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POLYESTERS HAVING INCREASED WHITENESS

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ABSTRACT OF THE DISCLOSURE

Linear synthetic polyesters having increased whiteness, the improvement in whiteness being obtained by incorporation into the polyesters of a minor amount of a difunctional compound selected from the group consisting of 1,3-bis(2-hydroxyethoxy)benzene, 3-(2 - hydroxyethoxy) phenol, lower alkyl esters of adipic acid, lower alkyl esters of suberic acid, lower alkyl esters of azelaic acid, and lower alkyl esters of sebacic acid, with 1,3-bis(2-hydroxyethoxy)benzene, bis(2-hydroxyethyl) azelate, and dimethyl azelate being preferred. The polyesters may be prepared via either direct esterification or ester interchange. When ester interchange is employed the ester interchange catalyst is selected from the group consisting of salts of transition metals in groups II–B, VII–B, and VIII of periods 4 and 5 of the periodic table of the elements, with salts of manganese and cobalt being preferred. Whiteness improvements are in the range from 6 to 41 percent relative to the unmodified polyesters.

BACKGROUND OF THE INVENTION

This invention relates to film- and fiber-forming linear synthetic polyesters. More particularly, this invention is directed to film- and fiber-forming linear synthetic polyesters having increased whiteness.

The utility and commercial acceptance of linear synthetic polyesters, particularly poly(ethylene terephthalate), are well known. There have been, however, numerous attempts to provide modified polyesters, and modified poly (ethylene terephthalate) in particular, with improved properties to further enhance the commercial acceptance of said linear synthetic polyesters. Representative of said improved properties are improved thermal stability, substantial elimination of diglycol, improved receptivity to dyestuffs of various types and improved whiteness.

Polymer whiteness is especially important when said linear synthetic polyesters are converted into filaments and fibers for fabric and apparel end uses. For these end uses, white filaments and fibers are highly desirable for both aesthetic and practical considerations. Whether as fabrics or apparel, increased yarn whiteness results in white goods having greater consumer appeal. This factor is sufficiently important to warrant a separate bleaching step for fabrics made from yarns which are off-white. Even if the yarn, as fabric, is to be dyed, a high degree of whiteness is desirable since off-white yarns result in dyed goods which are off-color. Thus, white yarns greatly simplify quality control and color matching of dyed goods and the aforementioned bleaching step is therefore required for yarns which are off-white in color. Furthermore, off-white fibers give a reeded out or underconstructed appearance to polyester or polyester/cotton fabrics.

By polymer (or fabric) whiteness is meant the degree of whiteness of said polymer (or fabric) when compared with a ceramic tile standard. In practice, this comparison is accomplished by means of an instrument (such as a Hunterlab Model D–40 Reflectometer for Whiteness) which measures the reflectance of the sample and standard. From the data obtained, a quantitative expression is secured which characterizes the degree of whiteness of the sample.

A more detailed description of the procedure may be found elsewhere in this specification. It is preferred that the products of this invention have a whiteness rating of at least 70 as measured on a Hunterlab Model D–40 Reflectometer for Whiteness as described elsewhere in this specification.

In the past various methods have been recommended to improve the whiteness of linear synthetic polyesters, Prominent among these methods is the incorporation of additives, including monomers capable of copolymerization, into said polyesters. Frequently, however, if whiteness were improved, another property such as lightfastness was detrimentally affected.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide modified polyester compositions which, when converted into fibers and fabrics, exhibit increased whiteness without losing the desirable properties of the unmodified polyesters.

Another object of the invention is to provide a process for the preparation of the modified polyester compositions exhibiting increased whiteness.

These and other objects and advantages of the present invention are described more fully in the specification and claims which follow.

It has now been found, quite unexpectedly, that incorporation into linear synthetic polyesters of a minor amount of a difunctional compound selected from the group consisting of 1,3-bis(2-hydroxyethoxy)benzene, 3-(2-hydroxyethoxy)phenol, lower alkyl esters of adipic acid, lower alkyl esters of suberic acid, lower alkyl esters of azelaic acid and lower alkyl esters of sebacic acid results in an increase in polymer whiteness in the range from 6 to 41 percent, relative to the unmodified polyesters. By the term "lower alkyl" is meant aliphatic radicals of from about 1 to about 6 carbon atoms. Preferably, the compound is selected from the group consisting of 1,3-bis(2-hydroxyethoxy)benzene, bis(2-hydroxyethyl) azelate and dimethyl azelate. By incorporation of a minor amount of the compounds of the present invention is meant less than about 5 weight percent, based upon the weight of dicarboxylic acid or its dialkyl ester; the preferred level of incorporation is 3 weight percent. In general, the compounds of the present invention are added prior to substantial polycondensation. The polyesters may be prepared by either direct esterification or ester interchange. When ester interchange is employed, the ester interchange catalyst is selected from the group consisting of salts of transition metals in groups II–B, VII–B, and VIII of periods 4 and 5 of the periodic table of the elements, with salts of manganese and cobalt being preferred.

DETAILED DESCRIPTION OF THE INVENTION

The term "linear synthetic polyester" as used herein, includes as a preferred class, polyesters based upon terephthalic acid or its dialkyl ester and as a more preferred class, polyesters prepared from terephthalic acid or its dialkyl ester and a polymethylene glycol having the formula:

$$HO(CH_2)_nOH$$

wherein n is an integer from 2 to about 8. In this more preferred class, the most preferred polyester, poly(ethylene terephthalate), is obtained when n is 2. While both direct esterification of a dicarboxylic acid with a diol followed by polycondensation, and ester interchange of a dicarboxylic acid dialkyl ester with a diol followed by polycondensation are within the scope of this invention, the latter process for the preparation of linear synthetic polyesters is preferred.

In the preferred process, ester interchange of a dicarboxylic acid dialkyl ester with a diol followed by poly-

condensation, an ester interchange catalyst usually is required in order to permit completion of the ester interchange step within a practical length of time. Unexpectedly, it has been found that the ester interchange catalyst employed may render the compounds of the present invention ineffective in increasing the whiteness of linear synthetic polyesters. Accordingly, the ester interchange catalyst is selected from the group consisting of salts of transition metals in groups II–B, VII–B, and VIII of periods 4 and 5 of the periodic table of the elements (Robert C. Weast, Editor, "Handbook of Chemistry and Physics," 49th Edition, The Chemical Rubber Co., Cleveland, Ohio, 1968, p. B–3), such as manganese acetate, ferric acetate, ferric stearate, ferrous carbonate, cobalt acetate, cobalt formate, lead acetate, lead oxide, zinc thioantimonate, zinc acetate, zinc cyanide, cadmium acetate, and cadmium cyanide. Preferably, the ester interchange catalyst is selected from the group consisting of salts of manganese and cobalt, and particularly manganese and cobalt salts of aliphatic monocarboxylic acids having up to about 6 carbon atoms.

In addition to the reaction components, the compounds of the present invention as heretofore described, and an ester interchange catalyst, various other materials may be present. For example, such polymerization catalysts as antimony trioxide, antimonic acid, germanium dioxide, stannous oxalate, organo-titanium compounds, and the like usually will be present. Preferably, the polymerization catalyst will be selected from the group consisting of antimony trioxide and antimonic acid. Furthermore, color inhibitors, such as alkyl or aryl phosphate esters, alkyl or aryl phosphite esters, and the like may be used. In addition, pigments, delustrants such as titanium dioxide, and other additives may be present. It is preferred that the linear synthetic polyesters of the present invention be delustered in order to realize the greatest benefit from the present invention.

The fibers or filaments in continuous or stable form produced in accordance with the present invention are suitable for the usual textile applications. They may be employed in the knitting or weaving of all types of products as well as in the production of non-woven, felt-like products produced by known methods. The physical properties of the modified fibers or filaments closely parallel those of their related non-modified polyester yarns. The modified yarns differ, however, in that they have increased whiteness.

Without intending to limit it in any manner, the following examples will serve to illustrate the invention.

Example 1

Preparation of pre-polymer.—A five-gallon jacketed autoclave, heated by means of a Dowtherm vapor system (heat transfer medium manufactured by Dow Chemical Co., Midland, Mich.) and fitted with an agitator and condenser, is charged with 30.0 pounds of dimethyl terephthalate, 21.6 pounds of ethylene glycol and 5.44 grams of cobalt acetate. The mixture is heated to reflux at atmospheric pressure. The temperature of the mixture is about 187° C. when methanol begins to distill. Methanol distillation is complete after about 2.5 hours; batch temperature has increased to about 220° C. The mixture is extruded, cooled, ground, and packaged and referred to hereinafter as cobalt prepolymer.

Preparation of polymer.—A two-liter, stainless steel, electrically-heated autoclave, fitted with agitator, condenser, thermocouple, and means for operating under reduced pressure, is charged with 750 grams of cobalt pre-polymer, 2.0 grams of titanium dioxide, 0.54 gram of a 50% solution of trimethyl phosphite in ethylene glycol, 0.23 gram of antimonic acid, and 17.1 grams of bis(2-hydroxyethyl) azelate. The autoclave is purged with nitrogen and heated to about 230° C. before beginning vacuum let-down. At the completion of vacuum let-down, which requires about 75 minutes, the batch is polymerized at 280° C. and 0.7 millimeter Hg pressure for 70 minutes. The batch is extruded into water. The resultant polymer is found to have an intrinsic viscosity of 0.562 deciliter per gram and a melting point of 255° C. as determined by differential thermal analysis.

As used herein, intrinsic viscosity is a measure of the degree of polymerization of the polyester and may be defined as:

$$\text{Limit}\ \frac{(\eta-\eta_0)}{\eta_0 C}\ \text{as C approaches zero}$$

where η is the viscosity of a dilute solution of the polyester in o-chlorophenol, η_0 is the viscosity of the pure solvent measured in the same units and at the same temperature as η, and C is the concentration in grams of polyester per 100 milliliters of solvent. Thus, intrinsic viscosity has the units, deciliters per gram.

The melting points of the polymers of this example and the examples which follow are readily determined by differential thermal analysis (DTA), a well known and widely recognized technique. The apparatus used is a du Pont Model 900 Differential Thermal Analyzer. The melting points are determined using a glass macro sampling tube with a ceramic sleeve under a nitrogen flow of one liter per minute and with a heat-up rate of 20° C. per minute; the reference is glass beads.

The polymer is converted into 70 denier filament yarn having 36 filaments and knitted into a hoseleg. The fabric is found to have a Hunter D–40 Whiteness Rating of 51.2.

The Hunter D–40 Whiteness Rating, as used herein, is the whiteness rating as determined with a Hunterlab Model D–40 Reflectometer for Whiteness (manufactured by Hunter Associates Laboratory, Inc., Fairfax, Va.), a reflectometer specifically designed for whiteness measurements. The illuminator is International Commission on Illumination (C.I.E.) Source C, and a rotating ultraviolet filter is located between the illuminator and the specimen. The ultraviolet wavelengths can either be filtered out or allowed to pass on to the specimen. The instrument is calibrated with ceramic tile standards. Readings of reflectances are taken by nulling a galvanometer with a calibrated potentiometer which is so scaled that percent reflectances are read directly from the instrument. The quantities measured are: (1) green reflectance excluding incident ultraviolet light, denoted as G(E); (2) blue reflectance excluding incident ultraviolet light, denoted as B(E); and (3) blue reflectance including incident ultraviolet light, denoted as B(I). The quantities calculated are: (1) percent blue reflectance due to fluorescent materials, such as optical brighteners, in or on the specimen, calculated according to Equation 1; and the whiteness of

$$\text{percent } BR = B(I) - B(E) \quad (1)$$

$$W = 4B(I) - 3G(E) \quad (2)$$

the specimen, calculated according to Equation 2. A more detailed discussion of the theory and function of the instrument, including the rationale behind the preferred use of Equation 2, may be found in the article, New Reflectometer and Its Use for Whiteness Measurement, by Richard S. Hunter, in the Journal of Optical Society of America, volume 50, number 1 (January 1960), pp. 44–48.

As a control, the polymerization of Example 1 is repeated, using cobalt pre-polymer, except that the bis(2-hydroxyethyl) azelate is omitted. The resultant polymer has an intrinsic viscosity of 0.640 deciliter per gram and a DTA melting point of 261° C. The polymer is converted into 70-denier filament yarn having 36 filaments and knitted into a hoseleg. The fabric is found to have a Hunter Whiteness Rating of 44.6.

Since the whiteness rating of any given sample is meaningful only upon comparison with a control, it is helpful to also express the whiteness of any given sample in

terms of percent improvement over the control. This is simply done by using Equation 3:

$$\text{Percent Improvement} = \frac{\text{Sample Whiteness Rating} - \text{Control Whiteness}}{\text{Control Whiteness Rating}} \times 100 \quad (3)$$

Accordingly, the polymer of Example 1, when converted into fabric, is 15% whiter than polymer made under identical conditions but lacking the bis(2-hydroxyethyl) azelate. This is a significant improvement.

Example 2

Using cobalt per-polymer, the polymerization of Example 1 is repeated, except that the bis(2-hydroxyethyl) azelate is replaced with an equal amount of 3-(2-hydroxyethoxy)phenol. Results similar to those of Example 1 are obtained upon comparing yarn prepared from the resultant polymer with the control of Example 1.

Example 3

Using cobalt pre-polymer, the polymerization of Example 1 is repeated, except that the bis(2-hydroxyethyl) azelate is replaced with an equal amount of dimethyl adipate. Results similar to those of Example 1 are obtained upon comparing yarn prepared from the resultant polymer with the control of Example 1.

Example 4

Using cobalt pre-polymer, the polymerization of Example 1 is repeated, except that the bis(2-hydroxyethyl) azelate is replaced with an equal amount of dimethyl sebacate. Results similar to those of Example 1 are obtained upon comparing yarn prepared from the resultant polymer with the control of Example 1.

Example 5

A two-liter, stainless-steel, electrically heated autoclave, fitted with agitator, thermocouple, condenser with proportional take-off head, and means for operating under reduced pressure, is charged with 600 grams of dimethyl terephthalate, 432 grams of ethylene glycol, and 0.21 gram of cobalt acetate. The autoclave is purged with nitrogen and heat applied. Methanol distillation begins when the batch temperature is 175° C. Methanol distillation is continued, initially at 50% take-off and finally at 20% take-off, for a period of about five hours at the end of which time the batch temperature is about 220° C. To insure the complete distillation of methanol, distillate take-off is increased to 90% and ethylene glycol distilled for about 20 minutes; the batch temperature is now 230° C. The condenser assembly is removed from the autoclave which is charged with 2.1 grams of titanium dioxide, 0.24 gram of antimonic acid, 0.30 gram of a 50% solution of trimethyl phosphite in ethylene glycol, and 18.0 grams of 1,3-bis(2-hydroxyethoxy)benzene. The autoclave is fitted with a concentrator (concentrating condenser) with vacuum adapter and the autoclave purged with nitrogen. Vacuum let-down is initiated and requires about 45 minutes for completion. The batch is polymerized at 280° C. and 0.6 millimeter Hg for 2 hours. The resulting polymer is extruded into water and has an intrinsic viscosity of 0.593 deciliter per gram and a DTA melting point of 252° C.

The polymer is converted into 70/36 filament yarn and knitted into a hoseleg. The fabric is found to have a Hunter Whiteness Rating of 72.1.

To prepare a control, the procedure of Example 3 is repeated, except that the 1,3-bis(2-hydroxyethoxy)benzene is omitted. The resultant polymer has an intrinsic viscosity of 0.564 and a DTA melting point of 258° C. The polymer is converted into 70/36 filament yarn which is knitted into a hoseleg. The fabric is found to have a Hunter Whiteness Rating of 67.5. Thus, the polymer of Example 3 is 7% whiter than the control polymer which lacks 1,3-bis(2-hydroxyethoxy) benzene.

Example 6

The procedure of Example 5 is repeated, except that the 1,3-bis(2-hydroxyethoxy)benzene is replaced with an equal amount of bis(2-hydroxyethyl) azelate. The resultant polymer is found to have an intrinsic viscosity of 0.581 deciliters per gram and a DTA melting point of 256° C.

The polymer is converted into 70/36 filament yarn and knitted into a hoseleg which is found to have a Hunter Whiteness Rating of 71.4. Thus, the polymer of this example shows an improvement in whiteness of 6% when compared with polymer lacking the bis(2-hydroxyethyl) azelate: the control of Example 5 which has a Hunter Whiteness Rating of 67.5.

Example 7

The procedure of Example 5 is repeated, except that the 1,3-bis(2-hydroxyethoxy)benzene is replaced with an equal amount of dimethyl azelate. The resultant polymer has an intrinsic viscosity of 0.529 deciliter per gram and a DTA melting point of 254° C.

The polymer is converted into 70/36 filament yarn and knitted into a hoseleg having a Hunter Whiteness Rating of 84.0, an improvement of 24% over the control of Example 5 which lacks the dimethyl azelate and has a Hunter Whiteness Rating of 67.5.

Example 8

The procedure of Example 5 is repeated, except that the cobalt acetate ester interchange catalyst is replaced with an equal amount of manganese acetate. The resultant polymer has an intrinsic viscosity of 0.574 and a DTA melting point of 244° C.

The polymer is converted into 70/36 filament yarn and knitted into a hoseleg. The fabric is found to have a Hunter Whiteness Rating of 56.9.

As a control, the procedure of Example 6 is repeated except that the 1,3-bis(2-hydroxyethoxy)benzene is omitted. The resultant polymer has an intrinsic viscosity of 0.564 deciliter per gram and a DTA melting point of 257° C. The polymer is converted into 70/36 filament yarn which is knitted into a hoseleg having a Hunter Whiteness Rating of 47.6. Thus, the incorporation of 1,3-bis(2-hydroxyethoxy)benzene into polyester results in an improvement in whiteness of 20%.

Example 9

The procedure of Example 6 is repeated except that the cobalt acetate ester interchange catalyst is replaced with an equal amount of manganese acetate. The resultant polymer has an intrinsic viscosity of 0.644 and a DTA melting point of 252° C.

The polymer is converted into 70/36 filament yarn and knitted into a hoseleg having a Hunter Whiteness Rating of 67.1, an improvement of 41% over the control of Example 8 which lacks the bis(2-hydroxyethyl) azelate and has a Hunter Whiteness Rating of 47.6.

Example 10

The procedure of Example 7 is repeated except that the cobalt acetate ester interchange catalyst is replaced with an equal amount of manganese acetate. The resultant polymer has an intrinsic viscosity of 0.565 deciliter per gram and a DTA melting point of 256° C.

The polymer is converted into 70/36 filament yarn and knitted into a hoseleg. The fabric is found to have a Hunter Whiteness Rating of 65.0, an improvement of 37% over the control of Example 8 which lacks the dimethyl azelate and has a Hunter Whiteness Rating of 47.6.

As already indicated, some ester interchange catalysts have a deleterious effect upon the usefulness of the compounds of the present invention in increasing the whiteness of linear synthetic polyesters. This effect is illustrated by Examples 11, 12, and 13.

Example 11

The procedure of Example 5 is repeated, except that the cobalt acetate ester interchange catalyst is replaced with an equal amount of magnesium carbonate. The resultant polymer has an intrinsic viscosity of 0.554 deciliter per gram and a DTA melting point of 248° C.

The polymer is converted into 70/36 filament yarn and knitted into a hoseleg having a Hunter Whiteness Rating of 54.8.

To prepare a control, the procedure of Example 11 is repeated except that the 1,3-bis(2-hydroxyethoxy)benzene is omitted. The resultant polymer has an intrinsic viscosity of 0.518 deciliter per gram and a DTA melting point of 261° C. The polymer is converted into 70/36 filament yarn which is knitted into a hoseleg; the fabric is found to have a Hunter Whiteness Rating of 65.0. Thus, the magnesium-catalyzed polymer containing 1,3-bis(2-hydroxyethoxy)benzene is 16% less white than the control polymer lacking 1,3-bis(2-hydroxyethoxy)benzene.

Example 12

The procedure of Example 6 is repeated, except that the cobalt acetate ester interchange catalyst is replaced with an equal amount of magnesium carbonate. The resultant polymer has an intrinsic viscosity of 0.635 deciliter per gram and a DTA melting point of 255° C.

The polymer is converted into 70/36 filament yarn and knitted into a hoseleg. The fabric is found to have a Hunter Whiteness Rating of 55.0, a decrease in whiteness of 15% when compared with the control of Example 11, which lacks the bis(2-hydroxyethyl) azelate and has a Hunter Whiteness Rating of 65.0.

Example 13

The procedure of Example 7 is repeated, except that the cobalt acetate ester interchange catalyst is replaced with an equal amount of magnesium carbonate. The resultant polymer has an intrinsic viscosity of 0.606 and a DTA melting point of 257° C.

The polymer is converted into 70/36 filament yarn and knitted into a hoseleg. The fabric is found to have a Hunter Whiteness Rating of 44.0, a decrease in whiteness of 33% when compared with the control of Example 11 which lacks the dimethyl azelate and has a Hunter Whiteness Rating of 65.0.

The ultimate utility of any process for improving polymer whiteness (and hence the whiteness of products made from such improved polymer) depends upon the permanence of the improvement in whiteness obtained. That the effects obtained by the use of the compounds of this invention are permanent is illustrated by Example 14.

Example 14

The hoseleg samples of Examples 8–13, inclusive, are bleached and heat-set and Hunter Whiteness Ratings obtained for the treated fabrics. The results are summarized in Table I.

TABLE I

Hoseleg sample	Additive	E.I. cat.	Rating	Percent improvement
Control of Example 8	None	Manganese acetate	75.2	
Example:				
8	1,3-bis (2-hydroxy ethoxy)benzene	do	83.1	11
9	Bis(2-hydroxyethyl)azelate	do	109.1	45
10	Dimethyl azelate	do	91.2	21
Control of Example 11	None	Magnesium carbonate	105.4	
Example:				
11	1,3-bis(2-hydroxyethoxy)benzene	do	91.5	−13
12	Bis(2-hydroxyethyl) axelate	do	94.0	−11
13	Dimethyl azelate	do	49.4	−53

An inspection of the data in Table I shows that the bleaching and heat-setting steps in general did not change the relative whitenesses of the samples, although the bleaching step increased the whiteness of each sample relative to untreated fabric.

Since the products of the present invention are suitable for fabric and apparel end uses wherein dyed or colored articles are desired, the properties of the dyed articles made from the products of the present invention are important. The most significant property of a dyed article is its fastness to light. The lightfastness of a textile article usually is determined by means of the Fade-Ometer (manufactured by Atlas Electric Devices Company, Chicago, Ill.), a self-contained, electrically-operated device for the accelerated testing of the stability of dyed articles to daylight. Basically, the device simply exposes the sample to light produced by a carbon arc for any given length of time. The exposed sample then is rated visually on a scale from 1 to 5, wherein 1 indicates complete loss of color and 5 indicates no change in color. It should be mentioned that the data obtained using a particular apparatus may not be compared with data obtained using a second, similar apparatus since the intensity of the light source varies from apparatus to apparatus. In general, a rating of 3 or above after 20 hours indicates satisfactory lightfastness for the usual textile end uses, carpet end uses excluded. That the products of the present invention have satisfactory lightfastness properties when dyed is shown by Example 15.

Example 15

The hoselegs of Examples 5–13, inclusive, separately are dyed with Eastman Blue GBLF, a disperse dye, according to the following procedure: The dyebath consists of an aqueous solution of 1% Eastman Blue GBLF containing 2 grams per liter of monosodium phosphate, 3 grams per liter of Carrolid ELFC, a carrier of the biphenyl type, and 0.5 gram per liter of Tanapon X–70, a surfactant. The fabric is treated in the dyebath for 1 hour at the boil, then rinsed, scoured, and dried. The dyed fabric then is exposed for 20 hours in the Fade-Ometer and the exposed fabric rated visually. The results are summarized in Table II.

TABLE II

Hoseleg sample	Additive	E.I. catalyst	Rating
	A. Heat-set prior to dyeing		
Control of Example 5.	None	Cobalt acetate	3
Example 5	1,3-bis(2-hydroxyethoxy) benzene.	do	3-4-
Example 6	Bis(2-hydroxyethyl)azelate	do	3-4
Example 7	Dimethyl azelate	do	3-4+
	B. Heat-set after dyeing		
Control of Example 5.	None	Cobalt acetate	3-4
Example 5	1,3-bis(2-hydroxyethoxy) benzene.	do	3-4
Example 6	Bis(2-hydroxyethyl)azelate	do	4
Example 7	Dimethyl azelate	do	4
	C. Bleached and heat-set prior to dyeing		
Control of Example 8.	None	Manganese acetate.	
Example 8	1,3-bis(2-hydroxyethoxy) benzene.	do	3+
Example 9	Bis(2-hydroxyethyl)azelate	do	3+
Example 10	Dimethyl azelate	do	4
Control of Example 11.	None	Magnesium carbonate.	3+
Example 11	1,3-bis(2-hydroxyethoxy) benzene.	do	3+
Example 12	Bis(2-hydroxyethyl)azelate	do	3-4
Example 13	Dimethyl azelate	do	3

Thus, the products of the present invention allow the preparation of dyed fabrics having lightfastness properties equal to or superior than the lightfastness properties of dyed fabrics made from unmodified polymer. This effect is independent of the effect of the compounds of the present invention upon the whiteness properties of the polymers.

It is well known in the art that polymer color is intimately related to catalyst residues, although the exact nature of said catalyst residues is not always known. For example, salts of lead tend to give polymers having a yellow color whereas salts of germanium tend to give polymers which are relatively white. Without wishing to be bound by theory, it is believed that the ester interchange catalyst interacts with the compounds of the present invention to either reduce the amount of colored catalyst residues or to alter the nature of such residues, thereby reducing the amount of coloration produced in the polymer. Accordingly, it is preferable to add the compounds of the present invention prior to polycondensation so that the desired color-reducing interaction may occur before the stringent conditions of polycondensation are imposed upon the system. Loss of the compounds of the present invention from the system during polycondensation generally is not a problem since the glycol component of the polyester usually will have a lower boiling point than the compounds of the present invention. Of course, addition of the compounds of the present invention at the beginning of the ester interchange reaction is possible and within the scope of the present invention.

Having thus disclosed the invention, what is claimed is:

1. In a process for producing a linear terephthalate polyester from a dialkyl ester of terephthalic acid and a glycol having the formula:

$$HO(CH_2)_nOH$$

wherein n is an integer from 2 to about 10, said process comprising effecting the ester interchange of said dialkyl ester and said glycol in the presence of a catalyst selected from the group consisting of salts of transition metals in Groups II–B, VII–B and VIII of periods 4 and 5 of the periodic table of elements, the improvement comprising adding to the products of the ester interchange reaction prior to substantial polycondensation up to about 5 weight percent, based upon the amount of terephthalic acid dialkyl ester, of a difunctional compound selected from the group consisting of 1,3-bis-(2-hydroxyethoxy) benzene, 3-(2-hydroxyethoxy)phenol, bis-(2-hydroxyethyl)azelate, alkyl esters of adipic acid, alkyl esters of suberic acid, alkyl esters of azelaic acid and alkyl esters of sebacic acid prior to substantial polycondensation, wherein said alkyl group contains from 1 to about 6 carbon atoms, said polyester being suitable for the production of films or filaments and fibers having improved whiteness as defined by a Hunter D–40 Whiteness Rating as compared with unimproved but otherwise equivalent polyester.

2. The process of claim 1 wherein the difunctional compound added is selected from the group consisting of 1,3 - bis(2 - hydroxyethoxy)benzene, bis(2-hydroxyethyl) azelate, and dimethyl azelate.

3. The process of claim 2 wherein the ester interchange catalyst is selected from the group consisting of salts of manganese and cobalt.

4. The process of claim 1 wherein said linear synthetic polyester is poly(ethylene terephthalate).

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