455	A1	10-04-2003